BIYANI'S THINK TANK

CONCEPT BASED NOTES

STRUCTURE AND FUNCTIONS OF INVERTEBRATES

(B.Sc. Part-II)

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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

SYLLABUS

Paper-I

Z-201 : Structure and Functions of Invertebrate Types

Section-A

Structure and functional organization of vital systems of non-choradates as exemplified by Amoeba, Paramecium, Euglena, Obelia, Sycon, Fasciola, Taenia, Nereis, Hirudinaria, Palaemon, Lamellidens, Pila and Aseterias :

1. Locomotion : Pseudopodal (Amoeba), ciliary (Paramecium) and flagellar (Euglena); Parapodial (Nereis); Pedal-Muscular foot (Pila) and tube-feet (Asterias).
2. Skeleton : Endoskeleton (Spicules of Sycon), Exoskeleton; chitinous (Palaemon), calcareous (Corals, Pila, Lamellidens and Asterias), siliceous (Radiolaria).
3. Nervous System : Sensory and nerve cells (Obelia); brain ring and longitudinal nerves (Fasciola and Taenia) : brain and ventral nerve cord (Nereis, Palaemon); Nervous system of Pila and Lamellidens.
4. Sense-organs : Statocyst and ospharadium (Lamellidens and Pila), compound eye (Palaemon) and simple eye (Nereis, Pila); tactile and olfactory organs (Palaelmon); nuchal organs (Nereis).

Section-B

Structure and Function-II

1. Food, Feeding, Digestive Structures and Digestion : Autotrophic (Euglena); Heterotrophic : through food vacuole (Paramecium) and in hydroid and medusoid zooids (Obelia); Parastitic (Fasciola, Taenia, Hirudinaria); Predatory (Nereis, Palaemon, Asterias) : Filter-feeding (Lamellidens).
2. Respiration : Aquatic : general body surface (Euglena, Nereis, Hirudinaria); dermal bronchiease (Asterias), parapodia (Nereis), gills (Palaemon, Lemellidens, Pila); Aerial : pulmonary sac (Pila), trachea (Insect) ; anaerobic (Faciola, Taenia).

3. Excretion : General body surface (Protozoa, Sycon, Obelia); protonephridial system and flame cells (Fasciola, Taenia); nephridia (Nereis, Hirudinaria); malphighian tubules (Insect); organ of Bojanus (Lamellidens, Pila).
4. Circulation : Cyclosis (Euglena, Paramecium); diffusion (Sycon, Obelia, Fasciola, Taenia) ; open circulatory system (Hirudinaria, Palaemon, Lamellidens, Pila, Asterias); closed circulatory system (Nereis).
5. Reproduction : Asexual (Paramecium, Euglena, Sycon); alternation of generation (Obelia); sexual (Fasciola, Taenia, Nereis, Lamellidens, Pila, Hirudinaria, Asterias).

Section-C

Invertebrate Ada ptations

1. Salient features of Hemichordata.
2. Evolution of canal system of sponges.
3. Parasitic adaptations in Helminths.
4. Social organization in termites and bees.
5. Direct and indirect development in insects.
6. Water vascular system of starfish.

Section A

Locomotion

Q1. Name the locomotory organelle of the following Animals.

Ans

a.	Nereis	Parapodia
b.	Star Fish	Tube Feet
c.	Amoeba	Pseudopodia
d.	Paramecium	Cilia
e.	Euglena	Flagella
f.	Pila & UNio	Foot
g.	Fasciola	Absent
h.	Sycon	Absent
i.	Prawn	Walking Legs, Pleopods & Uropods

Q2. What is locomotion? Write the significance of locomotion.

Ans. Locomotion is the movement of an animal as a whole from one place to another. It is the characteristic feature of the animals. It helps in nutrition, reproduction, respiration, excretion, protection and distribution of the species.

Q3. What is kinesiology?

Ans. Study of movements is called kinesiology.

Q4. How many modes of locomotion are found in Protozoa?

Ans: Protozoans have different locomotory organs and their presence or absence is one of the main bases of their classification. Different types of locomotory organs found in different classes are as follows:

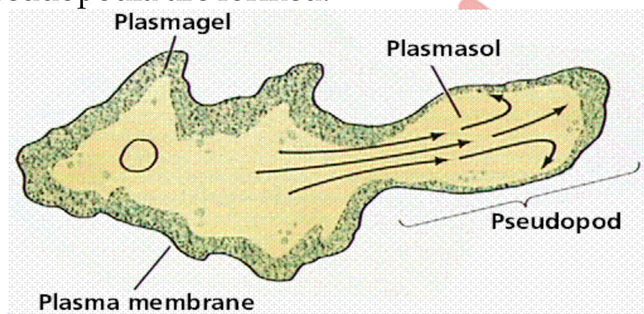
Rhizopoda: Peudopodia
Flagellata: Flagella
Ciliata: Cilia
Sporozoa: Absent

Q5. Describe the pseudopodial locomotion or amoeboid movement in detail.

Ans: **Pseudopodia means false feet derived from a greek word(pseudos, false + podos, foot).** Amoeboid movement is typically found in amoeba, a unicellular animal. As Amoeba moves by producing pseudopodia, such locomotion is called as the pseudopodial locomotion. Pseudopodia are cytoplasmic projections. This involves change in the shape of the cell body and streaming movement of cytoplasm into the pseudopodium. The movement due to pseudopodia in amoeba is termed as amoeboid movement. Amoeboid movement is characteristic of certain cells in other organisms. For example, the movement of white blood cells or leucocytes, in human blood.

This was discovered by Rossenhoff. The rate of speed of amoeba **is .02– .03 mm /minute.** At freezing point no pseudopodia are formed.

In general, Protozoans have four types of pseudopodia. Lobopodia,; filopodia; reticulopodia, and axopodial. Pseudopodial locomotion can be classed as either axial or appendicular, depending upon the definition of the pseudopodium. Outwardly, pseudopodial locomotion appears to be the extension of a part of the body that anchors itself and then pulls the remainder of the body forward.



- Internally, its cytoplasm (the living substance surrounding the nucleus) is divided into two parts: a peripheral layer, or ectoplasm of gel enclosing an inner mass, and endoplasm, of sol. As a pseudopodium is formed, part of the ectoplasmic gel is converted to sol, whereupon endoplasm begins flowing toward this area, the cell wall expands, and the pseudopodium is extended forward. When the endoplasm, which continues to flow into the pseudopodium, reaches the tip, it extends laterally and is transformed to a gel. Basically, the movement is one of extending an appendage and then emptying the body into the appendage, thereby converting the latter into the former. The energy required for amoeboid locomotion is available from **- ATP by the action of ATPase**

Q4. Describe various theories regarding formation of pseudopodia and pseudopodial locomotion or.

Ans. **S**everal theories have been given for the formation of pseudopodia and pseudopodial locomotion.

1. **Contraction theory** – Proposed by Schultuz.
2. **Walking theory** – Given by Dellinger.
3. **Rolling movement theory** – Given by Jenning by doing experiment on A. verucosa using charcoal.

4. **Surface Tension theory** – Given by Berthold. The point where surface tension is low, pseudopodia is formed.
5. **Adhesion theory** – Given by Jenning amoeba moveslike drop of water.
6. **Fountain zone theory** – Given by Allen.
7. **Folding and unfolding theory** – Given by Goldacre and Lorch.
8. **Hydraulic pressure theory** – Given by Renoldi and Jaun.
9. **Sol–gel theory** – Given by Hyman and supported by Mast and Pentin.

1. ***Surface Tension Theory:***

It was put forward by Butschli and was widely accepted for long. According to this view locomotion in amoeba is essentially like the movement of a globule of mercury or other liquid produced by local reduction of surface of the fluid protoplasm that makes the mass spherical. From such a sphere an outflow will occur wherever the surface tension is locally lowered, either by internal or external changes. In such a projection the fluid will flow forward and the centre and backward along the sides. Such streaming movement can be seen in active pseudopods of some amoeboid forms.

It is very simple and attractive theory which has been extended in its application to various types of activity in amoeba (by Rhumbler). There are, however, a number of fully established facts which show conclusively that surface tension as applied in this theory plays but a very insignificant role in the process of movement and locomotion in amoeba.

The objections to this theory are as follows:

1. The upper surface in many species moves forward in places of backward. That is, it moves in a direction opposite to that produced in a globule of liquid by local reduction in surface tension.

2. Many amoebae are so rigid that local reduction in surface tension cannot produce movement.

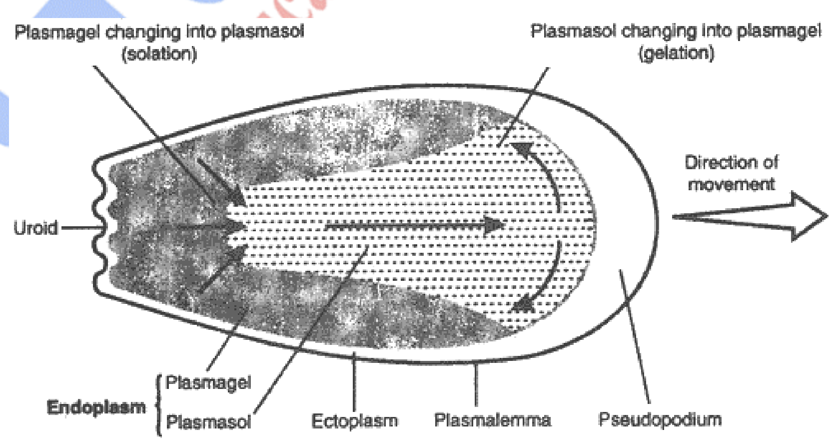
4. According to this view the surface is assumed to be liquid whereas in most amoeboid forms it is gelatinized. This theory is consequently untenable.

2. **Sol–gel theory** :
   The sol-gel theory was first advocated by Hyman (1917) and has been adopted, among other, by Pantin (1923-1926) and Mast (1925). This is the most accepted theory of pseudopodial formation.

   This theory is based upon the fact that the plasmasol changes into the plasmagel and vice versa. The cytoplasm inside the cell is capable of changing into different forms i.e. from fluid to solid and vice versa. When the cytoplasm is in fluid state, it is known as plasma sol, and the more solid or gel like state is called the plasma-gel. The plasmasol changes into rigid plasmagel (*gelates*) at the anterior end and at the posterior end the plasmagel changes into plasmasol (*solates*) causing a forward streaming of the more fluid plasmasol). The interchange of plasma sol to plasmagel is known as Sol-Gel theory and is responsible for amoeba movement.

Pseudopodial formation basically consists of some steps which are as follows:-

- When the cytoplasm is in solid or gel like state, there is no locomotion. Movement takes place only when the cytoplasm is in fluid state. This way the amoeba "drags" itself and this movement is known as amoebic movement.
- The protoplasm which is thick, less in quantity, non granular transparent and contractile is **- Plasmagel.** The protoplasm which is more in quantity less viscous, fluid like more granular and opaque is **plasmasol.**
- The change of Sol into Gel, and Gel into Sol is **a Physico - Chemical change.**
- The first stage in the formation of pseudopodia is - **Hyaline cap formation.** Hyaline cap contains **thickened ectoplasm at the advancing end.** The point of weakness in the elasticity of plasmagel develops below the **Hyaline cap.**
- Conversion of plasma gel into plasma sol by taking water is called - **Solation.**
- Conversion of plasma sol into plasma get by losing water is called - **Gelation.**



Sol-gel theory of amoeboid movement 2classnotes

- During amoeboid locomotion amoeba has - **Two ends,** The smooth round end is - **advancing end** and The trailing or retractile or wrinkled ends is Uroid **end.**
- Ectoplasm is - **Plasma gel,** and the Endoplasm is Plasma **sol.**
- The outer region of plasma sol produces Plasmagel **tube.**
- During pseudopodial formation conversion of sol into gel takes place near (gelation zone) at **the**
- **advancing end.** The protein molecules present in the cytoplasm that are involved in the amoeboid locomotion are **actin and myosin.**
- During pseudopodial formation, conversion of Gel into Sol takes place near the (Solation zone) i.e.
- **"Uroid".** Gelation and solation occur s**imultaneously at the same rate.**

3. **Hydraulic pressure theory** – Given by Renoldi and Jaun
   - Contraction of plasmagel tube at the trailing end exerts **Hydraulic pressure on plasma sol,** this results in the continuous flow of plasma sol forwards in the plasmagel tube and forms the pseudopodium.

4. **Folding and unfolding theory**
   - According to this view on sol gel theory was explained the basis of action of protein molecules by **Goldacre and Lorsch.**
   - When the protein molecules of Amoeba are in Folded or Contracted condition the endoplam is said to be in - **'Sol State".**
   - When the protein molecules are in relaxed or unfolded condition, the endoplasm is said to be in – **Gel State".**
   - Folded protein molecules unfold at the gelation point of the advancing end by - **losing water.**
   - Relaxed proteins at the solation point below the uroid surface fold due to - **The absorption of water**

5. **Rolling movement theory**
   It was given by Jenning by doing experiment on A. verucosa using charcoal. In some specimens locomotion is accompanied with 'rolling movement' of the surface. With the help of carbon particle Jennings stated that A.*verucosa* moves like a rolling ball. This generally occurs in the monopodal specimens.

Q.5 Describe different types of pseudopodia found in various species of protozoa.

Ans. The temporary outgrowths of the cell formed on the surface of the body are **Pseudopodia.** Pseudopodia are the characteristic of the classes- **Rhizopodia and Actinopodia** but they also occur in few mastigophorans - **Mastigamoeba**

➢ Based on number of pseudopodium organisms can be monopodium or polypodium. Organisms with many pseudopodia are called **Polypodial organisms Eg: Amoeba.** Organisms with a single pseudopodium are called **Monopodial organisms Eg: Entamoeba.**

Based on their form and structure pseudopodia are - **4 types, Lobopodia, Filopodia, Reticulopodia and Axopodia or Actinopodia**

- ***Lobopodia*** are blunt and finger like tubular pseudopodia containng ectoplasm and endoplasm with round tip Eg : **Amoeba, Entamoeba.**
- ***Filopoda*** are slender filamentous, pseudopodia with pointed tips. Eg : **Euglypha, Lecithium.**
- ***Reticulopodia*** are - Filamentous branched, net like pseudopodia chiefly meant for food collection **Eg : Elphidium, Globigerina.** Recticulopodia are also called **Myxopodia.** Primary function of Recticulopodia is - **Ingestion of food.** Retculopodia are common in – **Foraminifers**
- ***Axopodia or Actinopodia*** are needle like pseudopodia, which develop radially on the body surface with a central axial filament. These are pseudopodia with adhesive cytoplasm. The main function of Axopodia is **Food collection.** Axopodia occur in **Helozoans (Actinosphaerium, Actinophrys) and Radiolarians (Collozoum).**

Q. Describe the method of locomotion performed by Euglena.

Ans. Euglena is a flagellate protozoan possesses one main long **locomotory flagellum** (= primary flagellum) extending from the anterior (front) end of the body as its locomotory organelle. There are actually two flagella but one, the accessory flagellum, is very short. The primary flagellum emerges from an anterior invagination, the reservoir, which connects to the outside by a narrow canal. Both flagella arise from basal bodies in the cytoplasm at the base of the reservoir. The second flagellum is rudimentary and does not emerge from the reservoir.

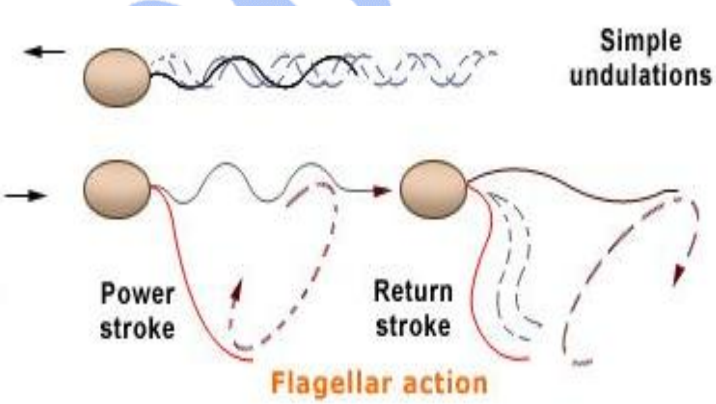
There is a small, red pigment eyespot, or stigma, located on one side of the reservoir. It is associated with a swollen, light-sensitive region at the base of the locomotory flagellum.

Flagellum is a long, thread like cytoplasmic projection. The locomotion performed by the flagella is called as the Flagellar locomotion. Flagellar movement is characteristic of Mastigophorans which bear one or more

flagellum. The flagellum requires liquid medium for movement. 3 types of flagellar movements have been recognized:-
All three of these forms of flagellar locomotion consist of contraction waves that pass either from the base to the tip of the flagellum or in the reverse direction to produce forward or backward movement.

1) **Paddle stroke:-**
According to Ulhela & Krijsman (1925) the common movement of flagellum is sideways lash. It consists of an effective downstroke/ power stroke with flagellum held out rigidly & a relaxed recovery stroke with flagellum strongly curved. The power stroke produces more thrust in the backward direction & as a result the animal moves forward.

2) **Undulating motion:-**
Wave like undulations of the flagellum, when proceeds from tip to base, pull the animal forward. Backward movement is caused when undulations pass from base to tip.



- Undulation from the base to the tip causes pushing force due to which the organism is pushed backward. The pushing force like a Propeller of a boat.
- Undulation from the tip to the base causes pulling force due to this the organism is pulled forward. The pulling force like a Propeller of an Aeroplane
- When the undulations are spiral organism shows - rotatory movements.
- If the flagella bend, to one side and undulations from base to the tip, the organism moves laterally in the opposite direction.
- Sidewise lash movement consists of 2 strokes -
  1) Effective strokes 2) Recovery stroke

3) **Simple conical gyration;-**
According to Butschli's screw theory the flagellum performs spiral turning like a screw. This exerts propelling action which pulls the animal forward through water with a spiral rotation as well as gyration around the axis of movement.

Structural organization of Flagella

Typical flagellum consists of central axoneme made up of 2 longitudinal microtubules enveloped by a central sheath & 9 pairs of peripheral longitudinal microtubules. All 20 fibres lie in a matrix of dense cytoplasm & covered by extension of cell membrane. They fuse at the base to join a basal granule or kinetosome. Flagella may be surrounded by very minute, fine, flexible lateral processes called mastigonemes.

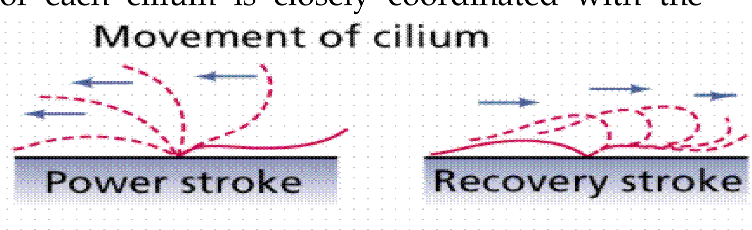
Q. Describe the Ciliary locomotion performed by a Ciliate.

Ans. Cilia are found in **Ciliophoran protozoans** used as the locomotory organelle of class ciliate, e.g. **Paramecium.** In paramecium holotriche like cilia are found. Paramoecium uses cilia not only for moving from one plate to another (locomotion) also to drive water and food into their gullet. Ciliary movement is the ***fastest*** locomotion in protozoa.

The central axoneme or axial filament of a cilium or flagellum is formed by m**icrotubules** which shows the arrangement of microtubules in the axoneme as **9 + 2.** The structures connecting kinetosomes are called **Kinetodesmata.** Kinetodesmata are also called **Neurofibrils.** The longitudinal row of Basal granules and their kinetodesmata together called **Kinety.** A network of kinety present in the ectoplasm of Paramecium is **Infraciliary system.** There is a neuromotorium centre near cytopharyx called as **Motorium.** Motorium and infraciliary system are together called the **Neuromotor system.** The neuromotor system coordinates & controls the ciliary movement. If neuromotorium is destroyed, the cilia loose coordination and stop **beating of cilia.**

Mechanism

During movement cilia operate like flexible oars; they have a unilateral (one-sided) beat lying in a single plane. As a cilium moves backward, it is rigid; upon recovery it is flexible, and its tip appears to be dragged forward along the body. The movement of each cilium is closely coordinated with the movements of all other cilia. Cilia of the same transverse row beat together & those of the same longitudinal row beat one after the other.



This coordinated movement pattern of the cilia is called ***metachronal rhythm***. It can be compared to the passage of wind over a field of paddy. Since the plane of the ciliary beat is diagonal to the longitudinal axis of the body, ciliate organisms rotate during locomotion.

Characteristic features of ciliary locomotion:

- Ciliary movement is similar to - **Paddle movement**
- Beating of cilia in longitudinal row one after another is called - **Metachronous movement.**
- The Cilia of transverse row best simultaneously in one direction is called - **Synchronous movement.**
- Synchronous movement seen in the - **Transverse row of Cilia.**
- The stroke in which cilia bends backwards and beats the water is called - **Effective stroke**
- The effective stroke - **body moves forwards and water moves backwards.**
- The cilia by its backward movement regains to its original position is called - **Recovery stroke**

Q. Write a note on the basal body of cilium.

Ans. The basal body is a centriole like cellular organelle from which the cilium arises. It remains separated from cilium by a basal plate. The ultrastructure of basal body is like those of an axoneme except that the central singlets are absent & 9 fibrils in the outer circle are triplets. Each triplet contains one complete 13-protofilament microtubule. In each triplet, one complete tubule is fused to middle incomplete tubule, which in turn is fused to the third outer incomplete C tubule. Dynein arms are absent in triplets.

Q. What is axoneme?

Ans. Axoneme is the inner core of cilia or flagella, composed of microtubules & other proteins. Here microtubules are modified & arranged in a ring of 9 doublets surrounding a pair of central singlets.

Q. Describe the Ultrastructure of Flagellum:-

Ans Electron microscopy has shown that the flagellum has 3 parts:

1. <u>Outer coat:-</u> A contractile membranous sheath that is physically continuous with the cell membrane but it contains far less amount of protein than the latter.
2. <u>Matrix:-</u> The bounded space of flagellum contains a watery substance known as matrix. The axoneme is embedded into it.
3. <u>Axoneme:-</u> It is the inner core, composed of microtubules & other proteins. Here microtubules are modified & arranged in a ring of 9 doublets surrounding a pair of central singlet. This arrangement is known as '9+2' array.

Each of the central microtubule is complete & composed of 13 protofilaments. Both central microtubules are connected by a bridge & are enclosed in a common central sheath.

Each of 9 peripheral doublet consists of 2 microtubules, one is smaller & complete, having 13 protofilaments & lying closer to axis; the other microtubule is larger & incomplete, having only 11 protofilaments.

- **Major protein structures of axoneme:-**

Axoneme component	**Function**
1. **Tubulin**	Principal component of microtubules.
2. **Dynein**	Project from microtubule doublets & interact with adjacent doublets to produce bending.
3. **Nexin link**	Hold adjacent microtubule doublets together.
4. **Radial spokes**	Extends from each of the 9 outer doublets inward to the central pair.
5. **Sheath projections**	Project as a series of side arms from the central pair of microtubules; together with the radial spokes these regulate the form of ciliary beats.

Flagellum arises from a basal body. The ultrastructure of basal body is like those of an axoneme except that the central singlets are absent & 9 fibrils in the outer circle are triplets.

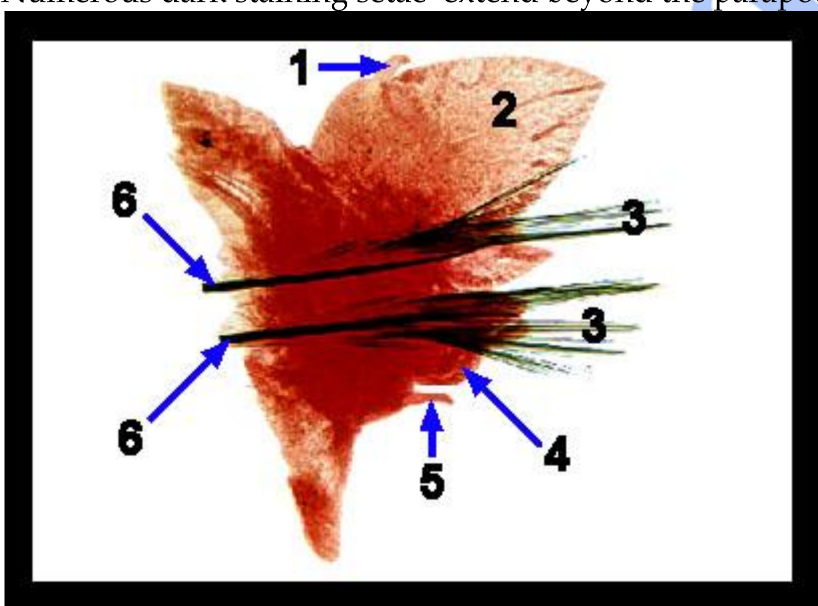
Q. Mention the differences observed in cilium & flagellum.

Ans. Morphologically & physiologically the cilia & flagella are identical structures but both can be distinguished from each other by their number, size & functions.

1. The flagella are less in no. (1-2) in number than the cilia which may be numerous (3000-14000) in no.
2. Flagella occur at one end of the cell, while the cilia may occur throughout the surface of the cell.
3. The flagella are longer processes while the cilia are short appendages of the cytoplasm.
4. The flagella usually beat independently, while the cilia tend to beat in a co ordinated rhythm.
5. The flagella exhibit undulatory motion while the cilia move in a sweeping or pendular stroke.

Q. What is locomotory organelle of Nereis? Describe its structure along with diagram.

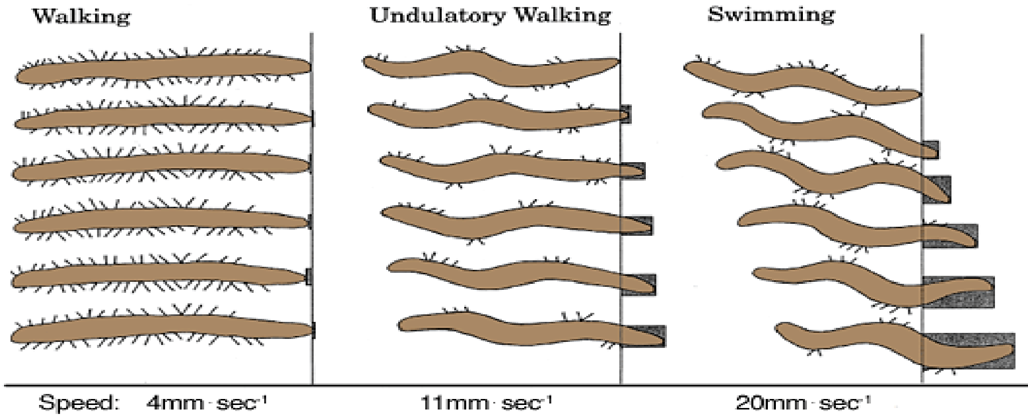
Ans. Parapodia are the locomotory organelle of Nereis. Nereis is a Polychete which bear parapodia in most segments. Parapodia are bilobed structures used in swimming, crawling, or for anchorage in tubes. Parapodia also serve as gills. Its structure is based on biramous plan which appendage consists of a ventral lobe called the neuropodium and a dorsal lobe called the notopodium. Each of which is supported by a stiff chitinous rod called an aciculum. A dorsal cirrus and ventral cirrus (richly supplied with sensory receptors) project from the notopodium and the neuropodium respectively. Numerous dark staining setae extend beyond the parapodium.



1. Dorsal cirrus 2. Notopodium 3. Setae 4. Neuropodium 5. Ventral cirrus 6. Acicula

Mechanism:

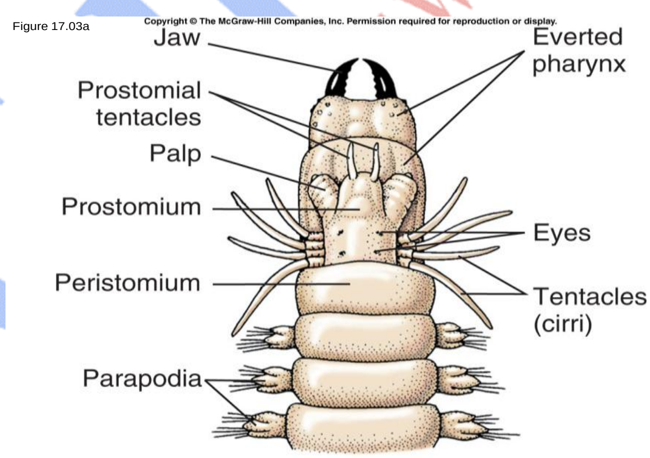
Nereis locomotes using moveable segmental parapodia bearing clusters of bristles or *setae*. Different gaits are used for slow and fast speeds when walking. During slow walking the body is more or less straight and the parapodia act like little legs moving step-by-step. A step involves the parapodium moving forward, extending to contact the substratum, exerting the power stroke, and recovering for the next step.



Each vertical panel shows 6 consecutive frames from videos of *Ophiodromus walking*, *undulatory walking*, and *swimming*, each over a 0.2sec period. The shaded boxes show relative distances moved in 0.2sec for the 3 gaits. Absolute speeds for each gait are given.

At faster speeds of walking, the body undulates, and a different mechanism is used. In this gait the parapodia and setae, when thrust into the sediment, act as pivots around which the body segments move. The parapodia are extended only on the outside curves of an undulatory wave, and withdrawn on the inside curves (see drawings upper Left).

The setae are able to bend in such a way as to increase their contact with the substratum during the power stroke when walking, and similarly against the fluid medium when swimming. The distal part of each seta is serrated, which may also increase frictional resistance with the substratum durig swimming.



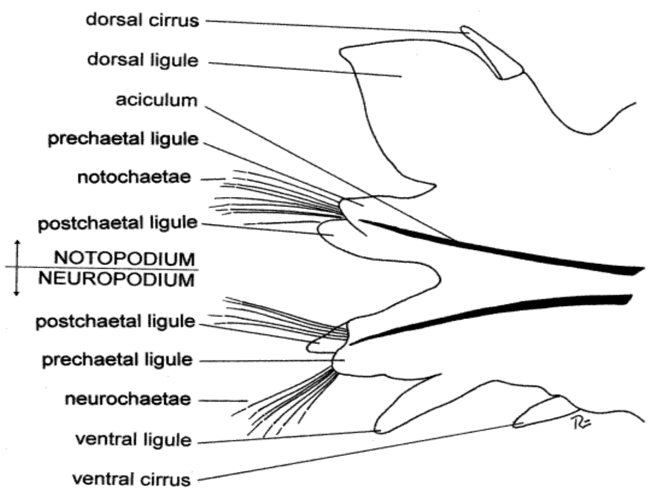
A

Q. What is locomotory organ of neris? Describe its structure and function in detail.

Ans. Parapodia are paired locomotory organs of the body of nereis attached on the lateral side of each trunk segment. The parapodia function not only in locomotion but are also important gas exchange surfaces. They have well-developed musculature and are heavily vascularized. A typical polychaete parapodium is composed of two major branches, or rami, and therefore it is said to be biramous. The dorsal ramus is the notopodium (noto = back, pod = foot) and the ventral ramus is the neuropodium (neuro alludes to the nerve cord, which is ventral). Each ramus bears clusters of chitinous bristles, or chaetae. Each ramus is composed of smaller lobes, or ligules. The notopodium has a small, pointed, sensory dorsal cirrus on its dorsal margin. It is divided into three ligules. The dorsal ligule is by far the largest and most conspicuous of the three and is leaf-shaped. It is a gill used for gas exchange and is heavily vascularized. The dorsal cirrus is located on the dorsal border of the dorsal ligule. Ventral to the dorsal ligule are two much smaller ligules associated with a bundle of chitinous chaetae. These are the notochaetae. The prechaetal ligule is anterior to the bundle and the postchaetal ligule is posterior to it, each being composed of two articulated pieces. The ventral ramus of the parapodium is the neuropodium. It is smaller than the notopodium and bears neurochaetae, three small ligules, and small ventral cirrus on its ventral margin. Each parapodium is supported by two internal, black chitinous rods called acicula, one in the notopodium and another in the neuropodium. The proximal ends of the acicula and the insertions of the muscles are covered by a cap of tissue, the chaetal sac that secretes the chaetae and acicula. Each chaetae has two parts, Shaft and blade. There are following types of chaetae found in neris:- a.Long bladed: having small shaft and long serrated blade. b. Typical: having long shaft and small serrated and curved blade. c. Oar- shaped : found in heteroneris, specially for swimming. Nephridiopore is situated on the parapodium near the ventral cirrus, so it serves for the excretion also. Heteronereis, the reproductive form of Nereis, instead of creeping about on sea bottom or living in burrows, swims actively in surface waters. Body is divisible into an anterior asexual atoke and a posterior sexual epitoke. Parapodia of posterior sexual region become larger and develop flattened leaf-like outgrowths for better respiration. Their setae are replaced by oar-shaped setae arranged in a fan-like manner for swimming. Dorsal cirri become sensitive. The eyes become greatly enlarged and more sensitive.

Function:

1. Helps in locomotion
2. Vascular skin serves for respiration
3. Aids in excretion by the presence of nephridiopore



Q. Describe the pedal locomotion in pila.

Ans Pila is a sluggish animal which has foot for locomotion. The locomotion by foot is called as the pedal locomotion. Pila has a large more or less conical foot adapted for creeping movement is present below and behind the head. The anterior part of the foot is round and the posterior dorsal surface bears the operculum. The foot is highly muscular and contains pedal glands, the secretions of which form a slime trail during locomotion.

Q. Describe the locomotory organelle of star fish and its mechanism.

Ans. Locomotion of sea stars is via multiple tube feet that are part of a larger system of hydraulic ducting known as the water-vascular system. Water vascular system consists of madreporite, stone canal, ring canal, radial, canal, lateral canal and tube feet. Water comes into the system via the madreporite. It is then circulated from the stone canal to the ring canal and into the radial canals. The radial canals carry water to the ampulla (reservoir) portion of tube feet. Each tube foot consists of an internal "ampulla" and an external podium, or "foot" and terminal "sucker". Rows of tube feet on oral surface (underside) are found in ambulcaral grooves under each arm. Mechanism: When the ampulla is squeezed, it forces water into the podium, which expands to contact the substrate. In some circumstances the tube feet seem to work as levers, but when moving on vertical surfaces, they form a traction system. Although the podium resembles a suction cup in appearance, the gripping action is a function of adhesive chemicals rather than suction. Other chemicals and podial contraction allow for release off the substrate.The tube feet latch on to surfaces and move in a wave, with one body section attaching to the surfaces as other releases.

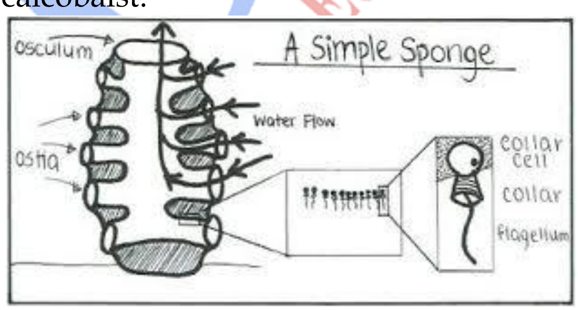
Hydraulic movement of fluid from storage sacs or *ampullae* to the tube feet (*podia*) accompanied by relaxation of longitudinal muscles, act to extend the tube feet. On contact with the substratum the tube feet attach momentarily to the substratum by means of a sucker. Contraction of *postural* muscles at the proximal regions of the tube feet moves the body in relation to the tube feet for locomotion. Contraction of the longitudinal muscles in the tube feet pull them closer to the substratum for anchoring, or pull prey closer to the arms for feeding.

SKELETAL SYSTEM

Q. Give an account of the skeleton found in Sycon & describe the development of spicules .

Ans:

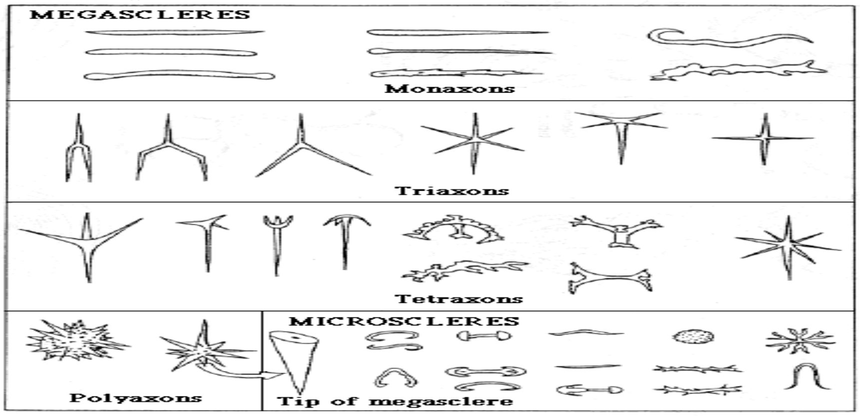
Sycon is a calcareous,poriferan sponge having sedentary nature. The soft body is anchored with minute, calcareous , crystalline, needle-like SPICULES with various definite shapes. These are embedded into the mesenchyme layer and provide protection and support to the soft body of the animal. Presence of Calcareous ($CaCo3$) spicules is the characteristic feature of Calcarea class. The chemical composition of the spicule is calcium carbonate (87%) magnesium carbonate, other minerals, water (3%) and organic materials (in trace). The organic material is forms the axis around which calcium Carbonate and other inorganic compounds get deposited. The spicules are covered with thin sheath of organic materials.
In Sycon spicules are megascleres and of various but definite shape and size. These are embedded into the mesenchyme but projected out through the pinacoderm. These are synthesized by a kind of sceleroblast cell, called calcobalst.



Types of spicules:

Two types of spicules found in Sycon are:

Monoaxon spicules
Tetraxon spicules



Different Calcareous Spicules 1

Monoaxon spicules
If spicules grow in one axis during spicule formation, these are monoaxon. These are needle like or rod like or curved in shape. These are categorized into two types:

i. ***Monoactinal monoaxon spicule:***

- Uniradiate i.e. spicules growth on the axis is unidirectional
- Found surrounding the osculum forming oscular fringe

ii. ***Bi actinal monoaxonal spicules:***

- Biradiate i.e. spicules growth on the axis is bidirectional
- Recurved in shape

Tetraxon spicules:
These have four rays on different axes. When four rays are present it is known as ***tetraradiate*** spicules. If all the four rays are of equal size it is termed as ***the Calthrops***. If there are only three rays it is known as ***triradiate*** spicules.

TRIRADIATE SPICULE

Q. Describe in brief about siliceous skeleton in any protozoa.

Or

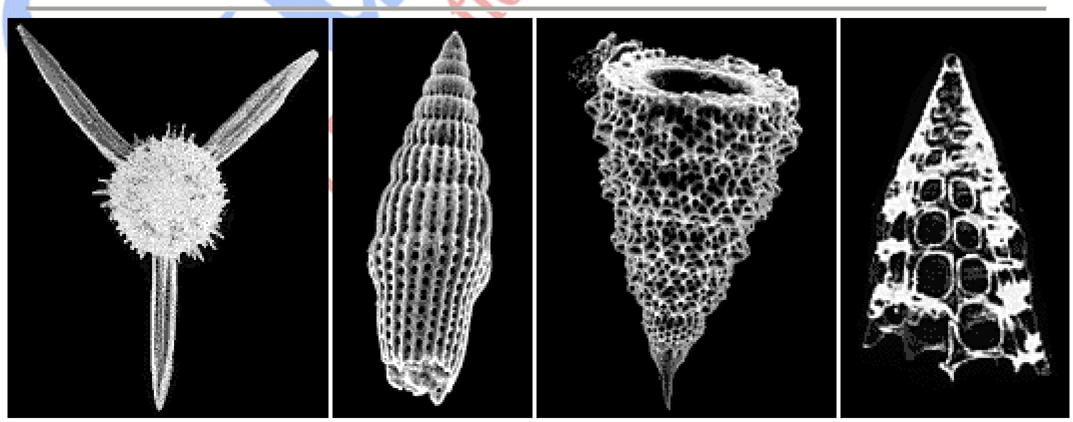
Q. What do you know about radiolarian skeleton?

Ans:

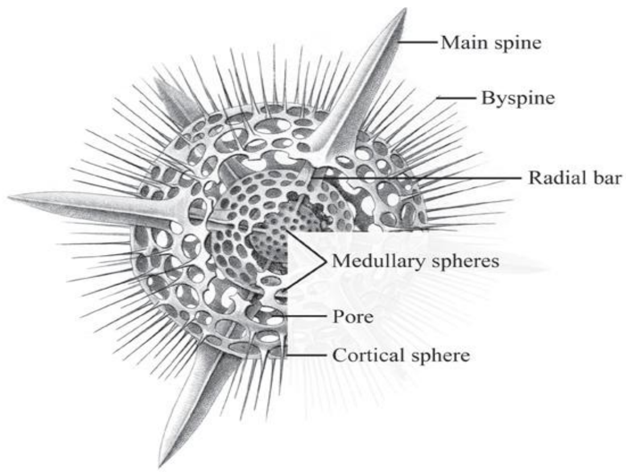
Radiolarians are unicellular protozoa that form glass skeletons and live exclusively in the ocean. They absorb silica from ocean water to construct tiny glass skeleton 0.1 to 0.2 mm in diameter. Radiolarian skeletons tend to have arm-like extensions that increase surface area for buoyancy and assist in the capture of prey also.

Their unique skeleton is an unusual and often strikingly beautiful characteristic of these organisms. Silica is thus vitally important to the protection and survival of radolarians, as well as for preserving the record of their existence in the world's oceans throughout prehistoric and modern times.

The skeletons of radiolarians are generally organized around **spicules**, or spines, which are sharp, dense outcroppings from the main skeletal mass. Formed from the fusion of many of these spines is the outermost skeleton, the **cortical shell**. Connecting this shell to the many concentrically organized inner shells are bars or beams, which also serve to strengthen and support the entire assembly. Within and extending into the many chambers created by this complex structure is the single cell of the organism.



Diversity of Radiolarian form : Though a radiolarian is a single-celled organism, each species is capable of producing its own distinctive skeleton of crystal silica. Skeletons may be spherical or cone-shaped, and may have spines or fins projecting from the surface.



Radiolaria are incredibly diverse in the form their skeletons may take, ranging from spherical to rod-shaped, and radial to bilaterally symmetrical. They show high degree of specialization. Their **cytoplasmic mass**, which constitutes the majority of the space within the cell, is divided into two regions separated by a perforated membrane. The first of these regions is the central mass, also known as the **central capsule**, and the second is the **extracapsulum**, a peripheral layer of cytoplasm surrounding the central capsule. The central capsule contains the all the cell organelles, such as the mitochondria and vacuoles. The extracapsulum is characterized by its thread-like extensions of cytoplasm, the **rhizopodia**. Rhizopodia aids in the capture of prey increase the surface area and are crucial in obtaining the energy necessary for the successful completion of the Radiolarian life cycle.

Q. What are corals? Describe the different types of coral reefs and their origin and significance.

Ans: Corals are invertebrate animals belonging to a large group of colourful and fascinating animals called Cnidaria. They mainly belong to class Anthozoa but some corals are Hydrozoans. The members of Order Madreporaria are true corals or Stony corals.

Coral are generally classified as either "hard coral" or "soft coral". There are around 800 known species of hard coral, also known as the 'reef building' corals. Soft corals, which include seas fans, sea feathers and sea whips, don't have the rock-like calcareous skeleton like the others; instead they grow wood-like cores for support and fleshy rinds for protection. Soft corals also live in colonies that often resemble brightly coloured plants or trees, and are easy to tell apart from hard corals as their polyps have tentacles that occur in numerals of 8, and have a distinctive feathery appearance. Soft corals are found in oceans from the equator to the north and south poles, generally in caves.

Hard corals have skeleton of calcium carbonate. They may be solitary or colonial. The skeletal of solitary coral is called as *Coralite,* and that of colonial is known as *the Corallium.*

Q. What are coral reefs?

Ans Hard corals extract abundant calcium from surrounding seawater and use this to create a hardened structure for protection and growth. Coral reefs are therefore created by millions of tiny polyps forming large carbonate structures, and are the basis of a framework and home for hundreds of thousands of other species. Coral reefs are the largest living structure on the planet, and the only living structure to be visible from space. The main contributor of coral reef are members of order Madreporaria, Hydrocorallines, Alcyonaria, foraminifera and Coralline Algae.

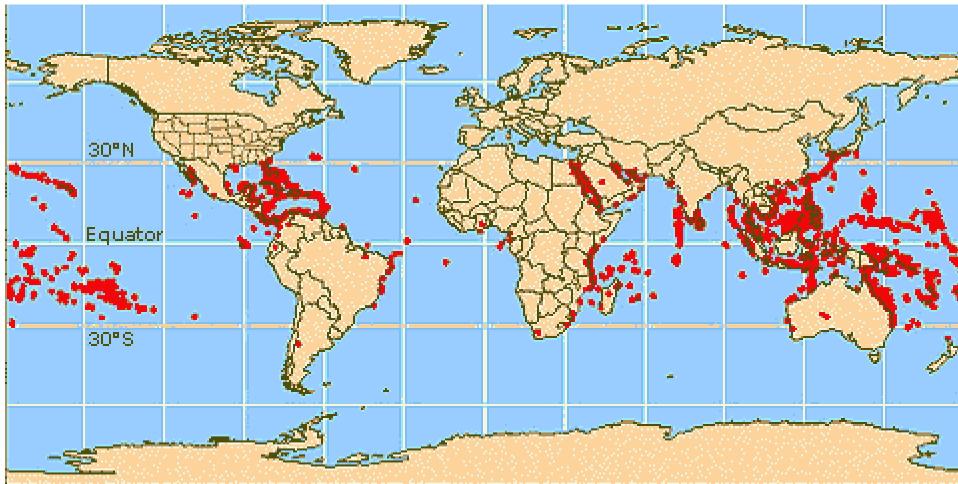
Coral reefs have evolved on earth over the past 200 to 300 million years, and over this evolutionary history, perhaps the most unique feature of corals is the highly evolved form of symbiosis. Coral polyps have developed this relationship with tiny single-celled plants, known as zooxanthellae. Inside the tissues of each coral polyp live these microscopic, single-celled algae, sharing space, gas exchange and nutrients to survive.

Q. How fast do they grow?

Ans In general, massive corals tend to grow slowly, increasing in size from 0.5 cm to 2 cm per year. However, under favorable conditions *(high light exposure, consistent temperature, moderate wave action*), some species can grow as much as 4.5 cm per year. In contrast to the massive species, branching colonies tend to grow much faster, and under favorable conditions, these colonies can grow vertically by as much as 10 cm per year.

Q. Where are they found?

Ans Coral reefs are found throughout the oceans, from deep, cold waters to shallow, tropical and Sub tropical waters. Temperate and tropical reefs however are ***formed only in a zone extending at most from 30°N to 30°S of the equator***; the reef-building corals prefering to grow ***at depths shallower than 30 m (100 ft)***, or where the temperature range is between ***16-22°C***, and light levels are high.



Distribution of coral reefs -
Source: NOAA's National Ocean Service, Education Division

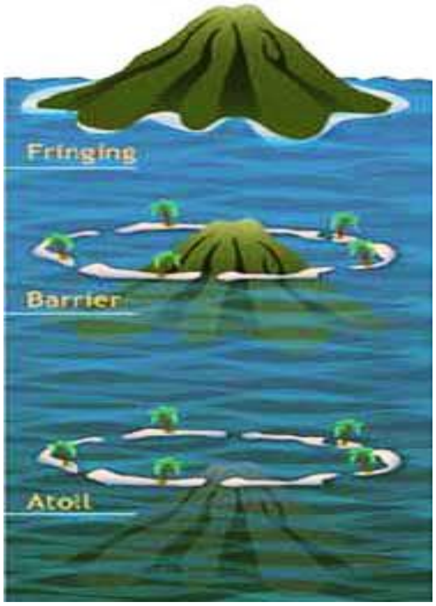
Based on current estimates, shallow water coral reefs occupy somewhere between 284,000 and 512,000 km2 of the planet. This area-about 198 thousand square miles in an ocean of 140 million square miles-represents less than 0.015 percent of the ocean. ***Yet coral reefs harbor more than one quarter of the ocean's biodiversity****. That's an amazing statistic when you think about it: no other ecosystem occupies such a limited area with more life forms.*

Ideal conditions for coral Reef Formation

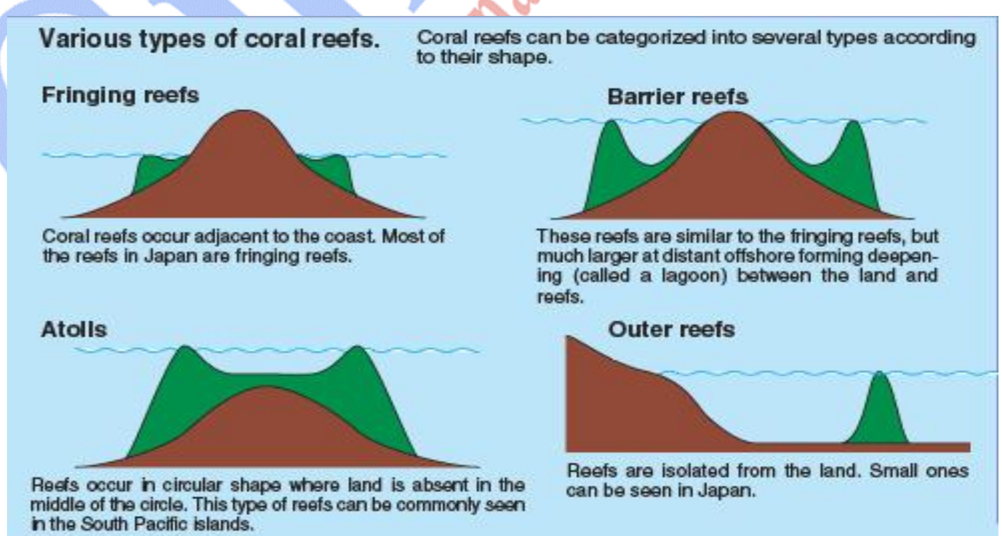
- Water temperature should be 20^0C, although the optimum temperature is **22^0C** for fast growth.
- Presence of shallow water up to **100 feet** depth.
- Presence of **sufficient light** is necessary.

Types of coral reef

It was Charles Darwin who originally classified coral reefs as to their structure and morphology, and described them as follows:



- **Fringing reefs** lie near emergent land. They are fairly shallow, narrow and recently formed. They can be separated form the coast by a navigable channel (which is sometimes incorrectly termed a "lagoon").
- **Barrier reefs** are broader and lie farther away from the coast. They are separated from the coast by a stretch of water which can be up to several miles wide and several tens of metres deep. Sandy islands covered with a characteristic pattern of vegetation have sometimes formed on top of a barrier reef. The coastline of these islands is broken by passes, which have occupied the beds of former rivers. Eg Australia's Great Barrier Reef
- **Atolls** are large, ring-shaped reefs lying off the coast, with a lagoon in their middle. The emergent part of the reef is often covered with accumulated sediments and the most characteristic vegetation growing on these reefs consists of coconut trees. Atolls develop near the sea surface on underwater islands or on islands that sink, or subside. Bermuda has been classified as an atoll,



Functions of coral reefs

1. Coastal protection as natural ramparts

- Coral reefs function as natural ramparts by reducing high-wave energy of typhoon and storm from their structures.
- Coral reefs are also protecting coastal beaches by providing sands that are by-products of foraminifera and/or eroded coral skeletons

2. Providing various resources

- Coral reefs provide us various resources not only fisheries products but also building materials, folk craft natural fertilizer, etc.
- It is potentially expected in the future that coral reefs may provide useful chemical resources for medical use

3. Rich field for educational and research use

- Coral reefs teach us many things serving as "natural school". The role of coral reefs is expanding in the field of environmental education, for example, as nature watch and nature clean ups.
- Many mysteries still remain in biology of corals and other organisms living in coral reefs.

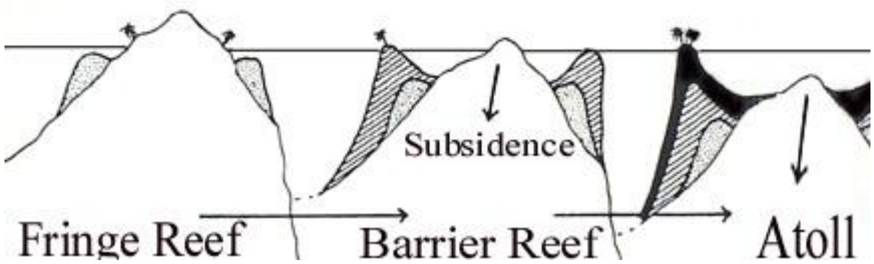
4. 【Coral reefs involved in CO2 circulation】 Coral reefs involved deeply in global warming ?

The increase of greenhouse effect gas such as CO_2 in the atmosphere induces temperature rise of the entire globe.

The coral skeletal framework is chiefly formed by CO_2 and calcium ion dissolved in seawater, which is a result of photosynthetic activity of zooxanthellae living in coral tissue in symbiotic relationship. Thus this biological activity is thought to have something to do with global CO_2 circulation. However it is not confirmed yet whether coral reef is playing as a sink or source of CO_2.

Coral reefs occupy only 0.3% of total ocean areas. It is surprising to know that such a small ecosystems might be playing a significant role in global CO_2 circulation.

Theories of origin of coral reef



There are several theories about how coral structures are formed. **The subsidence theory of Charles Darwin and Danna** originally described 3 major types of coral reefs fringing, barrier and atoll.

According to Darwin, barrier reefs begin as fringing reefs along the shores of a volcano. Over millions of years, the volcano sinks lower into the sea and the sea level rises around the volcano. The coral grows upwards to keep from getting too far from the sunlight at the sea surface. The outward side of the coral reef grows fastest since ocean currents bring in the plankton that the corals feed on. The water on the landward side of the reef is still and there is less oceanic plankton. Here the reef is unable to grow fast enough to keep up with the rising sea level and is eventually drowned. A lagoon develops between the reef and the land, resulting in the characteristic barrier reef shape.

The volcano continues sinking until it disappears under the sea surface. The result is an atoll, a ring of coral reefs surrounding the submerged, extinct volcano. Eventually sand is trapped by the reefs and sandy islands, called cays, appear.

Q. Describe the skeletal system of Prawn.

Ans: The body of Prawn consists of two regions, the anterior cephalothorax and the posterior abdomen

Cephalothorax: The cephalothorax is formed by the fusion of the head or cephalon and thorax.The head consists of five segments and the thorax is eight-segmented.The dorsal and the lateral sides of the cephalolhorax is covered by- a single chitinous exoskeleton called *carapace* or dorsal shield. It is formed by the fusion of five terga of the head and eight terga of the thorax. A transverse cervical groove on the dorsal side seperates the anterior head from the posterior thorax. The anterior region of the carapace forms in front a median serrated process known as rostrum. There are two compound eyes, which are attached to the base of the rostrum by movable stalks. The free ventral flaps of the carapace on each side of the thorax is called branchiostegite or gill cover.The space between the branchiostegite and body wall of each side is known as branchial chamber. The respiratory organ, branchiae or gills lie in the branchial chamber. The ventral sterna of the cephalothorax fuse and form a plate known as sternal plate. In female, the sternum of the last thoracic segment forms an outgrowth called thelycum,which encloses a cavity. The male deposits its spermatophores into it. Cephalothorax bears thirteen pairs of jointed appendages, of which the anterior five pairs are in the the cephalic region and the posterior eight pairs are in the thoracic region.

In female, a pair of genital openings lies at the base,of the sixth thoracic legs. In male, a pair of genital aperturelies on a small papillae at the base of last pair of thoracic legs.

Abdomen: The abdomen consists of six segments and a terminal piece called telson.The dorsal side of each abdominal segment is covered by an exoskeleton called tergum . The thin lateral downward prolongation of the tergum is known as pleuron. The ventral plate-like exoskeleton of the abdominal segment is known as sternum.The part between the pleuron and ventral abdominal appendage on each side is known as epimeron. The cuticle between the adjacent segments is thin. Each abdominal segment bears a pair of jointed ventral appendages. The last pair of abdominal appendages is called uropods. In male, the first pair of abdominal appendages forms a copulatory apparatus called petasma. The last piece of the abdomen, the telson, bears no appendages. Anus lies at the base of the telson ventrally. The uropods and the telson form the tail fin. They are used for backward movement

Q. Describe the appendages of Prawn.

Ans **Appendages:** Prawn bears ***nineteen pairs of appendages***. They include **cephalic, thoracic** and **abdomina**l appendages .The appendages of prawn are many-jointed. The segments of an appendage are known as **podomeres**. The appendages are typically biramous (= twobranched).Each appendage has a two-jointed **basal** region called **protopodite** to which are attached two distal processes, the **outer exopodite** and the **inner endopodite**. This basic plan of the appendages is modified in different parts of the body to suit the varying functions performed by them.

Cephalic Appendages:Head region bears **five pairs** of appendages. These include ***a pair of antennules, a pair of antennae, a pair of mandibles, first pair maxillae and second pair maxillae.***

Antennules: They are the anterior most appendages situated below the levei of the eyestalks. They are also known as first antennae. Each antennule has a proterpodite, an exopodite and an endopodite. Protopodite has three podomeres, the proximal precoxa, middle coxa and the distal basis. The precoxa has a hollow depression on one side. The eye and the balancing sense organ/ statocyst are located in it. The opening of the statocyst lies at the base of this podomere. The basis carries short many jointed flagella-like exopodite and endopodite. They function as tactile sense organs.

Antennae: They are also known as second antennae. They lie immediately behind the antennules. Each antennule consists of protopodite, exopodite and endopodite. Protopodite has two podomeres, the proximal coxa and distal basis. The opening of the excretory duct lies in the coxa. Exopodite and endopodite are situated on the basis. Endopodite has three basal podomeres and a long narrow many-jointed filament. It functions as tactile sense organ. The exopodite is a flat broad plate-like structure and it is also known as squame. It functions as a balancing organ.

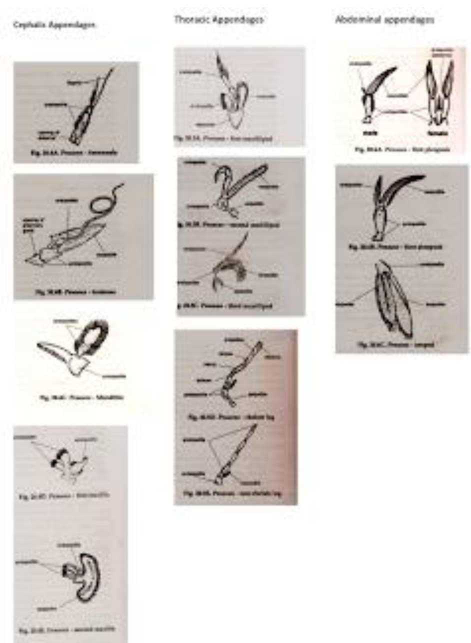
Mandibles: They lie on either side of the mouth. Each mandible has a protopodite and an endopodite. Exopodite is absent. Protopodite is a single stout calcified structure with toothed inner edge.
The teeth are used for grinding food to size. The endopodite, which is attached to the protopodite is segmented. The endopodite is also known as sensory palp.

First pair maxillae (Maxillulae): They are the smallest appendages of prawn. Each maxilla has a protopodite and an exopodite.Exopodite is absent. Each protopodite has two flattened leaf-like lobes, the coxa and basis. They protect inwards as jaws and are also called gnathobases.Endopodite is uniointed and leaf-like with narrow distal end. Both gnathobases and endopodite are provided with sharp hair like processes.

Second Pair maxillae: They lie just behind the first Pair of maxillae. Eacir maxilla is provided with a protopodite, an exoPodite and an endopodite.
Protopodite is flat and four lobed'.Their edges are flattened and provided with hair-like recesses.They aid in mastication.The endopodite is small, unsegmented and leaf-iike. It is situated between the protopodite and the exopodite. The exopodite is large, expanded, flat and boat-shaped and is also

known as scapho gnathite. Its movement produces water currents in the gill chamber.

Thoracic Appendages: Thorax bears eight pairs of appendages. They include maxillipeds and peraeopodes or walking legs.They have a protopodite of two podomeres, an endopodite of five podomeres and an unsegmented exopndodite. The podomeres of the protopodite are proximal coxa and distal basis. The podomeres of the endopodite are named from the base ischium, merus,corpus, propodus and dactylus.



Maxillipeds: The first three pairs of thoracic appendages are known as maxillipeds, or foot jaws. They are directed forwards and run parallel to the middle line of the body.

First maxillipeds: The first maxilliped has a foliaceous appearance. It has a protopodite, exopodite and endopodite. Protopodite is flat and incompletely divided into two small proximal lobes and large distal lobe.They are provided with setose processes on their edges. The exopodite is flattened and leaf-like with a broad base. Attached to the protopodite and exopodite is a proximal, triangular, flat structure called epipodite. It is respiratory in function.

Second maxillipeds: Protopodite has two podomeres, the proximal coxa and distal basis . Exopodite and endopodite are attached to the basis. Endopodite is made up of five segments. Endopodite curves distally and gives the shape ot an interrogation mark. Exopodite is slightly flattened with striations and feathery edges. A Y-shaped epipodite is attached to the coxa of the protopodite.

Third maxillipeds: This is similar to the second maxilliped, but the endopodite is straight with the five segments . Exopodite is flat with striations and feathery edges. Y-shaped epipodite is attached to the coxa of the protopodite.

Peraeopods (walking legs): There are five pairs of peraeopods. The first three pairs of peraeopods are known as chelate legs or chelipeds and the last two pairs of peraeopods are known as non-chelate legs. In all peraeopods, the exopodite is small and fringed with many hair-like structures.

Chelate legs (Chelipeds): All chelate legs are identical in structure. But they differ slightly in size, the third one being the longest. The five jointed endopodite shows chelate articulation of the terminal two podomeres, the propodus and the dactylus . By the hinged articulation of the dactylus to the side of the propodus, a pincer like apparatus is formed. This helps in grasping the food and passing it on to the mouth. The chelate legs are also used for walking

Non-chelate legs;In non-chelate legs, dactylus and propodus do not form chelate articulation . Epipodites are absent. Non-chelate legs are used for walking.

Abdominal appendages: There are six pairs of abdominal appendages. They are also known as pleopods or swimmerets. Each abdominal appendage consists of a protopodite and unjointed exopodite and endopodite. Protopodite is two-segmented and the exopodite is flattened and fringed with setose processes.

First pleopods: In female, exopodite is flattened, thick and fringed with setose processes. Endopodite is absent or may be present as a very small bud-like process. In male, endopodite is short and provided with hooks. The hooks of the endopodites of the two sides interlock and form a rod-like structure called the petasma which is used for transferring sperms into the thelycum of female.

Second, to fifth pleopods: The second, third, fourth and fifth pairs of pleopods have a typical biramous structure, with a two-jointed protopodite, and unjointed exopodite and endopodite .

Sixth pleopods (Uropods): The sixth abdominal appendages are known as uropods. Each uropod has a protopodite, an exopodite and an endopodite. In protopodite the podomeres, coxa and basis fuse to form one segment. The two uropods and the telson form the tail-fin or tail-fan which acts as a balancing organ. Its sudden flexion causes backward leap.

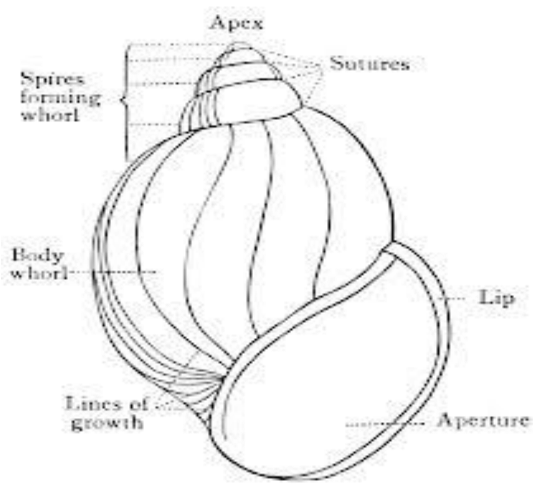
Q. Descrbe the structure of skeletal of Pila.

Ans.

Body of Pila is divided into head, foot and visceral mass which is enclosed within the calcareous shell.

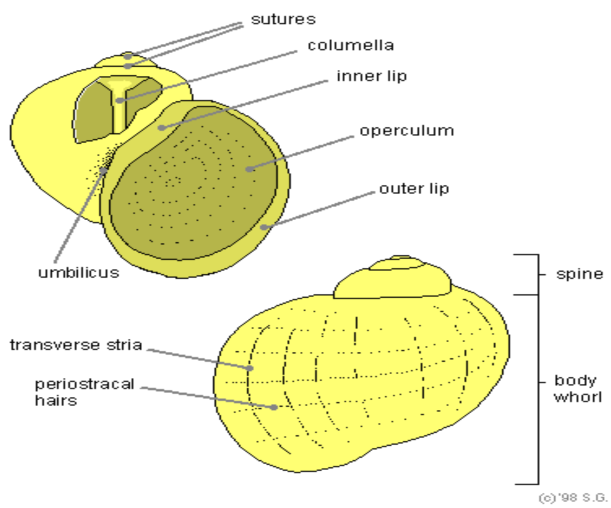
Structure of Calcareous Skeleton of Pila

The skeleton of Pila is calcareous called as the shell. The shell is composed of a single piece called as **univalve shell**. It has a conical structure, spirally coiled around a central axis called the **columella.** The columella is hollow and its cavity opens to the outside by **umbilicus**. A shell with an umbilicus is called as **umbilicate** or **perforate shell**. Each revolution around the axis is called a **whorl.** The small rounded tip of the shell is called the **apex** and the whorl surrounding it is called the **apical whorl.** The apex is regarded as the oldest part of the shell. The lower most whorl is the largest and is known as the **body whorl**. The whorl just prior to the body whorl is called the **penultimate whorl**. All the whorls except the body whorl together are called **spire**.



Internally, all the whorls freely communicate with one another and there is no separating partition between them. Such shell is known as **unilocular**. Externally, there is a line at the junction of the two successive whorls which is known as **suture.** The penultimate whorl and the body whorl are large enough to enclose most of the body parts. Fine vertical lines over the shell surface is called **lines of growth**. In addition to these lines of growth, there are few prominent deep vertical lines along the entire length of the shell. These are called **varices (singular varix)** and indicate fresh growth after every aestivation or hibernation**.**

The body whorl opens to the outside by a wide **aperture or mouth,** the outer margin of which is called the **outer lip** while the inner one is called the **columellar lip**. The margin of the aperture is smooth and rolled out and is known as **peristome**. The aperture can be closed by a flat calcareous plate called the **operculum** (Fig. 1), which is attached to the dorsal side of the hind part of the foot. The operculum is secreted by the glandular cells in the foot. A distinct elliptical area is seen on the inner surface of the operculum and is called the **boss. Opercular muscles** are attached to the boss. The operculum shows many concentric rings of growth arranged around a small central axis called the nucleus. When the foot is withdrawn into the shell,the operculum fits into the mouth of the shell and closes it. The whole body is enclosed within the whorls of the shell and is attached to the columella by **columellar muscles.** The columellar muscles arise from the foot and prevent the animal from extending out of the shell beyond a certain limit and also helps to withdraw the body into the shell.



shell of Pila

Nervous System

Q. Write short notes on nervous system of i) Obelia, ii) Fasciola and iii) Taenia

Ans: Nervous System of Obelia

Nervous system is essentially like that of Hydra in polyp and medusa forms. On each side of mesogloea, nerve cells form nerve nets. The nerve cell's cyton has many processes called the neuritis. Nerve impulse is transmitted in all directions.

In medusa , nerve cells are concentrated along the margin of bell forming two *circular nerve rings , upper and lower* on either side of the velum. Upper or inner nerve ring supplies the tentacles and the lower or inner nerve ring supplies the sub umbreller musculature and statocysts.

Sense Organs

Q. Discuss the sense organs found in prawn.

Ans. Important kinds of sense organs found in prawn are described below:

(i) Compound eyes:

At the base of rostrum a black, hemispherical movable stalked eye is found to be lodged in an orbital notch.

Each eye is compound eye and is made up of a large number (about 2500) of independent visual units, called ommatidia (***Gr. Ommaton, little eye***). This is the unique feature of phylum Arthropoda. All the ommatidia are radially arranged and structurally consist of two regions.

(A) Diopterical region:
This is outer region of the eye which focuses the light on receptor region of the eye. It has three layers, one below the other:

Cornea:
This is the outermost layer of eye, which consists of transparent cuticle. Its surface has a large number of squares or facets with clearly visible lines and gives the appearance of a graph paper. Below such a facet lies one ommatidium.

Corneagen cells:
Each facet thickens in the centre to form a biconvex corneal lens. Beneath the lens lie two corneagen cells which secrete a new cornea as soon as the old one is cast off in moulting.

Cone cells:
Beneath the corneagen cells lie four elongated cone cells or vitrellae which constitute a transparent, homogenous crystalline cone. Inner ends of cone cells are long and tapering.

(B) Receptor region:
This is a light sensitive inner region of eye. It consists of rhabdome and retinal cells :

Rhabdome and retinal cells:
Inner end of cone cells lie upon an elongated, spindle-shaped rod, the rhabdom. It is secreted and surrounded by a group of seven elongated retinal cells.
Retinal cells are layered upon basement membrane and are well connected with sensory nerve fibers of optic ganglia.

Chromatophores:
In between the ommatidium is a sheath of movable amoeboid dark pigment cells or chromatophores.
They are present in two layers, one outer layer is between the cone cells, called iris pigment and the inner one between the rhabdomes is called retinal pigment. Pigment cells vary in position according to the variation in the intensity of light.

Mosaic vision of the compound eye :

Working of compound eye is very complex. This is, however, deficient in focussing ability and clarity of image but efficient for picking up motion of the object and for peripheral vision.

It functions as a very efficient organ for photoreception. Movable stalked eyes provide 360-degree vision to the animal.

Each ommatidium makes separate image and all ommatidia combinedly make a mosaic image of an object because complete image is not single, instead it is total of all the separate small-small images formed from each separate ommatidium.

The nature of composite image formed varies according to different intensities of light. Two types of image are formed due to the movement of pigment cells.

(a) Apposition image:

This kind of image forms in bright light during day time. Pigment cells spread throughout along the ommatidia and separate them optically.

In this condition the rays of light which strike the cornea obliquely absorbed by the pigment cells. They do not reach the rhabdom and therefore produce no image.

Only those rays of light which fali perpendicularly upon the cornea can pass through the ommatidium and reach the rhabdom to form a point of image.

The other ommatidia form the images of other parts of the object. These all point images are fitted together into a single general picture.

It is known as mosaic or apposition image. Its sharpness depends upon the number of ommatidia involved and the degree of their isolation from one another.

(b) Superposition image:

In dim light (during night) the pigment cells migrate to be confined in distal and proximal segment. In this position the ommatidia are not optically separated but work in unison.

The oblique rays are not absorbed and are capable of forming a point of image after passing through a number of ommatidia instead of single ommatidia.

As a result, an overlapping of the adjacent point images occurs so that a continous or superposition image is obtained.

It is not sharp but the animal gets some sort of idea of the objects moving about in the surrounding.

The prawns, like most arthropods seem to adjust their eyes to form both types of images according to the prevailing intensity of light.

The optic nerve carries impulses (electrochemical waves of energy) to the brain, where they are interpreted and registered as an upright mental image,

(ii) Statocysts:

Statocysts are a pair of small white bead-like cuticular spherical sacs found inside the precoxa of each antennule.

It opens dorsally through a minute statocystic aperture, which remains covered by a small fold of integument.

It is supplied by a small statocystic branch of antennulary nerve. In transverse section the cavity of statocyst is oval, filled with minute sand particals and lined by a number of elongated delicate sensory hairs or receptor setae.

Each seta is supplied by a small branch of the statocystic nerve. Each setae has a swollen base towards the center.

Function:

Statocyst perceives the direction of the force of gravity and functions as the organ of orientation and equilibrium.

The sand particles function as statoliths. When position of palaemon changes in water, the sand grains press the setae and stimulate them.

The stimulated setae conveyed the massage to the brain so that the animal can correct its position.

(iii) Tangoreceptors:

Tangoreceptors are found in the form of plumose setae fringing the flat portions of appendages like the ramii of pleopods.

Each tactile seta is hollow cuticular outgrowth supplied with a nerve fiber. It consists of a swollen shaft and a blade.

The elongated feelers of both antennae are also said to be tactile in function.

(iv) Chemoreceptors:

Chemoreceptors or olfactory organs occur on mouthparts, flagella of antennules and inner wall of gill chambers. Each olfactory seta consists of basal shaft and a blade and innervated by a small nerve fiber from the olfactory branch.

Q. Describe the nervous system and sense organs of Nereis.

Ans:

NERVOUS SYSTEM

Nervous system includes a large bilobed cerebral ganglion or brain on the dorsal side of pharynx which supplies nerves to sense organs located on the prostomium and peristomium. Two connectives join the brain with the subpharyngeal ganglion by encircling the pharynx from the two sides and joining on the ventral side. Ventral nerve cord originates from the ventral side of the pharynx, from the suboesophageal ganglion and runs posteriorly along the midventral line. The ventral nerve cord is made of two separate cords which are enveloped by a common connective tissue sheath. Along its path, the ventral cord possesses a ganglion in each segment from which nerves are supplied to all organs.

SENSE ORGANS:

The prostomial tentacles, prostomial palpi and peristomial cirri on the acron are the tactile organs which are sensitive to touch. Nuchal organs are a pair of ciliated pits on the prostomium, which are chemoreceptors and perceive taste and olfactory sense.

There are four simple **eyes** on the dorsal surface of prostomium. Each eye has a cup that contains light sensitive retinal cells and pigmented cells. The external cuticle in the front part forms a transparent cornea. In the cup there is a large transparent, gelatinous refractive lens that focuses light rays on to the retinal cells. The retinal cells are joined to nerve fibres of the optic nerve. The eyes are photoreceptors but cannot form proper image and only help in detecting changes in the light intensity.

Q. Describe the nervous system of pila.

Ans. The nervous system consists of a series of paired ganglia with commissures and connectives. **The term commissure is applied to a nerve cord connecting two similar ganglia, while connective is applied to a nerve cord connecting two dissimilar ganglia**.

- A pair of **cerebral ganglia** lies anteriorly on the dorso-lateral sides of the buccal mass, one on each side of the head. The two cerebral ganglia are connected by a thick **cerebral commissure** running transversely above the buccal mass. Each cerebral ganglion gives off nerves that innervate the eye, the snout, statocyst and the tentacles of its side.
- A pair of **buccal ganglia** lies at the junction of the buccal mass and the oesophagus. They are connected to each other by a delicate transverse **buccal commissure**. Each buccal ganglion is also connected to the cerebral ganglion of its side by a **cerebro- buccal connective**, so that a nerve ring is formed anteriorly encircling the gut. The buccal ganglion gives off nerves to the buccal mass, radular sac, salivary glands, oesophagus and the oesophageal pouches.
- A pair of **pleuro-pedal ganglionic mass** is present on the ventro-lateral side of the buccal mass, one on the right side and the other on the left side. **Each**

pleuro-pedal ganglionic mass is formed by the partial fusion of outer pleural and inner pedal ganglia which lie very close to one another and are separated only by a notch. A small **infra-intestinal ganglion** is also fused with the right pleuro-pedal ganglionic mass, also called as **pleuro-pedal infraintestinal ganglionic mass**. The two pedal ganglia are connected by a broad **pedal commissure** lying under the buccal mass.

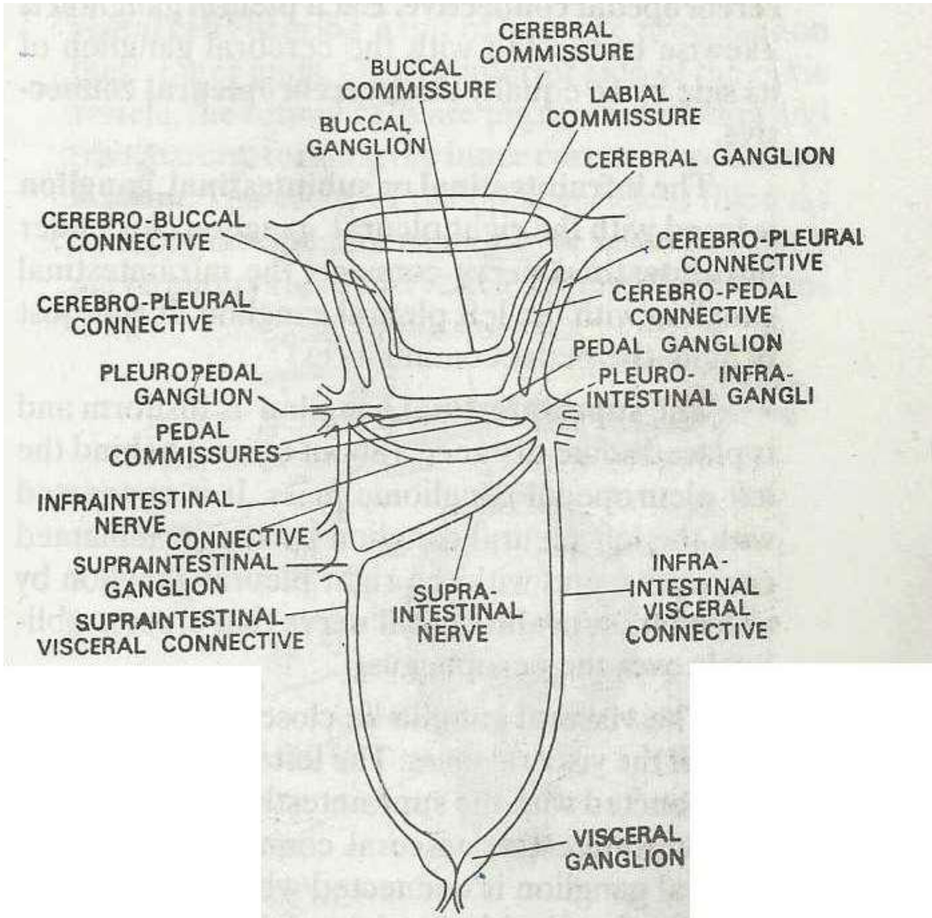
- The pedal ganglion supplies the nerves to the foot.
- The left pleural ganglion supplies the nerves to the body wall, mantle, osphradium, left nuchal lobe, columellar muscles, and anterior part of ctenidia
- The right pleural ganglion supplies nerves to the parietal wall, epitaenia, right nuchal lobe, copulatory organs, columellar muscles and the rectum.

The cerebral ganglion of each side is connected to the pleuro-pedal ganglionic mass of its side by two connectives called the **cerebro-pedal (connecting the cerebral and the inner pedal ganglion)** and **cerebro-pleural connective (connecting the cerebral and the outer pleural ganglion)**.

- A very slender nerve called **the infra –intestinal nerve** connects the pleural ganglion of the two sides. It forms a loop just behind the pedal commissure.
- An unpaired **supra-intestinal ganglion** lies a little behind the left pleuro-pedal ganglionic mass. The supra-intestinal ganglion is connected to the right pleuro-pedal ganglionic mass by a very fine oblique nerve lying just above the oesophagus called as the **supra-intestinal nerve**. The supra-intestinal ganglion supplies nerves to the ctenidium and the pulmonary sac.
- The **visceral ganglion** is really a ganglionic mass formed by the fusion of two ganglia lying very close to anterior lobe of the digestive gland. The pleural ganglion is connected with the visceral ganglion by **pleuro- visceral connective** on each side. The right pleuro-visceral connective lies below the oesophagus and is called as **infra-intestinal visceral connective**. The **left pleuro-visceral connective** lies above the oesophagus and is called as **supra-intestinal visceral connective**.

The visceral ganglion gives off nerves to the renal organs, genital organ, pericardium, intestine and the digestive glands.

Fig. Nervous system of *Pila*



Q. Describe the nervous system of Nereis.

Ans. *Nereis* has a typical well developed annelid nervous system (Fig-). The nervous system is divided into *CNS, PNS and ANS.*

1) CNS

It includes a bilobed cerebral ring and ventral nerve cord.

a. **Cerebral Ring**: The cerebral ring, lying at the dorsal side of the prostomium, is made of *cerebral ganglia* and *sub oesopharyngeal* ganglia. The cerebral ganglia are also called as the brain. It has three centres, anterior, mid and posterior. The mid centre has a paired lobes called as Corpora pedunculata that coordinates the impulses coming to the brain.

The cerebral ganglia are made by fusion of one pair ganglia, lying below the pharynx in first trunk segment. The cerebral and suboesophageal ganglia are connected together by circumpharyngeal connective, these three combinedly form the *cerebral ring* or *brain ring* or *nerve ring* that surrounds the pharynx of the body cavity. The ventral blood vessel lies on top of it (dorsal).

b. **Ventral Nerve Cord:** It is conspicuous, white, longitudinal cord, double **in** origin lying on the ventral midline of the floor two ventral nerve cords.

A swollen **segmental ganglion** is present on the nerve cord in the center of the floor of each segment. Three pairs of segmental nerves arise from most of the ganglia. Each ganglion is the fusion of two ganglia. The VNC has 5 giant fibres, 3 in centre and 2 in lateral position.

In the floor of the peristomium the ventral nerve cord expands to form the subpharyngeal ganglion and then bifurcates into right and left **circumpharyngeal connectives** that encircle the buccal cavity (Fig 13-14). The brain occupies most of the posterior prostomium and the four eyes are embedded in it. Nerves from the sense organs of the head enter the brain.

2) PNS

3) ANS

Summary:

Nervous system of nereis includes a large bilobed cerebral ganglion or brain on the dorsal side of pharynx which supplies nerves to sense organs located on the prostomium and peristomium. Two connectives join the brain with the subpharyngeal ganglion by encircling the pharynx from the two sides and joining on the ventral side. Ventral nerve cord originates from the ventral side of the pharynx from the suboesophageal ganglion and runs posteriorly along the midventral line. The ventral nerve cord is made of two separate cords which are enveloped by a common connective tissue sheath. Along its path the ventral cord possesses a ganglion in each segment from which nerves are supplied to all organs.

Section B

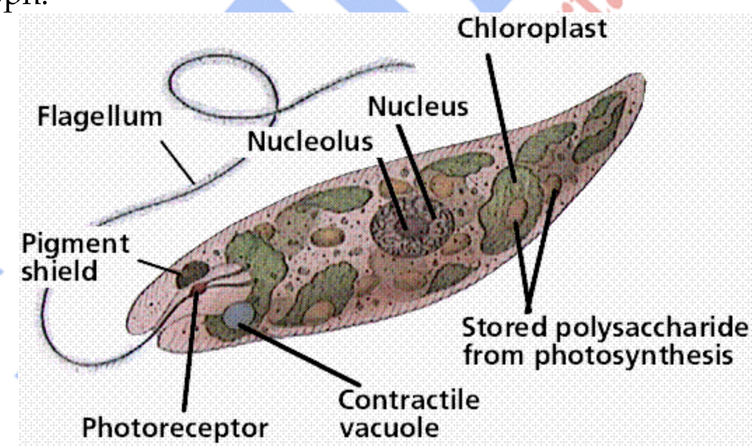
Q. What is the mode of nutrition in Euglena?

Ans:

The diflagellate Euglena have a contractile vacuole, a photoreceptive eyespot, and several chloroplasts, lack a cell wall. The Euglena is unique in that it is both heterotrophic (must consume food) and autotrophic (can make its own food) so also called as mixotrophic.

In autotrophic mode, chloroplasts within the euglena trap sunlight that is used for photosynthesis. Their chloroplasts are surrounded by three rather than the more typical two membranes and appear as several rod like structures throughout the cell. Euglenoid chloroplasts are probably derived from the green algae through endosymbiosis. The euglenoid protein synthesized is pyrenoid that produces an unusual type of carbohydrate polymer paramylum. Paramylum is scattered in cytoplasm surrounding the pyrenoid.

The autotrophic species E.gracialis becomes heterotrophic when light levels are low so they are Facultative Phototrophs. E.paciformis is Obligatory phototroph.



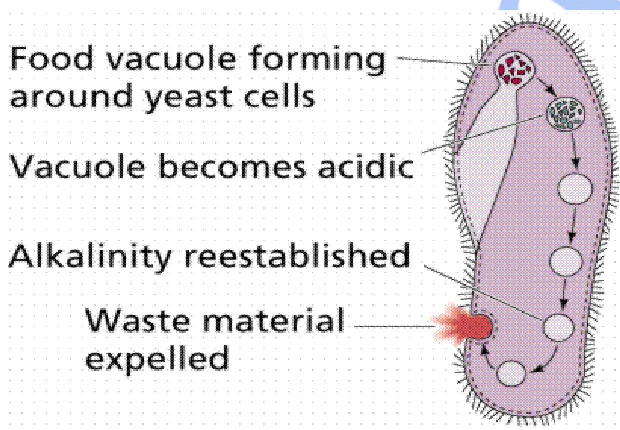
SECTION B

Q. Describe the nutrition in Paramecium.

Ans: Paramecium shows Holozoic nutrition. It has a developed oral apparatus. Food is taken into the cell by an oral groove (or gullet) alongwith water current generated by large cilia of the oral groove. The food path is vestibule -> oral grove-> cytostome-> cytopharynx,where small particles of the food are phagocytosed into food vacuoles.

Digestion: Thereis intracellular digestion occurring in the food vacuoles. Several enzymes are Lipase, Protease and Carbohydrase mixed in the vacuole by primary lysosomes. Initially the medium is acidic in the vacuole in which protein digestion occurs. Later on the medium becomes alkaline. The food vacuoles travel through the cytoplasm and are digested, with the molecules eventually passing into the cytoplasm, and wastes being expelled from the cell by exocytosis at the cytopyge.

Cyclosis: The movement of the food vacuoles by the cytoplasmic streaming movement is cyclosis.



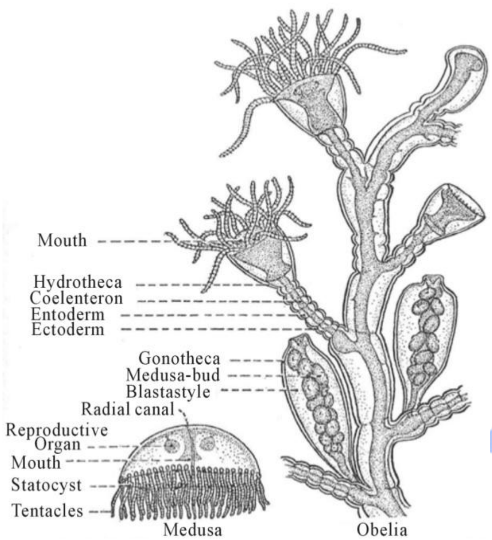
Q. Describe the nutrition in Obelia colony and medusa in brief.

Ans: **In** obelia colony the body wall consists of an outer cell layer or ectodermis and an inner cell layer or endodermis (or gastrodermis) with mesogloea separating the two. The endodermis encloses a central fluid-filled cavity, the gastrodermal cavity or enteron.

Nutrition in colony

The tentacled feeding polyps are called hydranths and the perisarc enclosing them forms a supporting cup called a hydrotheca. Each hydranth terminates in a cone (hypostome) bearing the mouth and surrounded by a ring of about 24 tentacles. Each hydranth is a feeding polyp that resembles a hydra.
However, the tentacles are solid (they are hollow in hydra) and each is filled with a cord of endodermal cells with secreted matrix material separating adjacent cells. The tentacles and the hypostome are the only parts of the colony that generally bear nematocysts (stinging structures located in cells called nematoblasts, nematocytes, cnidoblasts or cnidocytes). There is only one nematocyst type in Obelia - a barbed penetrant. The nematoblasts are derived from interstitial cells. The hypostome has the highest density of

sensory cells. The tentacles catch any prey that triggers the nematocysts. The tentacles pass the ensnared prey to the mouth and hence into the enteron where the first-phase of digestion, which is extracellular, takes place.

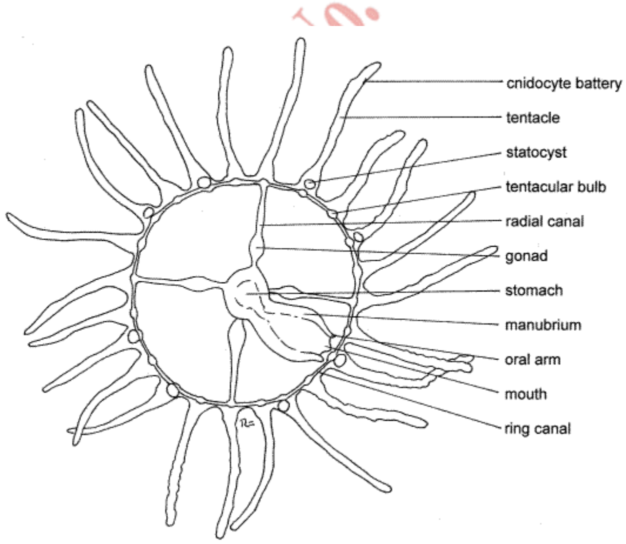


The enteron of the hydranth connects to the enteron of the coenosarc and the endodermis lining the enteron contains flagellated cells. The beatings of the flagella generate currents that carry the fluid containing the partially digested food around the colony. Endodermal cells throughout the colony phagocytose the food particles and complete digestion intracellularly. Soluble products of digestion are then passed to the ectodermal cells. Thus, even the gonangia, which cannot feed themselves, derive nourishment via the hydranths and the coenosarc transport system.

Nutrition in medusa

The *Obelia* medusae has a distinct tetramerous (4-part) radial symmetry and a convex upper, **exumbrella** (aboral surface) and a concave lower, **subumbrella** (oral surface). The aboral surface is smooth and rounded. Numerous **tentacles** extend from the margin of the bell.

The **manubrium** hangs like a pendulum into the center of the subumbrellar space below the oral surface. The **mouth** is in the center of the free, oral end of the manubrium and is flanked by four short **oral arms**. The manubrium and oral arms are well supplied with cnidocytes. The **coelenteron** consists of the stomach at the base of the manubrium, where extracellular digestion occurs, and a set of ciliated canals used to distribute partly digested food. The mouth opens into the spacious lumen of the manubrium which in turn empties into the **stomach**.

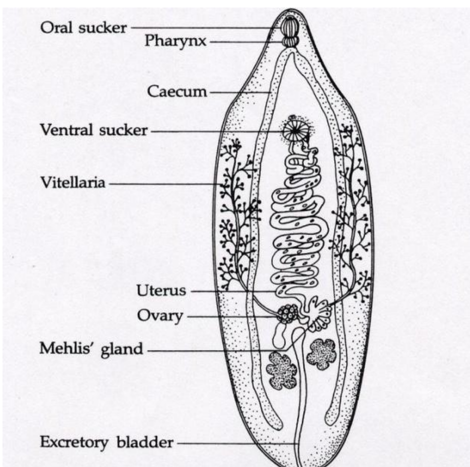


The stomach is in the center of the bell. Four **radial canals** extend from the stomach to the periphery of the bell where they join the circular **ring canal** in the margin of the bell. A distinct, darkly staining, epidermal **gonad**, either ovary or

testis, can be seen below each radial canal near the stomach.
Twenty to thirty solid **tentacles** radiate from the edge of the bell. The tentacle epidermis has abundant sensory cells and cnidocytes. The cnidocytes are concentrated in rings, or **batteries**, and are used to sting and subdue the prey. A swollen **tentacular bulb** in the base of each tentacle is the site of intracellular digestion and cnidocyte formation.

There are eight spherical statocysts spaced evenly around the margin of the bell. Each is at the base of a tentacle. The statocysts are hollow, thin-walled, epidermal vesicles containing a calcareous statolith and a ciliated sensory epithelium. There are no ocelli in *Obelia* .

Q. **Write short notes on parasitic mode of nutrition in – i) Fasciola and ii) Taenia**



Ans:

Parasitic mode of Nutrition in Fasciola

Fasciola hepatica has a blind sac alimentary canal with mouth as the only opening situated in the middle of anterior sucker. Mouth opens into bulb-like pharynx which is muscular and suctorial. The intestine is bifurcated into two caeca and gives off numerous branches or diverticula in order to carry food to all parts of the body. Therefore, digestive system also functions as circulatory system.*Fasciola* feeds on bile, blood and lymph and cellular debris. Digestion is extracellular and occurs in intestine and the digested food is accomplished by ramifying *diverticula* of intestine. Reserve food in the form of glycogen and fats is stored in the parenchyma. The undigested food is ejected through the mouth.

Nutrition in Taenia

Tapeworms are endoparasites which have numerous adaptations to enhance parasitic nutrition. Tapeworms live in the small intestine of humans, providing an ideal location to access a readily available, rich source of pre-digested nutrients. Since nutrients in the small intestine are plentiful and pre-digested by the host, tapeworms do not require a gut and instead have adaptations to maximise nutrient absorption.

The alimentary canal is absent and mode of nutrition is saprozoic. Tapeworms have a tegument which allows nutrients to be absorbed directly from the host small intestine by diffusion. Their flattened body has microtriches to maximise the surface area available for nutrient absorption.

The digested nutrients like glucose, amino acids, glycerol etc. from the host intestine diffuse directly through its skin. They also secrete enzymes to enhance host digestive enzymes e.g. pancreatic α-amylase. The reserve food is stored as glycogen and lipids in the parenchyma.

Q. Describe the nutrition mechanism in Hirudinaria in detail.

Ans: **A well** developed alimentary canal is present in Leech which is adapted to its sanguivorous behavior of nutrition. The alimentary canal has following parts:

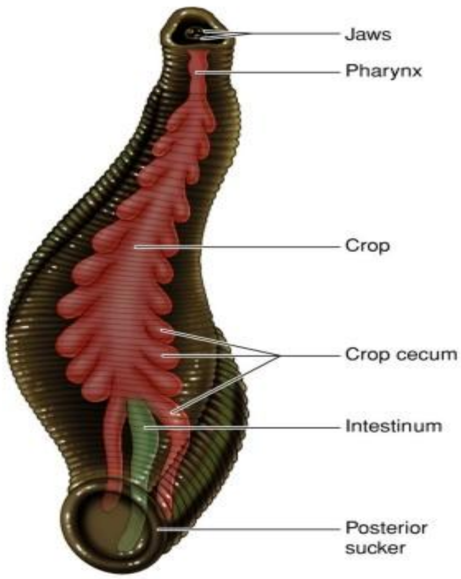
1. **Stomodeum: It** includes pre- oral chamber and mouth, Buccal Cavity and Pharynx.
2. **Mid gut:** It includes Oesophagus, Crop, Stomach and Intestine.
3. **Hind gut/Proctodaeum:** It includes Rectum.

Stomodaeum:

Mouth is a tri-radiate aperture situated in the middle of the anterior sucker into the cup shaped pre oral chamber. Mouth shape is inverted Y.it is surrounded with thin membranous Velum which forms lips of the mouth.

Mouth opens into a wide buccal cavity containing three jaws, one is dorso-median and the other two are ventro-lateral. Jaws are muscular, cuticle-lined containing one row of denticles.(*such jaw is called monostichodont jaw)* provided with **papillae** which bear the openings of salivary glands. There are about 103-128 denticles on mid dorsal and 85- 115 on ventro lateral jaws. Each jaw has about 40/45 salivary papillae.

A muscular pharynx extends from 5th to 8th segments, on the outer side of which are unicellular **salivary glands** that secrete *hirudin*, which prevents coagulation of host blood during feeding. Radial muscles dilate the pharynx and carry out suction of blood.



Midgut & Hindgut:

Oesophagus connects the pharynx to crop, lined with folded epithelium. The **crop** is the largest chamber of alimentary canal and extends from **9th to 18th** segments, one chamber in each segment and a total of ten chambers. It is the adaptation to store large amount of blood at a time. A pair of **caeca** project out laterally from each chamber, their length increases towards the posterior side and the last pair of caeca extends as far as 22nd segment. The crop leads to stomach whose walls are produced internally into transverse folds. The next chamber is **intestine** which is a small straight tube located in 20-22nd segments and narrows down at the posterior end into **rectum**, which opens on the dorsal side of 26th segment by anus.

Feeding

The animal is an ectoparasite. It adhares to the host animal skin by its anterior and posterior suckers and makes 'Y' shape wound and sucks blood by ruptured blood vessels of the host. The Hirudin secreted by the salivary gland mixes in the blood and prevents clotting of the sucked blood. At a time a leach can suck vast amount of blood which is sufficient food for months

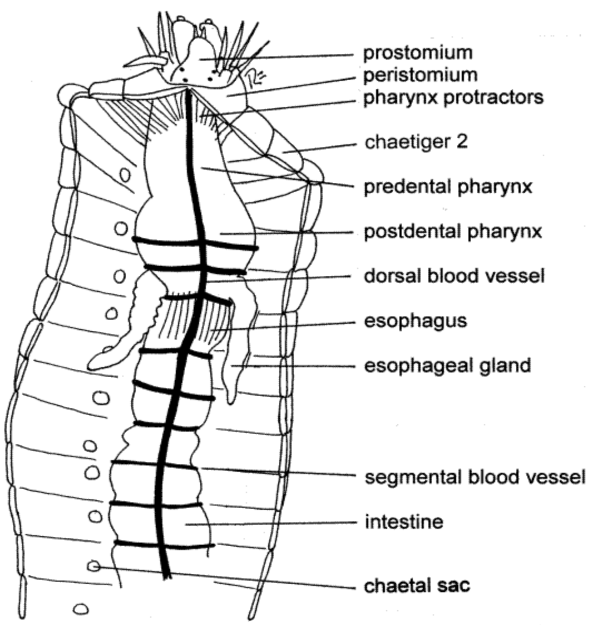
Digestion

The sucked blood is stored in crop and enters for digestion in stomach and intestine drop by drop and takes lot of time for digestion.In crop blood is uncoaugulated and hemolysis causes breakdown of RBCsand release of Haemoglobin. Now water is absorbed and blood as red jelly like substance is sent drop by drop to the stomach and intestine for digestion.Intestine also absorbs digested food and defecation occurs through the rectum.

Q. Which type of nutrition is found in Neres? Describe it in detail.

Ans **N**ereis is a predatory animal which gets nutrition by predation of other animals.

Alimentary canal is a straight tube extending from anterior to posterior end of the body. The anterior opening is the mouth and posterior opening the anus. *Mouth* is located on ventral side of peristomium and opens into the buccal cavity, which carries teeth or *dentacles*. Pharynx is a large chamber and is lined internally by cuticle. One pair of jaws is present at the posterior end of pharynx. *Pharynx* can be protruded out of mouth by protractor muscles and can be withdrawn by retractor muscles. *Oesophagus* occupies five segments and receives a pair of glands. It communicates with stomach–intestine, which is a more or less straight tube that is constricted in each segment. A distinct stomach is absent in *Nereis*. Epithelial lining of mid-gut contains gland cells which secrete digestive enzymes. Rectum is the last part of intestine and opens to outside by anus. Nereis is a carnivore and feeds on small animals such as crustaceans, molluscs, sponges and other animals.



Prey is captured by the eversion of pharynx, which brings the jaws in front to grasp the prey. Retraction is caused by contractions of retractor muscle which brings the prey deep into the pharynx. The ingested food is masticated in the buccopharyngeal region by denticles. Food passes through the intestine by peristalsis and digestion is mainly extracellular and the food is digested by the digestive juices secreted by the oesophageal glands and the glands in the epithelial lining of stomach-intestine. Absorption of digested food also occurs in the stomach-intestine. The undigested food passes into rectum from where it is egested through anus.

Q. Write a note on the digestive system and mechanism of feeding and digestion in i.) Prawn and ii) Asterias.

Ans: Digestive system of Prawn

The digestive system of the prawn is complete from mouth to anus and consists of alimentary canal and hepatopancreas.

I-Alimentary Canal:

It consists of Foregut, Midgut and hindgut. The foregut comprises the mouth, buccal cavity, oesophagus and stomach. The Foregut and hindgut have an internal lining of Cuticle (i.e. intima) and the midgut has a soft lining of endoderm.

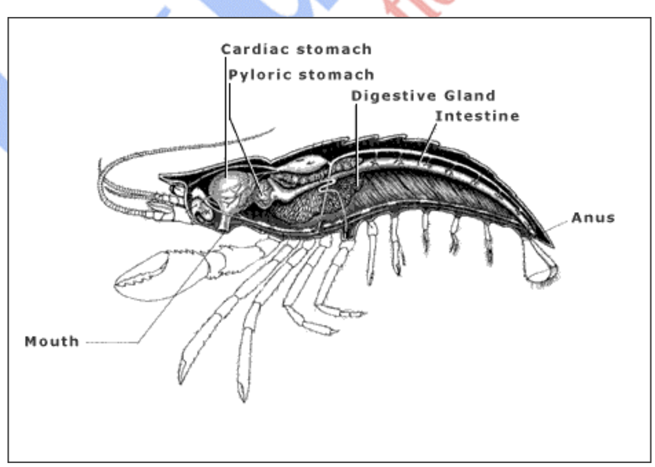
1) **Mouth:** It is a large slit-like aperture situated mid- ventrally below the anterior end of head between 3rd and 4th segments. It is bounded in front by a shield- shaped Labrum, on the sides by the incisor processes of the mandibles, and behind by the labium which is cleft to form two lobes or Paragnatha.

2) **Buccal Cavity:** The mouth leads into a short buccal cavity. It is antero-Posteriorly compressed and has a thick chitinouous lining which is thrown into irregular folds. The molar processes of the of the mandibles project into the buccal cavity from two sides to crush the food between them.

3) **Oesophagus:** The buccal cavity leads into short, broad oesophagus running vertically upwards from the buccal cavity to the stomach. Internally the thick muscular wall is thrown into four prominent longitudinal folds projecting into the lumen. The anterior fold is short and the posterior and two lateral folds are longer and prominent.

4) **Stomach:** It is a spacious chamber just after the oesophagus. It occupies most of the cephalothoracic cavity and surrounded from all sides except anteriorly by hepatopancreas. It has two parts:
    a. Cardiac Stomach
    b. Pyloric Stomach

a.



b. **CARDIAC STOMACH**: It is lined internally with delicate cuticle that is produced into a large number of inconspicuous longitudinal folds covered by minute bristles. The wall has following cuticular plates from inner side:

- **Circular Plate:** located on the anterior wall near oesophageal opening.

- **Lanceolate Plate:** on the anterior part of the cardiac stomach.

- **Hastate plate:** it is triangular plate embedded in the middle ventral floor of the cardiac stomach looks like the head of a spear. Its upper surface has a thick growth of delicate setae with a median ridge with gradually sloping sides. The posterior triangular part is depressed and fringed with setae along its age that forms the anterior valve of the cardio pyloric aperture. Its lateral sides are supported beneath by a pair of longitudinal cuticular rods.

- **Groove Plate:** The lateral side of the hastate plate has narrow grooves which floor is covered with a cuticle plate, known as Groove plate. It appears as an open drain pipe. Each lateral groove's inner border is supported with the supporting rod and outer side by a long cuticular ridged plate.

- **Comb Plate:** The inner border of the ridged plate is lined with a row of closely set bristles forming a long comb-like structures therefore called as Combed Plate. The bristles that cover the lateral grooves and lateral borders of the hastate plate. The plates from both sides join together in front of hastate plate.

Outside the combed plate the lateral sides of the wall of the cardiac stomach is folded to form two longitudinal folds, also known as the Guiding ridge because they guide the food towards the Cardio- pyloric aperture.

Cardio Pyloric Aperture

It is narrow X- shaped pore guarded by following four valves:-

One Anterior Valve: Formed by posterior triangular area of the Hastate plate

Two Lateral Valves: Formed by the posterior ends of the Guiding Ridges

One Posterior Valve: Formed by the semi-lunar fold of the posterior wall of the cardiac stomach.

It leads to the Pyloric Stomach.

c. PYLORIC STOMACH:

It is a very narrow and small chamber lying below the posterior end of the cardiac stomach. Its walls are thick & muscular. Its lumen has two compartments, small Dorsal Chamber and a large ventral Chamber. Each communicates with a small vertical slit. The ventral chamber is divided into two lateral compartments by a Λ shaped median longitudinal Filter Plate. Each lateral side of filter plate is rectangular and bears a series of alternating ridges and grooves. The ridges bear rows of bristles which cover the grooves. The side walls of the ventral chamber are also covered with closely set bristles. These alongwith filter plate form an efficient filter. Two openings of hepatopancratic ducts lie at the posterior end of the ventral chamber behind the filtering apparatus. The fliter apparatus allows only liquid food to pass through it.
The dorsal chamber gives out a small blind caecum dorsally and then opens into midgut. At their joint there are tufts of elongated setae which act like valve preventing the backward flow of the food.

5. MID GUT:
It is a long, narrow, straight tube running back along the median line above the ventral abdominal muscles up to the 6th abdominal segment. It is internally lined with epithelium. Its posterior part has thrown into many longitudinal folds reducing the lumen.

6. HIND GUT
The hindgut extends from the posterior end of the midgut to the anus and forms the shortest portion of the alimentary canal. Its anterior end is thick swollen sac termed the Rectum, and the posterior, narrow, tubular end opens to outside through anus. Anus is surrounded with a sphincter muscle and a number of radiating muscle fibres.

II-HEPATOPANCREAS
It is a large bi-lobed, compact, orange coloured glandular mass occupying most of the space of the cephalothoracic cavity. It lies behind the cardiac stomach and surrounds it from lateral and ventral sides. It is formed from one pair of hepatic caeca, lateral outgrowth of midgut. It consists of many globular tubules branching in racemose manner. The tubule is made of columnar epithelium cells having Granular, ferment, hepatic and Basal cells. The canals of tubules unite forming larger and larger canals which finally opens into hepatopancreatic duct. One pair hepatopancreatic ducts open into the ventral chamber of the pyloric stomach behind the filter plate.

Function:

It combines the functions of liver, pancreas and small intestine.

- Like the pancreas it secretes digestive juice capable of digesting carbohydrate, proteins and fat.
- Like the midgut it absorbs digested food.
- Like the liver it serves as storage organ for glycogen, fat and calcium.

Food and feeding mechanism of prawn/ Palaemon.

The food of Prawn includes algae, moss, aquatic weeds, small insects etc. The chelate legs help in in taking of food to the mouth, II & III maxillepedes hold the food and mandible's incisor processes cut up the food before taking into the mouth. The molar processes of the mandibles crush the food which then moves to the cardiac stomach.

Digestion, absorption and Egestion

The smaller food particles are passed to the pyloric stomach through cardiac stomach. The digestive enzymes secreted by the hepatopancreatic duct are mixed with the food for digestion. The secretion also reaches to the cardiac stomach. The various cuticular plates by contraction and relaxation of the wall of the cardiac stomach churn up the large particles and digest the food by the enzymes. When the food passes over the hastate plate, the bristles and combed groove again cut the food into fine particles. Then it enters into the ventral chamber of the pyloric stomach through cardio pyloric aperture. The digested and liquefied food is filtered through the filter plate and enters into the hepatopancreatic duct for absorption and digestion. The rest undigested food residue ascends up into Dorsal chamber from there it enters into the midgut. The undigested faecal matter is expelled out through the hindgut and the anus.

Q. Describe the nutrition in Asterias.

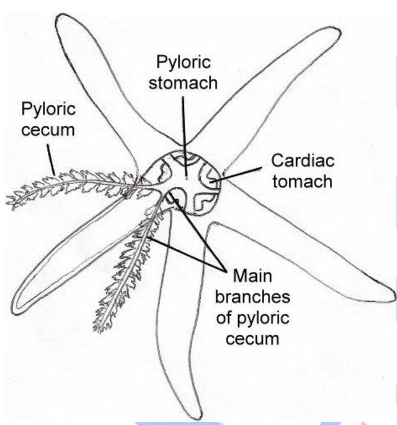
Ans: The Asterias is carnivorous in habit. The digestive system consists of Alimentary canal and Digestive glands.

Alimentary Canal

It has a tubular, short, straight alimentary canal extending along oral- aboral axis on the central Disc. It has following parts from oral to aboral side:

- **Mouth:** The anteriormost part of the gut on the oral surface in the centre of the perostomial membrane has a pentagonal mouth. It is supported with five interradial mouth papillae/ oral spines. Its opening, expansion and retaction is controlled with the sphinctermuscles and radial fibres. It leads to Oesophagus.

- **Oesophagus:** A very short, wide and vertical tube that opens into stomach.
- **Stomach:** It is a broad sac filled in the central disc. It is divided into a voluminous oral part, the cardiac stomach, and a flattened aboral part, the pyloric stomach.
  - **Cardiac Stomach:** It is muscular, five-lobed sac; each one is situated against each arm. It is anchored with the ambulacral ridge by gastric ligaments or mesenteries. The cardiac part is eversible through mouth by the muscular contraction. the retraction is done by 5 pair of retractor muscles.
  - **Pyloric Stomach:** It is a shorter, flat pentagonal sac and communicates with the intestine.
- **Intestine:** It is also short, narrow, five-sided tube that opens straight upward to open out the anus. It gives off 2 or 3 little hollow diverticula called intestinal caeca or rectal caeca placed inter radially. The caeca are brown coloured and assumed to be an excretory organ.
- **Anus:** This is the posterior most pore of the gut placed ecentrically on the aboral surface.



DIGESTIVE GLANDS

Pyloric Caeca:

Structure: Each arm of the star fish has one pair Pyloric Caeca or Digestive glands or Hepatic caeca, which are suspended with one pair mesenteries from aboral body wall. Each caecum has a median longitudinal axis and many a lateral branches ended into a bladder. Both the longitudinal axis of each arm unite together, termed Pyloric Duct, and opens into the pyloric stomach.

Histology: HIstologically it is a complex structure lined with the columnar epithelium. It has four types of cells:

Current producer Cells: Maintains a steady circulation of the fluids & digested food.

Mucous Cells: Secretes mucus.

Secretory or Granular Cells: secrete digestive enzymes for Carbohydrate, protein and lipid.

Storage Cells: Stores reserve food materials like, Lipid, Glycogen & polysaccharide- protein complex.
The pyloric caeca function like pancreas.

Physiology of Digestion
Asterias is a carnivorous animal eating worms, crustaceans, snails, bivalves etc. Some of them also feed upon the dead animals. They may live without food for several months in unfavourable conditions.
The mode of feeding and ingestion is very unusual. During feeding the stomach is everted over the prey and the digestive juices are poured over it from the pyloric caeca. The digested food is then absorbed through the caeca into the coelomic fluid. The starfish then withdraws its stomach into its body. The undigested waste is sent out through the mouth and only the little amount of foecal matter is expelled through the anus.

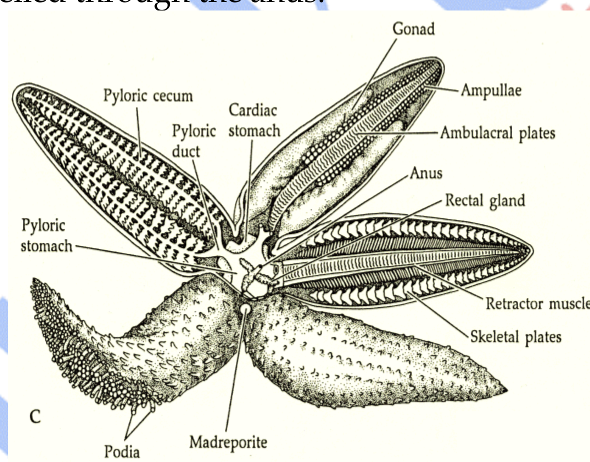


Fig. star fish showing alimentary canal

Q. Draw a well labeled diagram of Digestive system of Unio.

Ans:

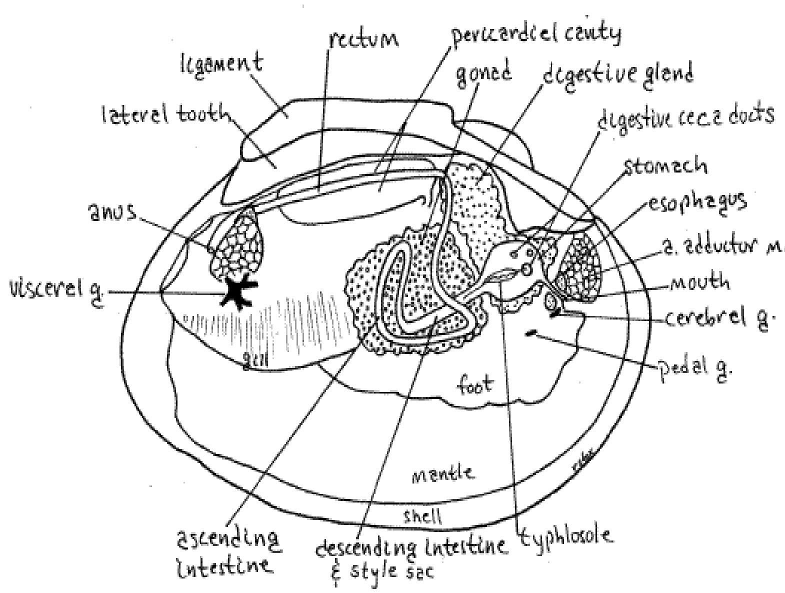


Fig. Digestive System: Unio

RESPIRATION

Q. Describe the respiration in i) Prawn, ii) Pila

Ans:

Respiration in Prawn

Respiratory system

Penaeus takes up oxygen dissolved in sea-water. Its respiratory organs are inner lining of branchiostegites, epipodites (mastigobranchiae) and branchiae (gills) .

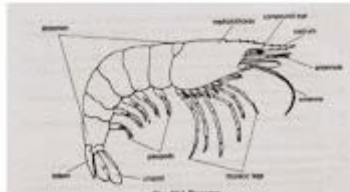
Branchiostegites: The ventral extension of the carapace on either side of cephalothorax is known asbranchiostegite.The space between the bodywall and branchiostegite is called gill chamber or branchial chamber. The inner lining of branchiostegite is highly vascular. It is bathed in water. Exchange of respiratory gases takes place through this inner lining.

Epipodites or mastigobranehiae;Penaeus possesses six pairs of epipodites or mastigobranchiae. They are the outgrowth of coxae of the thoracic appendages, three pairs of maxillipeds and three pairs of chelate walking legs. They lie in the branchial chamber. Epipodites of first pair of maxillipeds are flat conical plate like structures. The remaining epipodites are Y- shaped. They are bathed in water. They are richly supplied with blood. They exchange respiratory gases between water and blood.

Branchiae or Gills: Branchiae (gills) are the feather like (plumose) outgrowth of the lateral wall of the thorax and thoracic appendages. Each gill has a stem Three longitudinal blood channels run through the stem. They are two lateral channels and one median channel. The two lateral channels are connected by many transverse channels. Many lateral flat gill plates arise from the stem.Marginal channels from the lateral channels penetrate into the gill plate and open into the median channel, The stem and gill plate are covered externally a thin layer of chitin. A single layer of epithelial cells lies beneath it. Epithelial layer encloses connective tissue and blood channels. This kind of gill is known as dendrobranchia.
According to the point of origin, there are three sets of branchiae. They are:

Podobranchs (podobranchiae):They are commonly known as foot gills. Penaeusl possesses one pair of podobranchs. They are the ourgrowths of the coxae of the second pair of maxillipeds.

Pleurobranchs (pleurobranchiae): They are commonly known as wall gills. They arise from the lateral wall
of thorax above the attachment of appendages. Penaeus possesses six pairs of pleurobranchs. They lie on the thoracic wall above the third pair of maxillipeds and five pairs of walking legs.
Arthrobranchs (arthrobranchiae):They are commonly known as joint gilts. They arise from the articularn membrane connecting thoracic wall and the proximal segment of the thoracic appendage. In Penneus two pairs of arthrobranchs arise from the articular membrane connecting the thoracic wall and the proximal segment of the second maxillped,third maxilliped and first three pairs of walking legs. One pair of arthrobranchs arises from the articular membrane connecting the thoracic wall and the proximal segment of the fourth pair of walking legs.



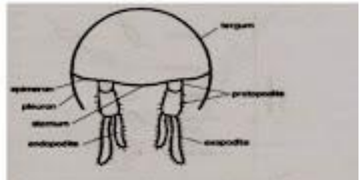
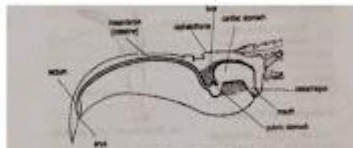


Fig. 20.2 Diagrammatic cross section of a segment to show parts of exoskeleton and appendages



Branchial Formula: The formula, which shows the number and arrangement of the branchiae or gills on one side of the thorax is known as branchial formula.

Mechanism of Respiration

There are two branchial or gill chambers. They enclose highly vascular respiratory organs (branchiae or gills, epipodites and inner lining of the brachiostegites). The anterior,ventral and posterior sides of each chamber are open. The exopodite (scaphognathite) of the second maxilla lies at the anteriorregion of the bianchial chimber. Its movement drives water out of the branchial chamber. So water from outside enters the chamber through the posterior side.A constant current of water flows over the respiratory organs.Oxygen dissolved in the water diffuses into the blood in the respiratory organs and carbon dioxide in the blood diffuses into the water. The setose processes along the anterior, ventral and posterior margins of the branchial or gill chambers prevent the entry of foreign particles into the chambers.

RESPIRATION IN PILA

RESPIRATION IN LEECHES

There are no special respiratory organs in leech. Skin also serves respiratory function as epidermis is a permeable membrane through which the carbon dioxide and oxygen dissolved in water can be exchanged. The skin is always kept moist by the mucus secreted by the slime glands which prevents it from drying even on land.

RESPIRATORY SYSTEM Of NEREIS

The parapodia having blood capillary network and body wall carry out respiration. Oxygen diffuses from the surrounding water into the blood through the integument or parapodial surface due to great partial pressure in comparison to blood. Similarly from the blood carbon dioxide diffuses into the surrounding water.

EXCRETION

Q. Describe the mode of excretion in Protozoa, Sycon and Obelia in brief.

Ans.

Mode of Excretion in Protozoa

Excretion is carried out in Protozoans by the general body surface by simple diffusion **and Osmoregulation is done** by Contractile vacuoles.

There are two contractile vacuoles in paramecium present at both the ends of the body. Each contractile vacuole has a **central bladder** and six **radiating canals**. These radiating canals absorb water and waste materials from the surrounding cytoplasm and passes into the central bladder from where the contents is expelled out periodically through the permanent opening of the contractile vacuole present in the pellicle.

Contractile vacuoles are the Osmoregulatory structures of protozoans like, amoeba, paramecium etc. **Osmoregulation** is the maintenance of both water and ionic contents of the body. Being a freshwater animal, large quantity of water enters into the body of paramecium and other protozoans, so that contractile vacuole helps the animal to remove the excess water from the body.

In Euglena a small and inconspicuous contractile vacuole is located to one side of the reservoir, into which it discharges. Its function is osmoregulatory, ridding the cell of excess water. Under ordinary conditions, the vacuole fills and empties about twice a minute but the rate ultimately depends on the osmolarity of the environment.

Mode of Excretion in Sycon

In sycon canal system is found through which excretory wastes products are discharged through excurrent water through osculum. Sycon, like another Poriferans, lack excretory system. According to some scientists, some Amoebocytes extracts wastes from the body and discharges it through osculum.

Mode of Excretion in Obelia

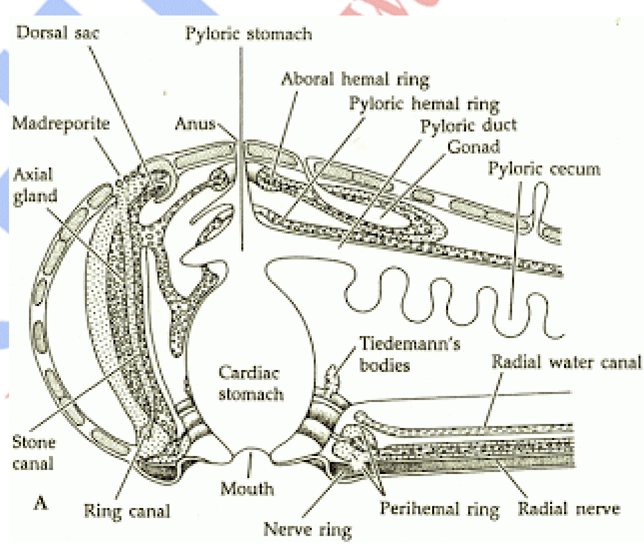
Both Polyp and Medusa forms lack any excretory organ. They discharge excretory waste product NH_3 general body surface in the marine water.

Respiration in PILA:

CIRCULATORY SYSTEM

Q. Describe the circulatory system of Starfish.

Ans:



Circulation occurs in three places:

- The perivisceral coelom (the space inside the body but outside the various organs),
- The water vascular system (of which the tube feet are the most obvious part),
- The hemal system (which actually looks something like a circulatory system).

The Hemal System:

There are hemal channels forming rings around the central part of the body around the mouth (the oral hemal ring), closer to the upper surface (the aboral hemal ring), and a third ring around the digestive system (the gastric hemal ring). These are connected by the axial sinus. There are also radial hemal channels running down the rays next to the gonads (which are also located in the rays). A dorsal sac attached to the axial sinus pulsates, sort of like a very inefficient heart (inefficient because it lacks a one-way valve system). The hemal system seems mostly organized to distribute nutrients from the digestive tract.

The water vascular system uses cilia and the constant contraction of ampulla (to extend and retract the tube feet) also helps keep things moving. There is an ionic imbalance that causes water to flow into the water vascular system through the madreporite, and then the Tiedemann's bodies divert some of it into the perivisceral coelom. Circulation in the perivisceral coelom is mostly by ciliary beating.

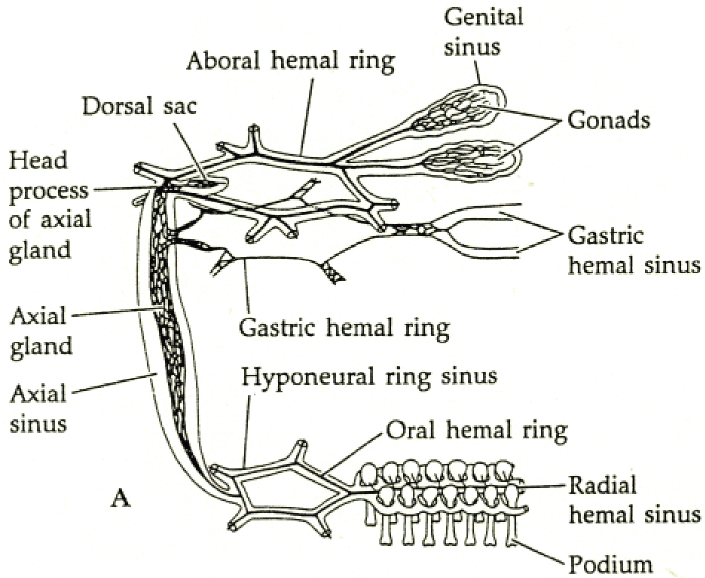
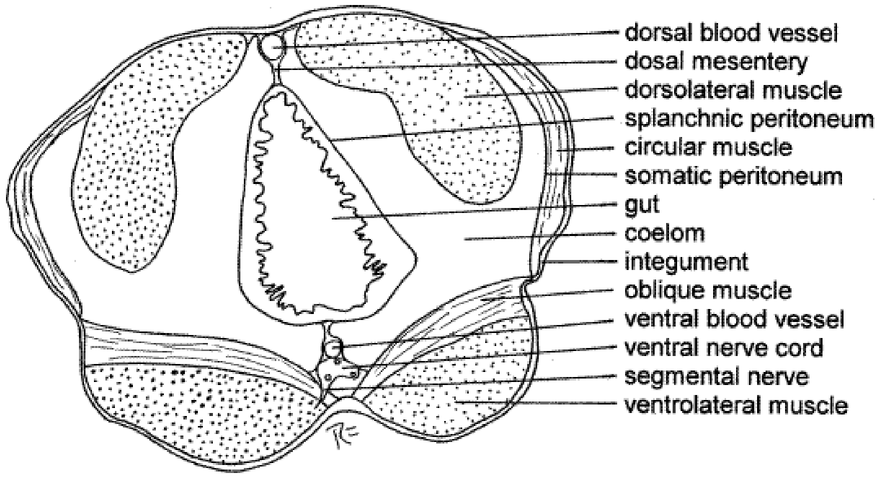


Figure : Circulation in star fish

Q. Describe the circulatory system of Neris.

Ans. In neris Closed blood Vascular system is found. The basic annelidan circulatory pattern is present in *Nereis*.



It consists of ***dorsal and ventral longitudinal vessels*** connected to one another in each segment by segmental vessels to and from beds of narrow capillary-like vessels in the various organs and ***Perineural Vessel***. Blood flows between these two vessels via segmental networks in the parapodia, septa, and around the intestine.

The dorsal blood vessel

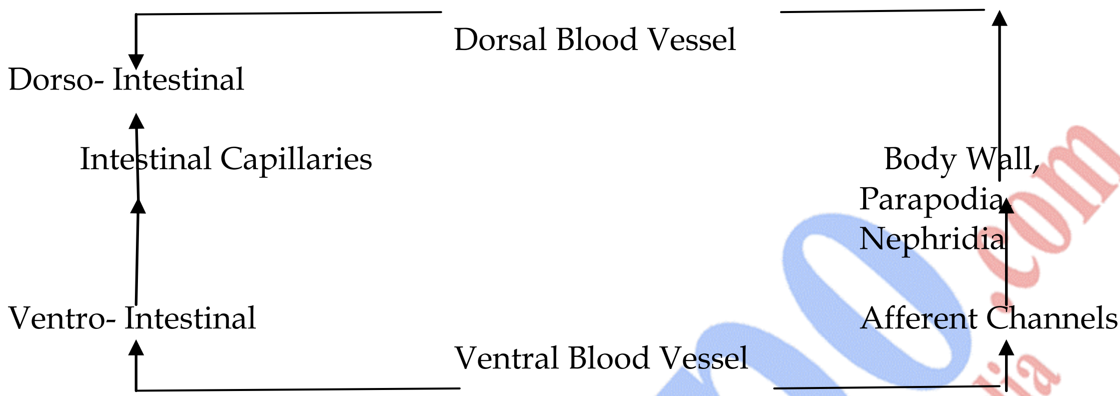
- contractile and muscular
- Blood is moved anteriorly by peristalsis.
- Lies just dorsal to the gut extending from the 5th segment to the last segment.
- Acts like collecting Vessel behind the Oesophagus.
- Collects blood from Parapodia, Nephridia, and the gut.
- In oesophageal region it divides into two and forms network of capillaries and now act as distributing channels.
- A median Channel collects blood and supplies to the Ventral Vessel.

The ventral blood vessel

- Lies ventral to the Gut, extending from the anterior to the posterior ends.
- Less contractile than Dorsal Channel
- Blood moves posteriorly in the ventral vessel
- leaves it via afferent segmental vessels to the gut, body wall, nephridia, and parapodia.
- Efferent segmental vessels drain these structures into the dorsal vessel.
- Acts as a **Distributing Channel** except in oesophageal region.
- In Pygidium it is connected to the dorsal channel by a **Circum Rectal Ring**.

Perineural Vessel

- It surrounds the Ventral Nerve Cord.
- Collects blood from ventral body wall and drain into the ventral Vessels



Course of Blood Circulation

Q. Describe the circulatory system of Prawn.

Ans. **Circulatory system** in Prawn is open type in which blood flows through open sinuses. Circulatory system consists of heart, Pericardium, arteries, pericardial sinus, haemocoel , bood channels and blood or haemolymph.

The heart is a triangular, muscular chamber, dorsally placed in the cephalothorax. It lies in the pericardial space. It is provided with paired openings called ostia. It has 5 pairs ostia or valves that permit blood to enter the heart. They are Dorsal, Ventral, Posterior, Anterio- lateral and Posterio – lateral Ostia, amed according to their position.

Pericardium is a haemocoelomic Chamber also called as **Dorsal Sinus**. It encased the Heart.

Arteries are the main tubes which arise from the anterior and posterior regions of the heart. Due to rhythmic contraction the heart distributes blood through anterior, posterior and ventral arteries to the body spaces. The sternal artery takes blood to the appendages from where blood is returned to the gills.
The main arteries are: **Median Opthalmic, Antennary, Hepatic, and Mid Posterior,**

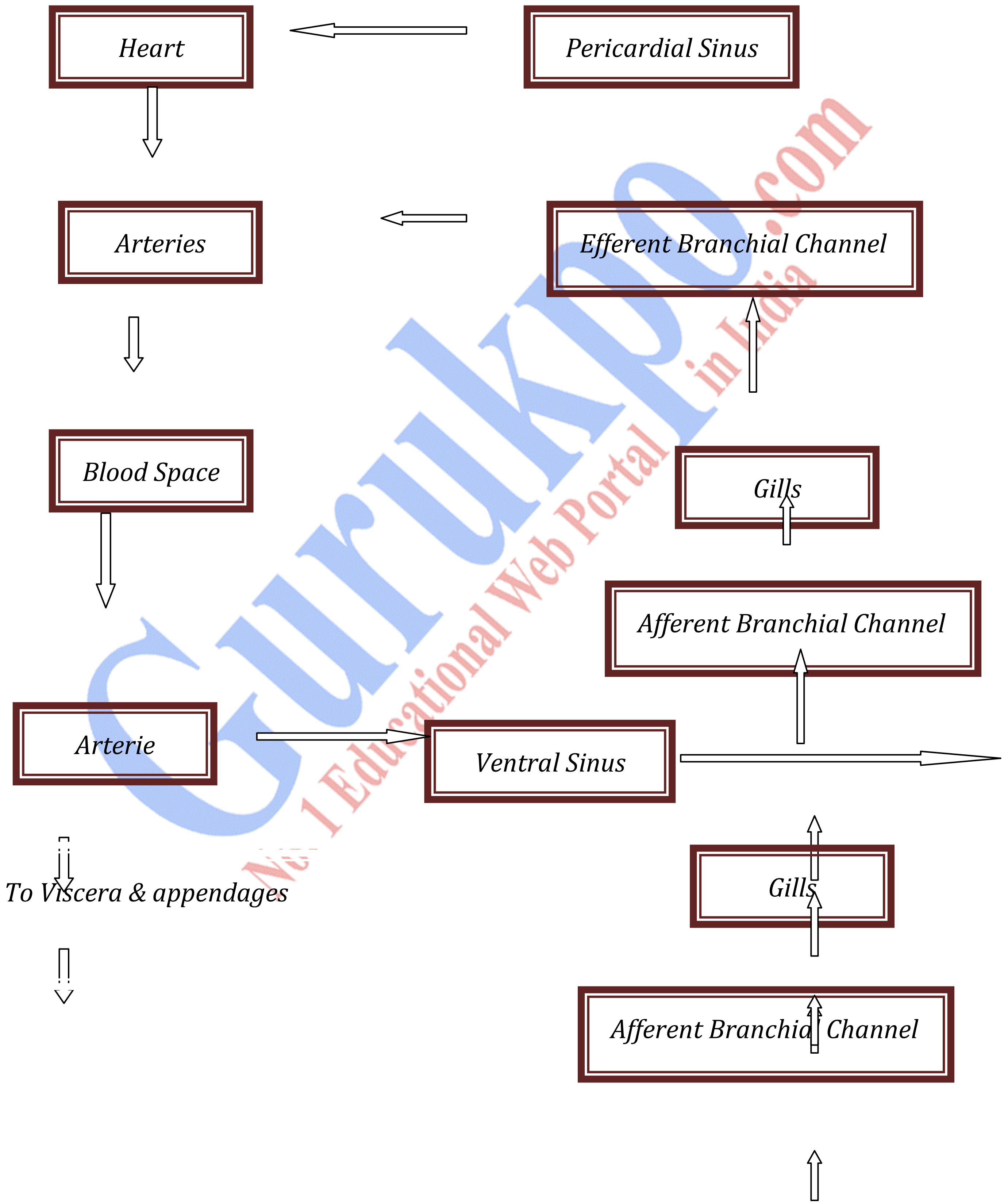
Pericardial sinus is the space between the dorsal body wall and the pericardial membrane. The spaces between the visceral organs form the haemocoel. It contains blood or haemolymph. From the haemocoel blood goes to the gills through the blood channels. From the gills blood goes to the heart through blood channels.

The blood contains plasma, haemocytes or blood cells and the respiratory pigment haemocyanin. The oxygenated blood is bluish red colour due to **Copper containing respiratory pigment**, *Haemocyanin*.
Blood Sinuses are open spaces where blood is collected. There are one

Dorsal and **two Ventral Sinuses in Prawn.**
Dorsal or Pericardial sinus is the space between the dorsal body wall and the pericardial membrane. 6 Efferent Blood channels bring oxygenated blood here.
Ventral Sinuses are two in number lying ventral to the hepatopancreas where deoxygenated blood from body is collected and 6 afferent channels emerge to send blood to the gills.The spaces between the visceral organs form the haemocoel. It contains blood or haemolymph. From the haemocoel blood goes to the gills through the blood channels. From the gills blood goes to the heart through blood channels.
The blood contains plasma, haemocytes or blood cells and the respiratory pigment haemocyanin. The oxygenated blood is bluish red colour due to **Copper containing respiratory pigment**, *Haemocyanin*.

Circulation of haemolymph
Haemolymph in the pericardial sinus enters the heart through the ostia. From the heart it reaches reaches the haemocoel through the arteries. Then it is collected by the afferent blood channels and returned to the pericardial sinus through the gills and efferent blood channels.

Course of Blood Circulation

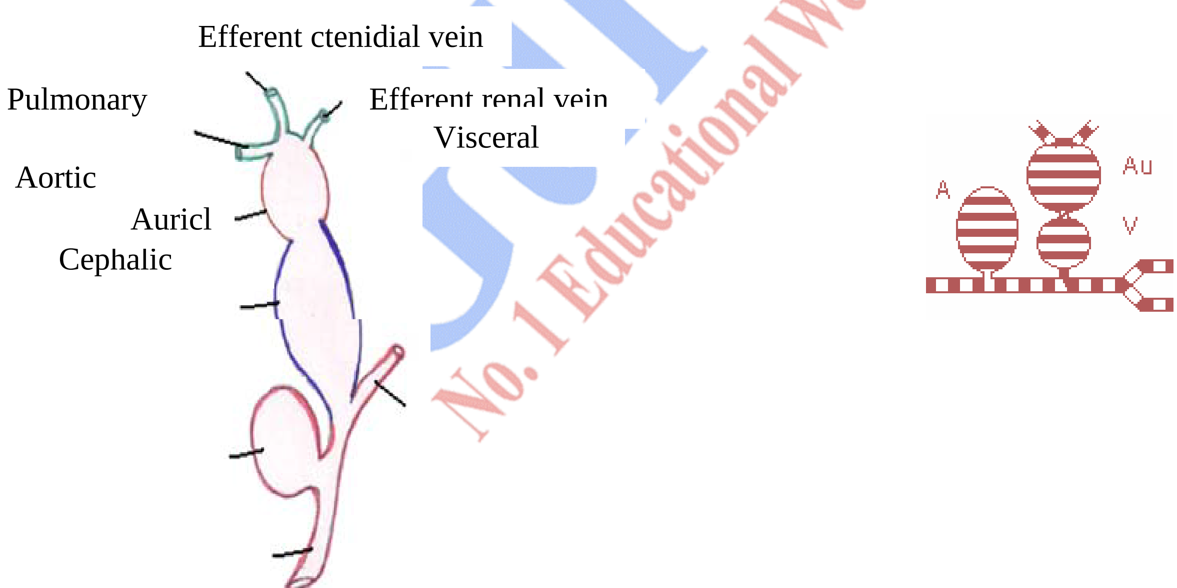


Q. Describe the circulatory system of Pila.

Ans The circulatory system is open and consists of heart, arteries, veins and the sinuses . It has attained

great complexity because of its amphibious nature. The **heart** is situated on the left side of the visceral mass very close to the posterior end of the ctenidium (Fig. 12 and 13). The heart is enclosed in a thin-walled coelomic cavity called **pericardium.** The pericardium is situated between the pulmonary chamber and the posterior renal sac on the left side of the body whorl (Fig.12). It extends anteriorly upto the stomach and digestive gland and communicates with the posterior renal chamber by a **reno-pericardial aperture**. Heart consists of two chambers: **an auricle** and **a ventricle** (Fig. 12). The auricle is thin walled, highly contractile and lies in the dorsal part of the pericardium. Ventricle is thick walled, spongy and muscular situated just below the auricle in the same vertical axis. The auricle communicates with the ventricle by a **auriculo-ventricular aperture** which is guarded by two **semilunar valves** to prevent the backflow of blood from the ventricle to the auricle (Fig.).

The auricle receives oxygenated blood from the ctenidium and the pulmonary sac through the efferent ctenidial vein and the pulmonary vein. It also receives blood from the posterior renal chamber by efferent renal vein.



12. Heart of Pila; Au= auricle, V= ventricle, A= ampulla

The opening between the ventricle and aorta is guarded by two **semilunar valves** which prevent the backflow of blood into the ventricle.

CEPHALIC AORTA: The cephalic aorta supplies blood to the head region. It is swollen into a thick walled contractile **aortic ampulla** at its base which helps in the propulsion of the blood. The cephalic aorta gives off three branches on its outer side:

1. **A fine cutaneous artery to the skin.**
2. **A thick oesophageal artery to the oesophagus.**
3. **A thick pallial artery to the left side of the mantle, left nuchal lobe and the osphradium.**

The inner side of the cephalic aorta gives off a single pericardial artery to the pericardium which finally enters the posterior renal chamber and gives off branches to both the renal chambers and part of reproductive system. The cephalic aorta enters the perivisceral sinus (space surrounding the buccal mass and oesophagus) along the left side of the oesophagus and then crosses beneath the oesophagus and gives off many arteries to the buccal mass, oesophageal wall, right side of the mantle, right nuchal lobe, copulatory organ, eyes, tentacles etc.

The visceral aorta passes through the visceral mass and supplies blood to the visceral organs. It gives out:

1. A small pericardial artery to the pericardium.
2. A large and stout gastric artery to the stomach.
3. Intestinal arteries to the intestine.
4. A hepatic artery to the digestive gland and the gonads.
5. Renal arteries to the anterior and posterior renal chamber.

Finally the visceral aorta terminates into branches that supply the rectum and the anus.

The blood that is supplied to the various organs of the body by the arteries and its branches is finally collected in small spaces called the **lacunae**. These lacunae unite to form large **sinuses** (Fig. 13). Sinuses are spaces between the body wall and visceral organs and together with the lacunae form the **haemocoel.** They connect arteries to veins and serve as capillaries. There are four blood sinuses in *Pila:*

1. A **peri-visceral sinus** surrounding the anterior part of the alimentary canal. It contains deoxygenated blood. **Three channels carry blood from this sinus to the renal chamber and the pulmonary sac.**
2. **Peri-intestinal sinus** surrounding the terminal part of the intestine and the the genital duct. **It collects blood from the digestive gland and the visceral organs.**
3. **Branchio-renal sinus** lying outside the anterior renal chamber and leading into the afferent ctenidial vein. **It receives blood from the roof of both the renal chambers.**
4. **Pulmonary sinus** present in the wall of the pulmonary sac. **It receives blood**

The blood from different organs of the body is collected by three main veins and poured into the auricle either directly or through the respiratory and excretory organs.

1. **Afferent ctenidial vein**: It collects deoxygenated blood from the peri- visceral sinus, the rectum and the terminal part of the genital ducts and carries it to the ctenidium where the blood is oxygenated. The **efferent ctenidial vein** collects the oxygenated blood from the ctenidium, mantle, and the copulatory organs and pours it into the auricle.
2. **Afferent renal vein**: It receives blood from the peri-intestinal sinus and carries it to the posterior renal chamber. The **efferent renal vein** then collects blood from the posterior renal chamber and conveys it to the auricle.
3. **Pulmonary vein** collects blood from the pulmonary sinus and sends it to the auricle.

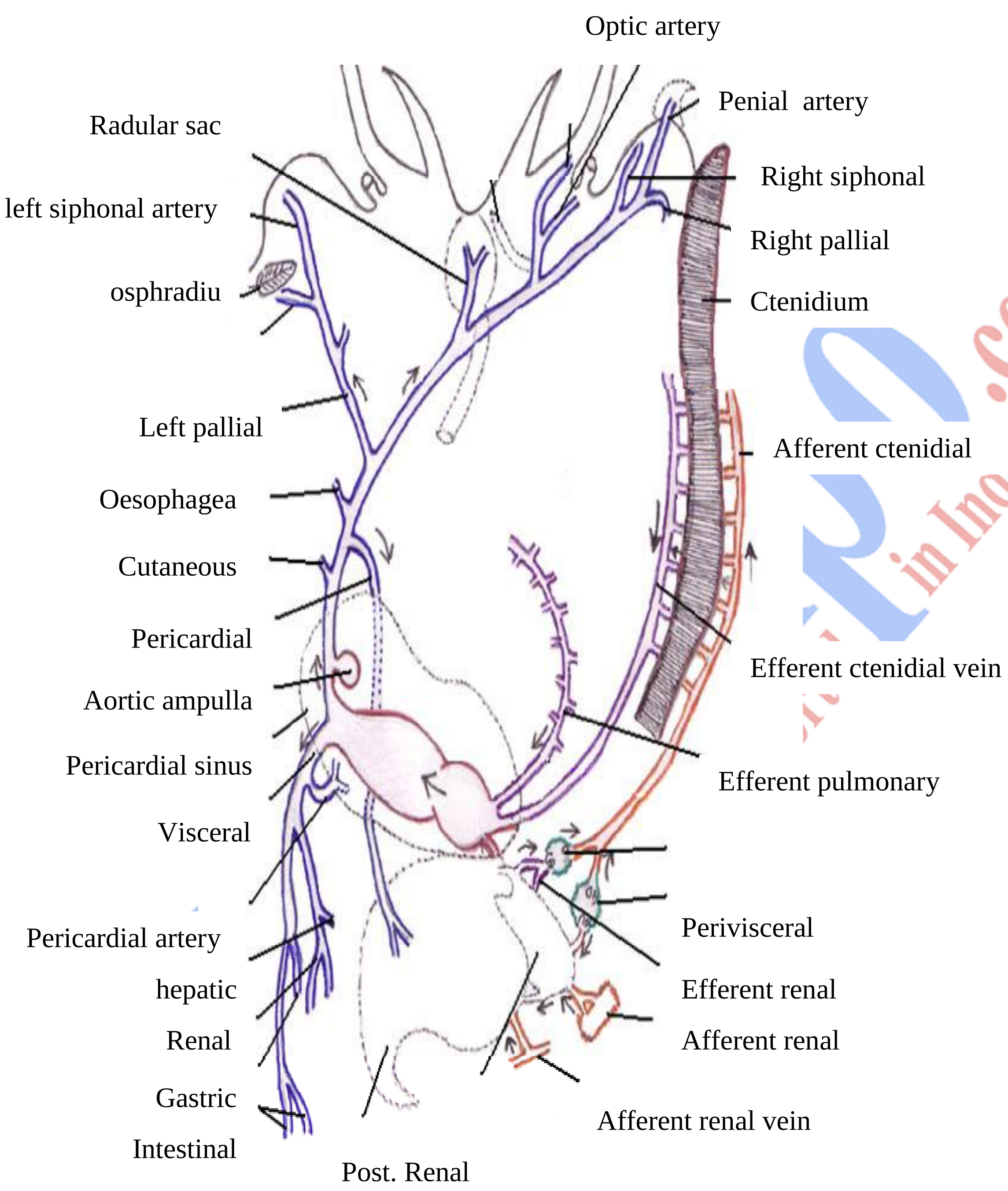


Fig. 13. Heart and blood vascular system of *Pila*

BLOOD:

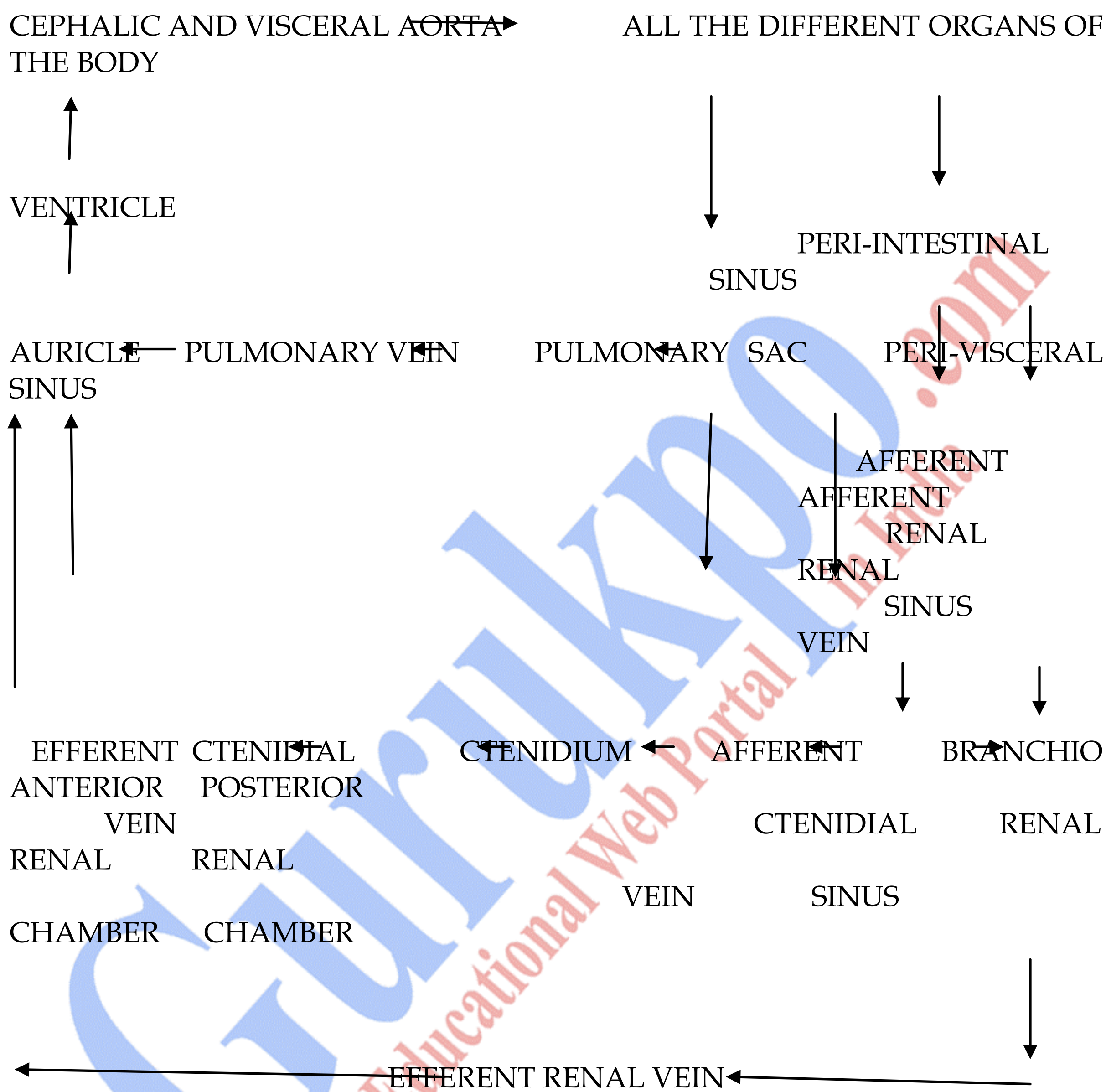
Blood is colorless because of the absence of haemoglobin. It contains the respiratory pigment **haemocyanin** which is dissolved in blood plasma. Haemocyanin contains copper and thus it becomes blue when it combines with oxygen and colorless when it combines with carbondioxide. Blood also contains some colorless stellate amoeboid cells which are phagocytic in nature and help in the removal of waste substances. Some intracellular digestion also takes place in these amoeboid cells.

COURSE OF CIRCULATION:

The cephalic and visceral aorta supplies blood to different parts of the body. The blood is then collected from various parts of the body in two main sinuses, the peri-visceral and peri-intestinal. From these sinuses, the blood passes either into the ctenidium, pulmonary sac or the kidney (Fig. 13).

During aerial respiration, the blood flows from the peri-visceral sinus into the pulmonary sac and after aeration comes to the auricle by the pulmonary vein. **During aquatic respiration**, the blood flows from the perivisceral sinus to the ctenidium and after aeration comes to the auricle by the efferent ctenidial vein.

The blood from the peri- intestinal sinus takes two courses: it either goes to the anterior renal chamber from where it goes into the ctenidium where it is purified and finally through the efferent ctenidial vein enters the auricle, or from the peri-intestinal sinus, the blood goes to the anterior renal chamber and then into the posterior renal chamber. However, the blood can enter the posterior renal chamber directly from the peri-intestinal sinus. Whatever may be the case, the blood is finally carried from the posterior renal chamber by the efferent renal vein to the auricle. This blood is not aerated. Thus, the aerated and non-aerated blood gets mixed up in the auricle. This mixed blood then enters the ventricle and is distributed to the arteries. The renal chambers remove the excretory products from the blood.



Q. Describe the excretory system of Fasciola,nereis, prawn, pila and insects.

Ans:

NEREIS:

The 'opened' or metanephridia are more advanced kind of nephridia which are found in *Neareis*. In Neris there are one pair nephridia in each segment except some anterior segments and pygidium.

A metanephridium is opened at both ends. It opens into the coelom by a ciliated funnel or nephrostome. The other end of it opens to the exterior through the nephridiopore.

Principal nitrogenous product in annelids is NH3. The excretory products diffuse from coelomic fluid or blood into the lumen of nephridial tubule. It is discharged to the outside through nephridiopore.

Structure:-

Each septal nephridium consists of **nephrostome , neck, body of nephridium** & **terminal duct.**

1. **Nephrostome :-**
   One end of the nephridial tube opens into the adjacent segment in the neck region via a ciliated funnel that is called as the Nephrostome. It communicates with the coelom.
2. **Neck:-**
   Nephrostome leads into the main body of nephridium through a short, narrow & ciliated, tube like neck. The Neck penetrates the anterior intersegmental septum and extends a short distance in adjacent segment.
3. **Body of nephridium:-**
   Body consists of 2 parts – **a syncytial mass of connective tissues and a coiled nephridial tube.**
   The nephridial loop opens at both ends, one by nephrostome and another opens by the nephridiopore.
4. **Terminal duct:-**
   Distal limb of the body of nephridium **ends in a short & narrow duct** called **terminal duct** that opens outside through the nephridiopore. The nephridiopore is situated near ventral cirrus of the parapodia **.**

Physiology:

Excretion occurs in two ways:

1. The whole body is covered with vast network of blood vessels and the glandular cells of the body extracts the waste product of blood, mostly Urea.
2. The nephrostome dipped into the coelom of the adjascent segment filters out dead or any waste products and these are carried away through the nephridiopore.
   Nephridia exhibits the phenomena of Selective Reabsorption.

Q. Name the excretory organ of flat worms. Describe its structure and function.

Ans. Excretion in Platyhelminthes occurs through **protonephridia/ flame cell** as in Fasciola and Taenia. Metabolic waste products of flat worms are excreted generally in the form of NH3 by diffusion across the general body surface. Flatness is helpful in diffusion. However flat worms release excess water as well as some excretory products through flame cells.

<u>Structure:-</u>

A typical flame cell is a uninucleated large cell. The flame cell may give out numerous branched protoplasmic processes in the surrounding mesenchyme. In the center of the cell is a conspicuous (easily visible/ attracting attention) bulbous cavity or cell lumen. The cavity narrows down forming a fine capillary duct. The cytoplasm occurs in the periphery of the cell containing a round or oval nucleus. The broad end of lumen encloses a tuft of long cilia or flagella. The tuft of cilia/flagella when undulates, resembles the flickering flame of a candle. Hence the common name is flame cell. These cells are usually connected to the lateral longitudinal collecting/excretory ducts.

<u>Mechanism of function:-</u>

Flame cells function on the basis of filtration & resorption. [The water from the intercellular spaces are collected by the extension of the plasmalemma. The collected water is ultrafiltered through the thin wall of pillar like rods. The ultrafiltered fluid (excluding the protein molecules) then moves through the neck of the cavity by the flickering movement of the cilia/flagella.]

The continuous beating of the cilia/flagella within the cavity of the flame cell produce sufficient negative pressure which causes ultrafiltration. The filtered fluid is passed into the longitudinal duct through the capillary duct & discharged through the nephridiopore. During passing through the tubes ions are selectively reabsorbed or secreted. The protonephridia thus plays an important role in regulating ionic & water balance in addition to the elimination of metabolic wastes.

Q. Name the excretory organ of insects. Describe its structure and function

Ans. The excretory organs of insects are ***Malpighian tubules***.

Structure & functions of Malpighian tubules:-

Malpighian tubules are numerous slender, threads like, yellow coloured structures. These are the principal excretory & osmoregulatory organs in insects.

- **Position:-**
  They are attached to the alimentary canal at the junction of midgut & hindgut.

- **Origin:-**
  Malpighian tubules are ectodermal in origin.

- **Structure:-**

The outer layer of the malpighian tubule which is in contact with the haemolymph is composed of thin, elastic, connective tissue & muscle fibres. The malpighian tubule lumen is lined by cuboidal epithelial cells.There are 2 distinct regions in each tubule –

A) ***Distal blind secretory region:*** *-* It hangs freely in the haemocoel. The inner cells lining the distal region have well developed brush border.

B) ***Proximal absorptive region:-*** It opens into the gut. The inner cells lining this region are less differentiated & have honey comb border.

- **Physiology of excretion:-**
  Insects produce nitrogenous waste in the form of potassium urate which is liberated into the haemolymph. This along with water is taken up by the distal region of the malpighian tubule. In the cells of the tubule potassium urate reacts with H2O & CO2 to form potassium bicarbonate & uric acid. Potassium bicarbonate is absorbed back into the haemolymph but uric acid is left out in the lumen.
  As the uric acid in dissolved condition moves into the proximal region of the malpighian tubule, the H2O is reabsorbed. [Reabsorption of H2O occurs to such an extent that the basal part of the proximal region becomes filled with solid crystals of uric acid.] Resorption of water further takes place in the rectum.

- ***Importance:-***
  Thus the malpighian tubules function excretory as well as osmoregulatory as they not only help by excreting nitrogenous wastes but also in conserving water in proper amount. This has helped insects in leading effective life activities in terrestrial environment.

Q. What do you know about the Organ of Bojanus? Describe the structure and function of excretory system in Unio.

Ans:

Molluscan excretion takes place by the kidney (organ of Bojanus) & Keber's organ. The kidney in bivalvian molluscs is known as organ of Bojanus.
Excretion in Unio sp. or Lamellidens sp. takes place by –
1. A pair of organ of Bojanus &
2. Keber's organ or pericardial gland.

- **Organ of Bojanus:-**

Kidneys of bivalves are called organ of Bojanus after the name of the discoverer.

Location:-

These are situated one on each side of the body below the pericardium.

Structure:-

Each kidney or organ of Bojanus is a long, dark tube, open at both ends. It consists of 2 parts –

- Brown, spongy, thick-walled, glandular part or kidney proper &
- Small, thin-walled, non-glandular, ciliated urinary bladder.

The glandular part of the kidney opens into the pericardium by renopericardial aperture.
The urinary bladder opens to the suprabranchial chamber of the mantle cavity by a minute opening, called renal aperture/ nephridiopore.

Physiology of excretion:-

Urine originates as an ultrafiltrate from the heart into the pericardium.
The glandular part of the kidney extracts guanin & other nitrogenous waste products of metabolism from the coelomic pericardial fluid. Here resorption of the minerals & water takes place.
The ciliated epithelial lining of the urinary bladder produces an outgoing current which takes away excretory product like NH_3 & urea etc. to the outside through renal aperture, suprabranchial chamber & exhalant siphon respectively.

- **Keber's organ:-**

It is also known as pericardial gland. It is a large, reddish brown, glandular mass situated in front of the pericardium, & responsible for the excretion of nitrogenous waste products. The excretory products are discharged into the pericardium from where these are collected by the organ of Bojanus to be discharged to the outside.

Q. Describe the excretory system of Pila.

Ans: EXCRETORY SYSTEM:

Excretion is performed by a large thick walled muscular **renal organ or kidney** which consists of an anterior chamber and a posterior chamber, the two communicating with each other by an aperture guarded by a valve. The renal organ communicates with the exterior on one hand and with the pericardial cavity on the other (Fig.14). It is also kown as Organ of Bojanus.

ANTERIOR RENAL CHAMBER:

The anterior chamber is more or less ovoid, reddish in color, smaller than the posterior chamber, situated in front of the pericardium. It opens into the mantle cavity by an elongated aperture on the right side of the epitaenial ridge. On the other end it communicates with the posterior renal chamber through an internal opening. The internal cavity of the anterior chamber is reduced due to the presence of numerous lamellae projecting both from the roof and the floor. The lamellae are arranged on the floor on either side of a single median axis, the afferent renal sinus and also on the roof on either side of the median longitudinal axis, the efferent renal sinus (Fig. 14).

POSTERIOR RENAL CHAMBER:

The posterior renal chamber lies on the left side of the rectum, closely pressed against the pericardium and the digestive gland. Its cavity communicates with the pericardium by the reno-pericardial aperture at one end while the other end communicates with the anterior renal chamber by an aperture. The posterior renal chamber is broad, somewhat hook shaped, brownish to grey in color. Its large internal cavity encloses a part of the genital duct and a few coils of the intestine. The roof of the chamber is richly supplied by the branches of the afferent and efferent renal vessels.

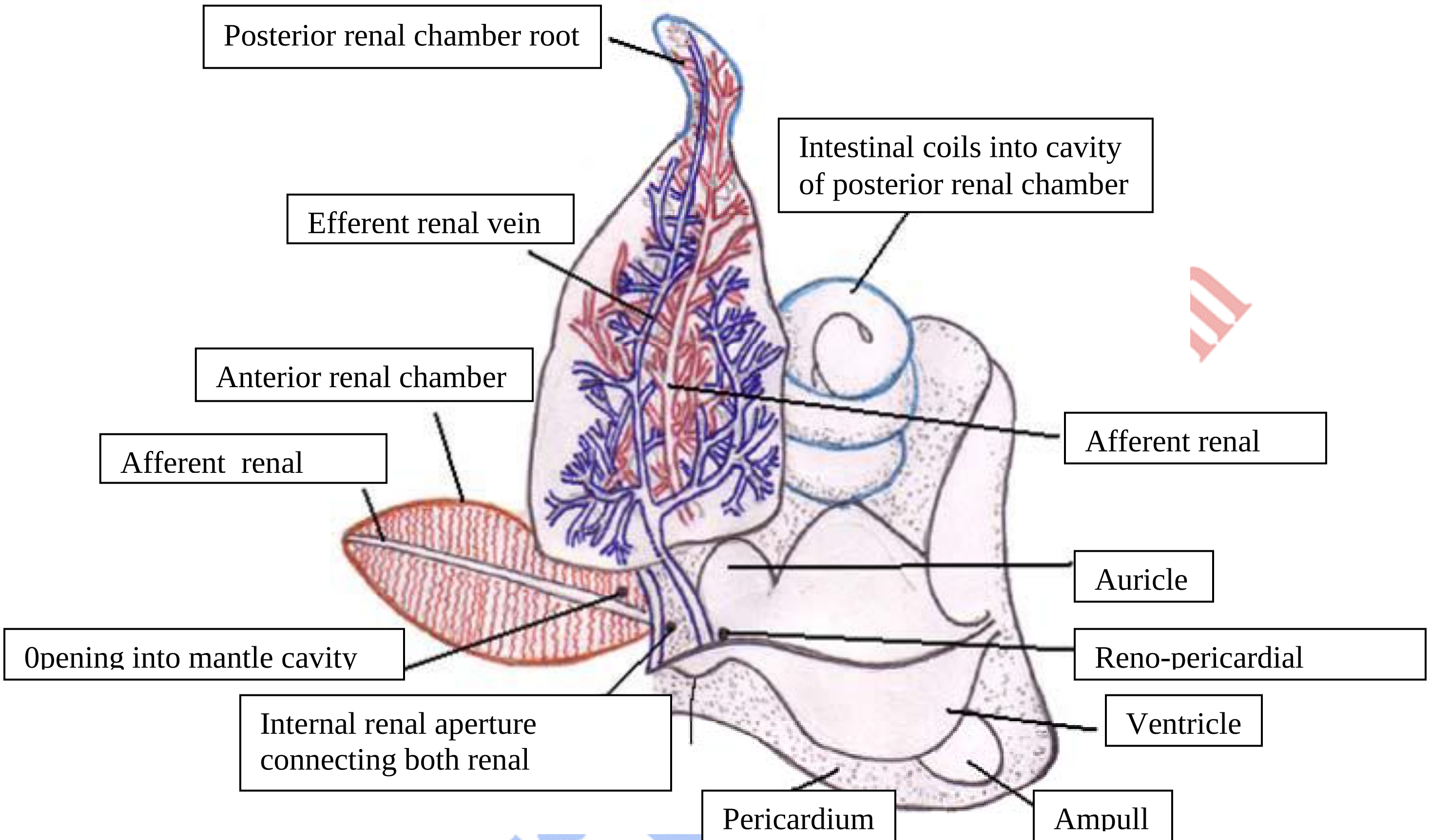


Fig. 14. Excretory organ of *Pila*

MECHANISM OF EXCRETION:

The walls of both the chambers are richly supplied with a network of blood vessels. The renal chambers separate the nitrogenous waste material from the blood. The excretory products are passed from the posterior renal chamber into the anterior renal chamber, from where it is discharged into the mantle cavity through the renal duct. The waste products are finally expelled out of the body from the mantle cavity through the right nuchal lobe along with the outgoing water current. The posterior chamber excretes uric acid and purines and the anterior chamber which has osmoregulatory function.

The excretory fluid mainly contains ammonia, ammonium compounds, urea and uric acid. During the aquatic phase, *Pila* excretes out ammonia (ammonotelic) but during the terrestrial phase it excretes out uric acid (uricotelic). This is so because during the terrestrial phase it needs to conserve water.

Excretory system of Prawn:

The excretory system consists of antennal glands and exoskeleton. There is a pair of antennal or green glands.Each lies enclosed in the proximal segment (coxa) of the antenna. Its parts are an end sac, a coiled tube and a bladder . The end sac is blind, the tubular part is glandular and the bladder is thin walled. The bladder opens to the exterior by the excretory pore. The end sac and the coiled tube are derivatives of the mesoderm and their spaces are part of the coelom. The body of Penaeus is covered by exoskeleton. It is shed during moulting. The nitrogenous waste materials are deposited on the exoskeleton and removed along with it.

Q. Name the excretory organ of Leech. Describe its structure and function.

Ans.

There are total 17 pairs of Nephridia located from 6th to 22nd segments of the body of Leech. These are divided into Testicular and Pre Testicular Nephridia.

- **Testicular Nephridia [12th to 22nd segment, 11 pairs]:**
  - it consists of main lobe, vesicle and vesicle duct, apical lobe, inner lobe, initial lobe and ciliated organ.
  - It is a horse-shoe shaped organ present one pair in segments from 12th to 22nd.

Main Lobe -> it lies ventrolateraly between two adjacent caeca and has 2 unequal large anterior and short posterior limbs.

Vesicle and Vesicle Duct-> A narrow vesicle duct arises from the anterior limb of the main lobe, that opens into a bladder or Terminal vesicle. Vesicle opens to the exterior via nephridiopore through a small excretory duct.

Apical Lobe->It arises from the free end of the posterior end of the main lobe which end appears as handle of a walking stick.

Inner Lobe-> It lies between anterior and posterior limbs of the main lobe.

Initial Lobe/ Testes lobe: This is long cord like structure twisted around the apical lobe and its posterior end joins the anterior limb of main lobe. Its anteriorend reaches over the testes sac and ends blindly close to the perinephrostomial ampullae.

Ciliated Organ-> It is special structural part that lies inside the perinephrostomial ampullae. It is supposed to be modified nephrostome. It consists of a reservoir of connective tissue cells, which manufacture coelomic corpuscles. It is covered with a thin membrane having numerous pores. A ciliated funnel lies in each pore. It is a part of haemocoelomic sysem.

- **Pre Testicular Nephridia:** Extending from 6th to 11th segment, these resemble to the testicular nephridia in all respect except the initial lobe end loosely in the connective tissue, as there is no testis sac, perinephrostomial ampullae and ciliated organ.

Physiology

The nephridium is profusely supplied with haemocoelomic channels and its glandular cells filters out the waste products from the haemocoelomic fluid, which is collected in vesicle through vesicle duct and excreted out via nephridiopore.

Q. Describe the Reproductive system of Fasciola hepatica.

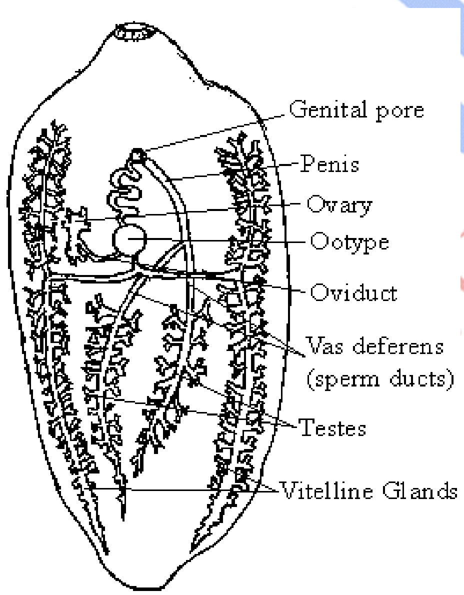
Ans:

The liver fluke is hermaphrodite, i.e. it contains both male and female reproductive organs in the one body.

Male Reproductive System:

It has following parts:

- I Pair of testes: produce the sperm.
- Sperm ducts: carry the sperm.



- Penis: pass sperm out of genital pore.The liver fluke can self fertilise or cross fertilise. Cross fertilisation is when two flukes
- exchange sperm during copulation. It takes place in the bile duct of the primary host.

Female Reproductive System

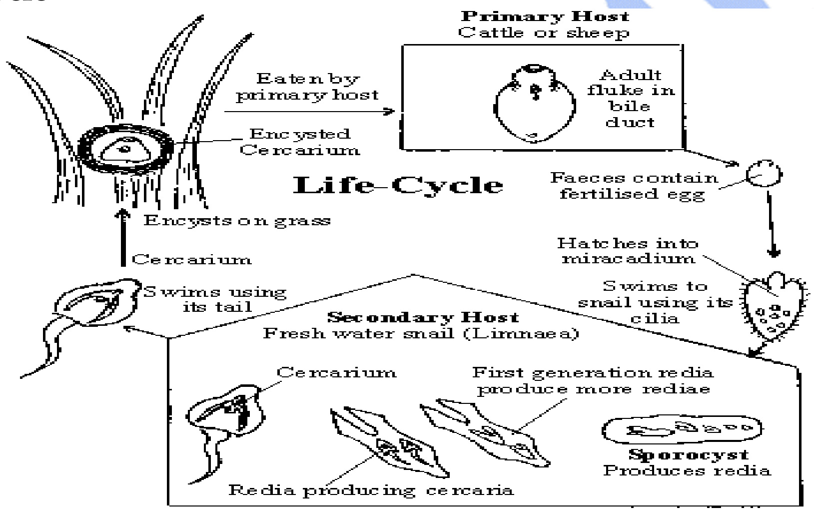
It has following parts:

Ovary: produces the eggs.

- Oviduct: carries the eggs.
- Ootype: this is where fertilization takes place and the fertilized eggs are surrounded by a yolk and a shell.
- Vitelline glands: produce the substances to make the yolk and shell.
- Uterus: matures and stores fertilised eggs.

Q. Write an essay on the life cycle of Fasciola hepatica. Describe the pathogenesis , harm caused by fasciola and their control.

Life cycle



It is digenetic, endoparasite found in the bile duct of the liver of sheep and goat which serve as primary host and in larval stages in an intermediate (secondary) host called Limnaea and Planorbis (snail). In primary host it causes liver rot.

Life history:

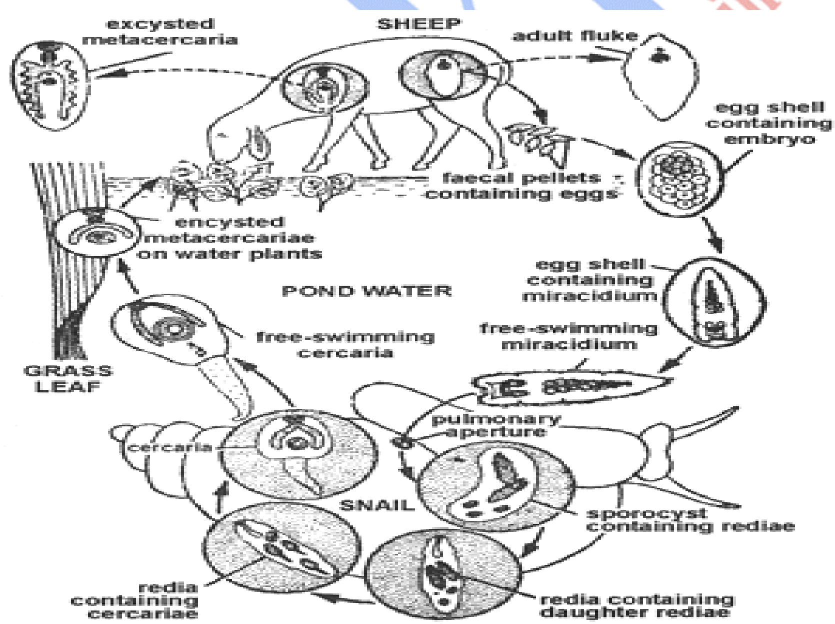
Cross fertilization takes place. The everted cirrus of one fluke penetrates the **Laurer's canal of the** other through the opening and injects spermatozoa into the oviduct. A single fluke may produce a total of about 2000,000 eggs in about 11 years. Each fertilized egg is surrounded by yolk cells, which provide yolk and shell material. The encapsulated embryo does not develop further in uterus. It is finally ejected out with faeces of host.

When suitable conditions commence (60 moisture content, temperature 220C-250C) then encapsulated embryo differentiates into a **miracidium larva**. It swims in the water and is free living. It does not feed. When comes in contact with intermediate snail host it enters the digestive gland.

It develop into the second larva i.e., ***sporocyst larva***. The sporocyst moves in the tissues of the host, absorbing nutrition from it. Each sporocyst produces five to eight rediae. **Rediae** emerges out from sporocyst and feeds upon host's tissue.

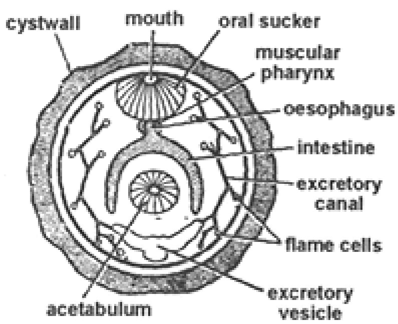
Cercaria larva is formed in the body of redia larva. It leaves the body of radia and ultimately escapes the host body in surrounding water(Temperature between 90C - 260C favours the emergence of cercaria from snail).

The cercaria swims in surrounding water and later on becomes inactive to form **metacercaria larva**. This larva is encysted, so when primary host feeds on grasses, it enters in the body and established itself in the liver, where it becomes mature.



Fosciola hepatica : Life cycle

The anterior end of the body is in the form of a conical projection, called the head lobe at the tip of which oral-sucker having mouth is present. There are present two muscular suckers; and oral sucker enclosing the mouth, and a ventral sucker or acetabulum without an aperature which is placed ventrally. The suckers are organ for attachment although anterior suckers also helps in taking the food. There are three permanent apertures on the body-mouth, common genital pore and excretory pore.



Fasciola hepatica. Metacercaria

With the help of mouth, the fluke feeds on bile, blood, lymph and cell debris of the host. There is no anus. Indigestible food matter is either probably ejected through the mouth or diffused into the excretory system. Respiration takes place in the absence of oxygen.

Economic and medical importance

The liver fluke can have some serious effects on the host:

1. The liver of the primary host will be damaged, this can cause liver rot.
2. Excretory products of the fluke have a toxic effect on the host.
3. The wool of infected sheep is very dry and of poor quality.
4. In cattle milk yields are reduced.
5. Loss of weight for all animals.
6. Fertility is reduced for all animals.
7. Resistance to disease is reduced.
8. Severe infection can result in death.

Controlling the Liver Fluke

Method	Stages of life cycle affected
1. Drain the land	(a) Snail is absent, miracidia die. (b) Encysted cercaria die after 6 weeks (can normally live for 12 months).
2. Dose the primary host	This kills the adult flukes in the primary host.

3. Spray molluscides	This kills the snails, miracidia die.
4. Fence off wet areas	(a) Encysted cercaria die eventually. (b) Miracidia die - no snails in dry areas.
5. Spread lime on the land	Lime increases the pH. If pH is greater than 7.5 the eggs will not hatch into miracidia. The fertilised eggs die.
6. Introduce ducks and geese	They eat the snails, miracidia die.

Adaptations of the Liver Fluke:

1. **Suckers:** Attachment to the primary host.
2. **Spines:** Attachment to the primary host.
3. **Cuticle:** Protection.
4. **Hermaphrodite:**
   (a) Any fluke can produce a fertilised egg (doubles the population).
   (b) Cross fertilisation can take place leading to increased variation.
   (c) Self fertilation can take place.
5. **20,000 eggs produced per day:** To increase chances of some surviving and gaining access to the secondary host.
6. **Light needed for eggs to hatch:**
Ensures eggs only hatch once outside the primary host. This gives the miracidium the full 24 hours to locate a snail.
7. **Cilia on miracidium:** Enables it to swim to secondary host.
8. **Spine on miracidium:** To help penetrate the snail.
9. **Asexual reproduction in the water snail:** Increase chances of some cercaria gaining access to the primary host.
10. **Tail on cercarium:** Enables it to swim to the top of the grass.
11. **Cyst:** This protects the cercarium so prolonging its lifespan.

Sample Question

Outline where and why a build up of parasite numbers occur in the life cycle of the liver fluke.

Solution:

Where?

1. In the cow or sheep; sexual reproduction leads to the production of 20,000 fertilised eggs per day.
2. In the water snail (asexual reproduction - polyembryony); One sporocyst produces many redia. One redia produces many rediae. Each redia produces many cercaria.

Why?

1. The 20,000 eggs increase the chances of some surviving and gaining access to the secondary host.
2. Polyembryony in the snail increases the chances of some cercaria gaining access to the primary host.

Therefore the buildup of numbers greatly increases the chances of gaining access to a new host.

A note on life cycle of Fasciola

It needs two hosts a primary host (sheep or cattle) and a secondary host (fresh water snail/mud snail)

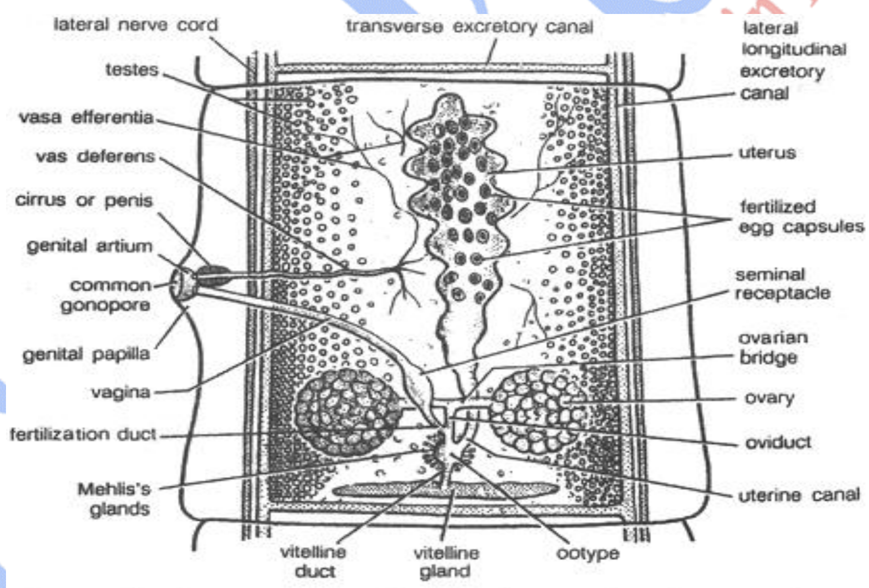
1. **Sexual reproduction** - in the bile duct of the primary host.
(a) A single fluke can produce up to 20,000 fertilised eggs per day.
(b) The eggs are released from the primary host with the faeces.
2. **Finding a secondary host** - external environment
(a) Light, moisture, and a temperature above 10 degrees Celcius are required for the fertilised eggs to hatch into the first larval stage, the miracidium.
(b) The miracidium has cilia to help it swim and has 24 hours to find a snail.
3. **Asexual reproduction (polyembryony)** - in the secondary host.
(a) The miracidium uses its spine to penetrate the snail.
(b) Each miracidium develops into a sporocyst.
(c) Each sporocyst produces many redia asexually.
(d) Each redia can produce many rediae.
(e) Each redia can produce many cercaria.
(f) The cercaria leave the snail.
4. **Finding a primary host** - external environment.
(a) The cercarium swims by means of its tail to a blade of grass.
(b) It forms a cyst about 0.25mm in size.
5. **The adult matures** - In the primary host.
(a) The encysted cercaria are ingested by the primary host.
(b) An immature fluke emerges from the cyst, burrows through the intestinal wall and migrates to the liver.
(c) Young flukes feed and grow in the liver.
(d) When sexually mature the adults enter the bile duct and copulate.

Q. Describe the reproductive organs of Taenia solium in brief.

Ans Taenia solium i.e. the Pork Tapeworm is an hermaphrodite organ but cross fertilization is common mode of reproduction.

Male reproductive system: Male organ consists of numerous testis of many small lobes lying scattered in the greater part of the proglottids towards the dorsal side; efferent ducts arise from the testes and unite to open into convoluted vas deference which passes trough a cirrus surrounded by a cirrus sac. The cirrus opens by the male genital pore.

Female reproductive organs include a single, bilobed ovary; single oviduct opens into ootype ; ootype surrounded by Mehli's gland; vagina combines ootype with common genital atrium and opens outside by female genital aperture; forms seminal receptacle before opening outside; long, tubular blind sac like uterus connected with ootype.



Reproductive structure : *Taenia*-a hermaphrodite organism

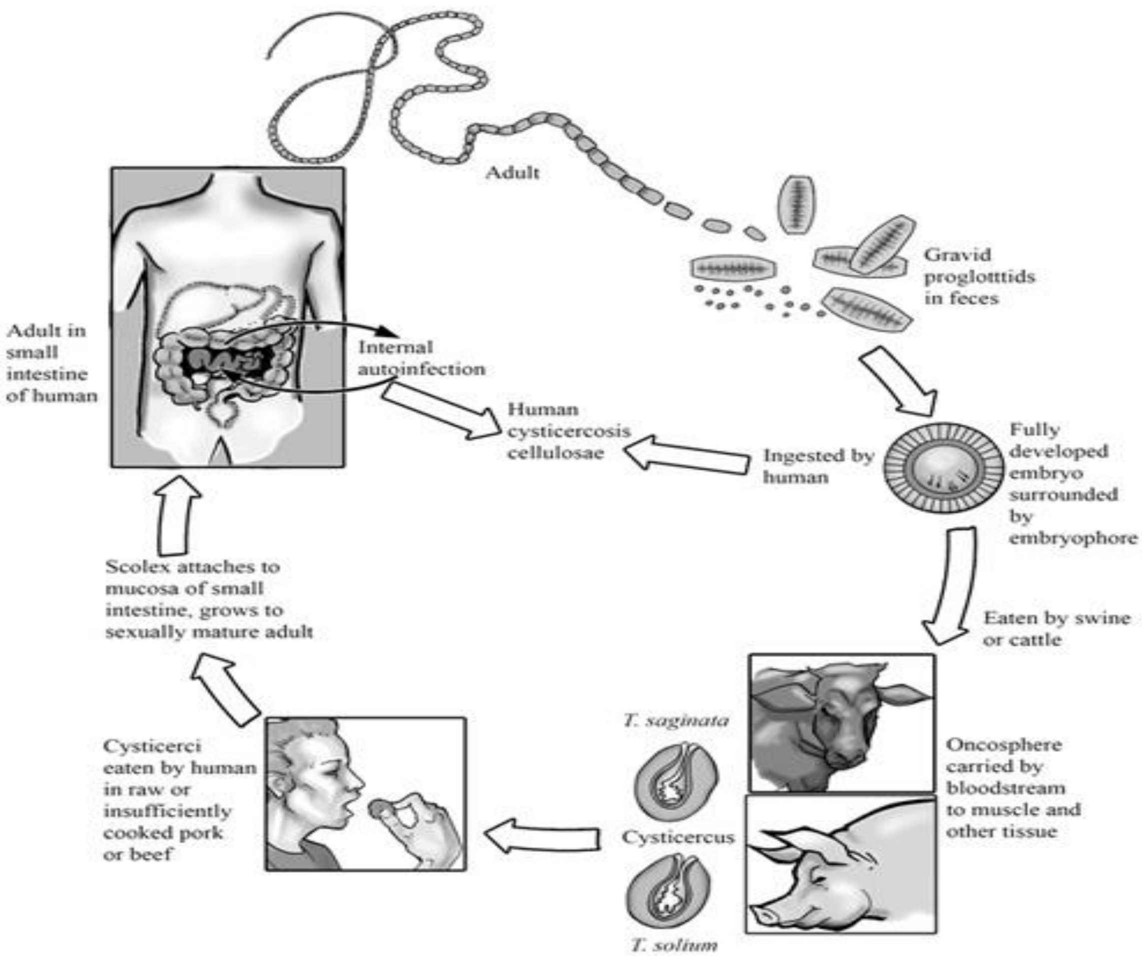
Q. Write an essay on the life cycle of Taenia solium.

Ans

Life Cycle:

This parasite is a digenetic having man as primary and pigs as the main intermediate host, but man may also act as an intermediate host for this parasite as well as being infected with the adult tapeworms.

The process of fertilization takes place either within the same proglottids or between two different proglottids to form zygote. The zygotes pass into the ootype, where they are enclosed by thick capsule. This capsulated zygote then passes into the uterus. Passage of capsules into the uterus is lubricated by the secretion from Mehli's gland. The process of cleavage takes place to form morula. The morula at posterior end develops three pairs of chitinous hooks. This six hooks embryo is called **hexacanth**. The hexacanth is surrounded by two membranes. This hexacanth along with the membrane is known as **onchosphere**. Onchosphere passes out with stool by process of apolysis (shedding of gravid proglottids).



The secondary host acquires infection by injesting the onchospheres. (Man may act as secondary host if detached gravid proglottids are passed to intestine by reverse peristalsis). The onchosphere looses its membrane by the action of gastric enzymes. The hexacanth then passes into the small intestine.

The hexacanth is now activated by bile salts. It reaches muscles (striated) by boring through intestinal mucosa. It now forms encysted **bladderworm** or **cysticercus larva**. The cysticercus develops in the adult tapeworm only when ingested by the human beings. Pork (pig flesh) containing cysticerci are called measly pork for its spotted appearance.

The human host gets the infection by eating under cooked measly pork. **Cysticercosis** is more harmful than **taeniasis**.

Morphology

Larvae - These small cysticerci are approximately 6- 18mm wide by 4 - 6mm in length when found in the muscles or subcutaneous tissues (the normal sites for the larval of this parasite). The cysticerci may however be found in other tissues such as those of the central nervous system where they may grow much larger, up to several cm in diameter.

Pathology of Infection

Larvae –

- Infection with the larval form of *T. solium Cysticercus cellulosae*, (called "Cysticercosis") may have severe consequences (the annual world-wide mortality due to cysticercosis having been estimated at approximately 50 000 cases).
- In man the cysticerci mainly develop in the subcutaneous tissues, but infections in both the Central Nervous System (C.N.S.) and ocular tissues are also very common.
- Infection of the C.N.S. may cause severe pain, paralysis, optical and/or psychic disturbances and epileptic convulsions.

Adults –

- Usually only a single adult specimen is present, which may cause a slight degree of mucosal inflammation.
- In some cases a variety of non-specific symptoms such as constipation, epigastric pain and diarrhoea, are present.
- Very rarely there may be perforation of the intestinal wall, with subsequent peritonitis may occur. However, more seriously, the presence of adult worms carries the risk of autoinfection due to reverse-peristalsis resulting in cysticercosis.

Important facts:
• The incidence of infection may vary considerably, and may be influenced by a number of factors such as religious inhibitions on eating pork, as in many Islamic countries, or in other countries by high degrees of sanitation, limiting exposure of the intermediate hosts to human faeces.
• Taenia saginata is commonly known as **beef tape worm** where the intermediate host is cow, buffalo and sheep. Rostellum hooks are absent. It is longer than T. solium and it is the commonest tape worm.
• **Echinococcus granulosus** It is commonly known as **dog tape worm** or hydatid tape worm. It is an endoparasite in dogs, cats, fox and other carnivores. It is **smallest tape worm**. It has well developed scolex with four suckers and rostellum with a double row of hooks.
• The cysticercus evaginates in the small intestine.

Symptoms/Pathology of Taenia solium

- Infection with *Taenia solium* adults is usually asymptomatic. The armed scolex may cause some inflammation of the intestinal wall, and rarely may penetrate the intestine, causing peritonitis.
- The most important health problem is infection by the cysticerci, cysticercosis. Eggs that pass through the stomach (either from ingestion or reverse peristalsis) hatch in the small intestine penetrate the intestinal wall and are distributed throughout the body in the circulatory system. The most common sites of infection are the skeletal muscle and brain.
- Cysticerci in the muscle may cause spasms, weakness and pain. Calcification of the cysticercus may occur after 1 year and significantly reduces the pathology. Cysticerci in the brain cause the most severe pathology, including headaches, local paralysis, optic disturbances, and possibly death.

The life cycle of T. solium is represented graphically below. It consists of six main steps:

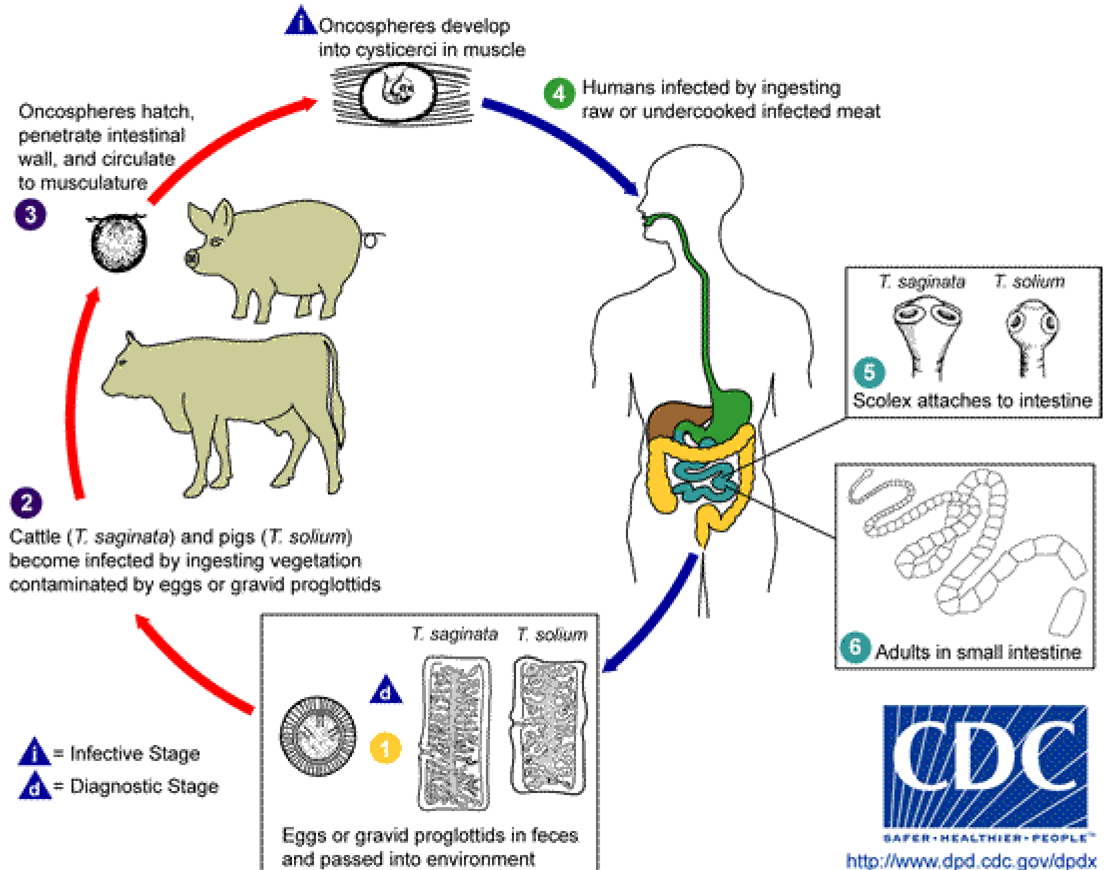


Figure courtesy of the CDC's Division of Parasitic Diseases. [C]

STEP 1. Infected humans (definitive host) excrete the eggs or gravid proglottids in their feces, passing the parasite from the gastrointestinal tract onto nearby vegetation. In egg or gravid proglottid form, *T. solium* is able to remain viable anywhere from days to months. *T. solium* can be diagnosed at this point in the life cycle.

*Note: **Autoinfection** can also occur at this point in the life-cycle via fecal-oral contamination. In this case, eggs or gravid proglottids re-enter the body through the mouth and often travel to the central nervous system (CNS), the muscles or the eye, where they develop into cysticerci. The presence of cysticerci in these locations leads to the pathogenesis of cysticercosis (neurocysticercosis in the CNS).*

STEP 2. Pigs (intermediate host) acquire infection by eating and digesting the eggs or gravid proglottids along with the parasitized vegetation.

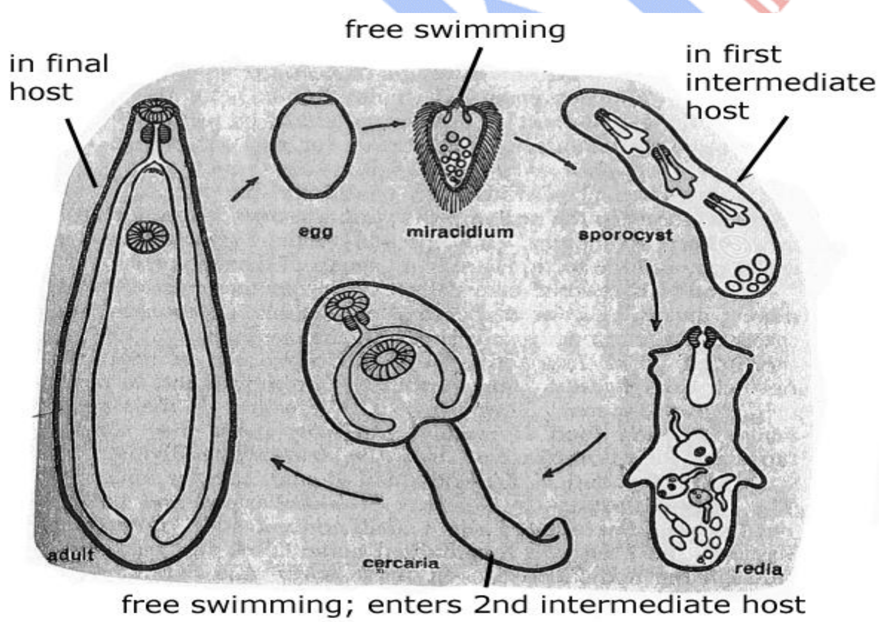
STEP 3. The eggs or gravid proglottids migrate to the pig's intestine and as oncospheres, break through the intestinal wall. Then, via the circulatory system, they embed themselves in the muscles of the pig and develop into cysticerci (the infective form of *T. solium*). Cysticerci have the ability to persist in the muscle for many years.

STEP 4. Humans acquire the infection by eating the undercooked or raw flesh of an infected animal.

STEP 5, 6. Cystercerci migrate to the small intestine of the human host and develop into their adult tapeworm form normally within two months. By attaching to the intestinal wall with their scolices (hooked structures), these adult tapeworms may persist for long periods of time, even years.

Q. Describe the features of larval forms of Fasciola hepatica.

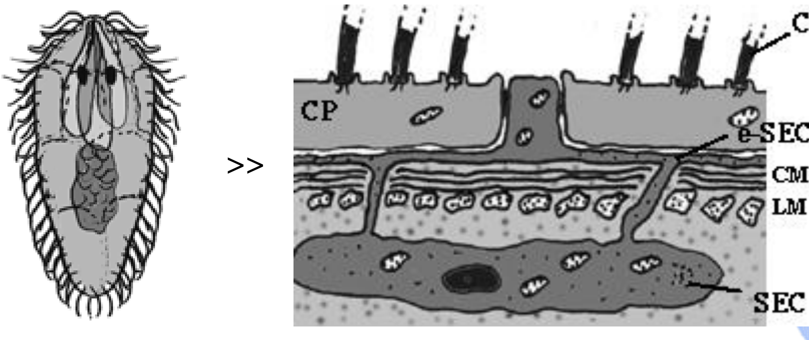
Ans



As the diagram shows various larval forms of fasciola are: Miracidium, Sporocyst, Redia, Cercaria and Metacercaria. The distinguished features are:

1. **Miracidium:**. The miracidium is the name of the ciliated larval stage that is hatched from the egg. It is usually a free swimming stage,that seeks out the secondary hosts of these parasites. The secondary hosts are generally a mollusc, like snail (Limnea). Morphologically the surface of the miracidium is covered with a series of ciliated plates. These ciliated epidermal plates are

discontinuous, not being in contact with each other but being separated by extensions of the underlying sub epidermal layer.



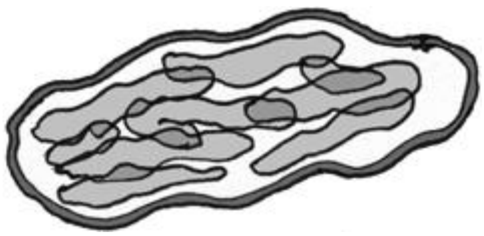
CP = Ciliated Plate
C = Cilia
SEC = Sub-epithelial cell
e-SEC = extension of subepithelial cell
CM = Circular Muscle
LM = Longitudinal Muscle

The plates themselves show a definite arrangement, being placed in four to five transverse rows, Beneath the plates are layers of muscle fibres. At the anterior end of the larvae is a non-ciliated conical projection, the terebratorium, (or anterior papillae), bearing apertures of the apical and penetration glands.

Miracidia possess a number of sensory organ, the most important of which are the dorsaly situated eye spots, beneath which is found the cerebral mass. Other sensory organs are situated within folds of the terebratorium. Below all of the structures is found the miracidium's large rounded germinal cells, which often are often grouped in clusters called germ balls. Finally the miracidia possess a protonephridial excretory system, basically similar to that found in the adult parasites.

On invasion of the molluscan tissue the miracidium sheds its ciliated plates, in almost all cases rapidly transforming into an endoparasitic form, the sporocyst, although in a few unusual groups the miracidium may contain a fully developed redia.

2. The Sporocyst



The sporocyst develops within the molluscan host as a hollow fluid filled germinal sac, into which protrude germinal masses. At the conical anterior of the sporocyst body a birth pore is located, from which subsequent generations of larvae emerge. The germinal masses develop internally into either daughter sporocysts, which are essentially the same as their parent sporocysts, or into a second larval stage, the redia described below.

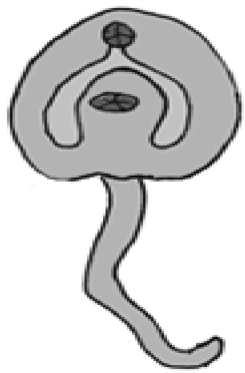
3. The Redia

The redia are the second larval form to develop within the molluscan host. They are similar to sporocysts, containing germinal masses within a fluid filled sac, which may develop into either second generation daughter redia, or more commonly into the final larval stage within the mollusc, the cercaria.

They differ from the sporocysts however, in that they are a much more active form, and importantly they possess simple gut. The tissue they feed on is predominantly molluscan in origin.

The gut itself consists of a mouth, opening into a large muscular pharynx, which in turn opens into a simple rhabdocoel like intestine. Externally, behind the mouth many redia have a ridge-like collar, below which the birth canal opens and from which either cercariae or daughter redia emerge. Further along the body there a lobe like extensions of the body, which are thought to aid the movement of the parasite within its host's tissues.

4) The Cercaria



(e.g. *Fasciola* sp.)

Both externally and internally the structure of the body of the cercaria resembles that of the adult into which they will grow.

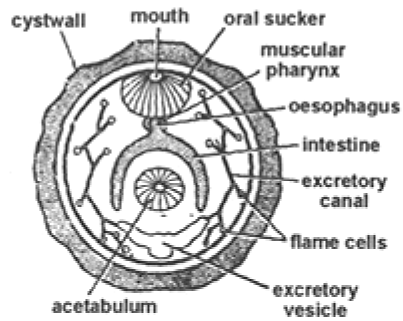
The outer surface of the cercaria is a tegument. Within the cercarial body a number of different types of gland cells are found, including cystogenous gland cells, used by the larvae to secrete a cyst wall during formation of the metacercarial stage, and penetration gland cells, used by the cercaria to penetrate its next host, either a second intermediate host.

The cercaria released from their molluscan intermediate host are usually a free swimming form. These must then locate either their next, and usually final intermediate host, their definitive host which they actively penetrate, or locate a suitable solid substrate to encyst upon, or be ingested by their definitive host.

To locate these various targets the cercariae are equiped with a variety of sensory organs. These commonly include two or more eye spots, as well as touch receptors, and allow specialised cercarial behaviour, designed to bring the cercariae into an environment giving the maximum probability of infecting their next hosts..

6) The Metacercaria

This is a much more common "resting" larval stage of the parasitic lifecycle. Generally the metacercariae are inactive encysted forms. The structure of the cyst wall itself varies considerably, though generally it is a complex mixture of tanned proteins, lipids and polysaccharides. Within the cyst wall the morphology of the larva usually closely resembles that of the cercarial body.



Fasciola hepatica. Metacercaria

To continue further the metacercaria must be ingested, either along with the body of the intermediate host it inhabits by a carnivorous definitive host or along with the vegetation it has encysted on by a herbivorous or omnivorous host.

7) The Juvenile Adult Stages

On ingestion the metacercaria must transform into the adult form. The metacercarial cyst wall is broken down to release what is essentially a young fluke, which only has to migrate a short distance to reach their prefered site within the hosts body i.e. the bile duct.

Q What is Polyembryony?

Ans:

Polyembryony is a special kind of reproduction involving a continuous line of germinal cells from the miracidium, through all the larval generation, to the gonads of the adult. This is known germinal lineage hypothesis. This view is widely accepted.
It is now believed that the germ cells present inside the larval forms are not ova. They are said to be diploid cells obtained by mitotic division from the propagatory cells of the zygote. Thus, the germ cells are the parts of the zygote. It means, all the larval stages are derived from a single zygote. This is known as polye mbryony.The various larval forms do not arise simultaneously bust at regular intervals from the zygote. This phenomenon has been termed as *delayed polyembryony*.

Example: Fasciola is supposed to show the phenomenon of polyembryony. ***Only miracidium and cercaria, which are free motile stages, are the actual larvae in the strict sense of the term***. The sporocyst, redia and metacercaria are not true larval stages, but rather and developmental or embryonic stages. Germ cells in the sporocust and rediae are direct descendants of the zygote.

These germ cells multiply mitotically and produce subsequent larval stages within the sporocyst and radiae. This process of reproduction in the sporocyst and radia is called polyembryony.

Q. Describe the reproductive system of Pila in detail.

Ans. Sexes are separate and sexual dimorphism is distinct. The shell of the female is larger and more globular than the male. Males have a less swollen body whorl, and a more developed copulatory organ than the female.

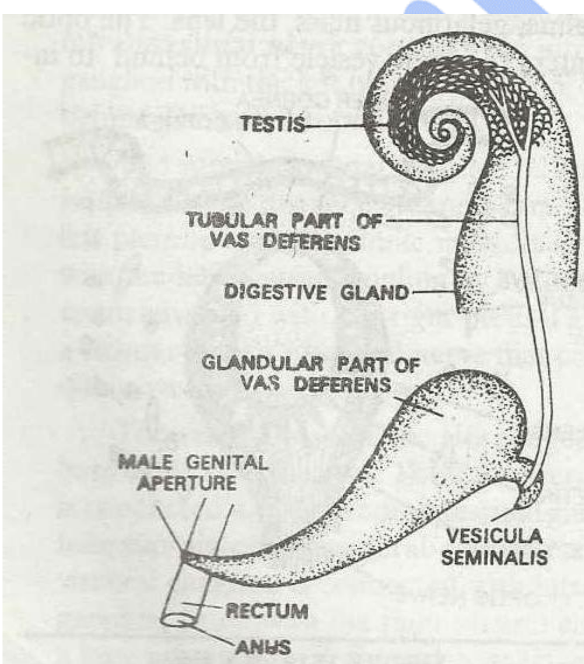
MALE REPRODUCTIVE SYSTEM:

A single cream coloured **testis** lies in the upper two or three whorls in close contact with the digestive gland. The testis is a flat plate-like structure, more or less triangular in shape. Many fine ducts known as **vasa efferentia** originate from different parts of the testis. The vasa efferentia unite together to open into a common **vas deferens** (Fig. 17). The vas deferens is divisible into three distinct parts:

1. The proximal thin walled tubular part

2. The middle slightly swollen seminal vesicle which stores the sperms

3. Terminal glandular part lying left of the rectum and opening into the mantle cavity close to the anus



Male reproductive organ

The male copulatory organ is the **penis** which arises from the edge of the mantle in front of the anus and is enclosed in a **penis sheath.** The penis sheath is a simple outgrowth from the inner surface of the mantle. At the base of the penis sheath is a glandular thickening- the **hypobranchial gland** of unknown function.

The spermatozoa of *Pila* are of two types:

1. Hair shaped or **eupyrene sperm**

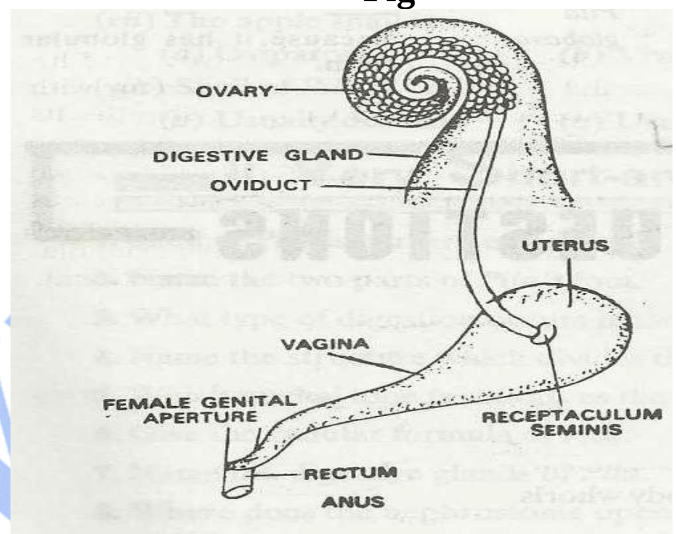
2. Worm-like **oligopyrene sperm**

Only the ***eupyrene sperms are functional*** and are capable of fertilizing the eggs. Also, the eupyrene sperm show a distinct head, a middle piece and a tail. The head and middle piece cannot be distinguished in oligopyrene sperm and also the tail bears four or five cilia (Fig. 17).The oligopyrene sperms are non-motile and cannot fertilize the eggs.

FEMALE REPRODUCTIVE SYSTEM:

A much branched orange colored **ovary** is situated in the upper two or three whorls, attached to the inner surface of the digestive gland. **The oviduct** leads from the ovary and extends downwards along the digestive gland. It is differentiated into an upper tubular part and the lower glandular part that remains on the floor of the mantle cavity parallel to the rectum. The glandular part is distinguishable into an anterior yellow colour **albumen gland** that secretes albumen and a posterior part called as **uterus** (Fig.18). A bean-shaped **receptaculum seminalis** or the **spermatheca** is present at the junction of the tubular and glandular portion of the oviduct. The sperms received from the male are temporarily stored in the receptaculum seminalis after copulation.

Fig



Female Reproductive System

The terminal part of the uterus is differentiated into **vagina.** The vagina opens into the mantle cavity close to the anus by a **female genital aperture** situated on a small papilla (Fig. 18). The male intromittent organ, the penis is rudimentary and useless in females. Existence of rudimentary penis in female is suggestive of the fact that this group had hermaphroditic ancestor. A rudimentary **hypobranchial gland** is present as a glandular thickening.

Q. Describe the reproductive system of Leech, Nereis, Prawn,

Ans Leech

Like earthworm leech is hermaphrodite and male and female reproductive organs occur in the same animal. Cross fertilization occurs by copulation in which mutual exchange of spermatophores takes place.

Male Reproductive Organs

Testes are located inside testis sacs which are eleven pairs located in segments 12-22nd, one pair in each segment. **Spermatogonia** are budded off from testes and float in the coelomic fluid within each testis sac and mature into spermatozoa.

Each **testis** sac is connected to a common longitudinal vas deferens running on each side of gut, by small **vasa efferentia,** through which the mature spermatozoa pass into vas deferens. In the 10^{th} segment each vas deferens forms a compact mass of tubules, the **epididymis**. In the two epididymes spermatozoa undergo maturation.

A short narrow ejaculatory duct connects epididymis with atrium, which is a pyriform sac situated in the ninth and tenth segments. The **atrium** is made of an anterior prostate chamber and a posterior penis sac, the former is covered with several layers of unicellular **prostate glands** that secrete seminal fluid. The penis sac contains a coiled evertible penis which is used to transfer sperms into the vagina of another leech.

In prostate chamber the spermatozoa are glued by the secretion of prostate glands into spermatophores, which pass through the penis into the vagina of other leech during copulation.

Female Reproductive Organs

The female reproductive organs consist of a single pair of ovaries, situated in the eleventh segment, which are coiled nucleated cords from which ova are budded off. The ovaries remain floating in the fluid of **ovisacs**. The oviducts of two sides unite to form a common **oviduct** in the middle of eleventh segment, where there is a mass of unicellular albumen glands opening into it. The common oviduct opens into a pear-shaped muscular vagina, which opens to the exterior through a mid-ventral female genital aperture in the eleventh segment. Ova are fertilized in the vagina and zygotes are release into the cocoon.

Copulation takes place in March-April. During copulation two leeches come together pointing in opposite directions so that the male aperture of one leech lies opposite the female aperture of the other. The penis of each leech is inserted into the vagina of the other and **spermatophores** are exchanged. Copulation may occur on land or in water and lasts for about an hour after which the two leeches separate. Fertilization is internal inside the vagina. The fertilized eggs are deposited into the cocoon in which further development of the embryo occurs.

The cocoons are secreted by the **clitellum**, which is formed around segments 9-11 during breeding season. The **clitellar glands** secrete albumen into the cocoon which is used as nourishment by the developing embryo. The cocoon is then passed over the head of leech as the leech withdraws its anterior end backwards by rhythmic movements of body. The **prostomial glands** secrete two polar plugs to close the two ends of cocoon. The cocoons are laid in moist soil where eggs develop into tiny leeches without undergoing through a larval stage.

NEREIS

Nereis is dioecious as sexes are separate. Gonads develop only during the breeding season, in the summer months. Gametes are released as spermatogonia in male and as oogonia in female into the coelomic cavity where they undergo maturation to develop into spermatozoa and ova, respectively. There are no gonoducts and mature sperms and ova are discharged to the outside in water either through nephridial tubules or by the rupture of body wall.

HETERONEREIS

It is sexually mature form of *Nereis* in which transformation in anatomy and behaviour of the animal takes place during breeding season.

The anterior one-third region of body is the asexual region or *atoke* while the sexually mature posterior region is called *epitoke* and the worm with these two regions is known as *heteronereis* and the phenomenon of transformation of *Nereis* into sexual form is known as *epitoky*.

Heteronereis, instead of creeping about on sea bottom or living in burrows, swims actively in surface waters. Body is divisible into an anterior asexual *atoke* and a posterior sexual *epitoke*. Parapodia of posterior sexual region become larger and develop flattened leaf-like outgrowths for better respiration. Their setae are replaced by oar-shaped setae arranged in a fan-like manner for swimming. Dorsal cirri become sensitive. The eyes become greatly enlarged and more sensitive. Peristomial cirri become longer. Intestine becomes atrophied and functionless. Pygidium develops specialised sensory papillae.

Sexually mature individuals or Heteronereis swarm to the surface of seawater in the night in order to shed sperms or ova. Both males and females swim rapidly in a circle, females releasing a substance called fertilium which attracts the males and stimulates shedding of sperms, which in turn excites the females to shed the eggs. Fertilization is external in sea water.

TROCHOPHORE LARVA

Eggs hatch into a larval stage called trochophore or trochosphere. This larva is ciliated, unsegmented and almost pear-shaped, pelagic creature. There is a sensory apical plate bearing a tuft of cilia. A ganglion is present beneath the apical organ. A preoral ciliated band called prototroch encircles the body anterior to mouch. Mouth is ventral and the digestive tract is complete. A postoral ciliated band or metatroch lies behind the mouth and help in locomotion and food gathering. In some species of *Nereis*, a typical trochophore larva does not occur and instead the larva which hatches out of the egg is advanced trochophore which is sometimes termed as *nectochaete*.

The trochosphere is pelagic and swims about by its ciliated bands. Then it sinks to the bottom and starts metamorphosing into adult. The apical organ forms the prostomium with brain, tentacles and eyes. The part immediately behind forms the peristomium. Posterior part develops segments of the body. Gradually the larva metamorphoses into a young worm which settles at the bottom of the sea and starts burrowing life.

PRAWN:

Reproductive system: Male and female sexes are separate (gonochoric) and they are sexually dimorphic. The female can be distinguished from the male by. the following external characters.

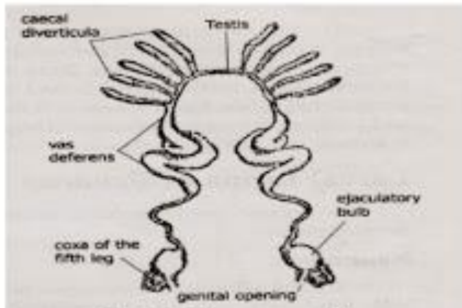
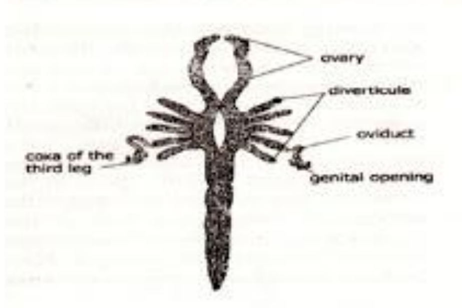


Fig. 20.12 *Penaeus* - male reproductive system



Life history of Penaeus: The female releases the eggs in the water Nauplius larva emerges from the egg. It passes thebmetanaupleus protozoea ,zoea,metazoea and Mysis stages and becomes the adult.When the exoskeleton of the larvae becomes hard,further growth and incresa in size is blocked. So the hard exoskeleton is shed and new soft exoskeletonis formed beneath it. The periodical shedding of the old exoskeleton is termed moulting or ecdysis.

Prawn Reproductive system

Male Reproductive System

Testes:

The two testes are soft, white and elongated bodies which fuse at their anterior ends to form a common lobe.

In between them a cardio-pyloric strand, connecting heart to pyloric stomach is situated. Histologically, each testes consists of a coiled and thin walled serriiniferons tubules embedded in connective tissue.

Each tubule is lined with germinal epithelium, the cells of which undergo spermatogenesis to form spermatozoa. A mature sperm consists of a large nucleus and a tail like blunt process.

Vas deferentia:

A long coiled and narrow tube, the vasa deferens arises from each testis near its posterior end. They form a coiled mass and run downwards between the abdominal flexor muscles on the inner side and thoracic wall on the outer side.

Vesicula seminalis:

Near the base of fifth leg vas deferens swells to form a club-shaped vesicula seminalis. They store spermatozoa in the form of white compact bodies called spermatophores.

They open outside through male genital pore situated on the inner side of coxa of fifth walking leg of its side.

Female Reproductive System

Ovaries:

The two ovaries are white compact and sickle-shaped bodies touching each other at both the ends but leaving a gap in the middle for the passage of the cardio-pyloric strand.

The size and shape of ovaries vary with age and the season of year. Each ovary is enclosed within a membranous capsule and is made of numerous radial rows of ova in various stages of development. Mature eggs are centrolecithal.

Oviduct:

A short, wide and thin walled tube, called the oviduct, originates from the outer middle border of each ovary.

It opens outside through a female genital aperture on the inner side of the coxa of third walking leg of its side.

Life history and development :

The breeding season of Prawn occurs during May, June and July. The male deposits spermatophores near the genital opening of the female and the eggs get fertilized as they come out.

Thus fertilization is external or in-situ. After fertilization eggs remain attached to the pleopod through the sticky secretion of certain tegumental glands. During breeding season a female carries the bunches of eggs in this way until they hatch.

Development:

Development is direct and the juveniles hatching out of the eggs resemble the adult except in size. It takes 5 to 6 weeks and juveniles remain cuing to pleopods and undergo moulting and growth.

Section C

Q. Describe salient features of Hemichordata.

Ans:

Classification:

Kingdom	Animalia
Subkingdom	Eumetazoa
Superphylum	Deuterostomia
Phylum	Hemichordata
Class	Enteropneusta
Class	Graptolithina
Class	Pterobranchia
Class	Planctosphaeroidea

Etymology:- From the Greek *Hemi* for half and the Latin *Chorda* a chord.

Characteristics of Hemichordata:-

1) Bilaterally symmetrical.
2) Body has more than two cell layers, tissues and organs.
3) Body cavity a true coelom.
4) Body possesses a through gut, straight or U-shaped, with an anus.
5) Body divided into three sections, a proboscis, a collar and a trunk.
6) Nervous system normally diffuse, but variable.
7) Has a partially open circulatory system.
8) Possesses glomerulus as an excretory organ.
9) Reproduction normally sexual and gonochoristic.
10) Feeds on fine particles in the water.
11) All live marine environments.

The Hemichordates, or Acorn Worms are a small phylum of generally small animals that were once considered to be a part of the Chordata. However modern science has proven that none of them posses a post anal tail or a notochord and they have been allocated to a phylum of their own.

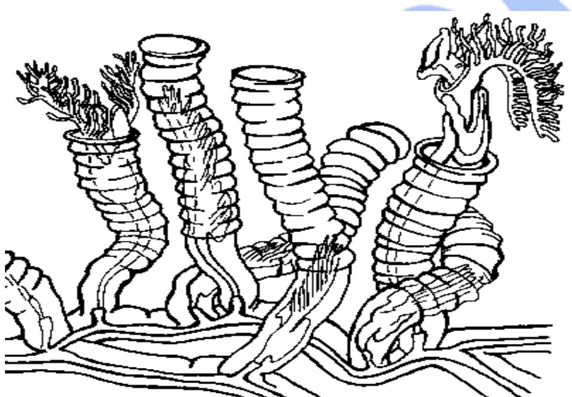
Hemichordates are distinguished by a **tripartite** (threefold) division of the body. At the forward end of the body is a **preoral lobe**, behind this is a collar, and last comes a **trunk**. The name "hemichordate" means "half chordate," and hemichordates share some (but not all) of the typical chordate characteristics. There are **branchial openings**, or "gill slits," that open into the pharynx; there is a rudimentary structure in the collar region, the **stomochord**, that is similar to a **notochord**; and there is a dorsal nerve cord, in addition to a smaller ventral nerve cord.

However, hemichordates are not classified as true chordates, although they are quite closely related. Recent DNA analysis such as 18r DNA analysis of enteropneusts suggests that they are closer to the echinoderms than to the chordates. This is supported by the resemblance of the larvae of at least some hemichordates to some echinoderms. Different Classes are:-

1. **Enteropneusta**:
   a. **Example**: **Balanoglossus, Saccoglossus**
   b. This is the most familiar living ones , commonly called **the acorn worms**.
   c. The triple division of the body is obvious.
   d. Acorn worms also have multiple branchial openings, as many as 200 in some species.
   e. They are slow burrowers, using the proboscis to burrow through sediment, and may either **deposit feed** (consume sediment and digest the organic matter, rather like earthworms in soil) or **suspension feed** (collect suspended particles from the water).
   f. Some of these worms may be very large; one species may reach a length of 2.5 meters (almost eight feet), although most are much smaller.
2. **Pterobranchia** :
   a. **Ex**amples: Rabdopleura, Cephalodiscus
   b. It is the second living class, an obscure group with only about 20 living species.
   c. They form colonies in which the individuals are interconnected by stems, or **stolons**. Individuals, or **zooids**, are often less than 1

millimeter long. The proboscis is not elongated, as it is in acorn worms, but shield-shaped.

d. The second division of the body bears a pair of branched tentacles that collect small food particles from the water. There is only one branchial opening.
e. Most strikingly, almost all pterobranch species create and live within a network of tubes, the **coenecium**. These tubes are made up of the protein collagen, secreted by special glands in the proboscis.
f. Yet similar larvae and a similar tripartite body plan unite the enteropneusts and pterobranchs. This diagram shows a colony of pterobranchs in the genus *Rhabdopleura*.



3. **Graptolithina:**
   a. **Also** called graptolites, which are common fossils in Ordovician and Silurian rocks.
   b. Careful study of the microscopic structure of the tubes of graptolites showed that they are very similar to the tubes of pterobranchs.
   c. Most graptolites are thought to have been planktonic, floating or slowly sinking through the water.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Q. What is canal system? Describe the evolution of canal system in sponges.

Ans: Canal system is the network of spaces inside the body of sponges which are connected to outside through pores. Canal system is the characteristic feature of phylum Porifera i.e. pore bearing animals.

Poriferans are sessile and aquatic so they face problems of nutrition, respiration, excretion, reproduction and distribution. But the evolution of canal system in them solves all these problems as the water circulating into the canals serves all these functions. It serves passage between internal and outermediumofthebody.

During evolution from simpler to complex poriferans, canal system also evolved accordingly and following changes occurred:-

1. Increase in complexity of canal system
2. Restricted distribution of Choanocytes to flagellated chambers.
3. Reduction in the size of spongocoel

Following types of canal systems are found in sponges:

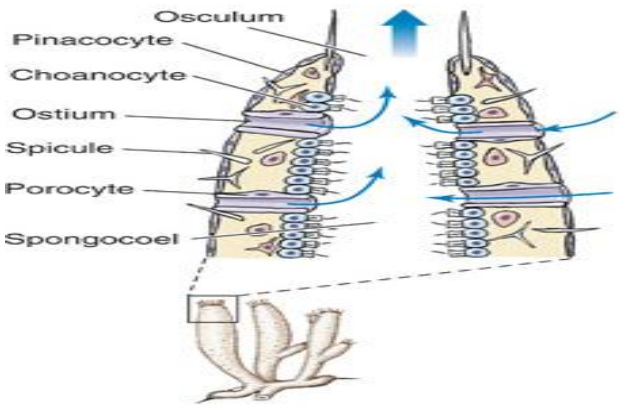
- Ascon type, with flagellated spongocoel
- Sycon type, with flagellated radial canals
- Leucon type, with flagellated chambers
- Rhagon type, with conical shape and broad base

ASCON TYPE

This is the simplest type of canal system and is found in Leucosolenia and other homocoela. Ostia are present on the surface of body and lead directly into the spongocoel, which is lined by flagellated choanocyte cells. Spongocoel opens to the outside through a narrow circular opening, the osculum located at the distal free end of the sponge body. Water enters through ostia into spongocoel and goes out of body through the osculum.

Features:

- Ascon is the simplest canal system.
- Choanocytes line the spongocoel.
- Water enters through the ostia and exit through the large osculum.
- Usually tube shaped.
- Found only in the Class Calcarea.



Asconoid (*Leucosolenia*)

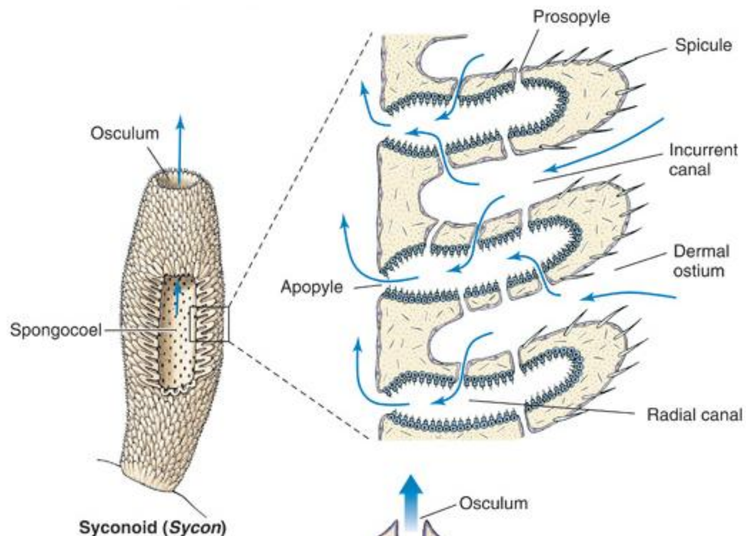
SYCON TYPE

This type of canal system is a characteristic of syconoid sponges, e.g. Scypha and Grantia. Body wall is secondarily folded to form incurrent and radial canals, which open into the spongocoel by an opening called apopyle. Both types of canals are interconnected by minute pores called prosopyles. Incurrent pores or ostia are found on the outer surface of body and open into the incurrent canals, which lead into adjacent radial canals through minute openings called prospyles. Radial canals are the flagellated chambers that open into central spongocoel by internal openings called apopyles. Spongocoel is a narrow, without flagellated cells but is lined by pinacocytes and opens to exterior through the osculum.

In more complex sycon type, as found in Grantia, the incurrent canals travel along an irregular course through the tissue and connect to the radial canals, thus forming large sub-dermal spaces.

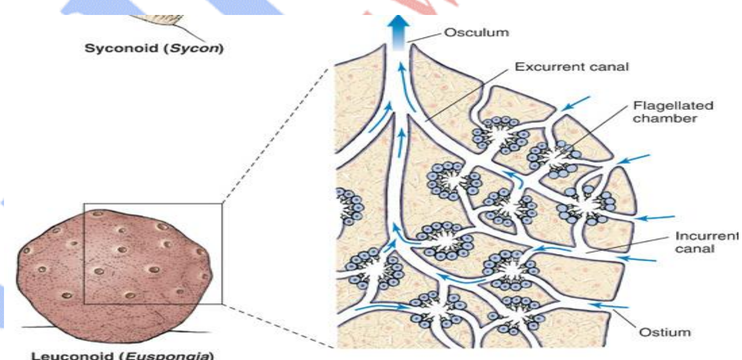
Features:

- Syconoid – tubular body and singular osculum like asconoids.
- The walls of the sponge are folded to form choanocyte lined canals.
- Increased area for feeding.
- Class Calcarea.



LEUCON TYPE

In this case, the radial canals get divided into small rounded or oval flagellated chambers by further folding of the body wall. This is a characteristic feature of the leuconoid sponges such as Spongilla. Incurrent canals open into flagellated chambers through prosopyles. Flagellated chambers, in their turn, communicate with excurrent canals through apopyles. Excurrent canals are formed as a result of division of spongocoel which has almost disappeared in these sponges. Thus excurrent canals communicate with the outside through a small spongocoel and an osculum.



This type of canal system has varying degree of complexity of canals and based on that it can be classified into the following three types:

- **Eurypylous type:** The flagellated chambers communicate directly by broad apertures called the apopyles, with the excurrent canals. Incurrent canal brings water into the flagellate chamber through prosopyle. E.g. Plakina

- **Aphodal type:** The apopyle is drawn out as a narrow canal, called aphodus, which connects the flagellated chamber with excurrent canal. Here also incurrent canal brings water into the flagellated chamber. E.g. Geodia.

- **Diplodal Type**: In some sponges, besides aphodus, another narrow tube, called prosodus, is present between incurrent canal and flagellated chamber. E.g., Spongilla and Oscarella.

Features:

- Leuconoids – most complex, permits an increase in sponge size.
- Choanocytes line the walls of small chambers where they can filter all the water that flows through.
- Found in Most sponges.

RHAGON TYPE

In Demospongiae, leuconoid condition is derived from the larval stage, called rhagon as found in Spongilla. The body is conical and tent like in shape, tapering towards the osculum. The spongocoel is bordered by oval flagellated chambers opening into it by apopyles. Mesenchyme is considerably thick and is traversed by incurrent canals and subdermal cavity. Water enters into the subdermal cavity through ostium and then enters the incurrent canal or it can be called prosodus. Flagellated chambers are connected to the spongocoel through the excurrent canal or it can be called aphodus. This canal system is primitive as compared to diplodal type and when the larva grows transformed to diplodal type.

Significance of Canal System

The flagella of choanocytes beat to produce a water current, which enters the sponogocoel through ostia. It carries food particles and oxygen and sweeps away the metabolic wastes through osculum. Therefore, the canal system serves the function of food collection, respiration and excretion. In simple type of canal system, there is lesser number of cells and thin body wall but as the canal system becomes more complex, the number of flagellated cells increases and the force to draw water current is increased. The syconoid canal system is therefore more efficient than the asconoid type and the leuconoid type is the most efficient.

Q. Describe the parasitic adaptations in Platyhelminths.

Ans Parasitism is a symbiotic relationship in which one organism (the parasite) benefits and the other (the host) is generally harmed. Parasites derive nutrition from their host and may also gain other benefits such as shelter and a habitat in which to grow and reproduce.Parasites can be ectoparasite(leech) or endoparasite (taenia), inter (Monocystis) or intracellular (Plasmodium), permanent (Fasciola), temporary (Glochidium of Unio), obligatory (Taenia) or faculatative (Pinntheros crab).

All these parasites modify themselves morphologically, physiologically for their existence which is known as the parasitic adaptation. The Platyhelminths are modified morphologically as well as physiologically to alive in their particular environments. These modifications depend on the degree of parasitism. Their various adaptation are as follows:-

(A) Morphological Adaptations:

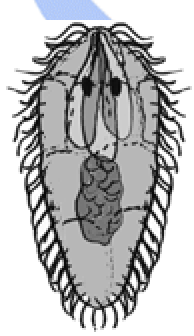
The structural modifications or adaptations of helminthes have taken place along two lines.

(1) Degeneration or loss of organs.

(2) Attainment of new organs.

(1) Degeneration:

Endoparasites undergo simplification of unused organs or parts. In helminthes, the loss particularly involves the locomotory and digestive organs.



(a) Locomotory organs:

The helminth parasites live in the body of the host therefore locomotory organs are quite unnecessary for them. So the locomotory organs are totally reduced except in larval forms.

(b) Alimentation: As the helminth parasites live on digested and semidigested food of the host, there is reduction in their elimination and digestive glands. The digested materials are absorbed directly in the body.

(c) Sensory organs: The sensory organs of helminths are also simple structures. Absence of complicated sensory structures can also be co-related to sedentary life in a sheltered habital, especially in the endoparasite.

(d) Circulatory system: Helminthes lack circulatory system and the distribution of food is done by branched intestine and waste products are collected by distributed flame cells.

(**2) Attainment of New Organs:** Parasitic existence leads to modification of old structures and attainment of new structures helpful in food absorption, protection, attachment and vast reproduction.

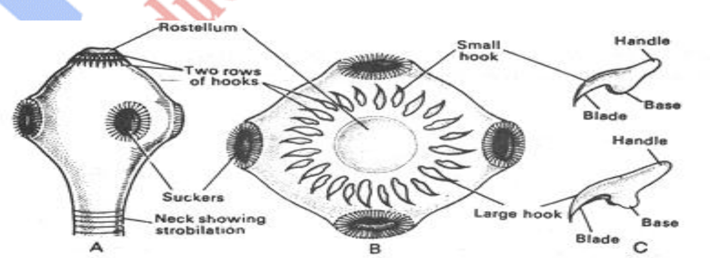
(a) Special structures on body wall:

Cuticle is the outermost integument the helminth parasites. It is made of an insoluble protein, Sceleroprotein and is so adapted as to resist against the digestive juice, passage of food and for adhesion.
In Fasciola hepatica the presence of spines and spinnules over the bodywall help in the attachment to the bile duct.
In Taenia, many microvilli are present on its tegument that increases its surface area for the absorption of digested food.

(b) Musculature:

The well developed musculature in tape worms enables them to distribute their elongated snake-like body through-out the length of the intestine of their host. Similarly, power of locomotion enables the roundworms to counteract gut parasites and to maintain their position in the intestine. The advantage is that the worm can obtain with greater ease of the pre-digested nutrients of the host.

(b) Organs for attachment:



Scolex of *Taenia* : (A) side view; (B) en-face view; (C) hooks

Helminths are variously modified for adhesion to the body of their hosts. Suckers are formed in all parasitic flat worms' foe adhesion. In some cestodes and nematodes, hooks or hook like structures also develop in or near the

cephalic end which help in attachment for ex, hooks and spines of taenia scolex, suckers of fasciola etc.
In some helminthes, as in miracidium and cercaria, unicellular secretory glands develop which help during penetration in to the host.

(d) Vast reproduction:

The reproductive organs show significant development and adaptation to parasitism. There is vast increase in the reproductive capabilities through greater egg production.

Life history usually includes several larval stages for multiplication and for easy and sure transfer from one host to another.
The nervous system in parasitic helminthes and excretory system, particularly in trematodes, show little deviation or adaptation to parasitic mode of life.

(B) Physiological adaptations:

(1) Intracellular digestion:
The fluke as tissue elements and inflammatory exudates and have probably intracellular digestion.

(2) Osmo-regulation:
The osmotic pressure of the parasitic worms remains less than or same as that of their hosts, so that there is no difficult in exchange of water. Cestodes have well developed water osmoregulatory system and their Ph tolerance is high.

(3) Anaerobic respiration:
The intestinal parasites live in an environment completely devoid of free oxygen. Their evolutionary adaptation has resulted in a very low metabolic rate which requires a minimum amount of oxygen. Moreover the respiration is of the anaerobic type, consisting of extracting oxygen from the food stuffs they absorb and assimilate through their cuticle. The manner in which oxygen is liberated from food is not clearly understood. In the absence of free oxygen, energy is obtained by the fermentation of glycogen, which is broken by glycolysis, into carbon dioxide and fatty acids. The glycogen and lipid contents in their body tissues are high and the protein content is less.

(4) Anti enzymes:
Most of the helminth parasites, particularly intestinal parasites, secrete anti-enzymes in order to protect themselves from the gastric juices and digestive

enzymes of hosts. In some strange evolutionary manner their ancestors developed these vital anti enzymes and are quickly digested by the host. Some of the new medicines aim at nullifying the protective effect of these antienzymes resulting in the digestion of the worms by their hosts. In cestodes the bladder of the cysticerous larva is digested by the host's digestive juices, but the scolex remains unaffected. The eversion of the scolex is also accelerated by the action of the host's bile.
Successful adaptation to parasitism brings a sort of equilibrium between the host and parasite and consequently there is reduction in pathogenicity and where this equilibrium is disturbed, the parasite causes considerable clinical symptoms.

(C) Life cycle adaptation

For successful life they have adapted themselves in following way:

i. Mostly they are hermaphrodites.
ii. They possess highly developed reproductive organs for successful breeding.
iii. They have very high fertility rate to compensate the high mortality and for survival of the species. To store large amounts of eggs the uterus of Taenia gets laterally branched.
iv. In Fasciola one larval form can produce the next stage larval foms, this potency is called as the polyembryony, eg. Redia from sporocyst, cercaria from redia.
v. The digenetic life cycle is also a kind of adaptation to ensure their survival in case of death of one of their hosts.

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Q. What do you mean by social organization in animals? Describe social organization in honey bees.

Ans: Social organization in honey bees

A colony of bees may have 40 to 50,000 of individuals. They belong to three castes.

(a) Queen (b) Drone (c) Worker.

The queen lays fertilized and unfertilized eggs. From unfertilized eggs male bees emerge which are known as Drones, where as from the fertilized eggs the worker bees are produced. The workers when feed on Royal Jelly, develop in to queen.

a. Queen:

They are fertile female with developed ovary. Always one queen remains present in one hive. She is guided by a number of attendances. It is 15 to 20 mm in length with short legs and wings. The queen gets fertilize only in her life span, which is sufficient to fertilize the eggs at the time of lying.

The queen lays fertilized or unfertilized eggs according to her willing. Queen lays about 1500 to 2000 eggs in a day. In whole life span queen lays about 15, 00,000 eggs. When the queen in a colony starts feeding on queen's diet i.e. royal jelly and develops into a new queen and is provided with the facility of real queen.

b. Workers:

The workers are the smallest of the three castes but they function as the main spring of the complicated machinery like honey bee colony. The workers are produced from fertile eggs. It takes 21 days in the development of the eggs and the life span is about 6 weeks. The indoor and outdoor duties are done by workers.

The outdoor duties are searching food sites, collecting nector, pollen etc. The indoor duty includes attending the queen, builders (produced waxes for formation of new hive), repairs (repairing the comb), and cleaners (to remove impurities and dead bodies and fanners (performing the fanning in the hive by wings) the guard bee always watches at the gateway. It is said that up to half of the life period workers perform indoor duties and later on become engaged in outdoor duties.

c. Drones:

The drone is the fertile male member of the honey bee colony, which fertilizers the queen. They take 24 days to develop from egg to the adult stage. The sting and the wax glands are absent but in the males the reproductive organs are well developed. They are reared from an unfertile egg in large drone cell.The sole duty if the drone is to fertilize the virgin queen.

Q. How many types of developments are found in insects?

Ans: Insects go through some or all of the following stages:-

Stage I: egg/embryo

Stage II: juvenile Called larvae,nymphs, or naiads depending on the species

Stage III: pupa Occurs only in insects undergoing complete metamorphosis

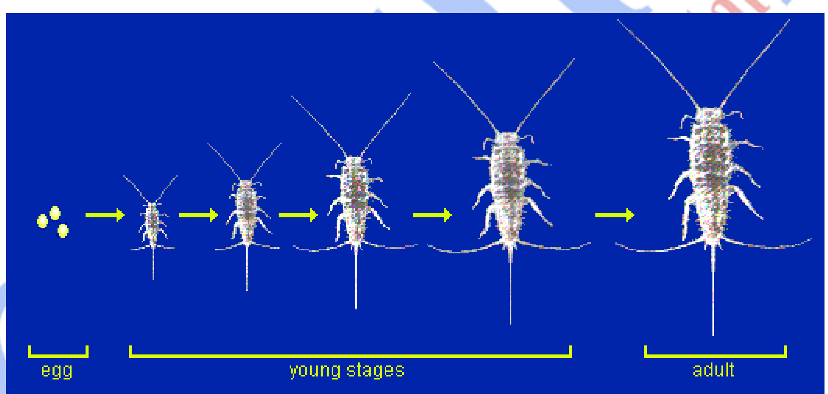
Stage IV: adult

Types of Development

There are 3 primary development pathways in insects

1. **Ametabolous Development:** In this development insects resemble small adults at hatching, lacking only fully developed reproductive organs. Like in the apterygote (or wingless) insects, which have lost their wings secondarily during the course of evolution, hatch in a form very like that of the adult except for the lack of reproductive organs. Apart from an increase in size there is little visible change in appearance as the insect grows. They show little or no metamorphosis.

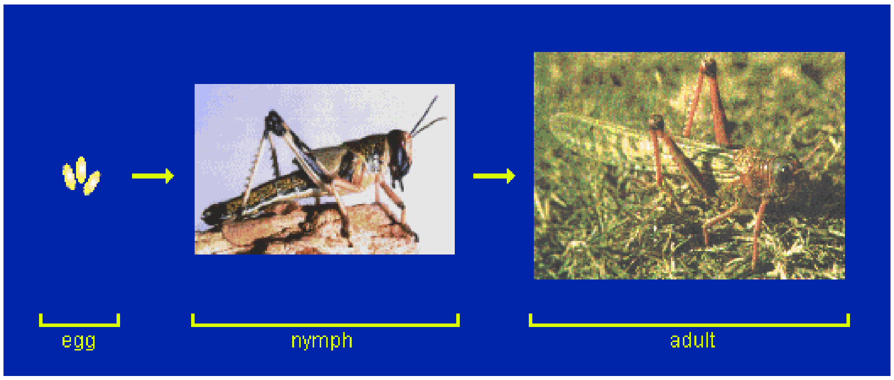
   Typical development of an apterygote insect with little or no metamorphosis e.g. Bristletail (Order Thysanura)



1. **Hemimetabolous Development**: Insects generally resemble small adults at hatching, but lack fully developed reproductive organs, wings, and some other structures; they undergo incomplete metamorphosis.

   Insects as cockroaches, grasshoppers, dragonflies and bugs, the wings develop gradually on the outside of the body and get larger at each moult until they are fully formed. The young stages of these insects are called nymphs and they usually resemble the adults in general appearance, often inhabiting the same places and eating the same kinds of food. This group of insects is classified as the Exopterygota, in reference to the external development of the wings. Since there are no dramatic changes in body-form during development, the insects are said to undergo a partial or simple or incomplete metamorphosis.

Typical development of a pterygote insect with a simple metamorphosis (Exopterygota)
e.g. Locust (Order Orthoptera)

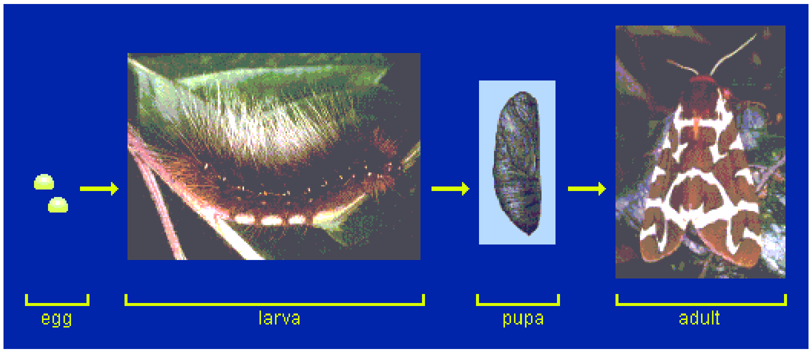


The desert locust, Schistocerca gregaria

2. **Holometabolous: Insects do not resemble adults at hatching; they undergo complete metamorphosis in such development.**

   This group of winged insects includes beetles, butterflies, moths, flies, bees, wasps,where the young stages are very unlike the adults. These young stages are called larvae (or grubs and caterpillars). They often occupy completely different habitat niches and exist on quite different food sources from those of the adults. The larvae undergo one very dramatic change that requires a special resting and non-feeding stage during which the transformation can occur. This resting stage is called the pupa (or chrysalis). In this group, the wing buds develop internally and are not visible until the pupal stage, so that in classification the group is known as the Endopterygota. Due to the large change from larval to adult form, the insects are said to undergo complete or complex metamorphosis.

Typical development of a pterygote insect with a complex metamorphosis (Endopterygota)
e.g. Moth (Order Lepidoptera)



Q. Describe the hormonal control of insect metamorphosis.

Ans: The hormonal control of insect metamorphosis was shown by the experiments of Wigglesworth (1934) on Rhodnius prolixus, a blood-sucking bug that has five instars before undergoing metamorphosis. When a first-instar larva of Rhodnius was decapitated and fused to a molting fifth-instar larva, the minute first instar developed the cuticle, body structure, and genitalia of the adult. This showed that blood-borne hormones are responsible for the induction of metamorphosis.

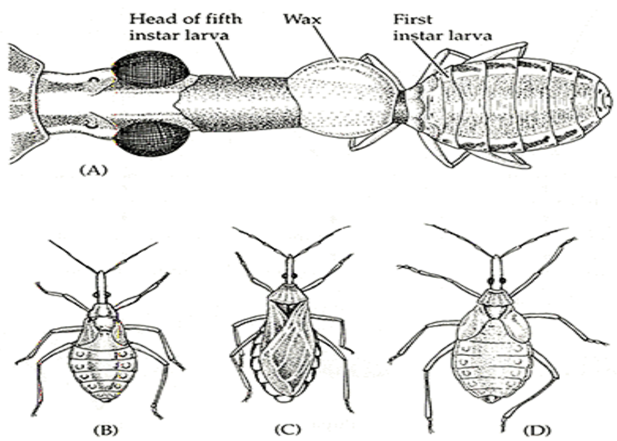


Figure: Demonstration of hormonal control of insect metamorphosis.

The corpora allata, near the insect brain, produces a hormone that counteracts this tendency to undergo metamorphosis. If the corpora allata was removed from a third-instar larva, the next molt turned the larva into a precocious adult. Conversely, if the corpora allata from fourth-instar larvae were implanted into fifth-instar larvae, these larvae would molt into extremely large "sixth-instar" larvae rather than into adults.

The metamorphosis of insects appears to be regulated by effector hormones controlled by neurosecretory peptide hormones in the brain. The molting process is initiated in the brain, where neurosecretory cells release prothoracicotropic hormone (PTTH) in response to neural, hormonal, or environmental factors.

PTTH is a family of peptide hormones (m.w.approx 40,000), and it stimulates the production of ecdysone by the prothoracic gland.

Ecdysone is a prohormone that converts into an active form 20-hydroxyecdysone. This conversion is accomplished by a heme-containing oxidase in the mitochondria and microsomes of peripheral tissues such as the fat body. Then ecdysone is changed to the active hormone 20-hydroxyecdysone.

Each molt is occasioned by one or more pulses of 20-hydroxyecdysone. For a molt from a larva, the first pulse produces a small rise in the hydroxyecdysone concentration in the larval hemolymph (blood) and elicits a change in cellular commitment. The second, large pulse of hydroxyecdysone initiates the differentiation events associated with molting. The hydroxyecdysone produced by these pulses commits and stimulates the epidermal cells to synthesize enzymes that digest and recycle the components of the cuticle.

In some cases, environmental conditions can control molting, as in the case of the silkworm moth Hyalophora cecropia. Here, PTTH secretion ceases after the pupa has formed. The pupa remains in this suspended state, called diapause, throughout the winter. If not exposed to cold weather, diapause lasts indefinitely. Once exposed to two weeks of cold, however, the pupa can molt when returned to a warmer temperature.

The second major effector hormone in insect development is juvenile hormone (JH). JH is secreted by the corpora allata. The secretory cells of the corpora allata are active during larval molts but are inactive during the metamorphic molt. This hormone is responsible for preventing metamorphosis. As long as JH is present, the hydroxyecdysone-stimulated molts result in a new larval instar. In the last larval instar, the medial nerve from the brain to the corpora allata inhibits the gland from producing juvenile hormone, and there is a simultaneous increase in the body's ability to degrade existing JH. Both these mechanisms cause JH levels to drop below a critical threshold value. This triggers the release of PTTH from the brain. PTTH, in turn, stimulates the prothoracic glands to secrete a small amount of ecdysone. The resulting hydroxyecdysone, in the absence of JH, commits the cells to pupal development. Larval-specific mRNAs are not replaced, and new mRNAs are synthesized whose protein products inhibit the transcription of the larval messages. After the second ecdysone pulse, new pupal-specific gene products are synthesized, and the subsequent molt shifts the organism from larva to pupa. The second ecdysone pulse transcribes the pupa-specific genes and initiates the molt.

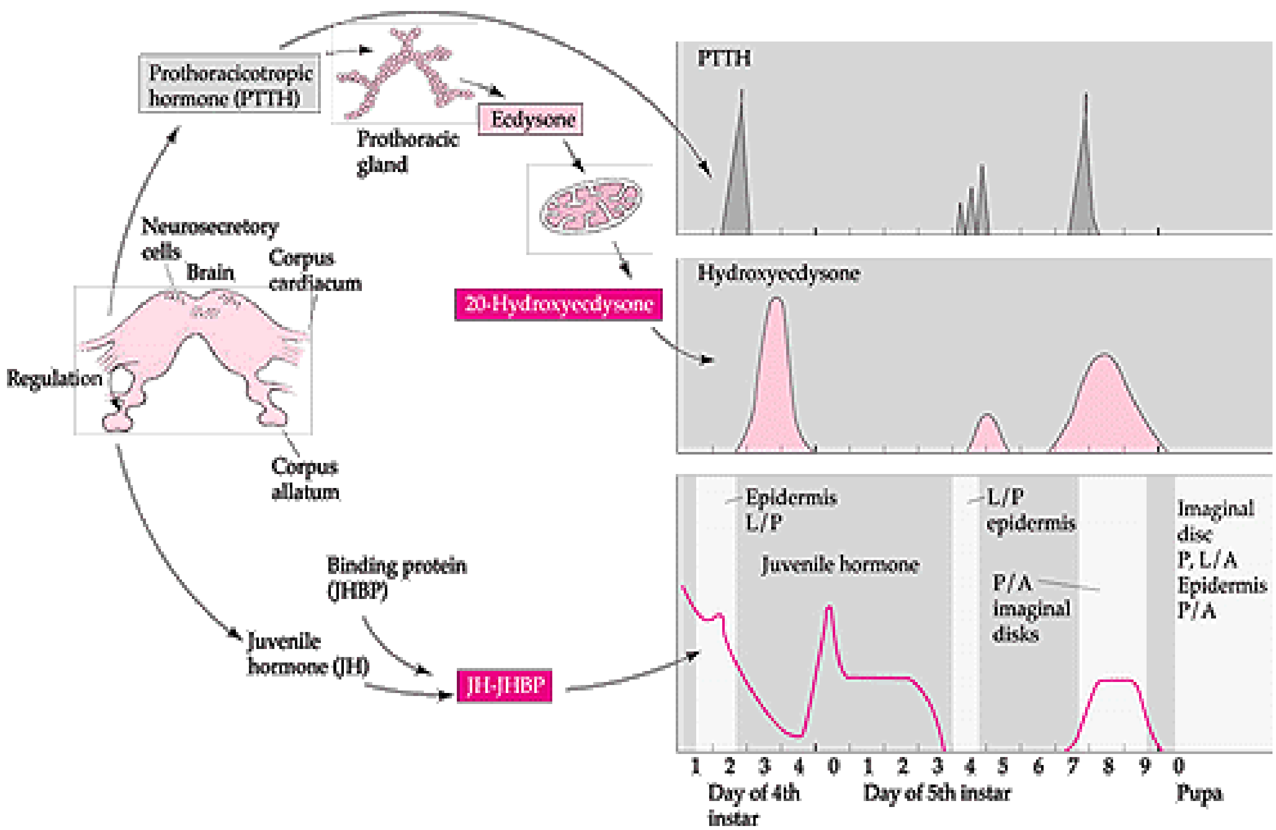


Figure: Schematic diagram illustrating the control of molting and metamorphosis in the tobacco hornworm moth. There appear to be critical sensitive periods when the presence or absence of JH determines whether a tissue is retained at the same stage or changes to a more mature state.

Q. **Describe Water Vascular system in starfish.**

Ans:

Introduction :-

The water vascular system is a modified part of coelom & consists of a system of sea water filled canals having certain corpuscles. It plays most vital role in the locomotion of the animals & comprises madreporite stone canal, ring canal, radial canal, Tiedman's body, lateral canals & tube feet.

(1) Madreporite :-

The madreporite is a rounded calcareous plate occurring on the aboral surface of the central disc in inter-radial position. Its surface bears a number of radiating, narrow, straight or wavy grooves or furrows. Each furrow contains many minute pores at its bottom. Each pore leads into a very short, fine, tubular pore-canal. Which passes inward in the substance of the madreporite. There may be about 200 pores and pore-canal. The pore-canals unite to form the collecting canals. Which open into an ampulla beneath the madreporite.

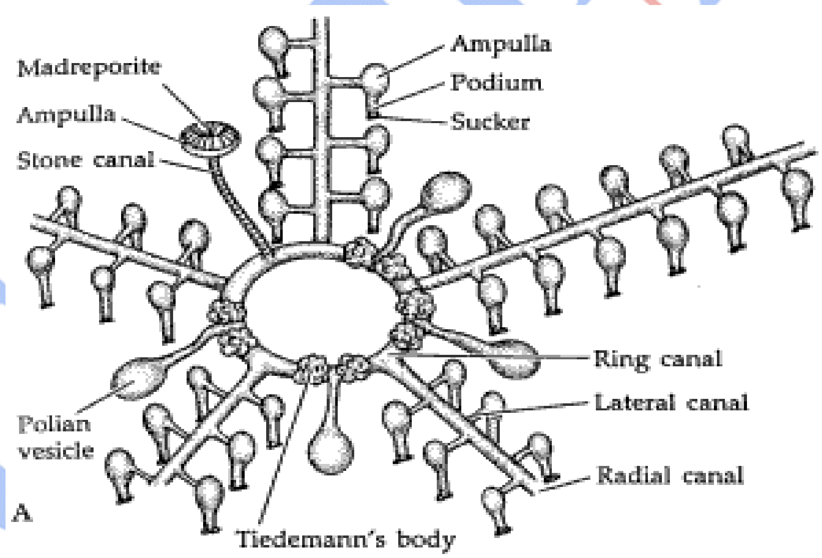


Fig : Water vascular system of Starfish

(2) Stone Canal:-

The ampulla opens into a "S" shaped stone canal. The stone canal extends downwards (orally) and opens into a ring canal, around the mouth. The walls of stone canal are supported by a series of calcareous ringd. The lumen of stone canal is lined by very tall flagellated cells. in embryonic stages and young Asterias, the stone canal remains a simple tube but in adult Asterias, lumen of stone canal possesses a prominent ridge with two spirally rolled lamellae.

(3) Ring Canal:-

The Ring canal or water ring is located to the inner side of the peristomial ring of ossicles and directly above (aboral) to the hyponeural ring sinus. It is wide and pentagonal or five sided.

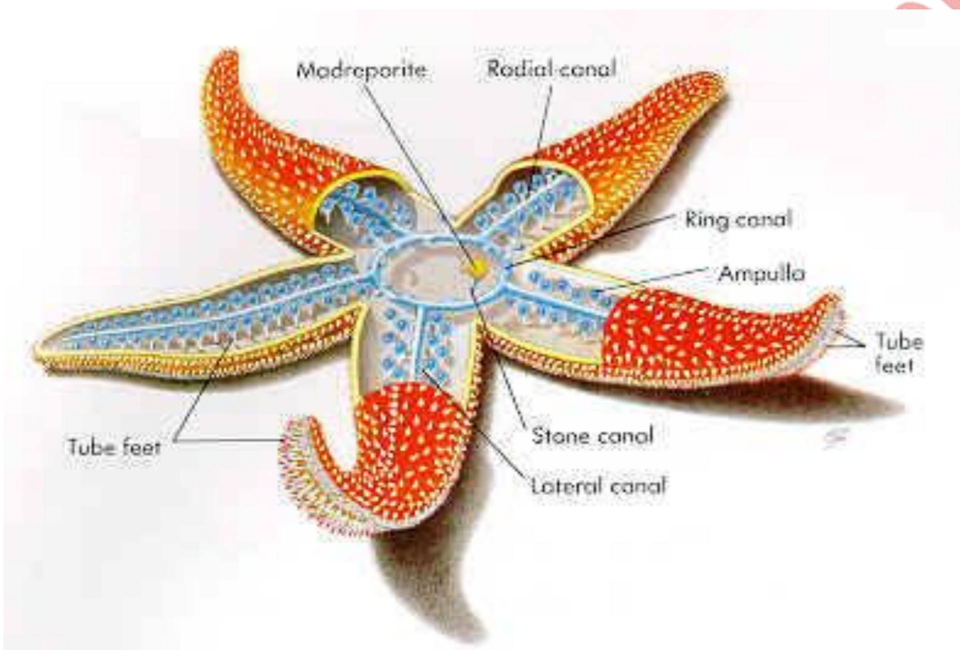


Fig : Star fish

(4) Tiedmann's Bodies :-

The ring canal gives out inter radially nine small, yellowish, irregular or rounded glandular bodies called racemose or Tiedmann's bodies from its inner margins. The Tiedmann's body rest upon the peristomial ring of ossicles. The actual function of tiedmann's bodies is still unknown, however they are supposed to be lymphatic glands to manufacture the amoebocytes of the water vascular system.

(5) Pollian Vesicles :-

The ring canal gives off on its outer side in the inter radial position one, two or four little, pear shaped, thin walled contractile bladder or reservoirs with long necks called pollian vesicles. They are supposed to regulate pressure inside ambulacral system and to manufacture amoeboid cells of ambulacral system.

(6) Radial Canal :-

From its outer surface the ring canal gives off a radial water canal into each arm that runs throughout the length of the arm and terminates as the lumen of terminal tentacle. In the arm the radial water canal runs immediately to the oral side of the ambulacral muscles.

(7) Lateral Canal:-

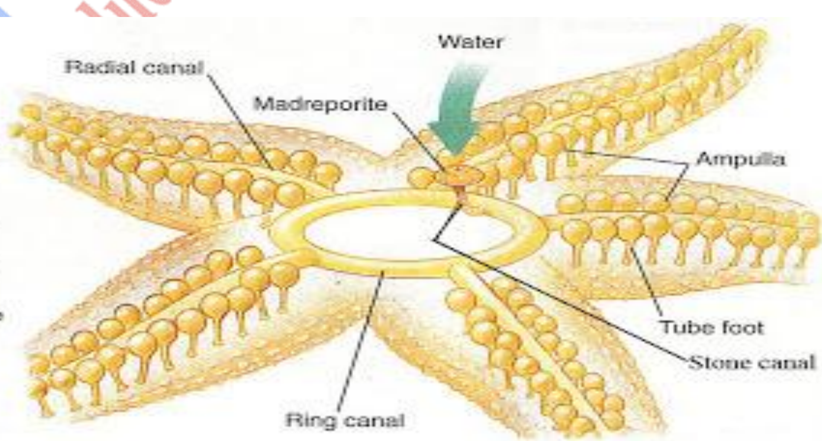
In each arm, the radial canal gives out two series of short, narrow, transverse branches called lateral or podial canals. Each lateral canal is attached to the base of a tube foot and its provided with a valve to prevent backward flow of fluid into the radial canal.

(8) Tube feet:-

As already mentioned, there are four rows of tube feet in each ambulacral groove. A tube foot is a hollow. elastic, thin walled, closed cylinder or sac-like structure having an upper sac like ampulla, a middle tubular podium & a lower disc like sucker. The ampulla lies within the arm, projecting into the coelom above the ambulacral pore which is a gap between the adjacent ambulacral ossicles for the passage of the podium. The tube feet are chief locomotory and respiratory organ of Asterias.

Function of Water Vascular System :-

The water vascular system has three main functions. They are as follows-



The starfish's water vascular system provides the water pressure that operates the animal's tube feet. From the madreporite, water moves into the ring canal, then into the rays through radial canals, and finally to the tube feet. The canals are like a network of water pipes attached to the tube feet. Water also exits the body through the madreporite.

Fig : Function of water vascular system of Star fish

(1) Locomotion :-

The water vascular system is used mainly for locomotion. The inner wall of the water vascular canals is provided with cilia. The beating of the cilia causes the seawater to enter through the madreporite. Finally, the seawater reaches the tube feet and their ampullae. The ampullae contract; the valves at the junction of the lateral canals and tube feet, prevent the flow of water into radial canals. The water is forced into the podia. The podia are elongated and protected out through the ambulacral groove. Then the suckers are applied to the substratum. The tube feet now contract & push the body forward. The water from the tube feet is pushed into the ampulla. Hence, the tube feet shorten. The suckers are released. Then the ampulla contracts & the whole process is repeated.

(2) Food Capture:-

The tube feet are used to capture the prey. The suckers are used to open the shells of molluscs.

(3) Attachment:-

The Starfish can be attached to the rocks by the tube feet.

****

Key Terms

Annelida	Phylum of segmented worms
Antennae	A pair of jointed sense organs on the head of a crab, lobster, etc.
Appendage	Any part of an animal coming from the main body trunk such as arms, legs
Arthropoda	Phylum of invertebrates having jointed appendages, segmented bodies, and an exoskeleton of chitin
Bivalve	Mollusc with two shells
Cephao	Head
Chitin	A complex carbohydrate material that forms the skeletal shell of arthropods
Chordata	Phylum of animals having a notochord and a nerve cord; contains a few types of invertebrates
Cilia	Minute hair-like projections
Cnidaria	Phylum of invertebrate animals having nematocysts, stinging cells
Coelenterata	An older name for the Phylum Cnidaria
Colonial	A group of organisms of the same species living together.
Crustacea	A class of arthropods
Development	More “drastic” changes, such as the development of the wings, development of reproductive organs or metamorphosis
Dorsoventrally	From back to front.
Echinodermata	Phylum of invertebrates having pentamerous (5-part) radial symmetry
Flagella	Whip-like structures on a cell
Foot	A muscular structure of molluscs for locomotion
Gastropod	A mollusk with a single or no shell
Growth	Typically refers to changes in body size (mass and length) and changes in the size of various body parts
Mantle	Tissue of a mollusc that secretes lime to create a hard shell

Mollusca	Phylum of invertebrates with soft, unsegmented bodies, usually protected by an external shell
Nematocyst	The stinging barb of cnidarians
Operculum	A lid or cover for the opening of a snail's shell
Ossicles	Tiny skeletal plates and fragments made of calcite crystals on an echinoderm.
Pentaramous	Divided into five parts.
Pincers	Front claws on a crab.
Radial	Having similar parts radiating from a central point.
Radula	A tongue-like toothed structure used by snails for chewing and rasping
Regenerate	To grow a new body part to replace one that is lost
Segmented	The division of the body into similar parts.
Sessile	Attached to one place.
Siphon	An extension of the mantle in molluscs for drawing wat into the mantle cavity
Solitary	By oneself.
Spicules	Needlelike rods of support that make a sponge stiff
Stalk	Long slender support
Swimmerets	Abdominal appendages of some crustaceans
Tentacles	Long cylindrical tubes for feeding or feeling
Univalve	Mollusc with only one shell

Multiple Choice Questions

Section A

1. Exoskeletons provide excellent protection to internal organs. However, animals that utilize exoskeletons are usually relatively small. Why?
   a). These animals are only able to produce a limited amount of chitin.
   b). Exoskeletons are not living tissue, and therefore they cannot grow.
   c). A large exoskeleton would be too heavy to move.
   d). During molting, these animals are especially vulnerable to predators and therefore do no usually live long enough to grow bigger.
   Answer: c

2. Of the mollusks, snails are in the class of
   a). gastropods.
   b). bivalves.
   c). cephalopods.
   d). chitons.
   Answer: a

3. A mantle is
   a). present only in bivalves.
   b). a structure that acts as a lung or contains gills.
   c). a rasping, tonguelike organ in mollusks.
   d). necessary for mollusks to be motile.
   Answer: b

4. Segmentation was first apparent in the
   a). flatworms.
   b). annelids.
   c). mollusks.
   d). arthropods.
   Answer: b

5. Which of the following is not present in polychaetes?
   a). a coelom
   b). parapodia
   c). permanent gonads
   d). setae
   Answer: c

6. The phylum that shows the greatest diversity, or the greatest number of species, is
   a). Arthropoda.
   b). Brachiopoda.
   c). Echinodermata.
   d). Mollusca.
   Answer: a

7. Arthropods shed their old exoskeleton as they grow in a process known as
   a). tagmatization.
   b). metamorphosis.
   c). chrysalis.
   d). ecdysis.
   Answer: d

8. Which animal group has radial symmetry, a water-vascular system, moves with tube feet, and has an endoskeleton?
   a). Arachnids
   b). Crustaceans
   c). Echinoderms
   d). Cnidarians
   Answer: c

9. The echinoderms that lack distinct arms are the
   a). Brittle stars.
   b). Sea urchins.
   c). Sea stars.
   d). Asteroidea.
   Answer: b

10. Cnidarians project a nematocyst to capture their prey by
   a). building up a high internal osmotic pressure.

b). ejecting it with a jet of water.
c). using a springlike apparatus.
d). muscle contractions that "throw" the nematocyst.
Answer: a

11. Consider the following statements:
1. Contractile vacuoles in Paramecium help in osmoregulation.
2. Peristome in Paramecium is situated on its ventral surface.
Which of the statements given above is/are correct?
(a) 1 only
(b) 2 only
(c) Both 1 and 2
(d) Neither 1 nor 2
***Answer:* A**

12. The exoskeleton of coral is made up of
(a) Silica (b) Chitin
(c) Calcium carbonate (d) D. Pu.tin
Answer: C

13. The organs of offence and defence of the coelenterates are the
(a) Flame cells (b) Nematocysts
(c) Parapodia (d) Tentacles
Answer: B

14. A key evolutionary development seen for the first time in the sponges is
a). a complete digestive system.
b). tissues.
c). body symmetry.
d). multicellularity.
Answer: d

15. All of the following are found in sponges except
a). spicules.
b). choanocytes.
c). a digestive tract.
d). sexual and/or asexual reproduction.
Answer: c

Section B

MCQs

1. The water current which constantly enters the body of a sponge comes out through the
(a) Ostium (b) Anus
(c) Osculum (d) Mouth
Ans. C

2. Asexual reproduction in sponges takes place by
(a) Budding (b) Fragmentation
(c) Regeneration (d) Fission
Ans. A

3. The predominantly marine phyla of the animals are the Porifera and
(a) Echinodermata (b) Platylielminthes
(c) Coelenterata (d) Mollusca
Ans. C

4. Jellyfish belongs to phylum
(a) Protozoa (b) Chordata
(c) Porifera (d) Coelenterata
Ans. D

5. The example of a free-living flat worm is
(a) Planaria (b) Tapeworm
(c) Liverfluke (d) Hookworm
Ans. A

6. The intermediate host in the life history of liverfluke is the
(a) Sheep (b) Snail
(c) Pig (d) Cattle
Ans. B

7. The larva of annelids and molluscs is known as the
(a) Radula (b) Trochophore
(c) Planula (d) Caterpillar

Ans. B

8. The coelom of arthropods is called as the
   (a) Pseudocoel (b) Blastocoel
   (c) Haemocoel (d) Enteron
   Ans. C

9. All of the following are found in sponges except
   a). spicules.
   b). choanocytes.
   c). a digestive tract.
   d). sexual and/or asexual reproduction.

   Answer: c

10.The first animal group to show extracellular digestion was the
   a). Sponges
   b). Cnidarians.
   c). flatworms.
   d). roundworms.
   Answer: b

11.The first animal group to show extracellular digestion was the
   a). sponges
   b). cnidarians.
   c). flatworms.
   d). roundworms.
   Answer: b

12.Cnidarians project a nematocyst to capture their prey by
   a). building up a high internal osmotic pressure.
   b). ejecting it with a jet of water.
   c). using a springlike apparatus.
   d). muscle contractions that “throw” the nematocyst.
   Answer: a

13.Which of the following is an example of an organism with the medusa body form?
a). a hydra
b). a coral
c). an anemone
d). a jellyfish
Answer: d

14.Key evolutionary advances of the flatworms are bilateral symmetry and
a). a coelom.
b). internal organs.
c). a one-way digestive tract.
d). a body cavity.
Answer: b

15.For excretion, flatworms use
a). miracidium.
b). osmosis.
c). flame cells.
d). proglottids.
Answer: c

16.The type of body cavity seen in the roundworms is called a(n)
a). coelom.
b). acoelom.
c). pseudocoelom.
d). gastrovascular cavity.
Answer: c

17.The type of pseudocoelomates found in soil, freshwater and marine environments, and as parasites are
a). nematodes.
b). *Trichinella*.
c). rotifers.
d). Cycliophora.
Answer: a

18.**The hydatid disease in humans is caused by which one of the following:**
(a) Cystic stage of Taenia solium

(b) Cystic stage of Fasciola hepatica
(c) Cystic stage of Echinococcus granulosus
(d) Adult stage of Dipylidium caninum
Answer: C

19. **With reference of Palaemon, which one of the following statements are correct?**
(a) Hastate plate is present in pyloric stomach
(b) 13 pairs of cephalothoracic and 6 pairs of abdominal appendages are present
(c) Statocyst as a sensory structure is located at the base of second antenna only and attached to ventral wall
(d) The gonopore in male is present at the base of each fourth walking leg
Answer: A

20. Flame cells are excretory organ of:
(a) Planaria
(b) Hydra
(c) Hydrilla
(d) Cockroach
Answer: A

21. Air for respiration enters the insect body through the
a). tracheae.
b). spiracles.
c). tracheoles.
d). Malpighian tubules.
Answer: B

Section C

1. **The water vascular system in echinoderms is known to consist of the following structures. But in Asterias, which one of them is absent?**
   (a) Ring canal
   (b) Madreporite
   (c) Polian vesicles
   (d) Stone canal
   Answer: C

2. What is the function of contractile vacuole?
   (a) Respiration (b) reproduction (c) osmoregulation (d) digestion (e) None of these
   Answer: C

3. Spicules are secreted by special mesenchymal amoebocytes called:
   (a) scleroblasts (b) microscleres (c) myocytes (d) collencytes (e) None of these
   Answer: A

4. True nerve cells or ganglion cells occur for the first time in:
   (a) Protozoa (b) Porifera (c) Coelenterata (d) Annelida (e) None of these
   Answer: C

5. The process by which an organism can replace its lost or damaged body parts is called:
   (a) reformation (b) regeneration (c) reclamation (d) reconstruction (e) None of these
   Answer: B

6. Nematocysts are found in:
   (a) Protozoa (b) Porifera (c) Annelida (d) Mollusca (e) None of these
   Answer: E

7. In polychaetes the locomotory organ is:
(a) pseudopodium (b) neuropodium (c) notopodium (d) parapodium (e) None of these
Answer: E

8. Worms belonging to phylum platyhelminthes are commonly known as:
(a) round worms (b) flat worms (c) segmented worms (d) earth worms (e) None of these
Answer: B

9. Bipinnaria is a larval form of:
(a) Coelenterate (b) Polychaeta (c) Echinodermata (d) Cestoda (e) None of these
Answer: C

10. Closed type of circulatory system is found in:
(a) Platyhelminthes (b) Annelida (c) Porifera (d) Arthropoda (e) None of these
Answer: B

1. What are coral reefs? Give an account of the various forms of coral reefs.
2. Given an account of the canal system in sponges.
3. What are coral reefs? Give an account of the various forms of coral reefs.
4. What is adaptation? Briefly discuss parasitic adaptations in platyhelminthes.
5. Define the following terms:

   i. Polymorphism (ii) Metamerism
   ii. Parasitism (iv) Osmoregulation
6. Describe the water vascular system of Echinodermata.
7. What is conjugation? Briefly discuss its significance.

8. Write short notes on:
   i. Flame cells (iii) Spicules (iv) Coelom
9. Describe the major characteristics of the Platyhelminthes; then name the three classes in this phylum, and list the distinguishing features of each.

10.Describe the tapeworm's special adaptation for parasitism.
11.Describe the distinguishing characteristics of the arthropods.

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