BSCZO- 101

B. Sc. I YEAR
NON-CHORDATA

DEPARTMENT OF ZOOLOGY
SCHOOL OF SCIENCES
UTTARAKHAND OPEN UNIVERSITY

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Course Title and Code	**: Non-Chordata (BSCZO 101)**
ISBN	**: 978-93-85740-53-4**
Copyright	**: Uttarakhand Open University**
Edition	**: 2017**
Published By	**: Uttarakhand Open University, Haldwani, Nainital- 263139**

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Non-Chordata

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Course 1: Non-Chordate

Course code: BSCZO101 **Credit: 3**

UNIT: 01 PHYLUM-PROTOZOA

Contents

1.1-Objectives:

- To study General characters of Phylum Protozoa and its classification up to order.
- Study of *Paramecium* with particular reference to locomotion, Osmoregulation and reproduction.

1.2-Introduction

The Protozoa are heterogeneous assemblage of some 50,000 cellular or single- cell organism found worldwide in most habitats. Protozoa means 'first animal' the simplest form of animal life. Protozoa are unicellular microorganisms (eukaryotes) that lack cell walls. They are found in marine habitat or soil, in fresh water bodies, symbiotic, some forms are parasites in other organisms. Protozoa depends on nutrition, temperature, pH, and some depends on sunlight.

Protozoa were defined as unicellular protists with animal-like behavior, such as movement. Protozoa were regarded as the partner group of protists to protophyta, which have plant-like behavior, e.g. photosynthesis. The term protozoan has become highly problematic due to the introduction of modern ultra structural, biochemical, and genetic techniques, which have showed that the group does not form a clade as required by modern classifications. Modern unicellular clades within Eukaryotes which may be viewed as approximately collectively replacing the class of protozoa include: *Excavata, Amoeba, Chromalveolata* and *Rhizaria*.

Protozoans are usually single-celled heterotrophic eukaryotes containing non-filamentous structures that belong to any of the major lineages of protists. They are restricted to moist or aquatic habitats (i.e., they are obligate aquatic organisms). Many protozoan species are symbionts, some are parasites, and some are predators of feces bacteria and algae. There are an estimated 50,000 protozoan species.

The Protozoa are considered to be a subkingdom of the kingdom Protista, although in the classical system they were placed in the kingdom Animalia. More than 50,000 species have been described, most of which are free-living organisms; protozoa are found in almost every possible habitat. The fossil record in the form of shells in sedimentary rocks shows that protozoa were present in the Pre-Cambrian era. Anton van Leeuwenhoek was the first person to see protozoa, using microscopes he constructed with simple lenses. Between 1674 and 1716, he described, in addition to free-living protozoa, several parasitic species from animals, and *Giardia lamblia* from his own stools.

1.3 - General characters and classification

General Characters of protozoa

- They are aquatic (fresh and salt water) free living parasitic, symbiotic or commensally. Usually microscopic with oval, elongated, spherical or ever changing shape
- They show cellular level of organization, where all the activities of the body are performed by a single cell.
- The protozoan cell body is either naked or surrounded by a non rigid pellicle. Cellulose is absent in the pellicle.
- Some protozoans secrete shells of various inorganic compounds as external covers.
- They possess different types of locomotory organs.
- They may bear flagella (flagellates), cilia (ciliates) or pseudopodia (scorodines).
- Locomotory organs are absent in the parasitic forms.
- They are holozoic (animal-like) and feed largely on bacteria, microscopic algae and minute animals such as rotifers or on other protozoan's including members of their own species.
- Some are holophytic (plant-like); they contain chlorophyll and prepare their own food by photosynthesis (Euglena).
- The parasitic protozoans devour on materials obtained from the hosts (Monocystis).
- Some are saprozoic (subsisting on dead organic matter) and saprophytic (feeding on liquid food).
- The osmotic concentration of cell body (Osmoregulation) is maintained by one or more contractile vacuoles and these contractile vacuoles are help in excretion.
- The excretory product is ammonia.
- Asexual reproduction takes place by binary fission or budding.
- Sexual reproduction is performed by the fusion of gametes or by conjugation.

  Examples:

Free living- *Euglena* (Fig.1), *Amoeba* (Fig.2), *Noctiluca* (Fig.3), *Paramecium* (Fig.4), *Elphidium* (Polystomella)

Parasitic-*Monocystis, Entamoeba, Giardia* (Fig.5), *Plasmodium* (Fig.6), *Trypanosome*, etc

- The single cell of the body performs all the vital activities.
- Encystment occurs to tide over the unfavorable conditions and to help in the dispersal of race.
- In certain animalcules, the life cycle is complicated and exhibits alternation of generations.

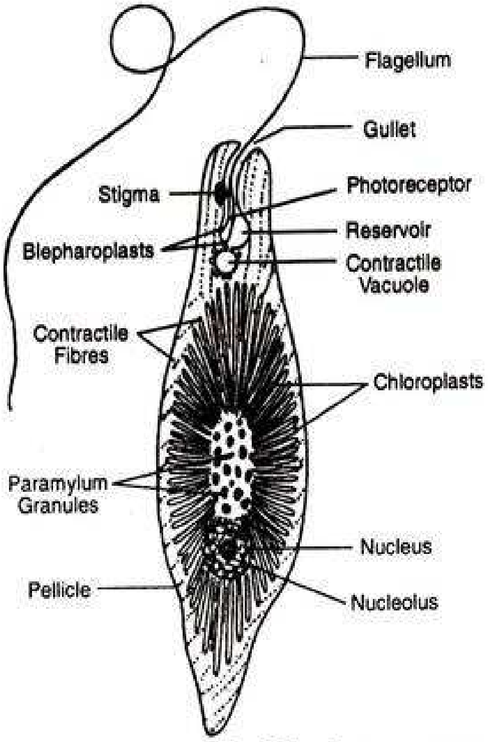

Fig. 1 Euglena

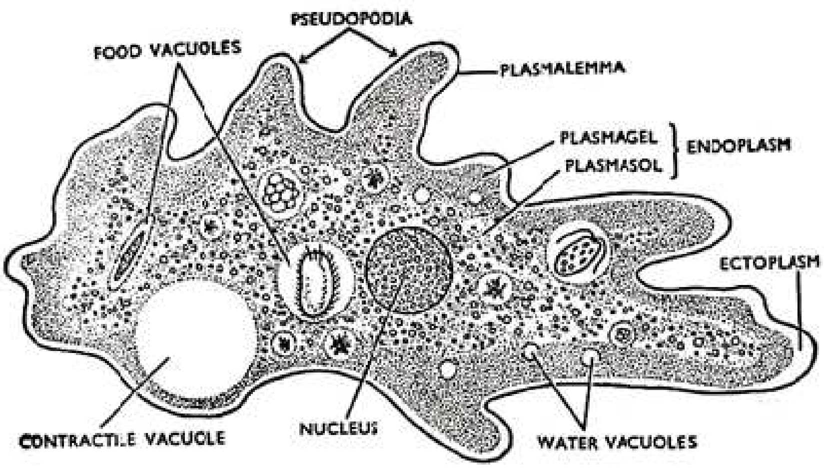

Fig. 46. *Amoeba proteus.*

Fig.2: *Amoeba*

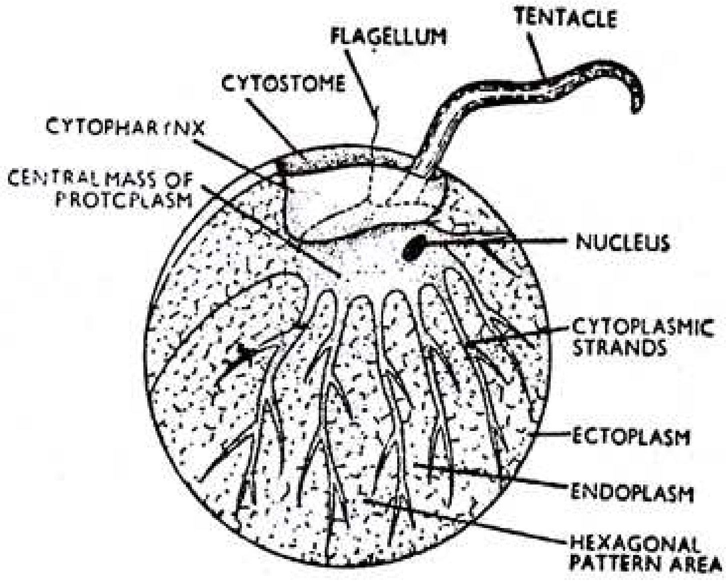

Fig.3 Noctiluca

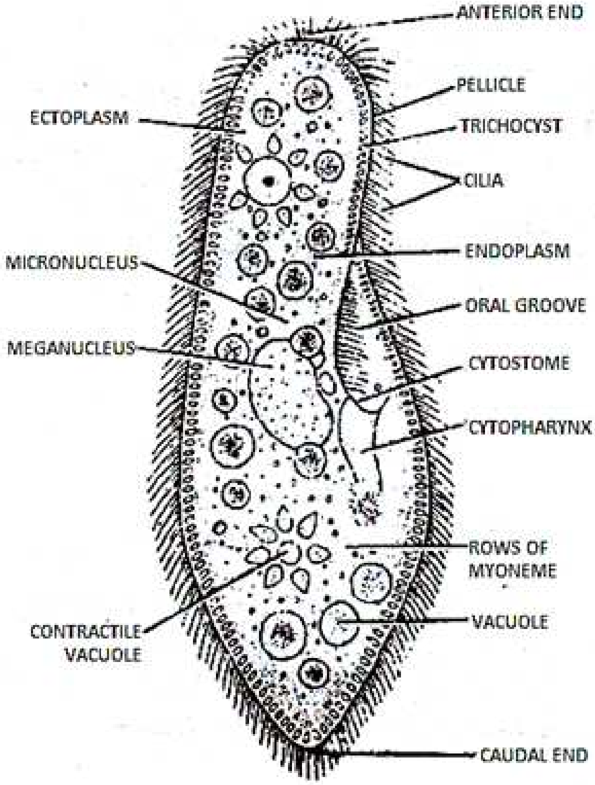

Fig.4: *Paramecium*

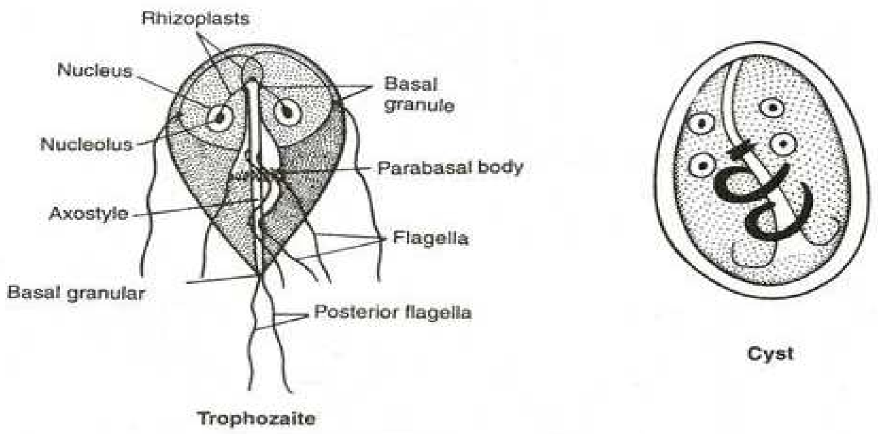

Fig.5 Giardia

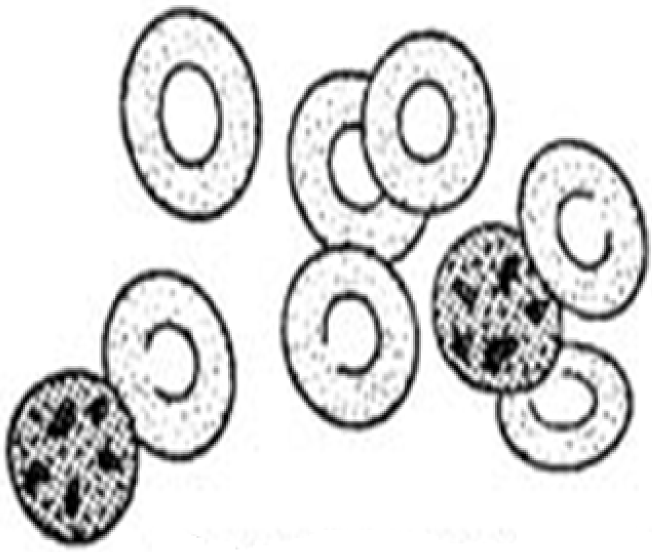

Fig.6: *Plasmodium (In Red Blood Cells)*

1.3.1 Distribution

Habit and habitat:

Paramecium is occurrence in fresh water ponds, lakes, rivers and streams. It is also found in abundance in stagnant water bodies.

Shape and size:

Pellicle:

The body is covered by a thin firm but elastic pellicle. Pellicle consists of three membranes.

a)-The outer or surface membrane is continuous with the membrane surrounding the cilia.

b)-The outer and inner membranes of the alveoli thus form the middle and inner membranes of the pellicle.

Cilia:

The entire body surface is covered by a uniform covering of hair like protoplasmic processes, the cilia.

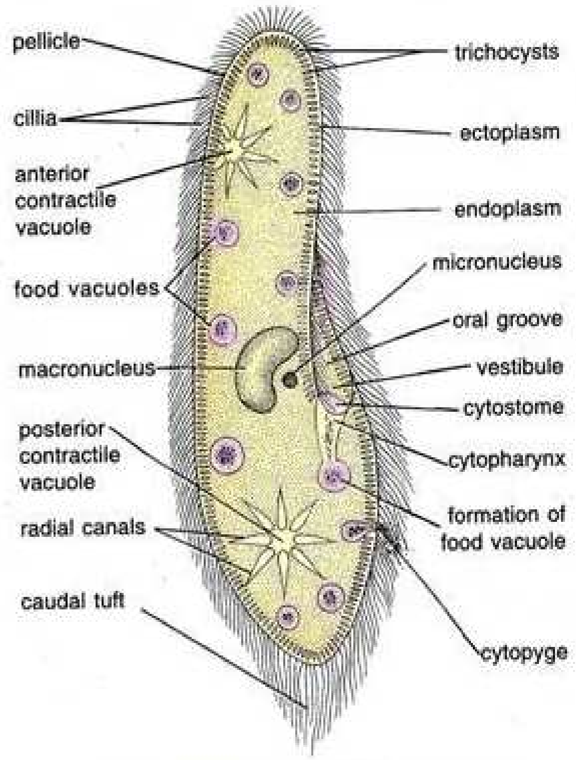

Fig.7. Paramecium Caudatum

Paramecium is unicellular microscopic organism. Its size varies in different species being 120-250µ in *P. Aurelia* and 170-290µ in *P. Caudatum.* It is commonly known as slipper animalcule. Its body is asymmetrical with flat oral and a convex aboral or dorsal surface.

Oral apparatus:

In Paramecium, there is a broad, shallow oral groove on the ventral surface. The oral groove extends obliquely backwards into a conical funnel shaped depression called vestibule. It leads into the buccal cavity followed by narrow cytopharynx through narrow apertures, the Cytosomes. Cytopharynax at its proximal end formed food vacuoles. Buccal cavity, at its right side is bordered by a row of cilia forming endoral membrane. At left side are the three groups of 4 rows of cilia. These are ventral peniculus, dorsal peniculus and quadrulus. From endoral membrane ribbed pellicles extends up to cytostome. Nemedesmal fibre are present in the cytostome & Cytopharynx.

1.3.2- Classification of Protozoa

Phylum protozoan's are a larger and varied group and possess a number of problems in its classification. The conventional scheme followed by Hyman (1940), Hickman (1961) and Store (1965) etc. recognizes two subphyla on the basis of organs of locomotion and 5 classes , briefly outlined as follows:

Subphylum A. Plasmodroma

- Locomotory organelles are flagella, pseudopodia, or none.
- Nuclei of one kind.

Class-1-Mastigophora:

- Move by one too many flagella.
  E.g. Euglena.

Class-2-Sarcodina:

- Move and capture food by pseudopodia.
  E.g. Amoeba.

Class-3- Sporozoa

- No locomotory organs.
- All Parasitic.
  E.g. Plasmodium.

Subphylum B. Ciliophora

- Cilia or sucking tentacles throughout or at certain stages.
- Nuclei of 2 kinds.

Class-4-Ciliata

- Move by cilia
  E.g. Paramecium

Class-5-Suctoria

- Move by cilia as young stage and by tentacles as adult stage.
  Eg. Podophyra.

The following classification of Protozoa is based on the scheme given by the committee on Taxonomy and Taxonomic Problems of the society of Protozoologists, and mainly proposed by B. M. Honigberg and others (1964).

Phylum Protozoa has been classified into four sub-phylum:-

Sub-phylum 1. Sarcomastigophora
Sub-phylum 2. Sporozoa
Sub-phylum 3. Cnidospora
Sub-phylum 4. Ciliophora

Sub-phylum1. Sarcomastigophora

1. Locomotors organelles pseudopodia or flagella or both.
2. Nucleus one or more and of the same kind.
3. Asexual reproduction by binary and multiple fission.

Superclass (A) - Mastigophora (Flagellata)

1. Simple, primitive and with firm pellic.
2. Locomotor organelles flagella.
3. Nutrition autotrophic or heterotrophic.

Class- 1. Phytomastigophora (Phytoflagellata)

1. Chlorophyll bearing chromatophores present.
2. Nutrition holophytic or photophytic.
3. Flagella 1 or 2 or many.

Order- 1. Chrysomonadida

1. Amoeboid forms without gullet but with stigma.
2. Flagella usually 1, sometimes 2 or 3.
3. Chromatophores 1 or 2, yellowish or brownish or yellowish green.
4. Starch absent but leucosin and fats may be present.
5. Siliceous cyst.
6. Marine or freshwater animals.
   Eg. *Chrysamoeba, Dinobryon*

Order- 2. Cryptomonadida

1. Anterior gullet reaches upto the middle of the body.
2. Flagella 2 and unequal.
3. Chromatophores 2, yellow, brown, colourless.
4. Reserve food starch.
5. Stigma present.
6. Marine or freshwater.

Eg. *Chilomonas, Crytomonas.*

Order- 3. Euglenida;

1. Anterior end with a gullet or cytophyarynx leading into a reservoir.
2. Flagella 1 or 2, and with mastigonemes.
3. Chromatophores numerous and green.
4. Mostly freshwater.
   Eg. *Euglena, Peranema*.

Order- 4. Volvocida (Phytomonadida)

1. Small with rigid cellulose covering and no gullet.
2. Flagella usually 2, sometimes more.
3. Reserve foodstuff starch and oils.
4. Stigma present,
5. Mostly freshwater, some from colonies.
   E.g. *Chlamydomonas, Volvox*.

Order- 5. Chloromonadida

1. Dorso-ventrally flattened forms with delicate pellicle.
2. Flagella 2, sometimes 1 or more.
3. Chromatophores green and numerous, some colourless.
4. Reserve foodstuff oil.
5. No stigma.
6. Large freshwater.
   E.g. *Coelomonas.*

Order- 6. Dinoflagellida

1. Small and planktonic, naked and amoeboid or with a thick pellicle or theca.
2. Flagella two.
3. Chromatophores numerous, yellow or brown.
4. Reserve food starch or oil or both.

5. Stigma present; contractile vacuoles two.
6. Some are bioluminescent.
7. Largely marine.
   E.g. Noctiluca, *Ceratium, Gymnodinium*.

Class-2. Zomastigophorea (Zooflagellata)

1. Chlorophyll or chromatophores absent.
2. Nutrition holozoic or saprozoic.
3. Parasitic, symbiotic or free living.
4. Reserve food glycogen.
5. Flagella one or many.

Order-1. Rhizomastigida

1. Small and amoeboid.
2. Flagella one or four.
3. Locomotion by flagella or pseudopodia.
4. Chiefly fresh water.
   E.g. *Mastigamoeba, Dimorpha*.

Order-2. Kinetoplastida

1. Small and more or less amoeboid in form.
2. Flagella 1 or 2.
3. Holozoic or saprozoic nutrition.
4. Solitary or colonial.
5. Parasitic forms living in blood.
   Eg. *Leishmania, Trypanosoma.*

Order- 3. Choanoflagellida

1. Free living.
2. Colonial
3. A collar around the base of a single flagellum.
4. Nutrition holozoic.
   Eg. *Proterospongia*.

Order- 4. Diplomonadida

1. Flagella 3 or 8, one forming the border of undulating membrane.
2. Uninucleate, sometimes multinucleate.
3. Mostly intestinal parasites.
   E.g. Giardia, Hexamita.

Order- 5. Hypermastigida

1. Highly specialized forms with numerous flagella.
2. Kinetosomes or parabasal bodies arranged in a circle or longitudinal or spiral rows.
3. Uninucleate or multinucleate.
4. Mouth absent, food ingested by pseudopodia.
5. Gut parasites of termites and cockroaches.
   Eg. *Trychonympha, Lophomonas*.

Order-6. Trichomonadida

1. Flagella 4-6.
2. One flagellum trailing.
3. Parasites in genital passage.
   Eg. *Trichomonas.*

Superclass (B) Opalinata

1. Body covered by flagella or cilia.
2. Nuclei 2 to many and monomorphic.
3. Nutrition saprozoic.
4. Reproduction by binary fission or by gametes.
5. Parasites of frogs and toads.
   E.g. *Opalina.*

Superclass (C) Sarcodina (Rhizopoda)

1. Body without definite pellicle.
2. Locomotion by pseudopodia.
3. Nutrition holozoic or saprozoic.
4. Asexual reproduction by binary fission.
5. Solitary and free living some parasitic or colonial.

Class- 1. Actinopodea

Pseudopodia are axopodia with axial filaments radiating from spherical body.

Subclass (1) Heliozoa

1. Spherical protozoans.
2. Pseudopodia (axopodia) radiating.
3. Body naked and differentiated into outer vacuolated ectoplasm and inner dense endoplasm.
4. Nutrition holozoic.
5. Mostly freshwater.
   E.g. *Actinophyrus, Clathrulina, Actinosphaerium.*

Subclass (2) Radiolaria

1. Perforated central capsule separating the ectoplasm from endoplasm.
2. Contractile vacuole absent.
3. Pseudopodia are axopodia or filopodia.
4. Skeleton of siliceous spicules.
5. Marine.
   E.g. *Collozoum.*

Subclass (3) Proteomyxidia

1. Pseudopodia are filopodia.
2. Marine or freshwater.
3. Reproduction by binary fission or multiple fission.
   E. g- *Pseudospora.*

Subclass (4) Actantharia

1. Central capsule non chitinoid and without pores.
2. Skeleton of strontium sulphate.
3. Pseudopodia are axopodia.
   Eg- *Acanthrometra*.

Class 2. Rhizopodea

Pseudopodia are lobopodia, filopodia or reticulopodia, without axial filaments.

Subclass (1) Lobosia

Pseudopodia are lobopodia.

Order- 1. Amoebida

1. Body amoeboid shaped, without skeleton
2. Pseudopodia (lobopodia) short with blunt ends.
3. Ectoplasm and endoplasm distinct.
4. Largely fresh water, some parasites.
   E.g. *Amoeba, Entamoeba*.

Order- 2. Arcellinida (Testacida)

1. Body enclosed in one chambered shell.
2. Shell with a single opening through which lobopodia protrude.
3. Free living, found in fresh water.
   E.g. - *Arcella, Difflugia*.

Subclass (2) Filosia

1. Pseudopodia are filopodia, tapering and branching.
2. Body naked or with a shell wit single aperture.
3. Ectoplasm not distinct.
4. Marine and freshwater forms.
   Eg- *Allogromia, Penardia*.

Subclass (3) Granuloreticulosia

Pseudopodia are reticulopodia.

Order-1. Foraminiferida

1. Large sized with uni or multichambered shell.
2. Shell with one or more opening through which reticulopodia emerge.
3. Reticulopodia fine and branching is forming a network.
4. Mainly marine,
   E.g. *Globigerina,*

Subclass (4) Mycetozoia

1. Body large, amoeboid and multinucleate.
2. Pseudopodia numerous and blunt.
3. From sporangia with spores.

   E.g. *Slime moulds.*

Class-3. Piroplasmea

1. Small parasite in R.B.Cs. of vertebrate.
2. Do not form spores.
   E.g. - *Babesia.*

Subphylum II. Sporozoa

1. Exclusively endoparasites.
2. Body with thick pellicle.
3. Locomotor organelles absent in adult.
4. Nutrition saprozoic.
5. Asexual reproduction by multiple fission and sexual reproduction by syngamy followed by spore formation.
6. Life cycle includes both asexual and sexual phase.

Class1. Telosporea

1. Spores without polar capsules or filaments.
2. Sporozoites elongated, microgamete flagellated.
3. Trophozoties with one nucleus only.

Subclass -1. Gregarinia

1. Trophozoites large and found in the gut and body cavities (i.e. extracellular) of invertebrates.
2. Zygote non motile.
3. Male and female gametes merogamous.
4. Sporozoites found in sporocyst.
5. Parasites of invertebrates.
   Eg. *Monocystis, Gregarine*.

Subclass- 2. Coccidia

1. Trophozoites small and intracellular.
2. Gametophytes dimorphic.
3. Sporozoites in sporocysts.
4. Blood or gut parasites of vertebrates.
   Eg- *Eimeria, Isospora.*

Class 2. Toxoplasmea

1. Spores not formed.
2. Only asexual reproduction.
   E. g- *Toxoplasma.*

Class 3. Haplosporea

1. Spores with spore cases.
2. Parasitic of fish and invertebrates.
3. Pseudopodia may be present but no flagella.
4. Reproduction by schizogony only (asexual)
   E.g. *Ichthyosporidium, Haplosporidium*

Subphylum- III. Cnidospora

1. Trophozoite has many nuclei.
2. Spore formation occurs throughout life.
3. Spores contain polar capsules with polar filaments.

Class 1. Myxosporidea

1. Spores develop from several nuclei.
2. Spore within two or three valves.

Order -1. *Myxosporida.*

1. Spores large and with a bivalve membrane.
2. Polar capsule 1, 2 or 4; each with a filament.

3. Tropozoites amoeboid.
   Eg. *Myxidium.*

Order- 2. Actinomyxida

1. Spores large and with a trivalved membrane.
2. Polar capsule 3, each with a filament.
   Eg. *Triactinomyxon, Sphaeractinomyxon.*

Class-2. Microsporidea

1. Spores small and with a univalved membrane.
2. With or without polar capsule
   E.g. *Nosema*.

Subphylum – IV. Ciliophora

1. Body organization complex.
2. Presence of cilia as feeding and locomotory organelles at some stage in the life cycle.
3. Two types of nuclei- micronucleus and macronucleus are present.
4. Asexual reproduction by binary fission or budding.
5. Sexual reproduction by conjugation.

Class1. Ciliate (Infusoria)

1. Protozoa with a definite from and size.
2. Body bounded externally by a firm pellicle.
3. Locomotor organelles cilia.
4. Definite mouth and gullet present. Anal Aperture. Permanent.
5. One or more contractile vacuoles present.
6. Have two kinds of nuclei large macronucleus and smaller micronucleus.

Subclass (1). Holotricha.

1. Body cilia uniform.

2. Buccal cilia absent.

Order- 1. Gymnostomatida

1. Body large.
2. Buccal cilia absent.
3. Cytostome opens to outside.
   E.g. *Coleps, Didinium, Nassula*

Order-2. Trichotomatida

1. Cytostome at the bottom of vestibule.
2. Spiral ows of cilia in vestibule; no cilia in bucal region.
   Example; *Colpoda, Balantidium.*

Order- 3. Chonotrichida

1. Body vase shaped.
2. Body cilia absent.
3. Funnel at the free end of body with vestibular cilia.
4. Ectocommensal on crustaceans.
   Example- *Lobochona, Spirochona*.

Order- 4. Apostomatida

1. Body with spirally arranged cilia.
2. Cytostome mid ventral.
3. Parasites or commensalism with complex life cycle, completed on two hosts.
   E.g. - *Hyalophysa, Polyspira*.

Order-5. Astomatida

1. Cytostome absent.
2. Body ciliation uniform.
3. Parasites or commensals in gut and coelom of earthworm.
   E.g. - *Anoplophrya, Hoplitophyrya.*

Order-6. Hymenostomatida;

1. Body small and with uniform cilia on body.
2. Buccal cavity with undulating membrane and adoral zone of membrane cells.
   E.g. - *Colpidium, Paramecium.*

Subclass (2) Peritrichia

1. Adult without body cilia.

2. Sessile organism.

Order- 1. Peritrichida

1. Characters of subclass peritricha,
   E.g. - *Vorticella, Carchesium.*

Subclass (3) Suctoria

1. Body sessile and stalked.
2. Young with cilia, adult; with tentacles.

Order 1 Suctorida

1. Characters as of subclass suctorida.
   E.g. - *Ephelota, Podophrya.*

Subclass (4) Spirotricha

1. Body cilia reduced.
2. Buccal cilia well marked.

Order-1. Heterotrichida

1. Body encased in lorica.
2. Body cilia usually absent.
3. Body naked with uniform body cilia.
   Eg. -*Bursaria, Stentor, Blepharisma*.

Order-2. Hypotrichida

1. Body dorso-ventrally flattend.
2. Body cilia at vental side, forming cirri.
   Eg. -*Euplotes, Kerona*.

Order -3. Oligotrichida

1. Body cilia reduced or absent.
2. Buccal membranelles at front end only. E.g. -*Strombidium, Halteria.*

1.4 Study of Paramecium with particular reference

Systematic position

PHYLUM PROTOZOA
SUB PHYLUM CILLOPHORA
CLASS CILIATA
SUBCLASS HOIOTRICHIA
ORDER HYMENOSTOMATIDA
SUBORDER PENICULINA
GENUS PARAMECIUM
Species caudatum

- Paramecium (Gr., Paramekos- oblong + Caudata-tail) is an elongated and slipper shaped animal.
- Paramecium is a typical ciliate microscopic organism.
- Its ten species are recognized all over the world.
- Ciliates are characterized by the presence of cilia as locomotors organelles (Fig.7).

1.4.1-Locomotion in Paramecium

Paramecium shows following two methods of locomotion.

1 -Ciliary movement:

- Cilia are main locomotory organ in paramecium this are fine hair like protoplasmic processes all over the body.
- These are inclined backward and their beating drives the body forward but they may be directed forward and then their strokes push the body backward.
- The cilia of longitudinal row beat one after the other in a metachronial succession or in a metachronous rhythm.

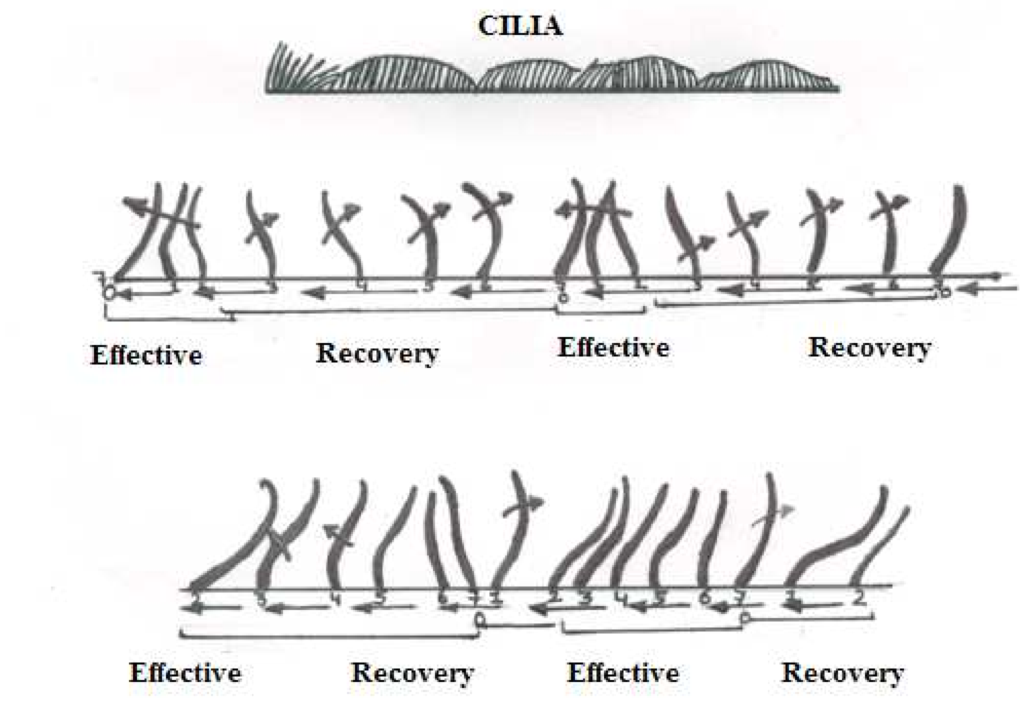

Fig.8 **Two stage in ciliary movement (A)Effective(B)Recovery**

- The cilia of transverse row vibrate simultaneously.
- The movement of cilia is controlled by the neuromotor system.
- Each oscillation of cilia consists of two stocks, one is effective stock and another is recovery stock.
- The cilia beat somewhat towards the right sight. as a result the body of paramecium rotates spirally slightly toward s the left.
- The cilia of oral groove strike more vigorously and obliquely (Fig.8 and 9).

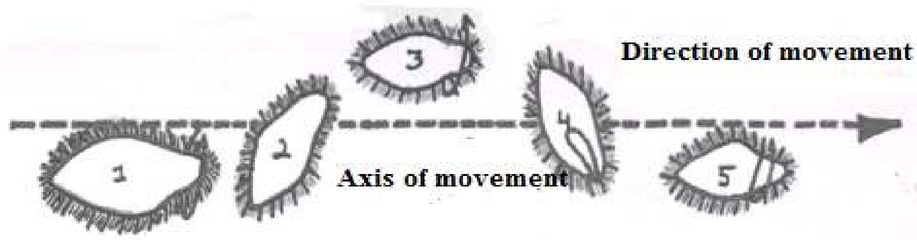

Fig.9 Path followed by Paramecium during swimming

2-Body contortions:

Paramecium can pass through a passage narrow than its body by the contraction and twisting of body, after which body assumes its normal size.

1.4.2- Osmoregulation in paramecium:

The amount of water in the body is controlled by the two contractile vacuoles present one on either end of the body.

- Excess of water from cytoplasm is collected in the microtubules of endoplasmic reticulum.
- From here water is passed on to the nephridia tubes and then to feeder canal.
- In feeder canal it accumulates in the ampullae.
- On getting filled the ampullae discharged it in the contractile vacuole.
- The vacuoles enlarge by gradually receiving water.

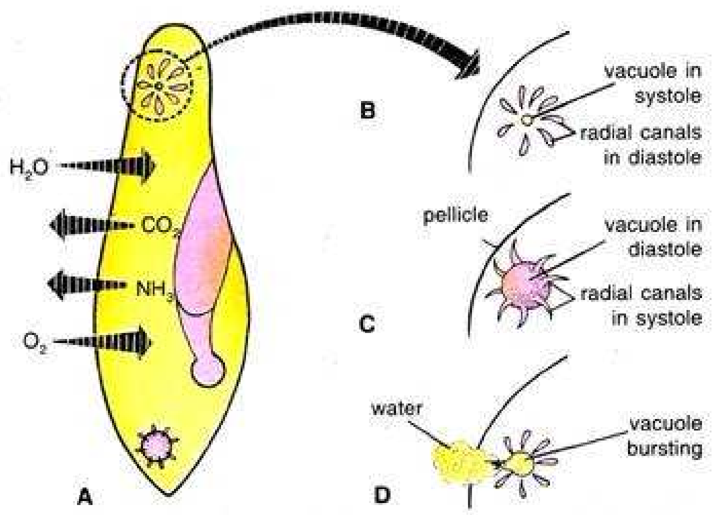

Fig.10 Paramecium:Diagramatic representation of Respiration,Excretion and Osmoregulation

- When grown to its maximum size, vacuole contracts and empties its water to the exterior through the canal that connects it with a pore in the pellicle.
- When the vacuole is in a state of diastole that is fully distended the feeding canals disappear as small streaks soon after the systole.
- The contractile vacuoles expand and contract at regular interval assisted by the myofibrils.
- The posterior contractile vacuole pulsates much faster than the anterior contractile vacuole probably because of large amount of water reaching the posterior region of the cytopharynx (Fig.10).

1.4.3-Nutrition:

Paramecium feeds in the holozoic manner like Amoeba. The food is mostly bacteria found in floating water. It has been estimated that about 2 to 5 million bacteria (Bacillus coli) are devoured in 25 hours by a single Paramecium *P. Bursaria* can live holophytically for long periods due to the presence of symbiotic zoo chlorella algae.

Food is ingested by cytostone situated at the bottom of buccal cavity. Constant lashing movements of cilia direct the food particles towards buccal cavity. Only selected food particle are passed on inside the buccal cavity. Beating of cilica of buccal cavity derives food in to cytopharynx through cytostaome. The food is collected at the bottom of cytopharynx, in the form of a food vacuole. Another food vacuole may be formed within 2 to 4 minutes.

Digestion: Each food vacuole consists of particles surrounded by a thin film of water. Food vacuole in circulated around the body along a definite path by a streaming movement of endoplasm known as cyclosis. Food vacuoles move particularly, than forward and aborally and again posterior & orally up to cytopyge. Digestion & assimilation of food takes place during cyclosis. Digestive enzymes are secreted by the

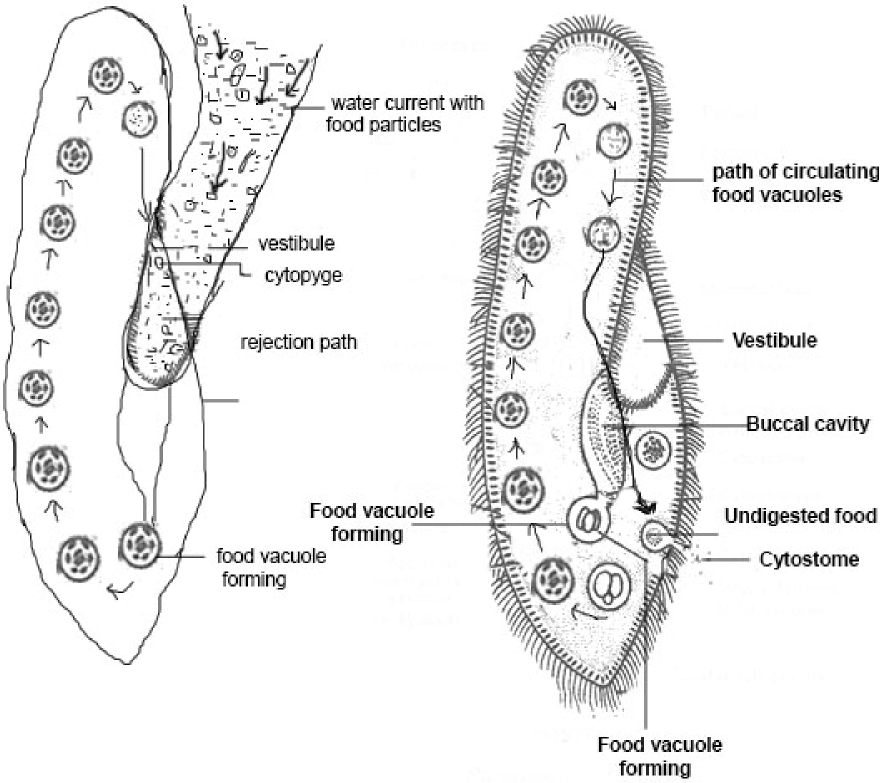

Fig.11 Paramecium showing cyclosis and path of food vacuoles in endoplasm

Lysosomes in to the food vacuoles. She contests of a food vacuole first become acidic but gradually become alkaline. Products of digestion (glycogen & fat) are diffused in to the surrounding cytoplasm.

Egestion: The vacuole gradually becomes smaller as absorption of digested food proceeds. The undigested residual matter is eliminated through cytopyge or anal spot.

1.4.4- Reproduction in Paramecium

Paramecium multiplies very quickly by transverse binary fission. But this is interrupted at intervals by the so called sexual process conjugation. Several types of nuclear reorganizations such as endomixis, hemimixis, auto gamy and cytogamy have also been reported.

1- Binary fission:

- During favorable conditions paramecium multiplies by transverse binary fission.
- The animal stops feeding and the micronucleus divide into two by an elongated type of mitosis.
- The two daughter micronuclei move apart toward the opposite end.
- Mean while the macronucleus elongates and gets constricted into two amitiotically.
- A transverse constriction appears in the middle of body, which deepens gradually dividing it into two equal valves.
- The oral groove of the parent is retained by one half and the mouth and cytopharynx by other. These later on regenerated the essential parts.
- The contractile vacuole in each half also divides.
- These now separated and start their free existence.
- The entire process is completed within half to two hour (Fig.12).

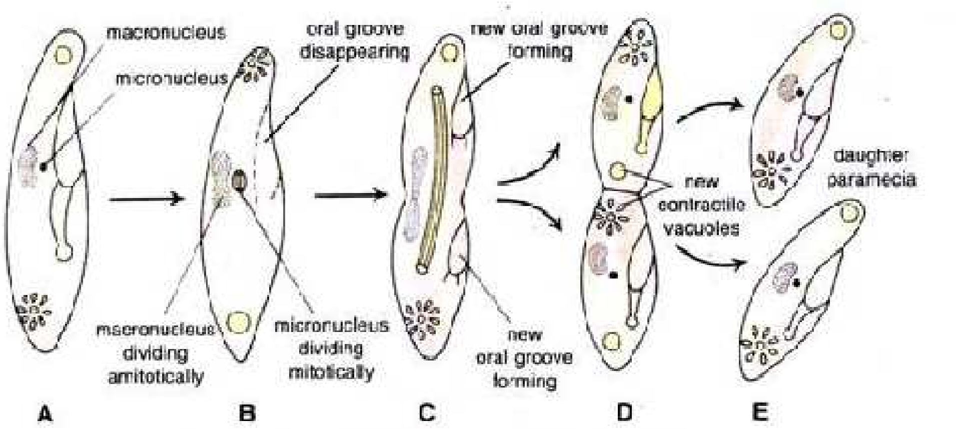

Fig.12 Paramecium: Stage showing Binary Fission

2-Conjugation:

Conjugation is a temporary process and completed in following steps-

Macronucleus Changes-Soon after pairing the macronucleus degenerates into fragment and is absorbed in the cytoplasm micronucleus Changes:-

A. Simultaneously the micronucleus undergoes two pre-gametic divisions, of which first is reduction division.

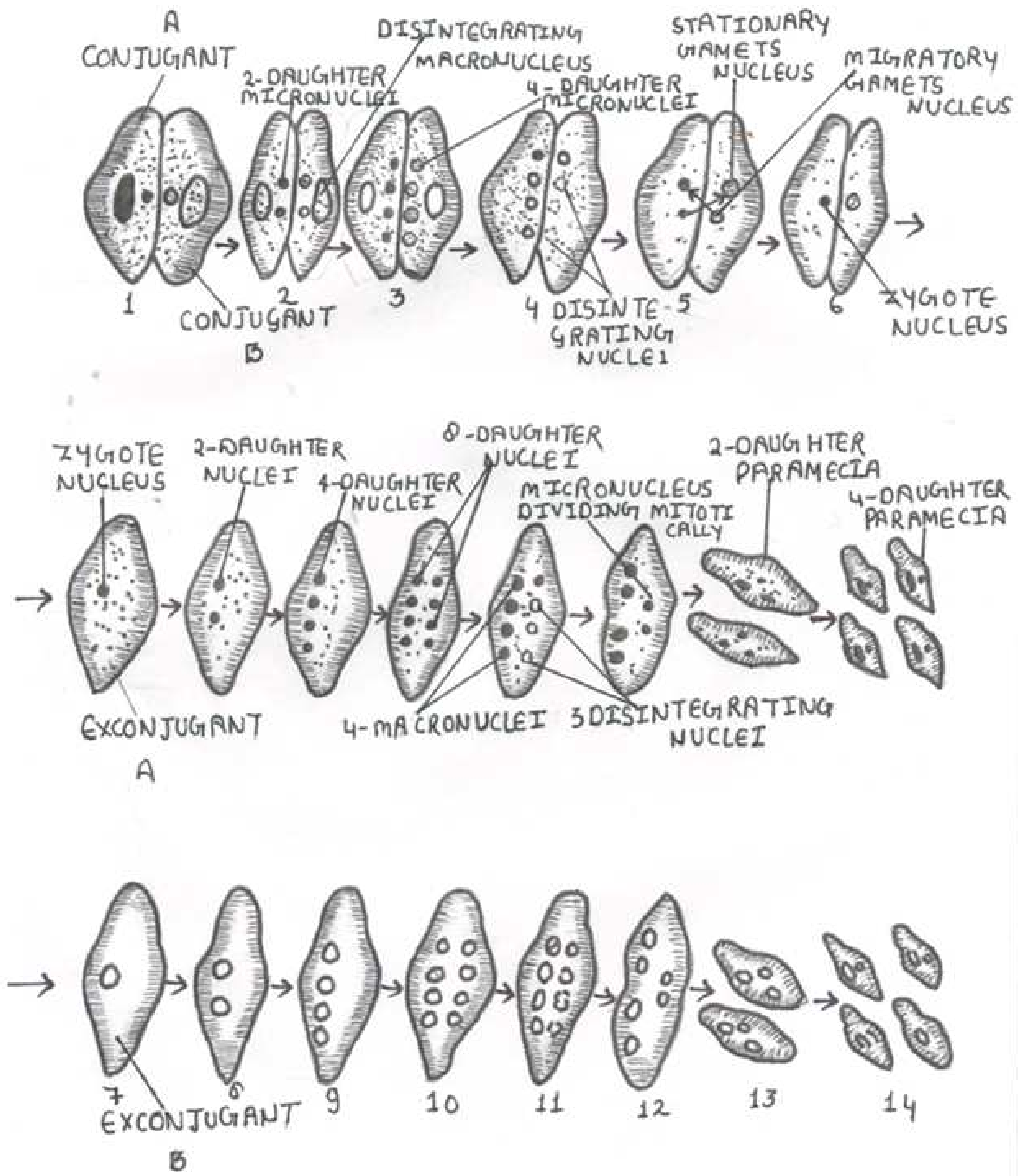

Fig. 13 Paramecium, stage in conjugation

B. As a result four daughter micronuclei are formed each with haploid number of chromosome.
C. Three of the four daughter micronuclei degenerate in each conjugant.
D. The remaining micronucleus divides unequally producing a small active migratory male pronucleus and large and passive stationary pronucleus potentially female.
E. The migratory male pronucleus of the two conjugant's are exchanged so that the male pronucleus of one passes into the other and fuses with the female pronucleus forming the zygote nucleus or synkaryon.
F. The conjugant's now separate and is called exoconjugants.
G. The synkaryon in each conjugant divides thrice and eight nuclei are formed.
H. Four of them enlarge and from macronuclei, while the remaining four are known as micronuclei.
I. Three of the four micronuclei disintegrate.
J. The single micronucleus in each exoconjugants divide twice and each division is accompanied with the division of body.
K. As a result four daughter paramecia are formed from each exoconjugants each with one micro and one macronucleus (Fig.13).

Significance of Conjugation:-

1-Rejuvenation- It has been found that individuals cannot continue to multiply indefinitely by asexual methods. After a definite number of asexual generations the rate of fission declines.

2. Nuclear reorganization: Old and decaying macronucleus is replaced by a new one during conjugation.

3. Heredity variations: The fusion of pronuclear facilitates exchanges of nuclear material.

Autogamy:-

It is found in *P.aurelia.* The process is similar to conjugation but found in a single individual. This is also called as self-conjugation. In P. Aurelia 2 micronuclei are meiosis to form 8 haploid daughter nuclei. 7 of them disintegrate nuclei. The macronucleus is absorbed in the cytoplasm. The 2-ganetic nuclei fuse to form homozygous diploid zygote nucleus or synkaryors. The zygote nucleus divides twice to form 4 nuclei 2 of which become macronuclei & 2 micronuclei. The call body & the micro nuclei divide to form 2 daughter individuals, each paramecium with a macronucleus & 2 micronuclei. Auto gamy was described by W.F. Diller (1936) in *P. Aurelia*.

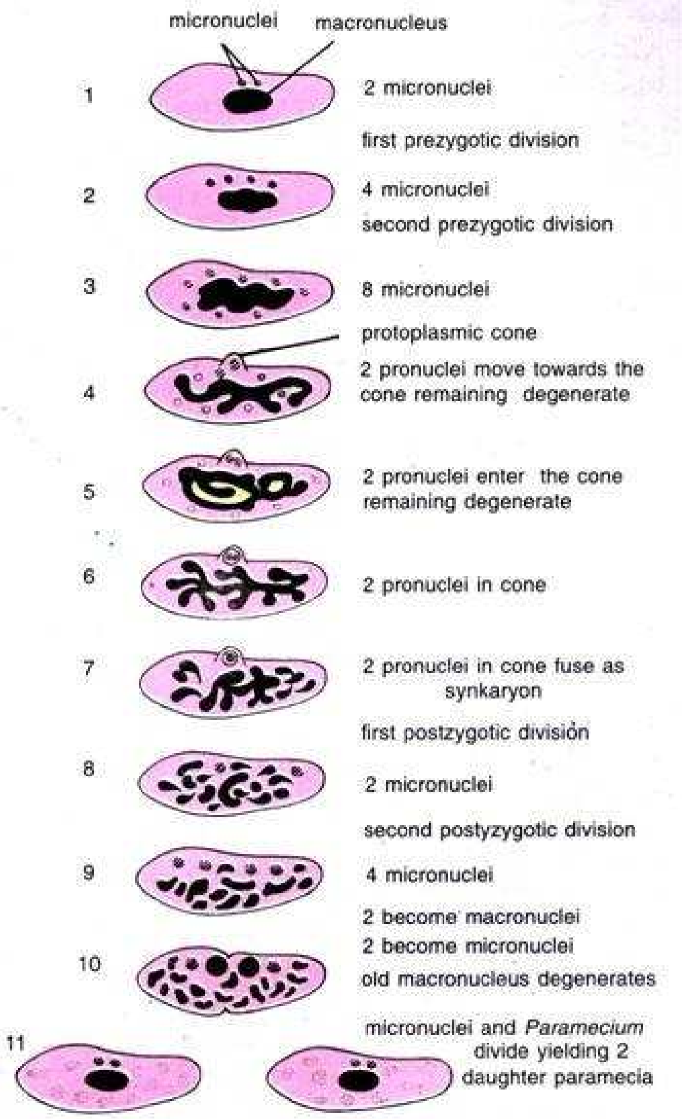

Fig.15 Diagramatic Representation of Autogamy

Cytogamy:

It is a sexual process without nuclear exchange thus called as cytogamy. The process resembles conjugation. Two small individuals temporarily fuse by their oral surfaces. The early nuclear divisions are similar to conjugation, but there is no nuclear exchange between two individuals. But two haploid gamete nuclei in each individual fuse to form a synkaryon as in auto gamy. The process completed in about 12 to 13 hours. Cytogamy was reported by R. Wichterman in *P. Caudatum* (1940).

Endomixis - This is the periodic nuclear reorganization in ciliate protozoans. It is internal nuclear reorganization within a single individual taking place in the absence of conjugation. Erdmann &

woodruff in 1914, first of all reported in the bimicronucleate species, *P. Aurelia* at regular intervals of about 30 days. The macronucleus disappears & degenerates. The micronuclei (2) divide twice mitotically forming 8 daughter nuclei of which 6 degenerate. At this stage Paramecium also divides, each daughter has one micronucleus. This micronucleus divides twice forming four micronucleus, two of which become microlei & two macronuclei, in each individual. The micronuclei again divide with the binary fission of Paramecium into two daughters, each getting one macronucleus & two micronuclei. Thus 4 daughters are produced from a single parent.

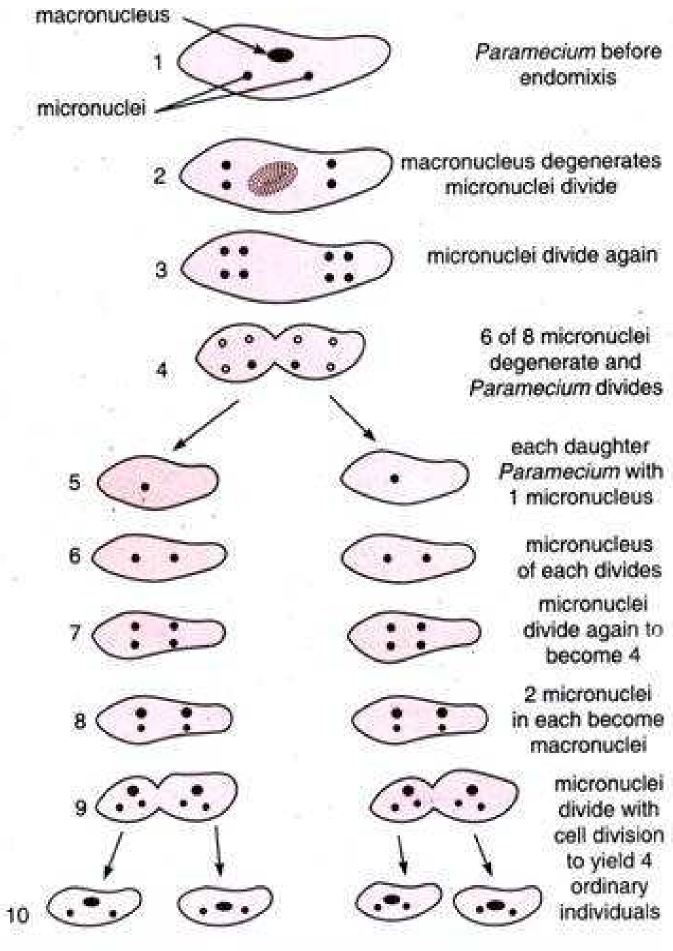

Fig.16 Stage of Endomixis in Paramecium

1.5- Summary

Protozoa means 'first animal' the simplest form of animal life. Protozoa are unicellular microorganisms that lack cell walls. It can grow in marine habitat or soil fresh water symbiotic parasites in other organisms. Protozoa depends on nutrition, temperature, pH, and some depends on sunlight. There are an estimated 30,000 protozoan species. They are aquatic (fresh and salt water) free living parasitic, symbiotic or commensally. They possess different types of locomotory organs. They may bear flagella (flagellates). Locomotory organs are absent in the parasitic forms. The osmotic concentration of cell body (Osmoregulation) is maintained by one or more contractile vacuoles. Asexual reproduction takes place by fission or budding. Sexual reproduction are occurring the fusion of gametes or conjugation **Eg. Free living**- *Euglena, Amoeba, Paramecium, Noctiluca, Elphidium* (Polystomella). **Parasitic**-*Monocystis, Entamoeba, Plasmodium, Trypanosome, Giardia* etc. Encystment occurs to tide over the unfavorable conditions and to help in the dispersal of race.

A phylum protozoon is a larger and varied group and poses a number of problems in its classification. The conventional scheme followed by Hyman (1940), Hickman (1961) and Storer (1965) etc. recognizes two subphyla on the basis of organs of locomotion and five classes.

Paramecium (Gr., Paramekos- oblong + Caudata-tail) is an elongated and sliper shaped animal. Paramecium is a typical ciliate microscopic organism. It is ten species known in world. Ciliates are characteristed by the presence of cilia as locomotor organelles. Paramecium is occurrence in fresh water ponds, lakes, rivers and streams. Its size varies in different species being 120-250µ in P.aruelia and 170-290µ in *P.caudatum.* Its body asymmetrical with flat oral and a convex aboral or dorsal surface. The body is covered by a thin firm but elastic pellicle. **T**he entire body surface is covered by a uniform covering of hair like protoplasmic processes, the cilia. In Paramecium, there is a broad, shallow oral groove on the ventral surface. Paramecium process by three following two methods
1 -Ciliary movement- 2-Body contortions-
Paramecium has two contractile vacuoles, one anterior and one posterior. The function of the contractile vacuoles is osmoregulation.
Paramecium reproduces asexually by transverse binary fission. Ordinarily Paramecium multiplies by binary fission for long periods of time, but at intervals this may be joining of two animals along their oral surfaces for sexual process of conjugation.

1.7-Glossary

Ampulla –	A small bladder like sac.
Asexual reproduction-	Reproduction without involving gametes
Binary fission –	The organism divides into approximately equal halves.
Budding –	It is a form of asexual reproduction.

Cilia – Microscopic hair-like projection.

Commensalism- Association of two different species in which at least one is benefitted and the other is neither benefited.

Conjugation- A method of sexual reproduction.

Contractile vacuole- A space in the cytoplasm of certain species of protozoa where fluids collect before being periodically discharged to the outside.

Cytopharynx – Pharynx of a protozoan such as Paramecium.

Ectocommensal – Pertaining to an organism that lives on the external surface of other organism, the host, without either benefiting or injuring.

Food vacuole- Intra- cellular digestive organelle.

Holophytic – Type of nutrition, found in green plants and in some mastigophores.

Locomotion - Movement involving the organism as a whole.

Micronucleus – In organism with micronuclei, smaller nucleus most useful in reproductive activity.

Mitosis – Cell division during which chromosomes appear to become doubled longitudinally, the halves of each one passing into separate daughter cells.

Multiple-fission- Type of asexual reproduction in which the nucleus perform several mitotic divisions before any cytokinesis.

Pellicle- The protective layer on the surface of some protozoans. E.g. *Paramecium*.

Pseudopodia – Blunt temporary protoplasmic projections found in amoeba.

Sessile – Attached, not free –moving.

Sexual reproduction- Reproduction involving the gametes.

Siliceous – Containing silica.

Stigma – A sensitive pigment or eye spot in certain Protozoa.

Syngamy- Union of gametes in sexual reproduction forming a zygote.

Taxonomic- Classification of organism.

Vacuole – Small structure consisting of a cavity in the cytoplasm filled with a liquid.

1.8-Self assessment question:

1. Describe the structure of Paramecium?
2. Describe the mode of nutrition and locomotion of *Paramecium*?
3. Give an account of the reproductive processes in *Paramecium?*
4. Classify phylum Protozoa upto orders?
5. Which type of excretion is found in protozoa? How does excretion occur in protozoans?

1.9-References:

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Hausmann, K.and Hu lsmann, N. (1996). Protozoology, 2nd edn. Stuttgart: Georg Thieme.

Kudo, R.R. (1966). Protozoology, 5th edn. Springfield, IL: Charles C Thomas.

1.10-Suggested Readings:

(a) Invertebrate Zoology, Author - E. L. Jorden and P. S. Verma.
(b) A text book of Invertebrate Zoology, Author –Dr. S. N. Prasad.
(c) Biology of the Invertebrate Zoology, Author –Jan A.Pechenik.
(d) Invertebrate Zoology, Author –Ruppert, Fox and Barnes.
(e) Invertebrate Zoology, Author –D.T.Anderson.
(f) Invertebrate Zoology, Author –Joseph G.Engeman and Robert W.Hegner.
(g)Invertebrate Zoology, Author –Fatik Boran Mondal
(h) Morden text book of Zoology Invertebrate, Author –R.L.Kotpal.
(i) Invertebrate Zoology, Author –Paul A.Meglitsch and Frederick R. Schram
(j) Text book of invertebrate Zoology, Author – G.S.Sandhu.

1.11-Terminal Questions:

1. What are the methods of reproduction in Protozoa?

2. What are the methods of nutrition in protozoa?

3. Describe the process of osmoregulation in *Paramecium*?

4. In some protozoans, a special structure called vacuole is present. What is its function and where is it found in protozoans?

5. Differentiate between commensalism and parasitism?

6. Describe modes of locomotion in protozoa?

1.12-Multiple Choice Questions:

1. Coprozoic nutrition is found in-
   (a) Balantidium [ ] (b) Euglena [ ] (c) Noctiluca [ ] (d) Copromonas [√]

2. Holophytic (autotrophic) nutrition-
   (a) Paramecium [ ] (b) Balantidium [ ] (c) Euglena [√] (d) Nyctotherus [ ].

3. Saprophytic or saprozoic nutrition is found in-
   (a) Euglena [√] (b) Leishmania [ ] (c) Amoeba [ ] (d) Monocystis [ ].

4. Photoreceptor organof euglena is-
(a) Stigma near reservoir [ ] (b) Paraflagella body at the base of flagellum [ ] (c) Stigma and paraflagella body [√] (d) chromatophore [ ].

5. Lactoflavin (sensitizer) found in-
(a) Eye spot [ ] (b) Paraflagella body [√] (c) Golgi bodies [ ] (d) mitochondria [ ].

6. Euglena is green in colour which is due to-
(a) Chromatophores [√] (b) Leucoplasts [ ] (c) Carotene [ ] (d) Pyrenoid and paramylum [ ].

7. Euglena belong to class-
(a) Phytomastigophorea [√] (b) Zoomastigophorea [ ] (c) Rhizopodea [ ] (d) Actinopodea [ ]

8. Connecting link between plank and animal kingdom-
(a) Paramecium [ ] (b) Euglena [√] (c) Bacteria [ ] (d) Virus [ ].

9. Which is oldest one of the anima--?
(a) Amoeba [ ] (b) Paramecium [ ] (c) Euglena [√] (d) opalina [ ].

10. Osmoregulation in euglena occur with the help of-
(a) Vacuole [ ] (b) Food vacuole [ ] (c) Contractile vacuole [√] (d) none [ ].

11. Main function of contractile vacuole is

(a) Nutrition [ ] (b) Excretion [ ] (c) Osmoregulation [√] (d) Locomotion [ ].

12. Digestion in protozoans is

(a) Intercellular [ ] (b) Intracellular [√] (c) Extracellular [ ] (d) All of these [ ].

13.. Cytopyge is found in

(a) Amoeba [ ] (b) Paramecium [√] (c) Euglena [ ] (d) Trypanosoma. [ ]

UNIT 02: PHYLUM- METAZOA

Contents

2.1- Objectives

(1) Study of Germ layers.
(2)Study of diploblastic and triploblastic Organization.

2.2-Introduction

Metazoans are the multicellular organism which develops from embryo; they are heterotrophic and motile eukaryotes organisms. Their body is polarized along an anterior-posterior locomotory axis. Metazoans body is composed of functional specialized cells, each type of which is dedicate to one or a few functions.There is a great diversity in metazoans and according to the most widely accepted groupings there are 30 phyla of which only one, viz. the chordata, contains animals which are not invertebrates. The important features on the basis of which the metazoan hierarchy is decided are: symmetry, coelom and metamerism.

Lower and higher Metazoa:

We saw that animal phyla can be arranged in several different ways on the basis of their structural traits, as follows:

1. Asymmetrial (most Porifera), radially symmetrical (Coelentrata) and bilaterally symmetrical (all others).

2. Diploblastic (Porifera and Coelentrata) and triploblastic (all others).

3. Acoelomate (Porifera to Plathelminthes), Pseudocoelomate (Entoprocta, Acanthocephala, Aschminthes) and coeloate (all others).

4. Segmented (Annelid. Arthopoda, Tardigrada, Chordata) and coelomate (all others).

5. Chordates (Proto-chordata and Vertebrate) and non- chordates (all others).

6. Vertebrates (higher chordates) and invertebrates (all others).

Major Groups of Animals	Phyla	Number of species
Subkingdom I Protozoa.............	➢ 1. Protozoa	50,000
Branch 1. Mesozoa..........	+ 2. Mesozoa	50
Branch2. Parazoa...........	➢ 3. Porifera	5,000
Grade A. Radiata	➢ 4.Coelenterata	11,000
	+5. Ctenophora	90
(i) Subdivision Acoelomata	➢ 6. Platyhelminthes	15,000
	+7. Rhyncocoela (Nemertinea)	750
(ii)Subdivision Pseudocoelomata	+8. Acanthocephala	500
	+9.Entroprocta	60
	+10. Rotifera	1,500
	+11. Gastrotricha	175
	+12. Kinorhyncha	100
	➢ 13. Nematoda	12,000
	+ 14. Nematomorpha	100
(iii)Subdivision Lophophorate Coelomata	+15. Phoronida 15	
	+16. Ectoprocat (Bryozoa)	4,000
	+17. Brachiopoda	260
(iv) Subdivsion Schizocoelous Coelomata	+18. Priapulida	08
	+19. Spinunculida	275
	➢ 20. Mollusca	80,000
	+21. Echurida	60
	➢ 22. Annelida	8,700
	+23. Tardigrada	180
	+24. Onychophora	73
Subkingdom II. Metazoa	➢ 25. Arthropoda	900,000
Branch3.Eumetazoa **Subdivision Enterocoelous Coelomates**	26. +Pentastomida	70
	27. +Chaetognatha	50
Grade B. Bilateria	➢ Echinodermaa	6,000
Division 2. Deuterostomia	+29. Pogonophora	80
	+30.Hemichordata	80
	*31. Chordata	49,000

➢ **Shows major phyla discussed in detail in this volume and + Shows Minor Phyla.**

*** Treated in second volume on "Vertebrates".**

1. **Lower Metazoa:**
    - Porifera, Colenterata, Platyhelminthes, Aschelminthes, Entoprocta and Acanthocephala are generally called Lower Metazoa.
    - They are unsegmented, radially or bilaterally symmetrical, diploblastic or triphloblastic and acoelomate.

2. **Higher Metazoa:**
    - The remaining phyla namely Mollusca, Annelida, Arthopoda, Echinodermata and Chordata etc. are known as higher Metazoa.
    - They are triploblastic and truly coelomate animals.
    - Except chordata, all are non-chordates or invertebrates.
    - However, the lower and higher metazoan phyla, based on structural traits or characters, must not be confused with the Minor and Major phyla which are based on different criteria, such as the number of species and individuals and their participation in ecological communities

2.3-Germ layers:-

The primitive cell layers, or first tissues, which appear early in the development of animals and from which the embryo body and its auxiliary membranes, when present, are constructed. These are more or less distinct anatomically, but do not necessarily have sharp boundaries of demarcation.

Germ layers are almost universal among animal embryos and appear to establish discontinuities of architectural importance without complete loss of continuity.

Three kinds of germ layers are recognized:

(1) The ectoderm or outer layer

(2) The endoderm or inner layer

(3) The mesoderm or middle layer

The layers have been named in accordance with their positions in the spherical type of gastrula such as that of the sea urchin or amphibian. The terms epiblast, mesoblast, and hypoblast are sometimes used as synonyms for ectoderm, mesoderm, and endoderm, respectively. The majority of organisms have all three primary germ layers: the exterior, or ectoderm; the interior, or endoderm; and the middle, or mesoderm. Exceptions are the sponges and coelenterates, in which only two germ layers are formed, the exterior and the interior and a distinct mesodermal layer are absent.

Derivatives of the ectoderm:

- Perform integumental, sensory, and motor functions:
- In the course of embryonic development they give rise to the nervous system;
- The skin integument and the skin glands that are formed from it;
- The hair, plumage, scales, nails, and so forth;
- The epithelium of the anterior and posterior sections of the digestive system;
- The connective-tissue foundation of the skin; the pigment cells; and the visceral skeleton.

Derivatives of the endoderm:

- The endoderm forms the lining of the intestinal cavity
- Provides nutrition for the embryo;
- From it originate the mucous membrane of the digestive system, the digestive glands.
- Forms the organs of respiration.

Derivatives of the Mesoderm:

- The mesoderm effects communication between the parts of the embryo
- Performs supportive and tropic functions;
- From it are formed the organs of excretion, the sex organs,
- Forms the circulatory system, and
- Forms the serous membranes that line the secondary body cavity (coelom) and clothe the internal organs and muscles;
- In vertebrates the skeleton is also formed from the mesoderm.

Analogous germ layers in different groups of organisms may have, in addition to common traits, substantial differences in their manner of formation and their structures, because of the adaptation of the embryos to different conditions of development.

2.4- Metazoan Organization

Animals show various patterns in their morphology. Relationships between animals or groups of animals are best explained by their cooperative morphology and embryology.
The gross external morphology of animals falls under a limited number of patterns (criteria).

- These include form of animals (symmetry),
- arrangement of body parts in segments (metamerism),
- formation of a head (cephalization), and
- Progressive sequence of specialization of structure (levels or grades of organization).

Similary, the criteria of internal morphology are differences in formation of body cavity (coelom) and reproduction (embryology), etc.

Symmetry and its significance:

- Symmetry means an arrangement of body parts into geometrical designs. It refers to the division of body into equal parts by lines or planes.
- An animal is called symmetrical when a plane passing through its centre will divide into similar halves.
- When an animal cannot be divided into like parts by a plane, it is called asymmetrical e.g. sponge, some Protozoa (Amoeba) and few others.
- Certain terms are often used when explaining symmetry.
- **An axis** is an imaginary line passing through the center of body, such as longitudinal axis and oral-aboral axis. Either end of an axis is termed a pole. Thus, each axis has two poles.
- **A plane of symmetry** is a straight line that divides into corresponding halves.
- Metazoa commonly display two types of symmetry, radial and bilateral. Two other types of symmetry are also recognized, spherical and biradial.
- Protozoa are not only asymmetrical but display all four types of symmetry in their diverse body forms.

1. Spherical symmetry:

- It is found in animals whose body has the shape of a sphere.
- All planes that pass through the center will cut it into similar halves.
- Some protozoans (e.g.Volvox, Helozoa, Radiolaria) have sepherical symmetry, and it is adapted for free-floting or rolling movments (Fig.1).

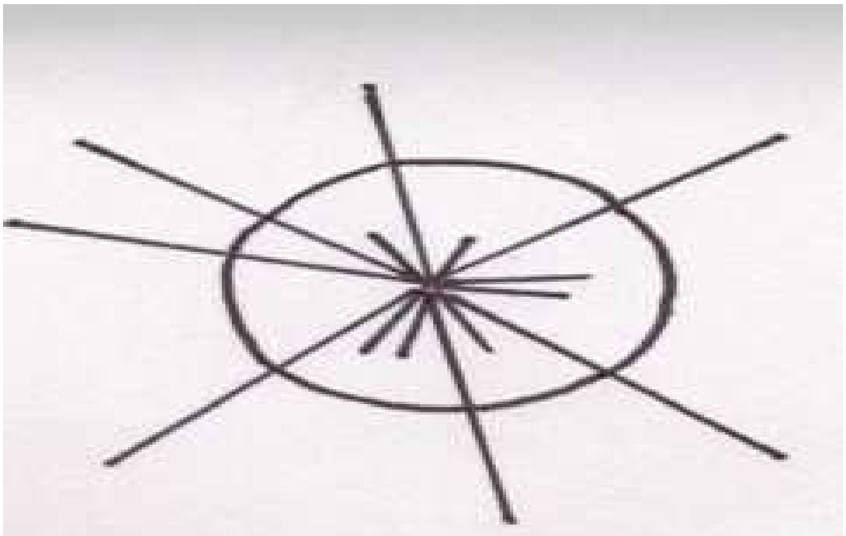

Fig 1.Spherical Symmetry

2. **Radial symmetry:**

- Many similar body parts, called antimeres, are arranged around one main, central or longitudinal axis in a circular or radiating manner like the spokes of a wheel.
- All the lines passing through this longitudinal axis, in any plane, will divide the body into equal halves or antimeres.
- The surface having mouth is the oral surface, and the opposite surface is the aboral surface. Examples are echinoderms and most colelentrates (e.g. Hydra).
- The body is in the form of a flat or tall cylinder.
- Radial symmetry is best suited for a sessile existence.
- Most of them attached by the aboral surface.
- Some are free-swimming but remain at the mercy of water current.
- Due to similarity of antimeres, their sensory receptors are equally distributed all around the periphery.
- This enables them to receive stimuli and to meet the challenges of the environment equally from all direction.
- They can obtain food or repel enemies from all sides (Fig.2).

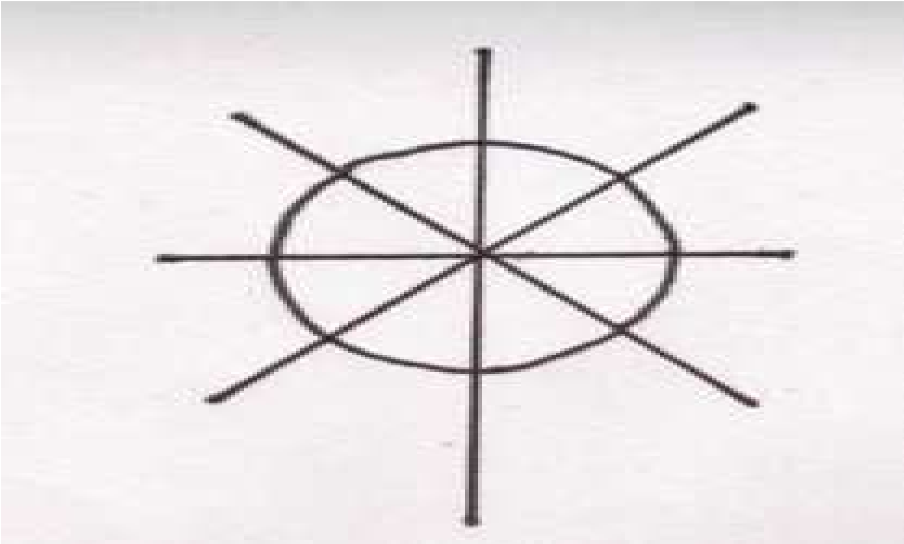

Fig 2. Radial Symmetry

In the animal kingdom, radially symmetrical phyla and porifera, Coelenterata, Ctenophora and Echinodermata. Out of these, only Coelenterata and ctenophore display a fundamental radial symmetry. Both the phyla were groupe together by Haatschek (1888-91) under the division Radita. Adult porifera are mostly asymmetrical larva. On the other hand, larval stage of Echinodermata has bilateral symmetry, but the adults become radilly or pentaradially symmetrical.

3. Biradial symmetry:

- It is a variant from of radial symmetry found in Ctenophora and most Arthozoa (e.g.anemones), and is best fitted for a floating life.
- There are only 2 planes of symmetry, one through the longitudinal and sagittal axis and the other through the longitudinal and transverse axis, which will divide the animal into equal halves (Fig.3).

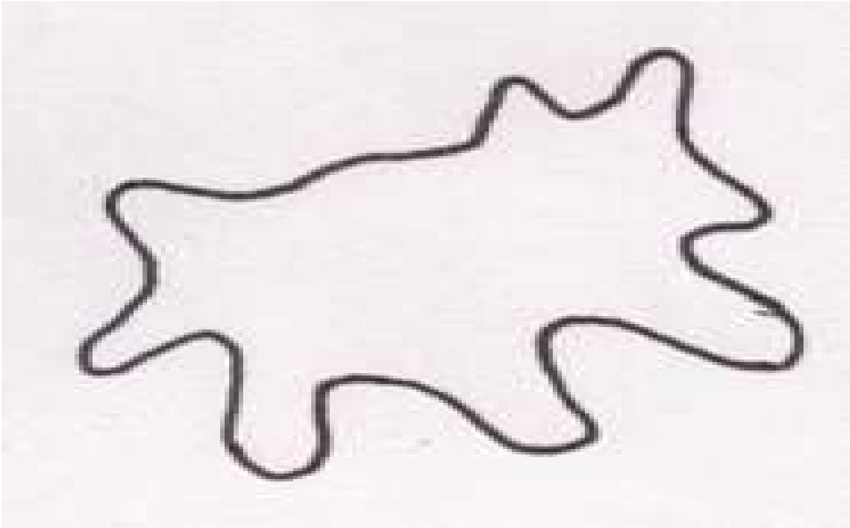

Fig 3. Asymmetry

4. Bilateral symmetry:

- In higher animals, the longitudinal axis of body runs from the anterior end (head) to the posterior end (tail).
- There is a single plane, the median longitudinal or sagittal plane, through which the body can be divided into two similar rights and left halves. This is called bilateral symmetry.
- Besides right and left sides, an upper or dorsal surface and a lower or ventral surface are also recognizable, which are unlike because they are exposed to different condition.
- Bilateral symmetry is characteristic of the most successful and higher animals, including the remaining invertebrates and all vertebrates. In most of them, the anterior end is differentiated into a head (Fig.4).

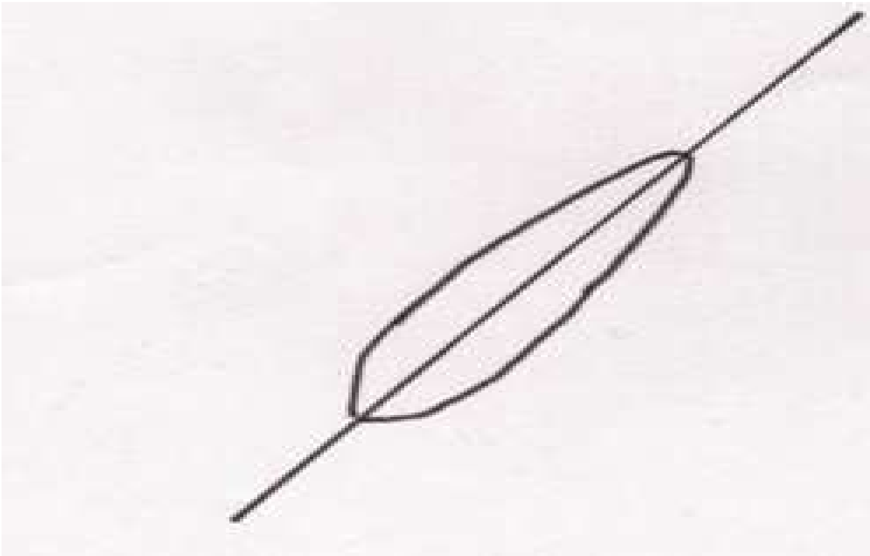

Fig 4. Bilateral Symmetry

- First phylum of animal kingdom to exhibit bilateral symmetry is the phylum Platyhelminthes.
- All bilateral symmetrical metazoans were grouped together by Hatschek (1988-91) under the division bilateria. As already mentioned earlier, some bilateria, such as echinoderms, display a radial symmetry which has been secondarily derived from bilateral ancestors due to assumption of an attached mode of life by adults.
- Cephalization and Polarity; Bilateral symmetry is correlated with the locomoter movements brought about by these animal. One end of their body, usually containing the mouth, always moves forward in a particular direction.
- It is the first to come in contact with the environment, so that there is great concentration of nervous tissue and sense organs at this anterior end called head. The posterior or rear end is usually equipped with some locomotory organ. This modification of anterior or oral end of the animal into a definite head is called cephalization which is characteristic of most bilateral animals.
- Cephalization is always accompanies by a differentiation along an antero-posterior or oral aboral axis. This condition is known as polarity, and it usually involves gradients hitch refers to ascending or descending activates between anterior and posterior ends.

2.4.1-Diploblastic and Triploblastic Organization

- In Metazoa, special regions of the body are set aside for dealing with different functions.

- The Metazoa produce gametes of two types, the male gametes are spermatozoa and female gametes are ova.
- A spermatozoon fertilizes an ovum to from a zygote which undergoes a series of mitotic cell division to from a hollow ball of cells called blastula it has a cavity known as blastocoel.
- Further increase of the cells of the blastula causes an invagination of the wall on one side, and by different processes the cells eventually come to lie in two layers, an outer layer of ectoderm and an inner layer of endoderm, the blastocoel is obliterated; the mouth of the invagination is a blastopore which leads into a new cavity, the archenteron; this two layered bag is a gastrula.
- The development of some Metazoa stops at gastrula stage, these two –layered Metazoa are diploblastic, such as Cnidaria and Ctenophora.
- In all other metazoan phyla, a third layer of cells called mesoderm arises between the ectoderm and endoderm.
- The phyla which possess three layers are triploblastic, and their mesoderm opens up further possibilities of increase in size and complexity.
- In triploblastic phyla, the ectoderm and endoderm retain most of the function which they perform in diploblastic animals.
- The ectoderm forms the outer protective epidermis, external sense organs, nephridia and the nervous system, but in Echinodermata, part of the nervous system is mesodermal in origin.
- The endoderm gives rise to the lining of alimentary canal and organs associated with digestion and respiration.
- The mesoderm is not single entity but has parts which originate in two ways; the cells which migrate from the ectoderm or endoderm form a loose cellular tissue called mesenchyme which fills the spaces between the other layers, and it is comparable to the cells which are found in the mesogloea of Cnidaria.
- The second type of cells which from the wall of the body cavity are known as mesothelium or real mesoderm which gives rise to connective tissue, muscles, skeleton, blood, circulatory system, excretory system and reproductive system.
- In lower triploblastic phyla (Platyhelminthes and Aschelminthes), there is no mesothelium, in Chaetognatha there is no mesenchyme, but the other phyla possess both kinds of mesoderm.
- The triploblastic acoelomate animals may attain a degree of complexity not seen in diploblastic animals. (Fig.5).

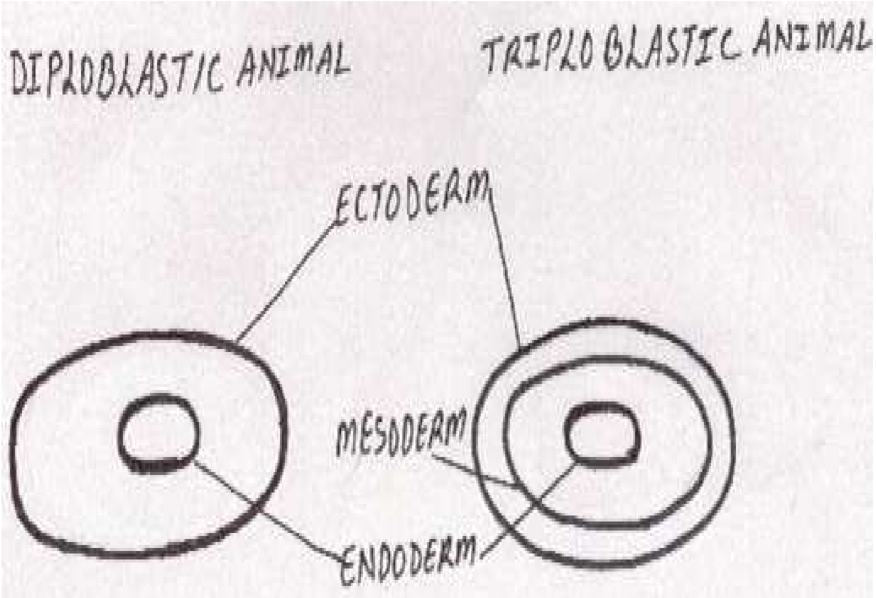

Fig 5. Diploblastic & Triploblastic Animal

Eg. Diploblasts (e.g. *Hydra, Nematostella-)* - Only two germ layers Radial Symmetry.
Triploblasts or Bilateria (the rest) **-** Three germ layers Bilateral Symmetry

2.4.2- Theories on the origin of metazoans:

Cnidarians have been regarded as the most primitive eumetazoan and the possession of radial symmetry has been regarded as a primitive character of cnidarians. The origin of metazoa is based on this assumption.

(1) COLONIAL THEORY:

Most widely accepted theory was first conceived by Haeckel (1874). Later, the theory was modified by Metschnikoff (1887) and Hyman (1940). According to this theory the ancestors of the metazoans are the flagellates. The ancestral metazoan probably arose from a spherical, hollow, colonial flagellate. The colony possessed a distinct anterior-posterior axis with monoflagellate cells on the outer surface. It moved with its anterior axis forward. The somatic cells were differentiated from the reproductive ones. This hypothetical stage was called **blastaea**. It is believed to reflect, the blastula stage which occurs in the development of all animals. The blastaea invaginated to produce a double-walled **gastrea** which was regarded as the hypothetical metazoan ancestor by Haeckel. This gastrea was equivalent to the gastrula stage in the embryonic development of living metazoans. Division of labor of the somatic cells probably led to increasing interdependence of cells and finally an original colony of unicellular individuals became a multicellular organism.

Metschnikoff argued that the originally hollow blastaea became transformed into an organism having a solid structure (gastraea) by the proliferation of the cells from the blastula wall into the blastocoel. This hypothetical ancestral metazoan is believed to be radially symmetrical, ovoid, with no definite mouth. The outer flagellated cells assumed a locomotory function while the inner ones were nutritive and reproductive in function.
This hypothetical ancestral metazoan resembled the planula larva of cnidarians and has been called as the planuloid ancestor who has given rise to the lower metazoans **.**Thus, this theory clearly suggests that the cnidarians have been derived from the planuloid ancestor and that the radial symmetry is primary one and that the bilateral symmetry is a later modification.

(2) CELLULARISATION / SYNCYTIAL THEORY:

Hadzi (1953) and Hanson (1977) are the chief proponents of this theory. They suggested that the metazoans have evolved by the cellularization of a syncytial protistan. According to them most primitive acoelous turbellarians e.g. *Convoluta* were derived from multinucleate ciliated protistans by the process of cellularisation. Since many ciliates tend towards bilateral symmetry they argued that the ancestral metazoans were bilaterally symmetrical and gave rise to the acoels which were regarded as the primitive living metazoans.

POINTS IN FAVOUR:

(a) Size of the acoels is comparable to the ciliates.
(b) Acoels are also ciliated.
(c).Bilaterally symmetrical.
(d).Both lack a hollow digestive cavity.
(e).Imperfect cellularisation is found in the acoels. Syncytial aggregates have been found in the central region of the parenchyma of the acoels.

However, Hadzis theory also suggests that the Cnidarians, more specifically the anthozoans were derived from the turbellarians and that their radial symmetry is because of their sessile mode of existence. These cnidarians retained some of their ancestral bilateral symmetry internally in the stomodaeum, mesentries and muscle bands. Thus, according to this view, the Hydrozoans are advanced rather than being primitive and that their simple structure is a secondary adaptation to its mode of existence.

CRITICISM:

- This theory is based on the adult structure and disregards the embryological evidences.
- The development of turbellarians, nemerteans, annelids, molluscs and some other groups show spiral cleavage which is not found in cnidarians or ctenophora.
- The cnidarians show a wide variety of cleavage patterns suggesting a primitive nature of this group.

- The mere fact that cnidarians have evolved from the turbellarians would mean the abandonment of spiral cleavage which seems improbable.
- The primitive groups are generally more variable with a simple body plan than the highly evolved ones.
- Hydrozoans are more variable than either Anthozoa or Scyphozoa or Turbellaria and therefore Hydrozoa should be considered most primitive. However, according to Hadzi, hydrozoans are regarded as advanced and their structural simplicity is a secondary development.
- According to this theory, the acoels are the most primitive living metazoans. Thus, the bilateral symmetry becomes primitive for the metazoans. This would mean that the radial symmetry of the cnidarians has been secondarily derived from the flatworms. Many zoologists now doubt that the acoels are the most primitive flatworms.
- A ciliate ancestry does not explain the occurrence of flagellated sperm in metazoans.
- Most sessile animals are hermaphrodite. With a few exceptions, anthozoans are not hermaphrodites. Thus, it seems dubious to consider anthozoans as the descendants of hermaphroditic turbellarian

2.5- Summary

- All are Multicellular/Specialized cells.
- All are Eukaryotic Heterotrophs.
- No cell wall or Chloroplasts Dominant diploid (2n) organism.
- Store glucose as Glycogen**.**
- Most mobile at some point in life cycle.
- Larva (free living sexually immature form) may be only time in some
- Development of Zygote undergoes cleavage (Mitosis) to make Blastula (hollow ball of cells).
- Gastrulation: Cells in blastula move inward over lip of Blastopore Form digestive system (tube within a tube) .
- Germ layers form some animals only two germ layers form (Diploblastic).
  Eg: Sponges and cnidarians
- Most animals -Three germ layers form (Triploblastic). Germ Layers i.e. :
- **Endoderm-**forms lining of digestive tract, digestive (Liver and Pancreas) and respiratory organs (Lungs).
- **Mesoderm-** forms muscle, skeletal, circulatory, excretory, reproductive systems.
- **Ectoderm-** forms outer covering (epidermis), brain, central nervous system.

2.6-Glossary

Acoelomate: Animals without coelom.

Archenteron: Primary digestive tract of the metazoan embyo, formed during gastrulation.

Asymmetry: Condition in which opposite sides of an animal are not alike, without symmetry.

Bilateral symmetry: The arrangement of the body parts so that the right and left haflves are mirror images of each other.

Bilateria: The metazoans with bilateral symmetry.

Biradial symmetry: Condition in which an animal has radially arranged parts that lay half on one side and half on other side of a median longitudinal plane. E.g. Ctenophora.

Blastocoel: cavity of the blastula.

Blastula: The early embryo in which the cells form a hollow ball.

Coelom: The body cavity lined with the tissue of mesodermal origin in which the digestive and other organs lie.

Diploblastic: Derived from two embryonic germ layers, ectoderm and endoderm.

Ectoderm: outer Layer of cells in the gastrula. This layer gives rise to the epidermis, sense organs and nervous system.

Endoderm: Innermost layer of the early embryo which gives rise to the lining of the digestive tract.

Gastrula:| An embryonic stage with two germ layers: ectoderm and endoderm.

Gastrulation:	Process by which gastrula is formed; invagination of the blastula.
Mesoderm:	The middle layer of the embryonic cells, between the ectoderm and endoderm.
Metamerism:	Segmentation or longitudinal division of body into many segments.
Phylum:	One of the main taxonomic divisions into which the animal kingdom is divided.
Platyhelminthes:	Phylum that includes the flatworm such as planarian.
Radial symmetry:	The condition in which similar parts are arranged about a common centre like the spokes of a wheel.
Triploblastic:	Derived from the three primary germ layers-ectoderm, mesoderm and endoderm.

2.7- Self assessment question:

1. What are Metazoa and how do they differ from Metaphyta?
2. Define true metamerism and give the various theories of its origin and evolution in metazoan?
3. What is coelom? Describe its conditions throughout Metazoa?
4. Give an illustrated account of various grades or level of structure met within the animals?

2.8-References

- R.L.Kotpal, R. L. (2003). Morden text book of Zoology Invertebrate.
- E. L. Jorden and P. S. Verma (2015). Invertebrate Zoology

2.9-Suggested Readings

(a). Invertebrate Zoology, Author - E. L. Jorden and P. S. Verma.
(b). A text book of Invertebrate Zoology, Author –Dr. S. N. Prasad.
(c). Biology of the Invertebrate Zoology, Author –Jan A.Pechenik.
(d). Invertebrate Zoology, Author –Ruppert, Fox and Barnes.
(e). Invertebrate Zoology, Author –D.T.Anderson.
(f). Invertebrate Zoology, Author –Joseph G.Engeman and Robert W.Hegner.
(g). Invertebrate Zoology, Author –Fatik Boran Mondal
(h). Morden text book of Zoology Invertebrate, Author –R.L.Kotpal.
(i). Invertebrate Zoology, Author –Paul A.Meglitsch and Frederick R. Schram
(j). Text book of invertebrate Zoology, Author – G.S.Sandhu.

2.10-Terminal Questions

(1).Give a detailed account of Metazoa**?**
(2).Write a note on germ layers?
(3). Difference between diploblastic and triploblastic?
(4). Explain the theories on the origin of metazoans?

Multiple choice questions:

1. Animals which develop mouth away from blastopore are called-
(a). Protostomia [ ] (b). Parazoa [√]
(c). Parazoa [ ] (d). Metazoan [ ]

2. Which phyla are radially symmetrical-?
(a).Cnidaria and annelid [ ] (b). Echinodermata and Arhtropoda [ ]
(c). Platyhelminthes and nematode [ ] (d). Cnidaria and protozoa [√]

3. Pseudocoelo develops from-
(a). Mesoderm [ ] (b). Blastocoels [√]
(c). Archenteron [ ] (d). Gut [ ]

4. Radial symmetry generally occurs in-
(a).Free swimming organisms [ ] (b).Sessile organisms [√]
(c).Terrestrial organisms [ ] (d). Parasitic organisms [ ]

5. Syncytial theory explains-
(a). Formation of coelom [ ] (b). Symmetry of animals [ ]
(c). Origin of life [ ] (d). Origin of metazoan [√]

6. Which animal transforms from bilateral to radial symmetry in its history;
(a).Obelia [ ] (b). Starfish [√]
(c). Sponge [ ] (d). Hydra [ ]

7. True coelom is the space between alimentary canal and body wall enclosed by layers of:
(a).Mesoderm on one side and ectoderm on the other [ ] (b). Endoderm on one side and ectoderm on the other [ ] (c). Mesoderm on both sides [√] (d). Ectoderm on both side [ ].
8. Coelom produced from mesoderm cells is called;
(a). Hydrocoel [ ] (b). Enterocoel [ ] (c). Schizocoel [√]
(d). Pseudocoel [ ].
9. On the basis of body organization evolution of animals are grouped as;
(a). Metazoan [ ] (b). Protozoa and Metazoa [√]
(c). Protozoa [ ] (d). Eumatazoa [ ].

UNIT 03: PHYLUM-PORIFERA

(Pours-pore; Ferro-bearing; Robert Grant, 1836)

Contents

3.1-Objectives:-

Understanding the general characters and classification up to order level, *Sycon* structure, reproduction and development, different types of canal system and affinities.

3.2-Introduction:-

Members of phylum Porifera or sponges are most primitive of metazoans or multicellular animals. It includes more than 5,000 species. They appear to be quite life-less and plant like. Porifera are a conspicuous and colorful component of many seascapes.

3.3- General characters and classification up to order level

3.3.1- General characters:

1. Porifera is multicellular organisms.

2. All are marine with few exceptions (A single family of freshwater species. e.g., Spongilla).

3. Its shape some time cylindrical, branching, globular, brightly or dull in colour, they are orange, red, yellow or green colour.

4. Solitary or colonial.

5. The body is perforated by pores and canals but lack other organs (mouth or nervous system).

6. Body is asymmetrical or radially symmetrical. Body surface has numerous pores, the ostia, serving for inflow of water.

7. The water current passes through ostia into the chambers and the central cavity and finally comes out of the body through terminal aperture, the osculum.

8. Body wall has outer pinacoderm (dermal epithelium), inner choanoderm (gastral epithelium) and gelatinous non-cellular mesenchyma in between.

9. No definite organ for feeding and digestion.

10. Digestion is intracellular.

11. The water current serves to bring food organisms and oxygen in the body and carry away the excretory and reproductive products.

12. Cells are loosely arranged and do not form definite layers. Thus are not truly diploblastic.

13. Choanocytes (flagellated collar cells) usually line special chambers.

14. Choanocytes are present only in sponges.

15. Sensory and nerve cells absent.

16. Each cell is directly stimulated and transmits sensations to other cells also.

17. Development is indirect through free swimming cilliated larva, the amphiblastula or parenchyma.

18. All sponges are hermaphrodite.

19. The sexual reproduction occurs by the sperms and ova but asexual reproduction by buds or gemmules.

20. Sponges have great power of regeneration.

21. Sponges are cultivated for commercial purposes.

22. About 10,000 species of sponges are known in the world.

3.3.2-Classification up to order level:

The classification of sponge is based chiefly on types of skeleton found in them. This phylum has been classified variously but the classification suggested by Hyman in 1940 and Burton (1967) are of considerable importance. The phylum porifera is divided into three classes:

PHYLUM-PORIFERA

CLASS-1: CALCAREA OR CALCISPONGIAE

- ORDER:
  1. Homocoela (Asconosa)
  2. Heterocoela (*Sycon*osa)

CLASS-2: HEXACTINELLIDA OR HYALOSPONGIAE

- ORDER:
  1. Hexasterophora
  2. Amphidiscophora

CLASS-3: DEMOSPONGIAE

- SUBCLASS- 1 TETRACTINELLIDA
- ORDER:

1. Myxospongida
2. arnosa or Microsclerophora
3. horistidia

- ❖ SUBCLASS-2 MONAXONIDA
- ➢ ORDER:

1. Halichondrina
2. Poecilosclerina
3. Haplosclerina
4. Hadromerina

- ❖ SUBCLASS-3 KERATOSA

CLASS 1: CALCAREA OR CALCISPONGIAE

- These are small sized calcareous sponges (10cm in height).
- Solitary or colonial.
- Body cylindrical or vase like in shape.
- Skeleton formed of calcareous spicules which may be one, three, or four rayed.
- All are marine animals.
- Body organisation may be asconoid, Syconoid or lenconoid type.

➢ ORDER-1 HOMOCOELA

- Asconoid sponges with radially-symmetrical and cylindrical body.
- Body wall thin and unfolded; choanocytes line the spongocoel.
- Often colonial.

Example- *Leucosolenia, Clathrina*

➢ ORDER-2 HETEROCOELA

- Syconoid and leuconoid sponges with thin walled vase shaped body.
- Choanocytes are found in radial canals or inflagellated chambers only.

Example-*Schypha* (Fig.1-*Sycon*), *Grantia*.

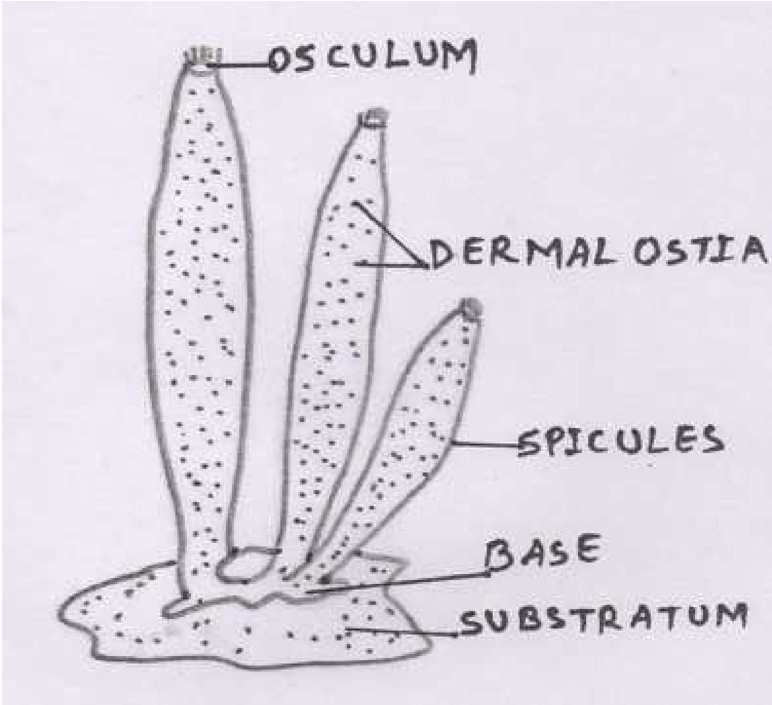

Fig.1: Colony of Sycon

CLASS 2: HEXACTINELLIDA OR HYALOSPONGIAE

- Generally hyalospongiae are found in medium sized sponges but some time few sponges reached one meter in length.
- It is commonly known as glass sponges.
- Its body shape cylindrical, funnel shaped or cup shaped.
- The canal system was very typical and body organization Syconoid type.
- Hexactinellida class is found in deep marine water.
    - ORDER-1 HEXASTEROPHORA
- Spicules are star shaped (six-shaped) eg., hexasters.
- Flagellated chambers regularly and radially arranged.
- Usually attached to substratum directly.

  Example-*Euplectella* (Fig.2-Venus's flower basket)

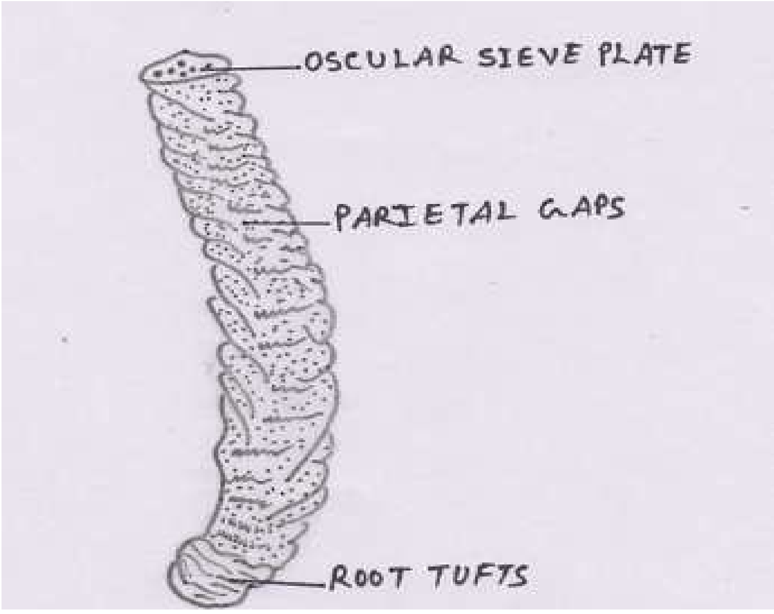

Fig.2: Euplectella

- ORDER-2 AMPHIDISCOPHORA

- Spicules with amphidics, i.e. with a convex disc bearing backwardly directed marginal teeth at both the ends-hexasters absent.
- Attached to substratum by root tufts.

  Example-(a) *Hyalonema* (Fig.3-Glass-rope sponge),

  (b) *Pheronema* (Fig.4-Bowl sponge).

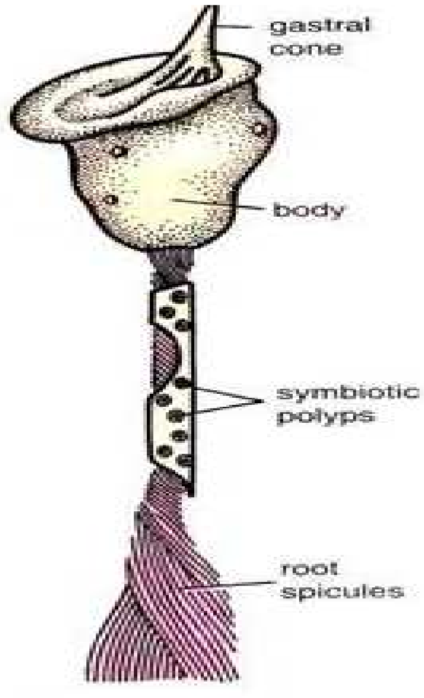

Fig.3: Hyalonema

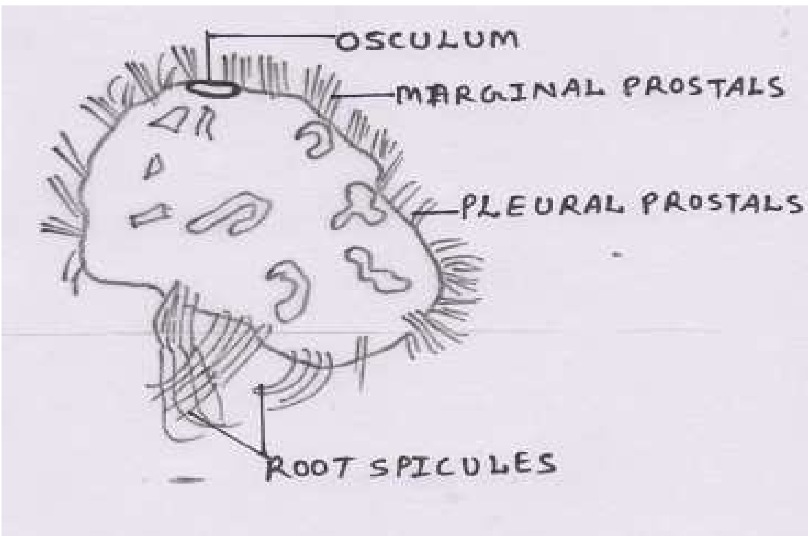

Fig.4: Pheronema

CLASS-3: DEMOSPONGIAE

- Solitary or colonial.
- Its body is cup or vase shaped.

- Demospongiae showed both small and large size.
- Spicules are seen monaxon or tetraxon.
- The canal system is leuconoid type.
- All are marine porifera but except freshwater sponges (Spongillidae).
- The class Demospongiae is classified into the three sub classes.

SUBCLASS: 1 TETRACTINELLIDA

- Spicules siliceous and four rayed (tetraxon) or absent.
- Spongin fibres are absent.
- Mostly found in shallow water.
- Subclass Tetractinellida has been divided into three orders-

  - ORDER1- MYXOSPONGIDA
- Both spicules and spongin fibres are absent.
- Structure simple.
  Example- *Oscarella* (Fig.5), *Halisarca*

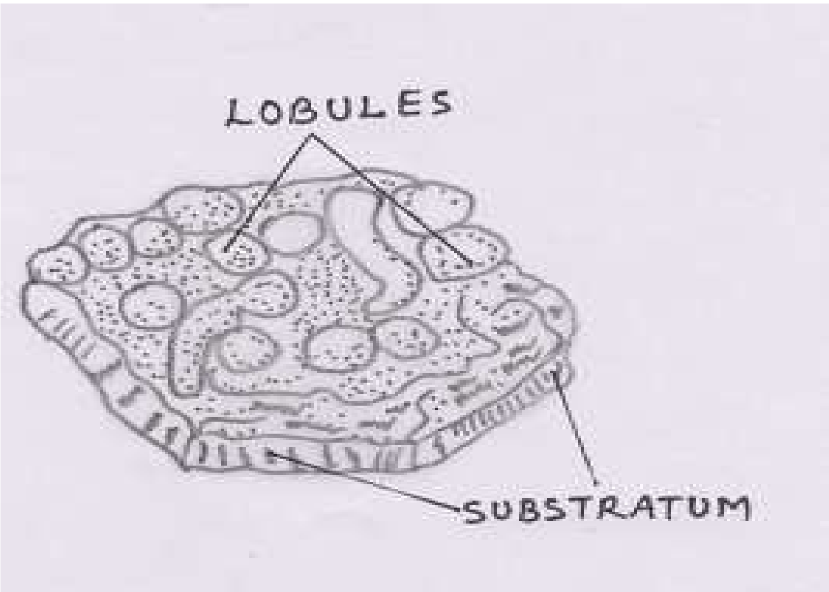

Fig.5: Oscarella

- ORDER2- CARNOSA
- Micro and are indistinct.
- All spicules are monaxons.
  Example- *Chondrilla* and *Plankia.*

- ORDER3- CHORISTIDA
- Micro. Tetraxon spicules with long axis.
  Example-*Thenea, Geodia*

SUBCLASS:2 MONAXONIDA

- Spicules monaxon and siliceous type.
- Spongin fibres some time present or absent.
- Mostly monaxonida is occurring in shallow water.
- Some subclass lives in deep sea but some found in fresh water.

- ORDER1- HADROMARINA
- Spongin fibres absent.
- Microscleres star shaped when present.
  Example- *Cliona* (Fig.6; Boring sponge that bores in molluscan shell)

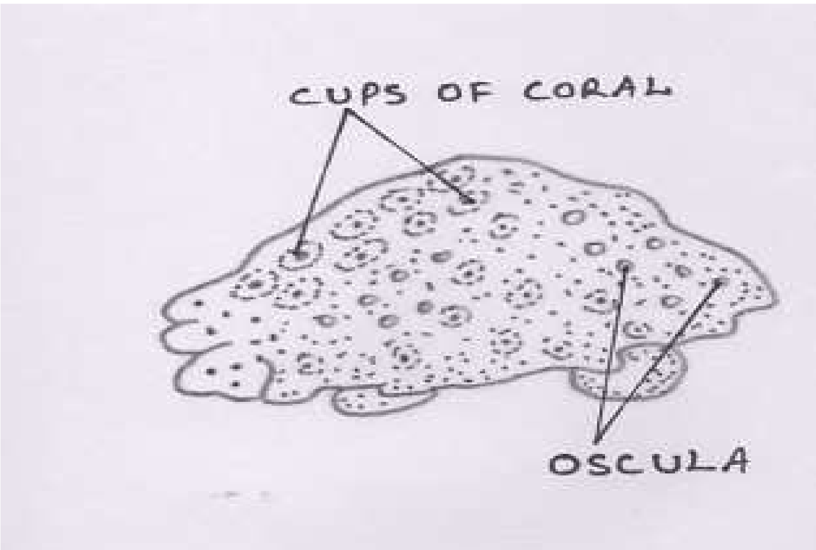

Fig.6: Cliona

- ORDER2- HALICHONDRINA
- Spongin fibres very little.
- Microsclers usually absent.

Example-*Halichondria* (Fig.7-Crum of bread loaf).

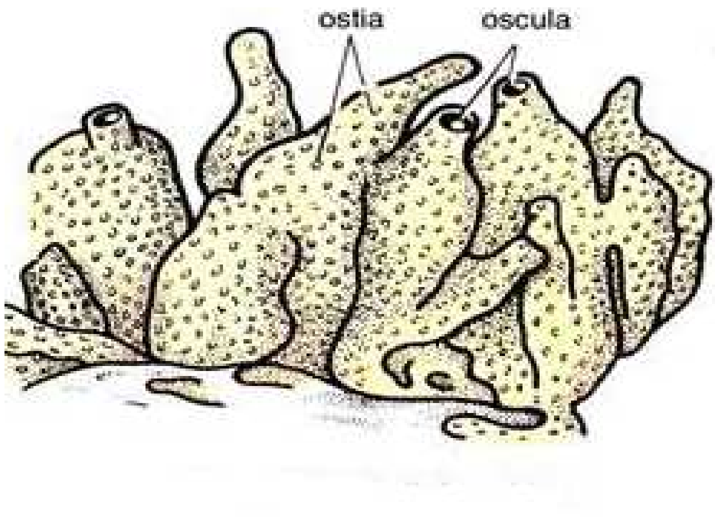

Fig.7: Halichondria

- ORDER3- POECILOSCLERINA
- Large spicules or megascleres of many types and united with spongin fibres and form network.
- Microscleres C-shaped.

Example- *Microciona*

- ORDER4-HAPLOSCLERINA
- Megascleres are only of one type having 2-rays only.
- Microscleres may be present or absent.
- Spongin fibres present.

Example- *Spongilla* (Fig.8) and *Chalina* (Fig.9-Mermaid's eye)

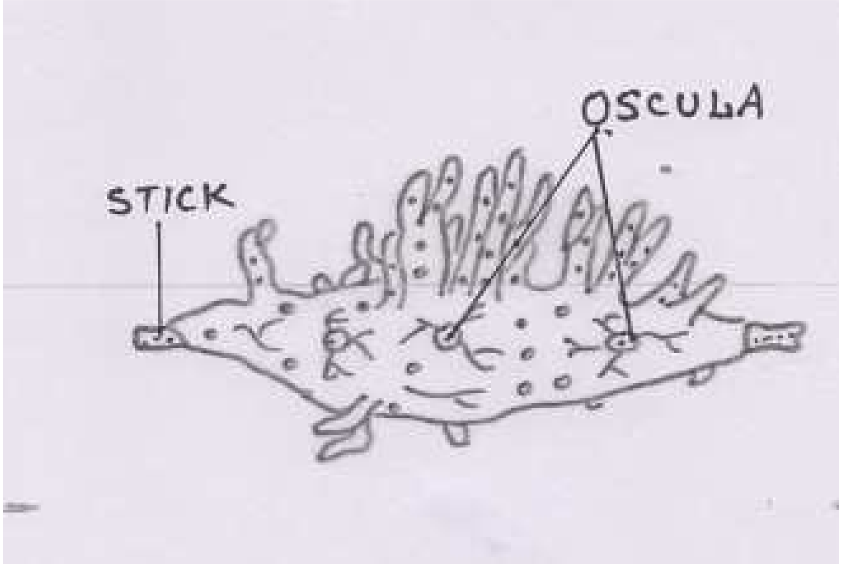

Fig.8: Spongilla

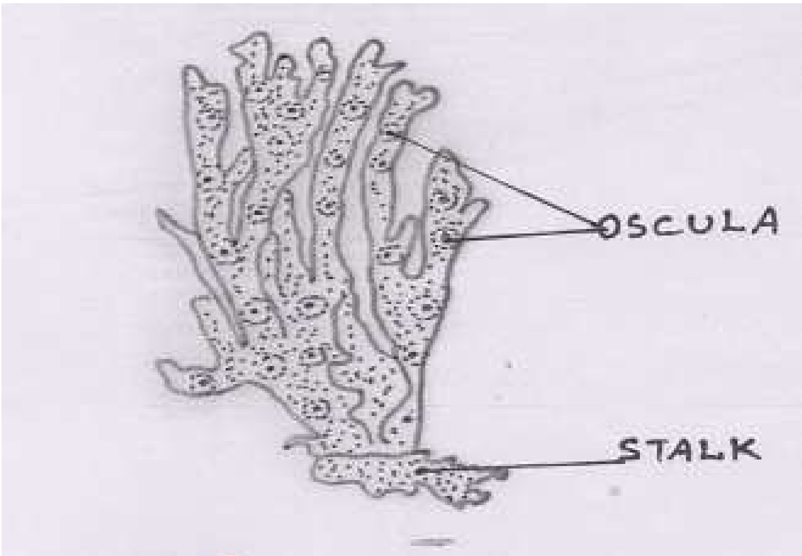

Fig.9: Chalina

SUBCLASS: 3 KERATOSA

- Generally spicules are absent in subclass Keratosa.
- The subclass Keratosa consists of horny sponges.
- Skeleton contains spongin fibres only.

  Example- Horse sponge (Fig.11-*Hippospongia*) and Bath sponge (Fig.10- Euspongia).

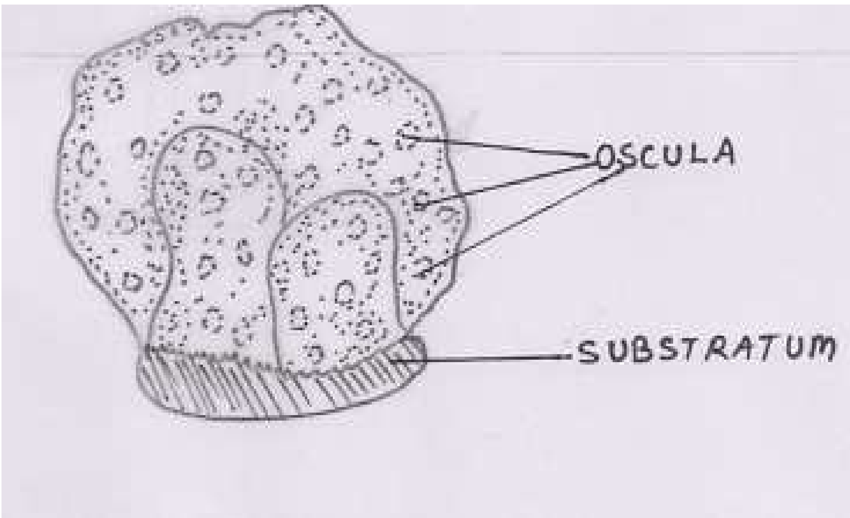

Fig.10: Euspongia

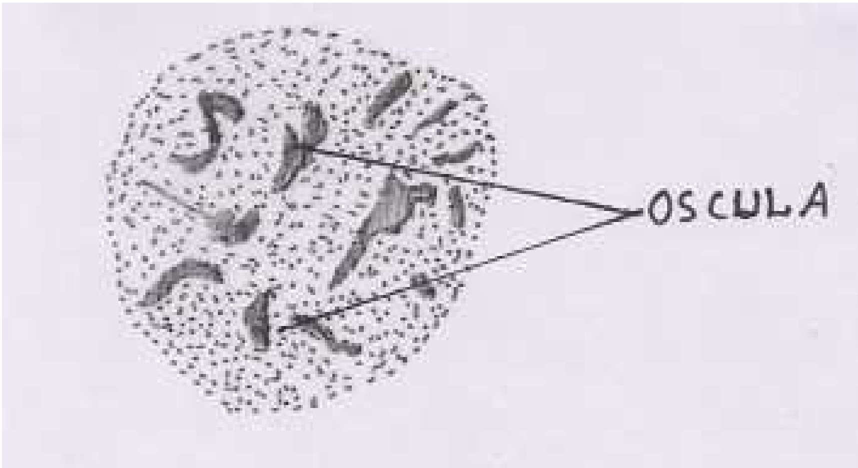

Fig.11: Hippospongia

3.4- Scypha or *Sycon*

Classification:

PHYLUM - PORIFERA

CLASS - CALCAREA

ORDER - HETEROCOELA

GENUS - SCYPHA

Habit and Habitat:-

Scyphy or *Sycon* is commonly called as 'urn sponge or crown sponge' because of its typical shape. *Scyphy* or *Sycon* is marine sponge.This has been found widely in nature. It is found attached to submerged rocks in shallow water near coast. It occur solitary or as branching colonial form (Fig.12).Several species of *Scyphy* are *S. elegans, S.ciliatum, S.lingua* and *S. gelatinosum* etc.

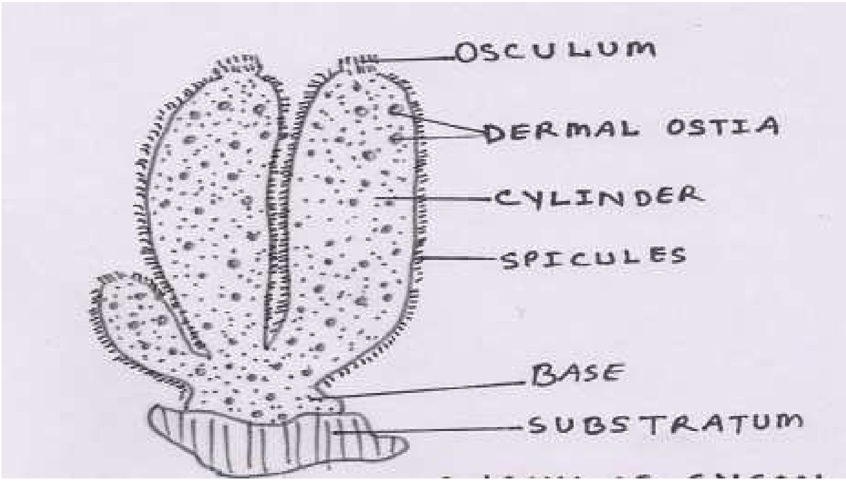

Fig.12: Colony of Sycon

3.4.1-Structure:

External morphology:

Shape- The colony has the appearance of a branching tree.It consists of two to several cylindrical branches connected together to a stolon at their bases. The latter is attached to substratum. Each cylinder is vase like (Fig.12).

Size- The size of a cylinder varies from 2-8cms.

Colour- The sponge presents various shades of grey or light brown colour.

Osculum and oscular fringe:

The free distal end of each cylinder has wide opening, the osculum or exhalent pore.

It is surrounded by numerous straight needles like calcareous spicules arranged in a circle.

Dermal pores or *ostia*:

Body surface of *Sycon* has regularly arranged polygonal elevations separated lines or furrows. In furrows present numerous apertures, the ostia or inhalant pores and open into current canals. Entire body surface has spicules protruding out from it.

Canal System in *Sycon:*

Sycon, like all other sponges, possesses the characteristic peculiarity-the canal system. The body wall of sponges is folded to produce complex system of pores and canals for entrance of water current. Scypha or *Sycon* represents *Sycon* type of canal system (Fig.13 and 14).

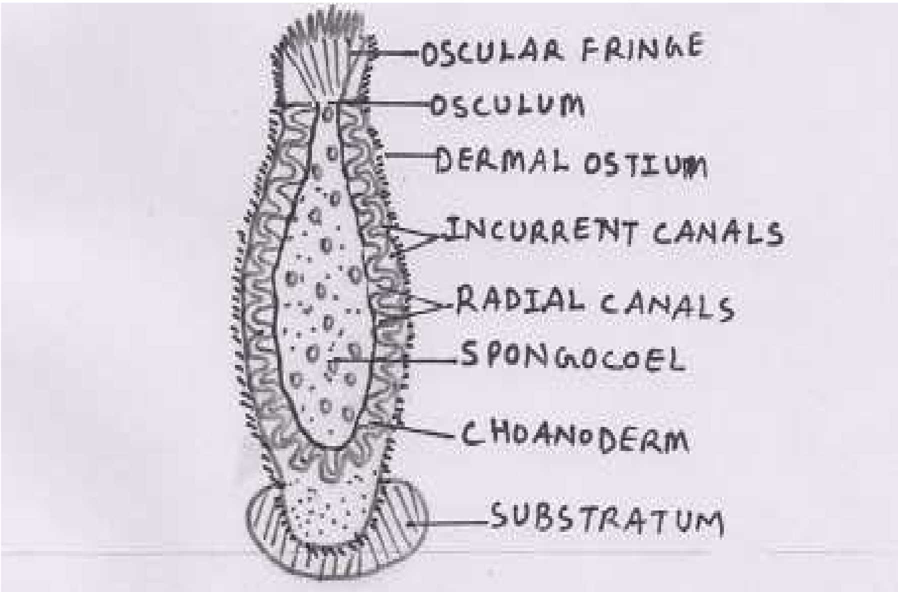

Fig.13:L.S of a single cylinder to show internal structure & Canal System

Its components are:

1. Ostia or dermal pores- The external body surface is covered by thin pore membrane.

   It bears two or more openings, the ostia or the dermal pores.

   The pores are surrounded by myocytes.

These can reduce the diameter of dermal pores and thus reduce amount of incoming water. These open into incurrent canals.

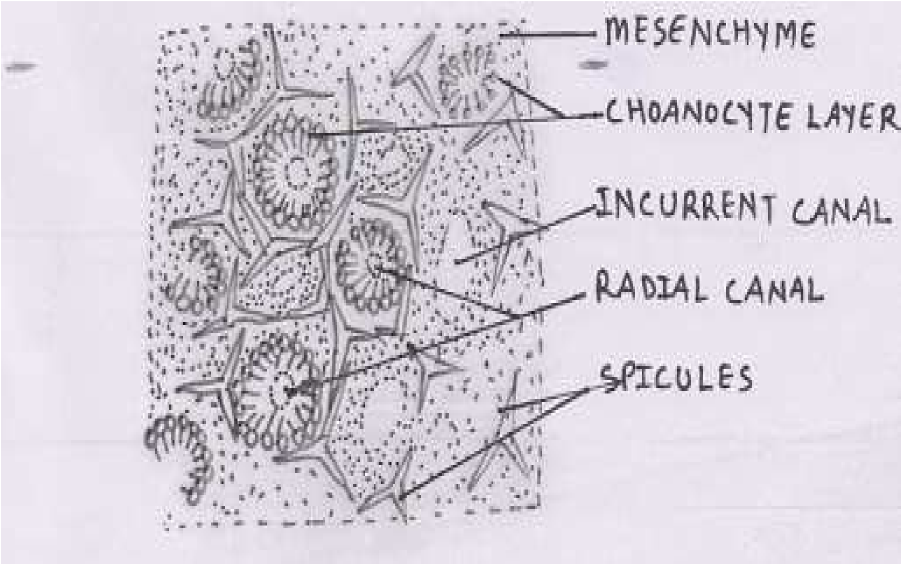

Fig.14: V.S of Sycon

2. In current cannels- These are narrow spaces placed radially between adjacent radial canals.These are lined with pinacocytes and opens outside by ostia.

3. Prosopyles- Incurrent canals communicate with radial canals by prosopyles.

4. Radial or flagellated canals- The body of *Sycon* invaginates to form thimble-shaped chambers. Chambers are lined by flagellated choanocytes and called flagellated chambers or radial canals. The radial canals and incurrent canals lie parallel and alternate to each other and are separated by mesenchyme. Radial canals end at their outer ends but open into spongocoel.

5. Apopyles- The openings of radial canals into spongocoel are called apopyles or gastric ostia.

6. Spongocoel- It's the large central cavity into which radial canals open through apopyles.The choanocytes line radial canals and spongocoel is lined by flattened pinacocytes. Spongocoel is central space all along the length of body.

7. Osculum- The spongocoel opens to outside by a terminal opening, the osculum. Osculum is surrounded is surrounded by a contractile myocytes. These form a sphincter which regulates the rate of water flow.

Mechanism of water circulation:

The water current is produced and water is pumped into the body by beating of flagella of choanocytes which line the radial canals. A wave of spiral undulations passes from base to tip of each flagellum and water is pushed in. Water enters the body by ostia into incurrent canals, from there by prosopyles into radial canals and then by apopyles it reaches spongocoel and discharge into exterior by osculum (Fig.15, 16 and 17).

In other way, the path of water into the canal system can be represented as following-

Water from outside

↓

Dermal ostium

↓

In current canal Exterior

↓ ↑

Prosopyle Osculum

↓ ↑

Radial canal → Apopyle → excurrent canal → Gastric ostium → Paragastric cavity

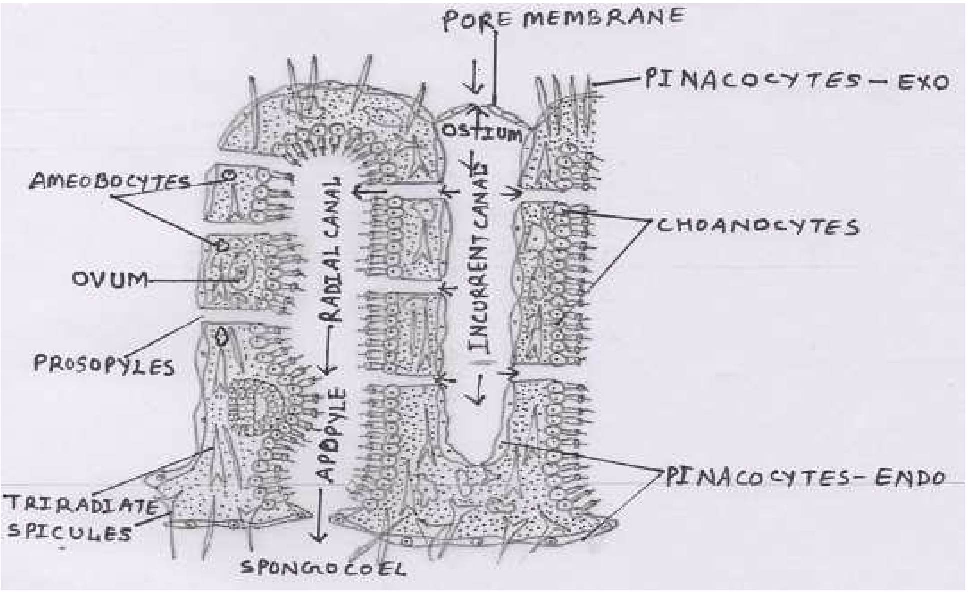

Fig.15 Representation of Body wall showing one In-current & one Radial Canal.

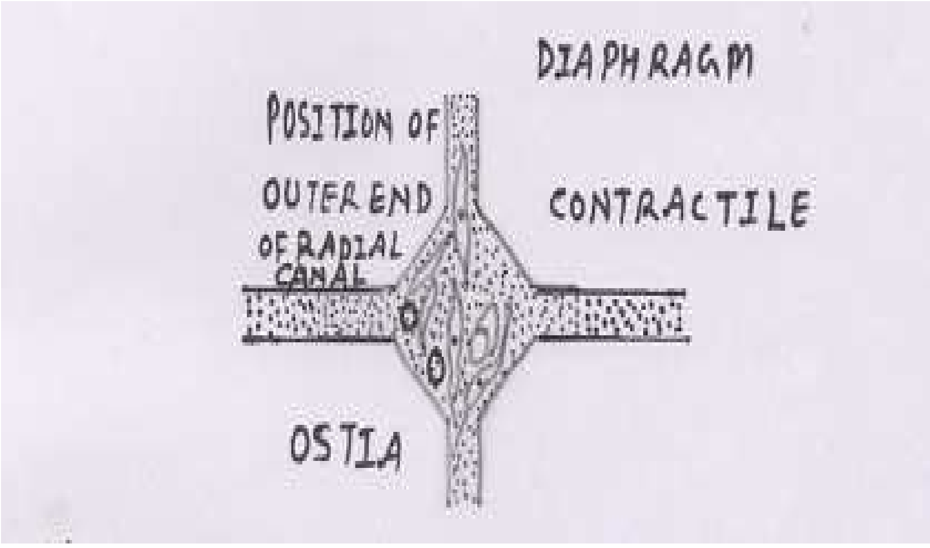

Fig.16 Sycon surface view of pore membrane showing Ostia

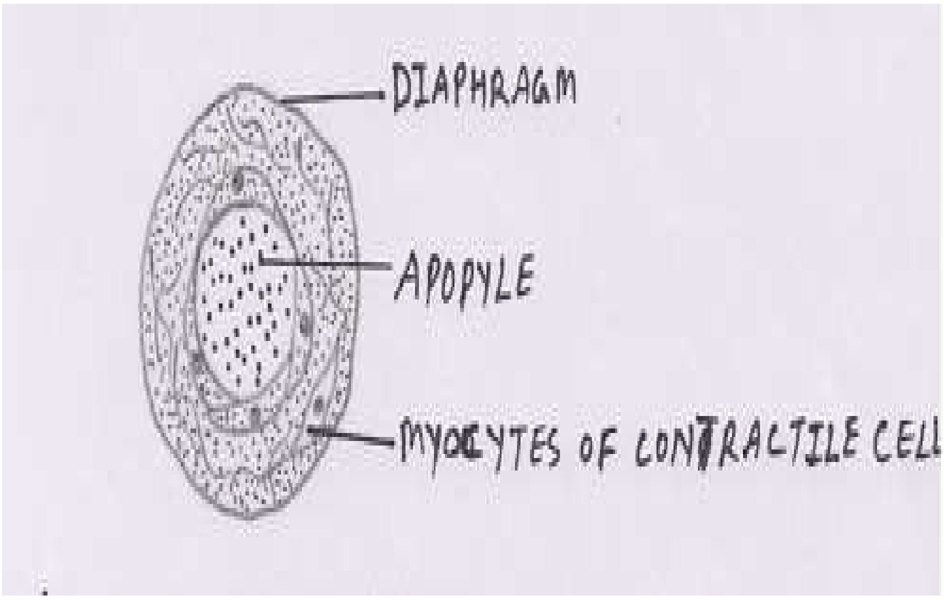

Fig.17 Sycon: An apopyle lined by myocyter

Importance of water circulation of canal system:

Water current plays a very important role in the physiology of the sponges. The water circulation system helps the sponges in nutrition, digestion, respiration, excretion and reproduction. The water current brings in food and oxygen and it takes away waste products.

- **Nutrition**

Scypha feeds on particles of organic matter and small living organisms, like a diatoms, bacteria and protozoa; they are drawn in the water current.

- **Digestion-** It is entirely intracellular, as in protozoa.

Partly digested food is taken up by amoebocytes in which digestion is completed, the amoebocytes transport and supply the digested food to all parts of the body.

- **Respiration-**

The Gaseous exchange occurs by simple diffusion, between the cells of sponge and the current of water. Water entering body is rich in oxygen and facilities exchange of gases. The rate of consumption of Scypha was found to range from 0.16 ml.of oxygen per gram of fresh weight per hour in the smaller specimens to 0.04ml. in the larger ones.

- **Excretion-** While outgoing, water current removes CO_2 and nitrogenous products.

- **Reproduction-**The spermatozoa enters body of other sponges along water current.

3.4.2- Reproduction in *Sycon:*

The sponges reproduce both asexually and sexually.

- **Asexual Reproduction** –Asexual reproduction occurs throughout the Porifera.

The asexual reproduction takes place by budding, regeneration and gemmule formation.

a) **By budding** - During favorable conditions *Sycon* reproduces by budding.

The buds arise basally near its attachment and then constrict off after sometime to lead independent existence (Fig.18).

b) **By regeneration** - Sponges have a great power of regeneration. They not only replace parts lost during injury, but any piece of body can grow into complete sponge.The process is however very slow and is completed in months or years. The regeneration power is used for cultivation of bath sponge industrially.

c) **By Gemmule formation**- Gemmules are not formed in *Sycon*.

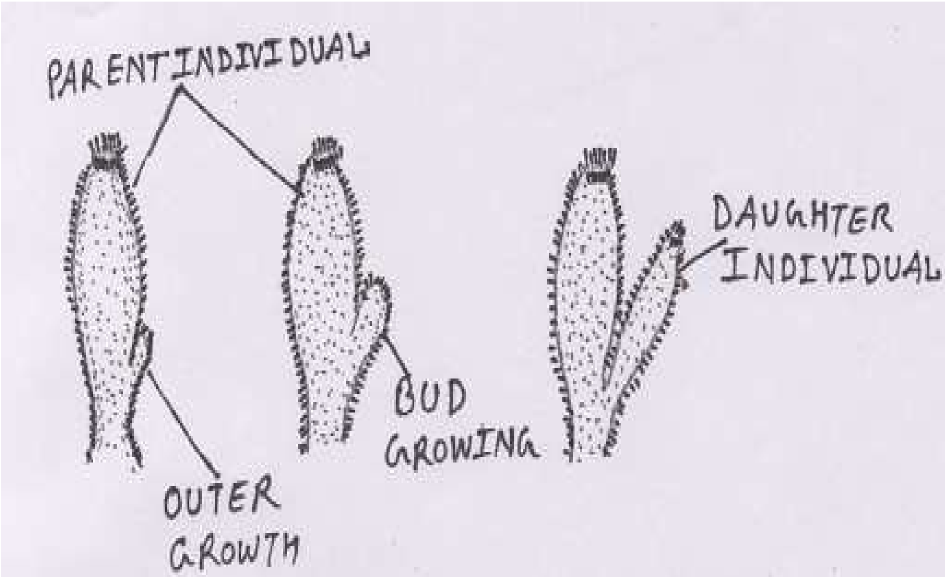

Fig.18 Sycon: Budding stage in Sycon

➢ Sexual Reproduction

Both male and female gametes are formed inside body of same animal (hermaphrodite) Gametes develop specialized amoeboid cells, called archaeocytes found in mesenchyme.

- **Spermatogenesis-**sperms are produced from amoebocyte or spermatogenesis and get surrounded by one or more flattened cells cover cells. The spermatocyte divides two to three times and cells develop into sperms. Mature sperm has round head with nucleus and long tail (Fig.19).

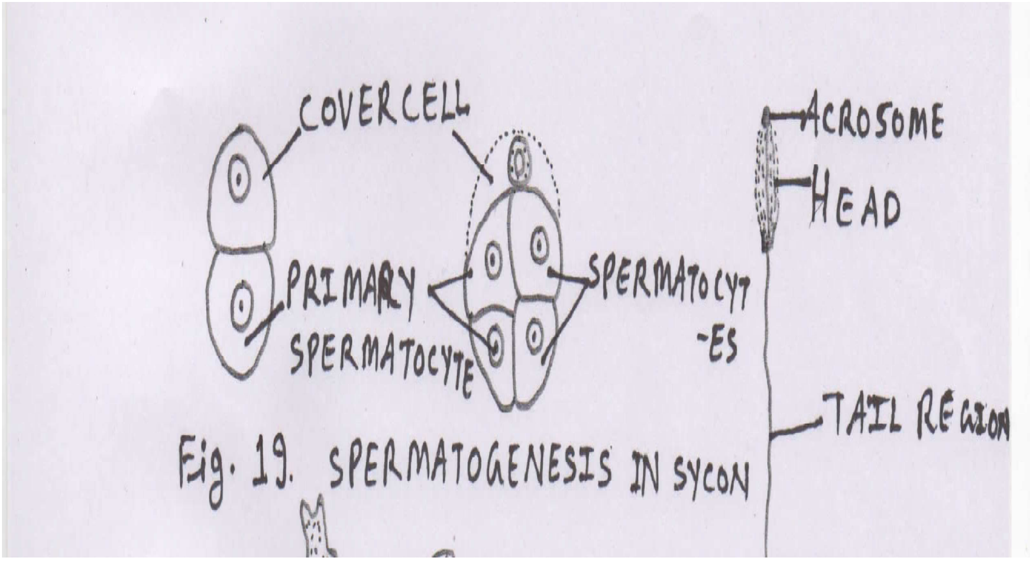

Fig.19 Spermatogenesis in Sycon

Oogenesis- Oocyte is differentiated into an enlarged amoebocyte with nucleus. It increase in size, stores food material, is nourished by choanocytes called trophocytes or nurse cells. Its nucleus undergoes two maturation divisions (meiosis) to form ovum (Fig.19).

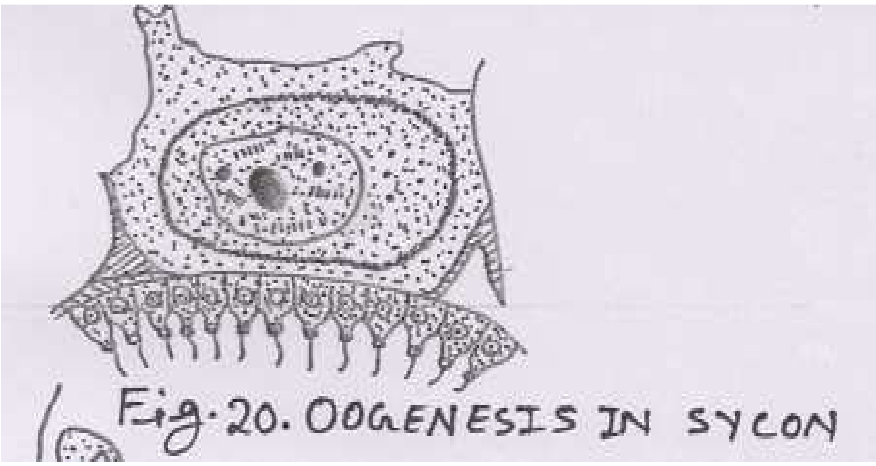

Fig.20 oogenesis in Sycon

Fertilization- The fertilization is internal and cross fertilization occurs. The sperm does not enter directly in the ovum but reaches a radial canal and is dispersed by the water currents (Fig.21).

Sperm cell enters the nurse cells or choanocyte adjacent to mature oocytes, which becomes amoeboid and fuses with ovum liberating the sperm. The nuclei of ovum and sperm fuse and form zygote.

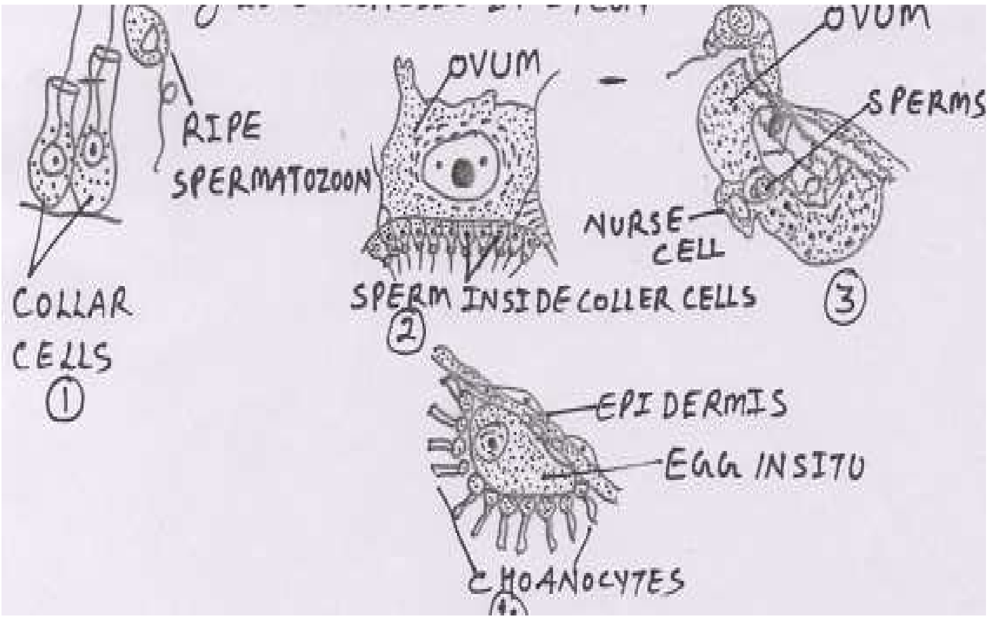

Fig.21: Fertilization in Sycon

3.4.3-Development of *Sycon:*

1. Cleavage- The divisions are holoblastic and development occurs inside the body of sponge.

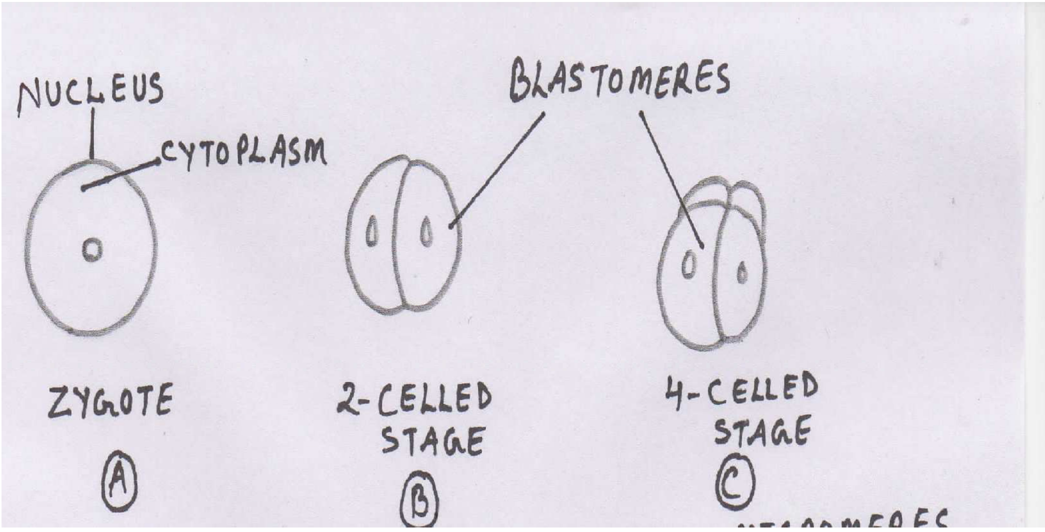

Fig.22 Cleavage in Sycon

The 1st three divisions are vertical and produce pyramidal plate of 8 cells.

The 4th division is horizontal and divides blastomeres unequally into 8 micromers and 8 macromers (Fig. 22: A to E).

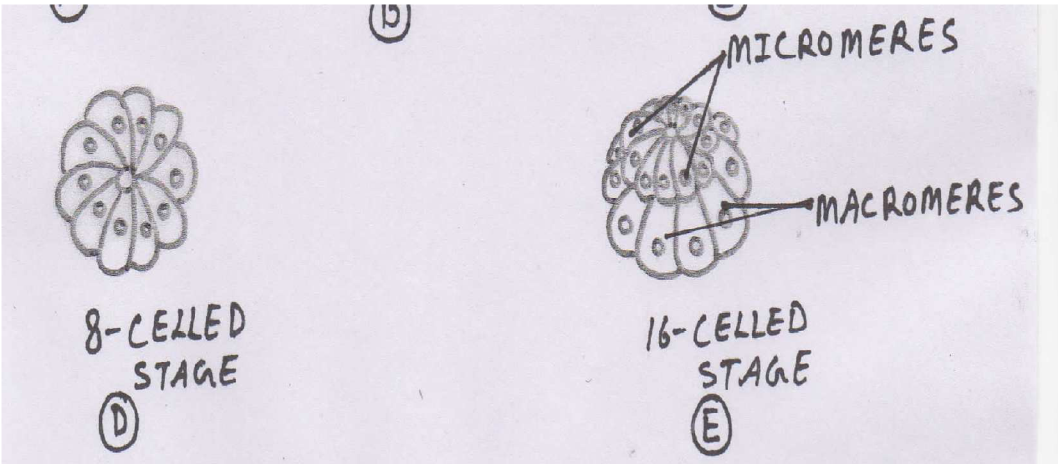

Fig.23 Cleavage in Sycon

A cavity develops in between and embryo enters into the blastula phase. Micromeres divide more rapidly and develop flagella at their free ends, while macromere becomes rounded and represents the stomoblastula.

2. Stomoblastula- one side of stomoblastula is composed of many small, elongated, flagellated micromeres, while other side composed of 8 rounded, non flagellated macromeres (Fig. 24: F).

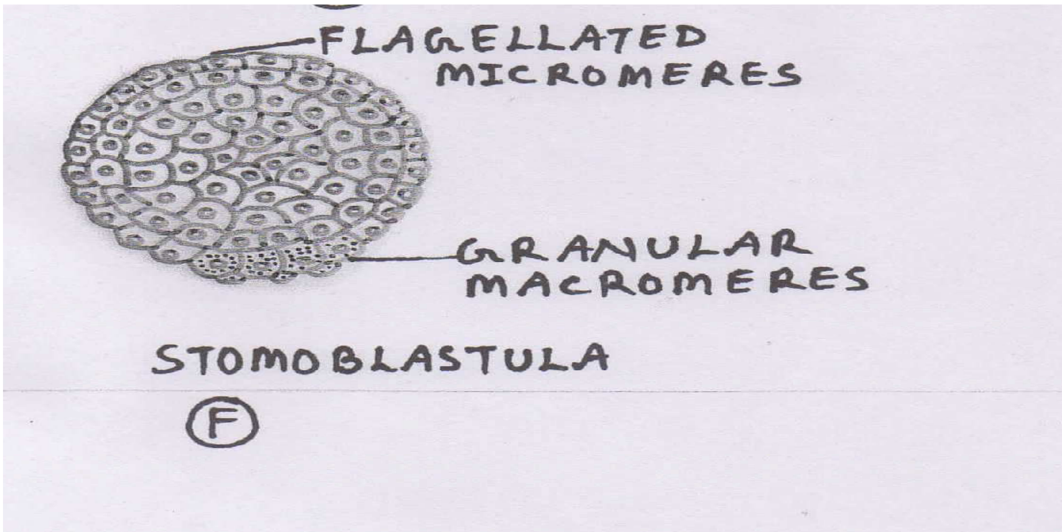

Fig.24 Stomoblastula in Sycon

Inner cavity (blastocoel) opens outside through the mouth.

It is used to engulf the surrounding amoebocytes for nutrition.

- **Amphiblastula-** The stomoblastula undergoes inversion and flagellated ends of flagellated cells comes to lie to the exterior.

The flagellated stomoblastula is called amphiblastula larva. The fully formed amphiblastula is set free into radial canal (Fig. 22: G to H).

It escapes by osculum along the water current and leads free swimming existence and undergoes gastrulation by invagination and emboly.The flagellated cell invagination into blastocoel and macromere grows over them by rapid multiplication. Thus gastrula is formed.

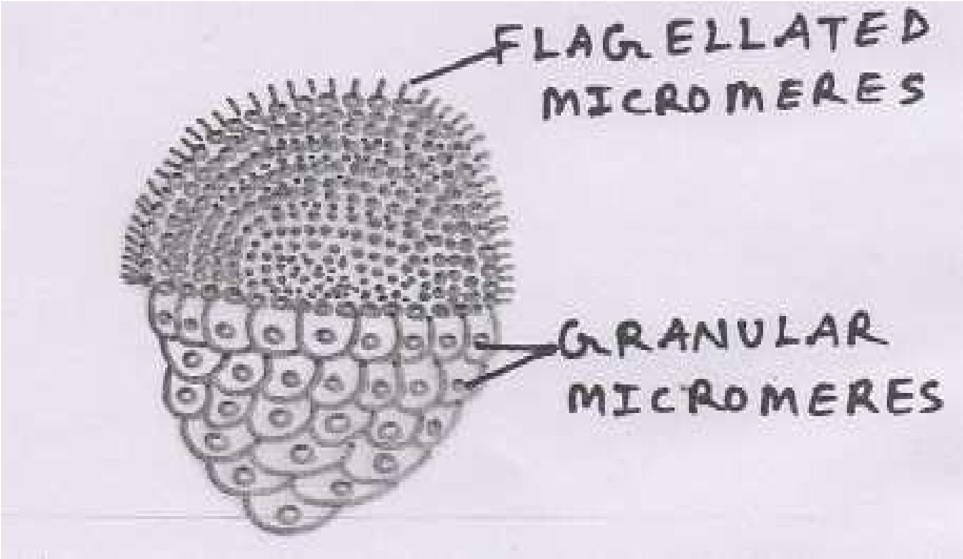

Fig.25 Amphiblastula in Sycon

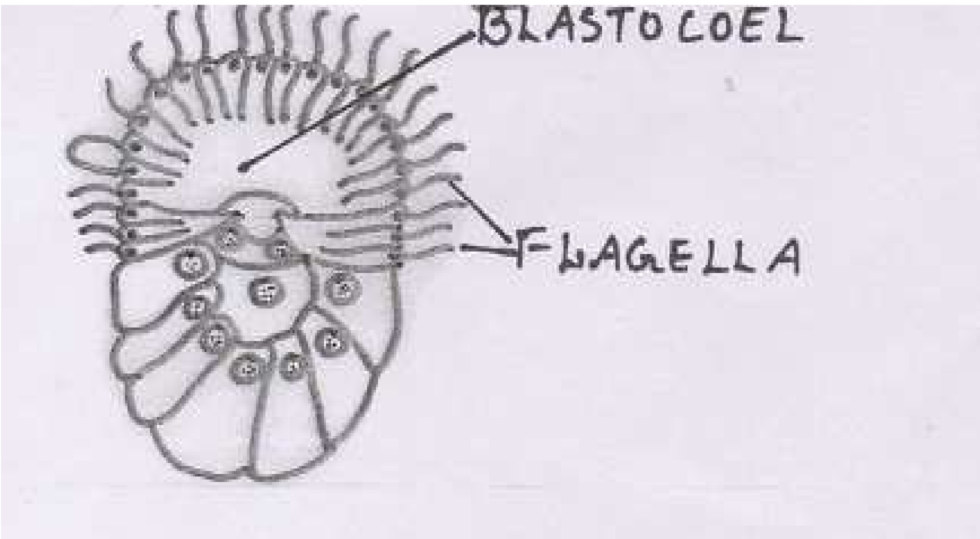

Fig.26 Development in Sycon (T.S of Amphiblastula)

- **Gastrula-** Gastrula has two layer bodies.

Outer layer is granular, ectoderm and inner is non-granular flagellated cells, endoderm.

The central cavity opens outside by opening called blastopore (Fig. 22: I to J).

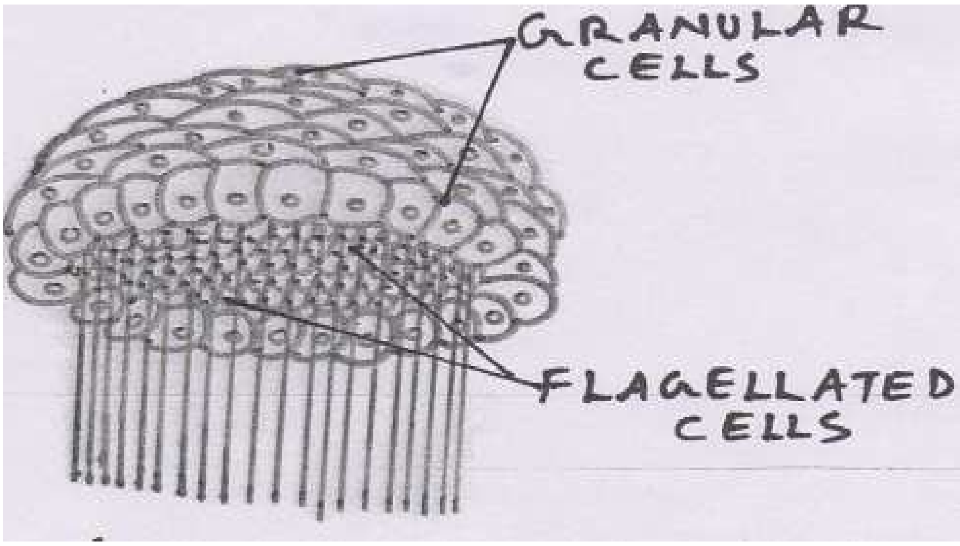

Fig.27 Gastrulation in Sycon

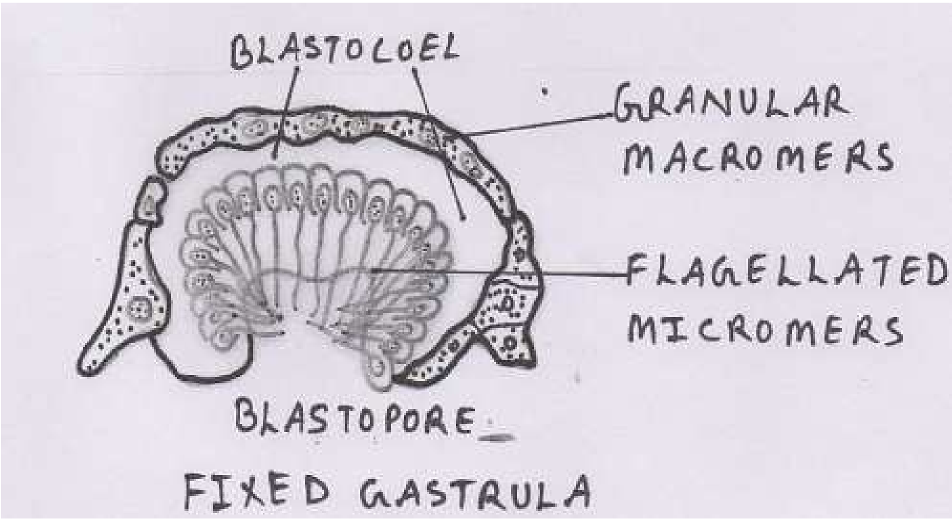

Fig.28 Fixed Gastrula

5. **Metamorphosis (Post embryonic development)** - The gastrula adheres to substratum like rock, sea weeds, etc., by its blastoporal end and undergoes metamorphosis to form adult *Sycon*.

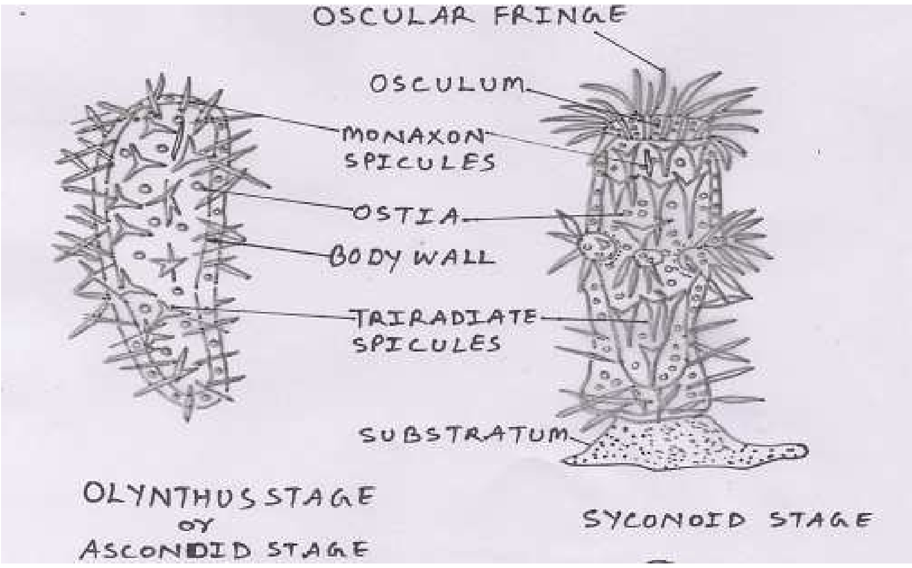

Fig.29 Post embryonic development in Sycon

- The larva lengthens into a cylinder and develops osculum at free distal end.
- The non-granular flagellated cells of endoderm form choanocytes.
- The granular non-flagellated cells of ectoderm give rise to pinacocytes of dermal epithelium.
- The body wall gets perforated by Ostia and Olynthus stage is attained by *Sycon* (Fig. 23: K to L). The choanocytes are shifted in these radial canals and the body wall increase in thickness, the adult Scypha is formed and its colony develops.

3.5-Canal system and affinities

Canal system in sponges:

In majority of sponges the body wall is folded and is placed by a complicated system of canals, through by which water current enters the spongocoel. This system of canals is collectively known as canal system.

These are of 3 types in porifera-

1: Asconoid or ascon type of canal system (Fig. 29).

2: Syconoid or *Sycon* type of canal system (Fig. 30 and 31).

3: Leuconoid or leucon type of canal system (Fig.32, 33 and 34).

1: **Asconoid or ascon type of canal system -**

- It is a simplest type of canal system.
- The body is radially symmetrical.
- The body wall of an asconoid sponge is formed of two layers (Outer and inner epithelium).
- Thin walled and vase like with central cavity, the spongocoel opens free end, narrow aperture, the osculum.

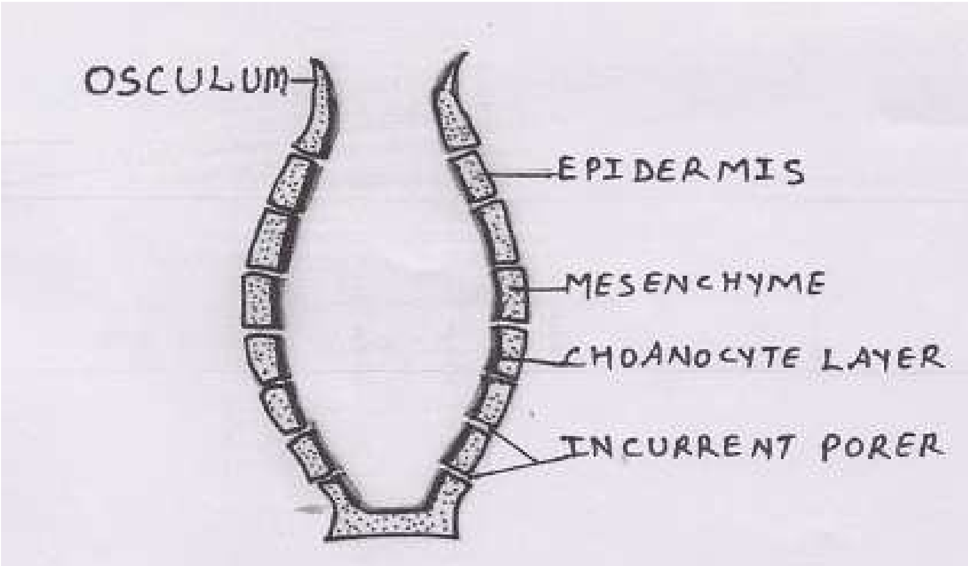

Fig.30 Asconoid Types of Canal System in Sycon

The thin wall of cylinder has numerous regularly arranged small intracellular appertures, which are known as inhalants pores or Ostia. Each of them opens in a canal through a tubular porocyte (tubular cell called porocyte). and extends from the exterior to the spongocoel.The water current enters through ostia, reaches the spongocoel and finally leaves the body through osculum. The outer ectoderm is formed of pinacocytes while the inner endoderm of loosely arranged choanocytes (Fig.24).

2. **Syconoid or *Sycon* type of canal system**

It's theoretically derived from asconoid type by out pushing its wall into finger like structures. These structures are lined by choanocytes and are called as radial canals. The wide opening between two radial canals forms ostium and space is called as incurrent canal.

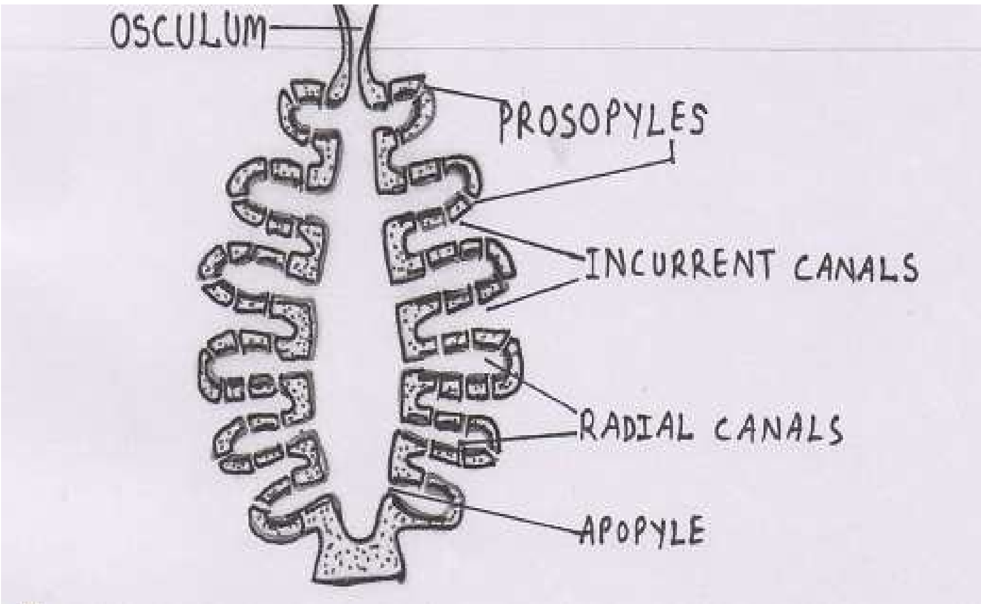

Fig.31 Syconoid Types of Canal System in Sycon

The water current in Syconoid sponges takes the following route: dermal pores → in current canals → prosopyles → radial canals → internal ostia (apopyles) → spongocoel → osculum → out.

The Syconoid sponges differ from the Asconoid type in two important particulars:-

(a) - The thick folded walls containing alternating incurrent and radial canal.

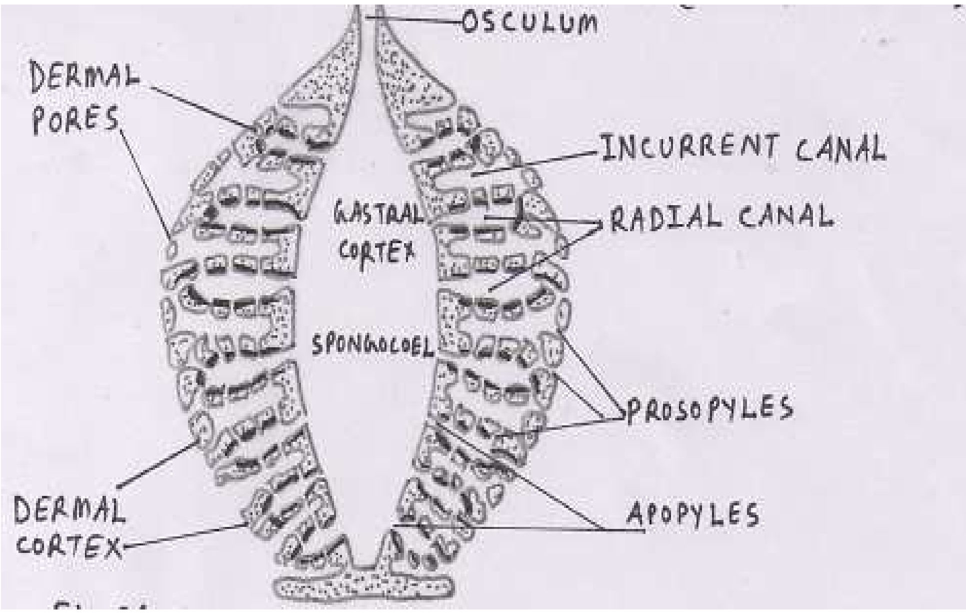

Fig.32 Final Syconoid Canal System in Sycon (with cortex)

b) - The breaking of the choanocyte layer, which no longer lines the whole interior but is limited to certain definite chamber(radial canals).

Syconoid structure occurs in two main stages-

- In its simplest form the radial canal extends out freely to exterior and do not touch each other at any point so that water surrounds the sponge body.
- In complex form the epidermis and mesenchyme spread over the outer surface forms cortex which may be thin and becomes thick in still more complex forms. The wide space between radial canals has tubular appearance and forms in current canals. The epidermis at distal end has pores known ostia by which water enters inside. E.g-Sycon (Fig.25 and 26).

3. Leuconoid or leucon type of canal system:

The more complex leuconoid structure develops by further out folding of the radial canals of Syconoid stage and thickening of mesenchyme. Radial canals are replaced by clusters of small rounded flagellated chambers.

The mesenchyme fills space between flagellated chambers, so that sponge assumes irregular shape. Its interior has network of channels.These are excurrent channels between radial canals.

The excurrent canal from different radial chambers opens into wider chambers and finally to exterior osculum. Similarly incurrent canal also gets branched and irregularly arranged. The dermal ostia may lead directly into incurrent canals or open into subdermal spaces crossed by spicules.

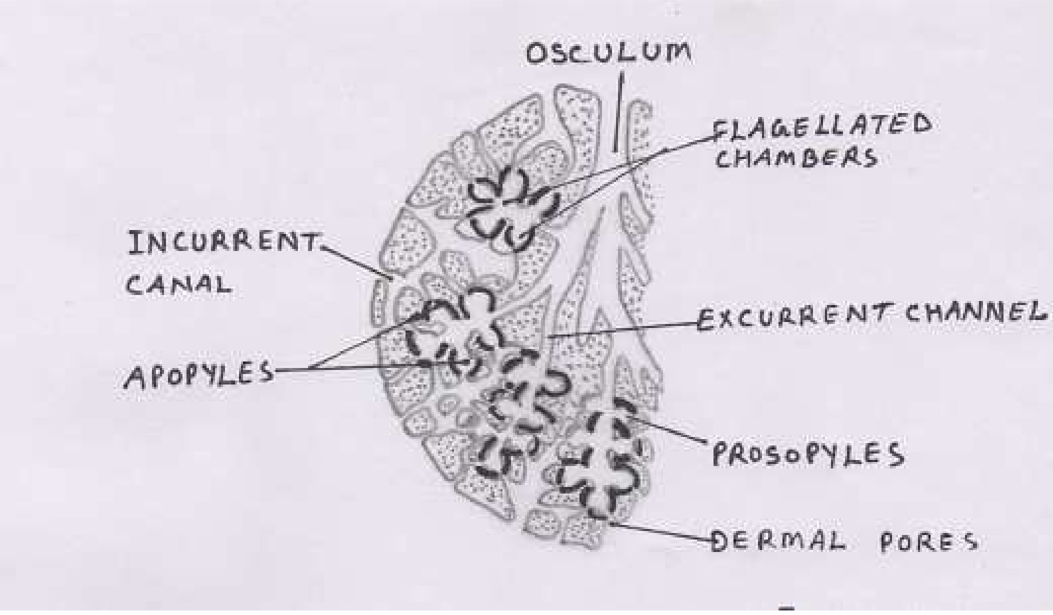

Fig.33 Leuconoid type of Canal System in Sycon

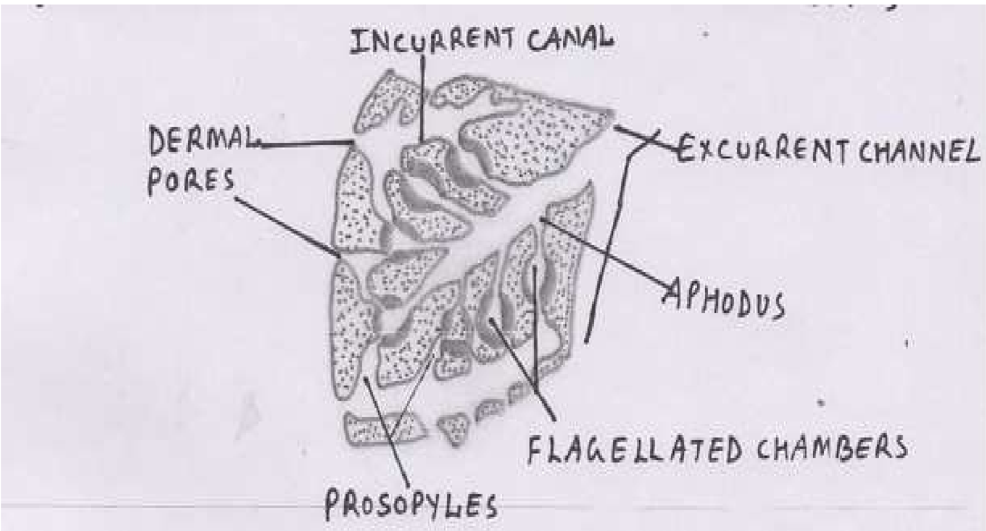

Fig.34 Leuconoid type of Canal System in Sycon (Aphodal Chamber)

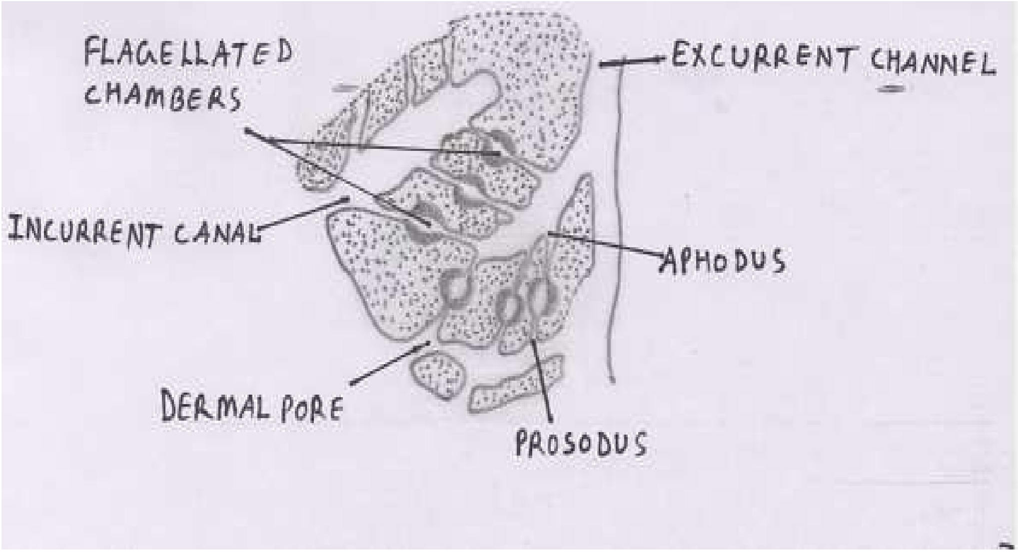

Fig.35 Leuconoid type of Canal System in Sycon (Diplodal Chamber)

The special features of the leuconid type of canal system are the limitation of the choanocytes to small chamber, the major development of the mesenchyme, and the complexity of the incurrent and excurrent canals.The leuconid type of canal system exhibits numerous variations but present three stages of evolution, viz., eurypylous, aphodal and diplodal (Fig.27, 28 and 29).

(a)- **Eurypylous-** In this type of canal system, the flagellated chamber are wide and thimble – shaped, each opening directly into the excurrent canal by a wide aperture called apopyle and receive the water supply direct from the incurrent canal through the prosopyle. Eg. *Leucilla* (Fig.27).

(b)- **Aphodal-** In this type of canal system, the flagellated chamber is small and rounded. The opening of each flagellated chamber into the excurrent canal is drawn out into a narrow tube, usually not of great length, known as aphodus. E.g. *Geodia* (Fig.28).

(c)- **Diplodal-** In this type of canal system, a narrow current tube, the prosodus between the incurrent canal and the flagellated chamber, this type of situation are known as diplodal. This type of canal system is found in *spongilla* (Fig.29).

Table1: Different kinds of sponge structure.

	Asconoid	***Syconoid***	**Leuconoid**
Sponge wall	Simple	Out folded with alternating radial and incurrent canals	Irregular
Choanocytes	Lining central spongocoel	Lining radial canal	Restricted to flagellate chambers
Mesenchyme	Limited amount, simple layer completely traversed by porocytes	Increased in thickness. No longer completely traversed by porocytes	Highly developed
Direction of water current	In-current pores ↓ Spongocoel ↓ Osculum	Dermal pores ↓ In-current canals ↓ Prosopyles ↓ Radial canal ↓ Apopyles spongocoel ↓ Osculum	Dermal pores ↓ Subdermal spaces ↓ In-current channels ↓ Prosopyles ↓ Flagellate chambers ↓ Apopyles ↓ Excurrent channels ↓ osculum

Affinities:

There has been a great controversy over the nature and affinities of sponges ever since they were discovered. Aristotle (384-322 B.C.) was the first to recognise them as animals. Phylum Porifera shows affinities with protozoa as well as with metazoa.

1. AFFINITIES WITH PROTOZOA

(a) Resemblance with protozoa

- Intracellular digestion and absence of definite and digestive system.
- Production of skeletal spicules by cells.
- Presence of collar cells and amoeboid cells.
- The cells of sponge body are interdependent in their function.
- Inversion process occurs in amphiblastula larva like those of volvox.

(b) Differences with protozoa

- Sedentary in habitat.
- Diploblastic acoelomates with absence of cellular mesenchyme.
- Development of multicellular organization by cleavage of fertilised egg.
- Possession of a canal system and skeleton made of spicules.
- Differences between characteristic feature of skeleton and canal system
- Development of specialised cells such as pinacocytes, choanocytes and porocytes show division of labour in somatic cells. Thus, sponges are more complex than a colony of protozoans but resemble multicellular metazoa.

2. AFFINITIES WITH METAZOA

(a) Resemblance with metazoa

- Both are sedentary in habit.
- Both are diploblastic and acoelomate.
- Both reproduce asexually and form colonies.
- Both sponges and coelenterates show the presence of same nucleic acids and amino acids.
- Parenchymula larva of sponges resembles planula larva of coelenterates.

- Spongocoel in sponges opening out through osculum can be compared with gastro-vascular cavity of coelenterates opening out through mouth.

(b) Differences with metazoa

- In sponges, cells are less specialised and less independent than those of metazoa.
- Sponges do not have anterior end though osculum serves physiologically as controlling region.
- Primary openings are not present as osculum in sponges.
- Body surface is perforated by inhalent pores or ostia extend by water channels, a unique feature of sponges only.
- Tissue formation is restricted to the formation of epithilial lining on the surface. There are no organs as found in higher animals.
- Sponges lack true mouth. Osculum does not correspond with the mouth of coelenterates.
- Stinging cells are found in coelenterates are lacking in sponges.
- Nervous system is lacking in sponges.

3.6-Summary:

- Porifera are multicellular organisms.
- All are aquatic with only some exceptions of freshwater.
- Body surface containing numerous pores.
- No definite organs for feeding and digestion.
- Intracellular digestion.
- Cells loosely arranged.
- So are not truly diploblastic.
- Sensory and nerve cells are absent.
- Differentiated into 3 classes-Calcarea, Hexaactinellida and Tetractinellida.
- Canal systems are of three types' as-asconoid or ascon type, synconoid type and leuconoid or leucon type.
- All are hermaphrodite but cross fertilization occurs.
- Asexual reproduction occurs by budding.
- Sexual reproduction occurs by ova and sperms. They enjoy great power of regeneration.
- Development is indirect.

3.7- Glossary

Acellular-	Without cellular organisation.
Amoebocyte-	Amorphous independently mobile cell.
Amoeboid-	Cell movements resembling those of the amoeba.
Amphiblastula-	Blastula-like sponge larva.
Archeocyte-	Amoeboid cell which receives digests and transports food.
Asconoid-	Type of sponge structure in which canals pass directly from the ostia to the Spongocoel, which is lined with collar cells.
Apopyle-	Pore leading from the chamber into the central cavity in sponge.
Budding-	Production of offspring by development of a lateral branch from part of the body.
Choanocyte-	Flagellated coller cells found in sponges.
Cleavage-	Series of early division of an egg into cell.

Endoskeleton-	A supporting framework on the inside of an animal, whether it be cartilaginous, bony.
Exoskeleton-	A supporting structure on the outside of an animal body. The skeleton of an invertebrate is usually an exoskeleton.
Fertilisation-	Union of a mature ovum and a mature sperm to from zygote.
Gemmule-	Multicellular vegetative bud of certain sponges.
Invagination-	Infolding of any part, infolding of a layer of tissue in gastrulation.
Myocyte-	Contractile cell surrounding pores and oscula, able to close them.
Osculum-	Relatively large external opening of the central cavity through which water leaves a sponge.
Ostium –	An opening to a passage or to a canal system in sponges.
Porocyte-	Water intake cell of certain sponges, characterised by canal passing through it.
Radial symmetry-	The condition in which similar parts are arranged about a common center like the spokes of a wheel.
Solitary-	Living alone, not a member of the colony or group.
Spicule-	One of much solid structure that composed the structures that composed the structural framework of a sponge.

3.8- Self assessment question

Q.No. 1. Describe various types of canal systems found in sponges.

Q.No. 2. Which sponge is commonly known as Dead Man's Finger?

Q.No.3. what is the economic importance of Euplectella and Euspongia? What is their significance?

Q.No.4. Write short on:

(1) Euplectella; (2) Hyalonema;

(3) Spongilla (4) Chalina;

(5) Euspongia; (6) Cliona.

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Prasad, S. N. (1963). A text book of Invertebrate Zoology.

3.10-Suggested reading books

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(b). A text book of Invertebrate Zoology, Author –Dr. S. N. Prasad.

(c). Biology of the Invertebrate Zoology, Author –Jan A.Pechenik.

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(e). Invertebrate Zoology, Author –D.T.Anderson.

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(h). Morden text book of Zoology Invertebrate, Author –R.L.Kotpal.

(i). Invertebrate Zoology, Author –Paul A.Meglitsch and Frederick R. Schram

(j). Text book of invertebrate Zoology, Author – G.S.Sandhu.

(k). Invertebrate Zoology. Author – E. L. Jorden and P. S. Verma,

3.11. Terminal Questions

1. Write the outline classification of Phylum Porifera?

2. Into how many classes is Phylum Porifera divided? Write their names and important characters?

3. What is the characteristic feature of phylum Porifera? What is its importance?

4. on basis of which characters is the classification of Porifera based?

Multiple Choice Questions:

1. Most primitive group of animals, which are multicellular, is

(a) Coelenterata [ ] (b) Colonial protozoans [ ] (c) Sponges [√] (d) Nemertine. [ ]

2. In class demospongiae, leucon type of canal system is derived from

(a) Ascon type of canal system of larva [ ] (b) *Sycon* type of canal system of larva [ ]

(c) Rhagon types of canal system of larva [√] (d) all of the above. [ ]

3. Animal of phylum Porifera are characterised by

(a) Gland cells [ ] (b) Choanocytes [√] (c) Amoeboid cells [ ] (d) Pigment cells.[ ]

4. Ascon type of canal system is found in

(a) Euspongia [ ] (b) Leucosolenia [√] (c) Grantia [ ] (d) Hyalonema. [ ]

5. Which one of the sponge is harmful to the oyster industry?

(a) Cliona [√] (b) Euspongia [ ] (c) Spongilla [ ] (d) Hyalonema. [ ]

6. 'Venus Flower Busket' is the name of the dried skeleton of

(a) Euspongia [ ] (b) Spongilla [ ] (c) Euplectella [√] (d) Leucosolenia [ ]

7. Which of the following is a freshwater sponge?

(a) Spongilla [√] (b) Euplectella [ ] (c) Euspongia [ ] (d) *Sycon*. [ ]

8. The simplest type of canal system in Porifera is

(a) Leucon type [ ] (b) Radial type [ ] (c) Ascon type [√] (d) *Sycon* type [ ]

9. Porifera is characterised by the presence of

(a) Paragastric cavity [√] (b) Coelenteron [ ](c) Coelom [ ] (d) Water vascular system[ ]

10. In Poriferans, skeleton secreting cells are

(a) Amoebocytes [ ] (b) Thesocytes [√] (c) Archaeocytes [ ] (d) Sclerocytes. [ ]

11. Correct sequence of evolution of canal system in sponges is

(a) *Sycon*-Ascon-Leucon [ ] (b) Ascon-*Sycon*-Leucon [√] (c) *Sycon*-Leucon-Ascon [ ]

(d) Leucon-Ascon-*Sycon*. [ ]

12. Members of Phylum Porifera are

(a) Mostly marine animals, few being freshwater [√] (b) Exclusively marine animals [ ]

(c) Mostly freshwater animals few being marine [ ] (d) exclusively freshwater animals [ ]

UNIT: 4 PHYLUM COELENTERATA

Contents

4.1-Objectives

(1)-Understanding the general characters and classification up to order level, Aurelia with special reference to structure, reproduction, development and polymorphism.
(2)-To understanding the coral, coral reefs and their economic importance.

4.2-Introduction

Phylum Cnidaria (formely known as coelenterata) includes about 9000 species. Some are found in fresh water, but the greater numbers are marines. Coelenterates (Gr. koilos- hollow + enteron- gut) are the simplest of eumetazoans. This interesting group of animals takes its name from the large cavity in the body that serves as the intestine. They include the hydra, jellyfish, sea anemones and corals.

4.3- General characters and classification up to order level

4.3.1-General Characters:

- Coelenterata are metazoa or multicellular animals with tissue grade of organisation.
- 2Body radial or bi-radially symmetrical with oral-aboral axis.
- 3They are diploblastic animals.
- Coelenterate animals are represented by two morphologically different types of individuals, polyps and medusa.
- Polyps are sessile (attached to the substratum) with a tubular body (eg. *Hydra*). Whereas medusa are free-swimming with an umbrella or bell-shaped body, eg. *Aurelia, Metridium*.
- They are all aquatic, mostly marine and some freshwater (eg. *Hydra*).
- They may exhibit solitary or colonial habitat.
- One of the most characteristic structures of all coelenterates is the stinging cells, called nematocysts.
- Nematocysts serve for adhesion, food capture and offence and defence.
- They have a single gastro-vascular cavity, into which mouth opens.
- Short and slender tentacles encircle the mouth in one or more whorls.
- Coelenterate animals are usually carnivorous.
- The coelom, excretory, circulatory and respiratory organs are absent.
- Anus is absent.
- Locomotion is brought about by smooth muscle fibers.

- Nervous system consists of one or more networks or nerve cells and neurites located in the ectoderm and endoderm.
- Sense organs are ocellii and statocysts.
- Skeleton either calcereous or horny and external or internal but absent in few.
- Reproduction is both asexual and sexual methods.
- Asexual reproduction occurs by budding and sexual reproduction by the formation of gametes.
- The Planula larva present in the life history of Coelenterata.
- The life history exhibits the phenomena of alternation of generations or metagenesis in which the asexual polypoid, sessile generation alternates with sexual medusoid, free-swimming generation.

4.3.2-Classification up to order level

- Phylum Coelenterata was classified by L.H. Hyman in 1940.
- Phylum Coelenterate includes nearly 11,000 known species half of which are extinct.
- Phylum Coelenterata has been divided into three classes as follows:-

PHYLUM-COELENTERATA

Class 1.Hydrozoa

(Gr., hydra- water + zoon- animal)

- Hydrozoa mostly colonial and marine.
- Some hydrozoa are solitary and freshwater.
- They exhibit tetramerous or polymerous radial symmetry.
- Gastro-vascular cavity without stomodaeum, septa or nematocysts bearing gastric filament.
- They exhibit either only polyps or both asexual polyps and sexual medusa form.
- Gonads are epidermal in origin.
- Sex cells are shed directly to the outside.
- The cleavage pattern is holoblastic, embryo ciliated planula.

It includes following orders:

- **Order1:** Hydroidea
    - They may be solitary or colonial.
    - The medusae form is absent or short-lived.

- The sense organs are exclusively ectodermal.

- **Sub-Order (a)-Anthomedusae**

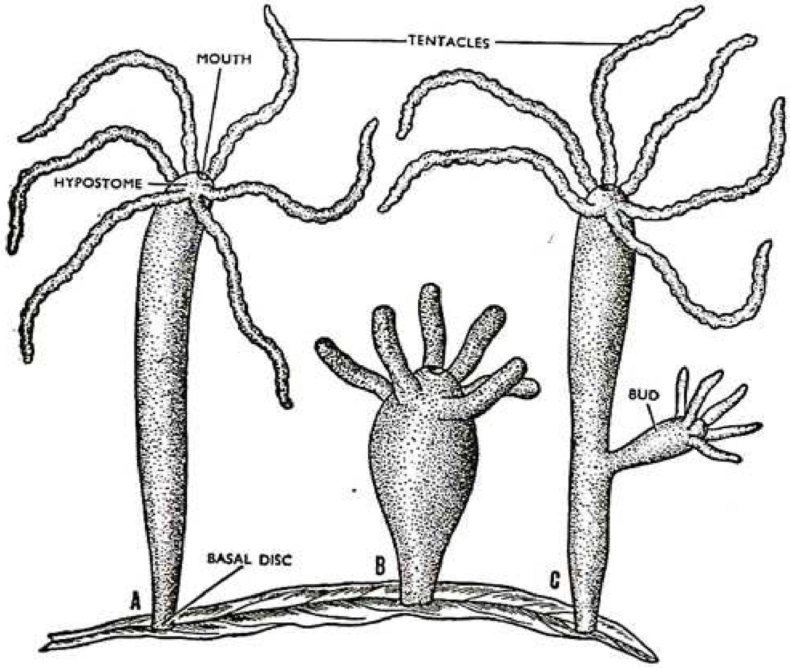


Fig.1 Hydra

- Colonial or solitary.
- Polyps are not enclosed in hydrothecae.
- The medusae are naked without gonothecae.
- Medusae are tall and bell like.

Eg.- *Hydra* (Fig.1) and *Tubularia*.

- **Sub-Order (b)-**Leptomedusae
  - Colonial Hydrozoa.
  - Polyps are enclosed in hydrothecae.
  - The medusae are covered with gonothecae.
  - Eye spots or ocelli are absent.

Eg.-*Obelia* (Fig.2).

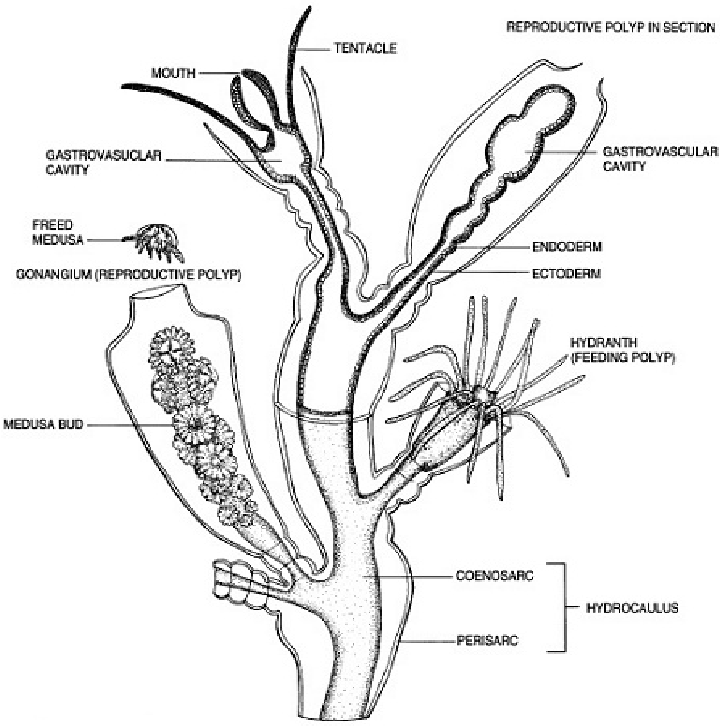


Fig.2 Obelia

❖ **Order2:** Trachylina
- Polypoid stage is absent or reduced.
- The medusoid stage is large, dominant and free-swimming.
- They may develop directly from fertilized egg by which the polyploidy stage is reduced or absent.
- Sense organs or statocysts with endo-dermal statoliths.

o **Sub-Order (a)- Trachymedusae**
- Margin of the umbrella is smooth.
- Gonads borne on the radial canals.
- Manubrium is long.

E.g. *Geryonia*.

o **Sub-Order (b)-Narco medusae**
- Manubrium is short.
- Gonads borne in the floor of the stomach.

Eg. *Solmaris*

❖ **Order3:** Hydrocorallina or Milleporina
- Colonial coral like Hydrozoa without perisarc.

- These are fixed, colonial polyploid hydrozoa in which coenosarc secretes a massive exoskeleton of calcium carbonate
- Colonies have two kinds of zooids, the gastrozooids and dactylozooids.

E.g. *Millepora*.

- **Order4:** Siphonophora
  - These are pelagic colonial hydrozoa showing extreme polymorphism of zooids,
  - Polyps are without oral tentacles.
  - Medusae are incomplete and rarely freed.

- **Sub-Order (a)-**Calycophora
  - Upper end of the colony is provided with one or more swimming bells.
  - Apical float or pneumatophore absent.

  E.g. *Diphyes*.
- **Sub-Order (b)-**Physophorida
  - Upper end of the colony bear a float or pneumatophore.

  E.g. *Velella* (Fig.4) and *Physalia* (Fig.3).

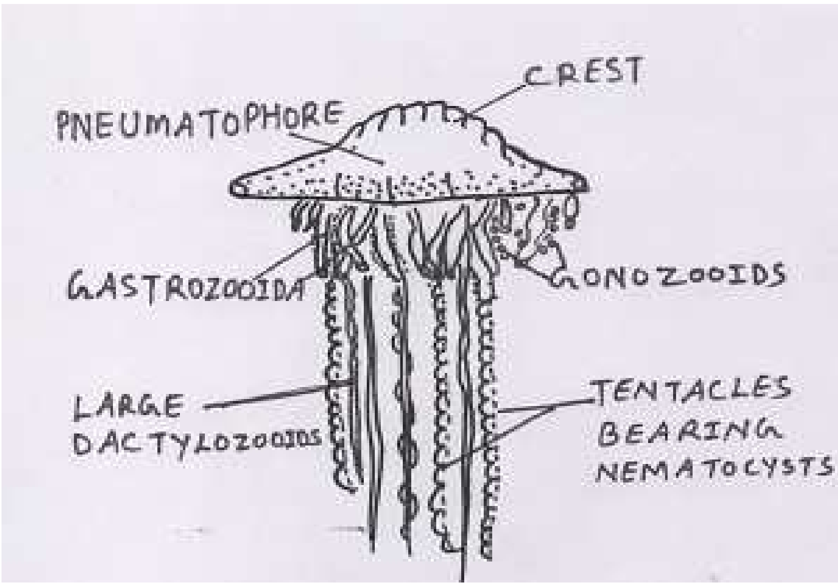


Fig 3 Physalia

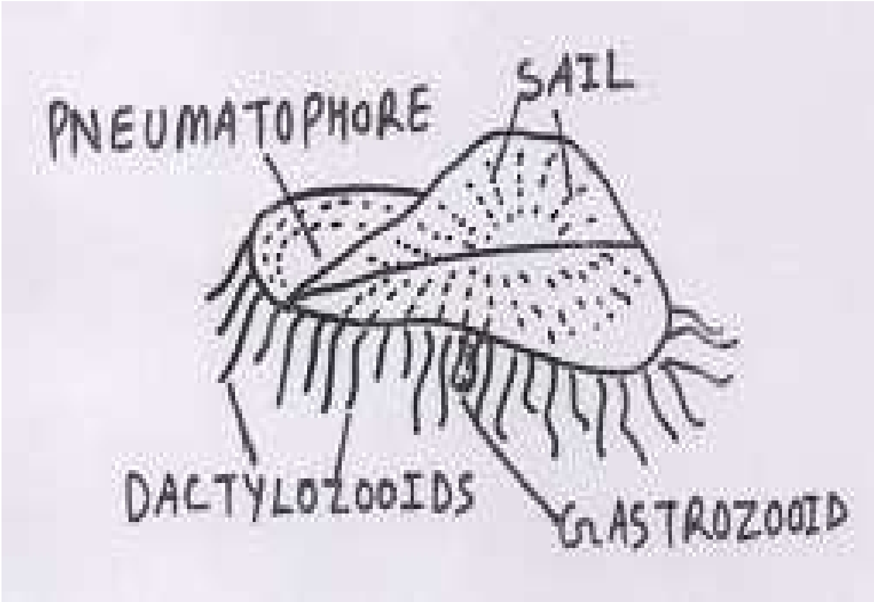


Fig.4 Velella

Class 2.Scyphozoa:

(Gr.Skyphos-cup + zoios-animals)

- They are exclusively marine and solitary forms.
- The medusa stage is dominant but the polyp stage reduced or absent.
- The gonads are gastro-dermal and sex cells are shed or released in digestive cavity.

❖ **Order(a):** Stauromedusae (lucernariida)

- These are bell-goblet or trumpet-shaped.
- All are sessile, attached by an aboral stalk.

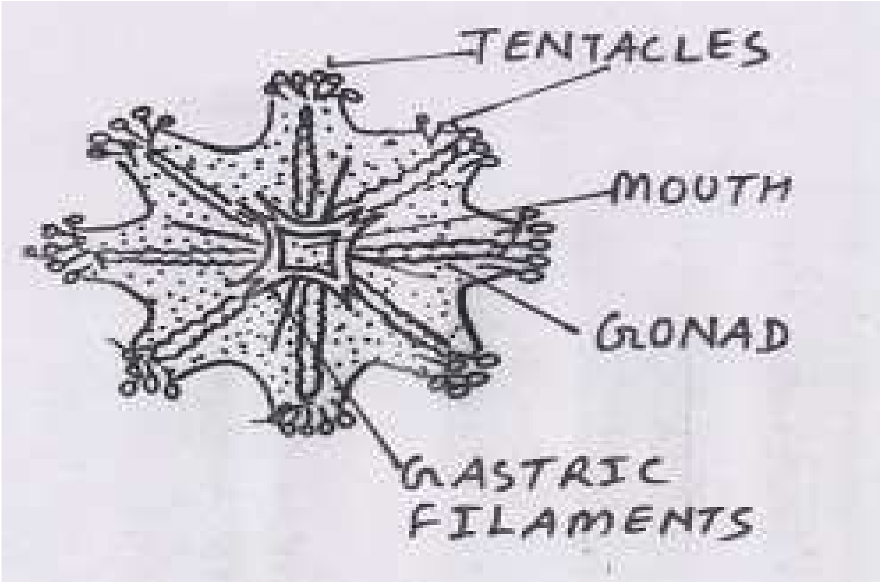


Fig.5 Lucernaria

- Mouth cruciform (four cornered) with small oral lobes.
- They have no marginal sense organs or tentaculocysts.
- Fertilization is external.
- Planula larva without cilia.

E.g. *Lucernaria* (Fig.5) and *Haliclystus*.

❖ **Order (b):** Cubomedusae (Carybdeida)

- Free-swimming Scyphozoa found in warm and shallow water of tropical and subtropical region.
- They are bell-cubical, with 4 flattened sides.
- Four per-radial tentaculocysts are present.
- Gonads are life like structure.

E.g. Charybdea and Chiropsalmus.

❖ **Order(c):** Coronatae

- Free-swimming Scyphomedusae found inhabiting the deep water of ocean.
- They are bell-conical, divided by a deep circular coronary groove.
- Tentacles are long, born on pedalia.
- Four to sixteen tentaculocysts present.
- Mouth is cruciform.

E.g. Periphylla and Pericolpa.

❖ **Order(d):** Semaeostomeae (Discomedusae)

- Most common free-swimming medusae found inhabiting the coastal water of all oceans.
- Gastric pouches and filaments are absents.
- They have flat saucer or disc-like umbrella.
- Eight tentaculocysts present.
- Mouth extending into 4 long oral arms.
  Eg. Aurelia (Fig.6), Pelagia and Cyanea (7) & Chrysaora

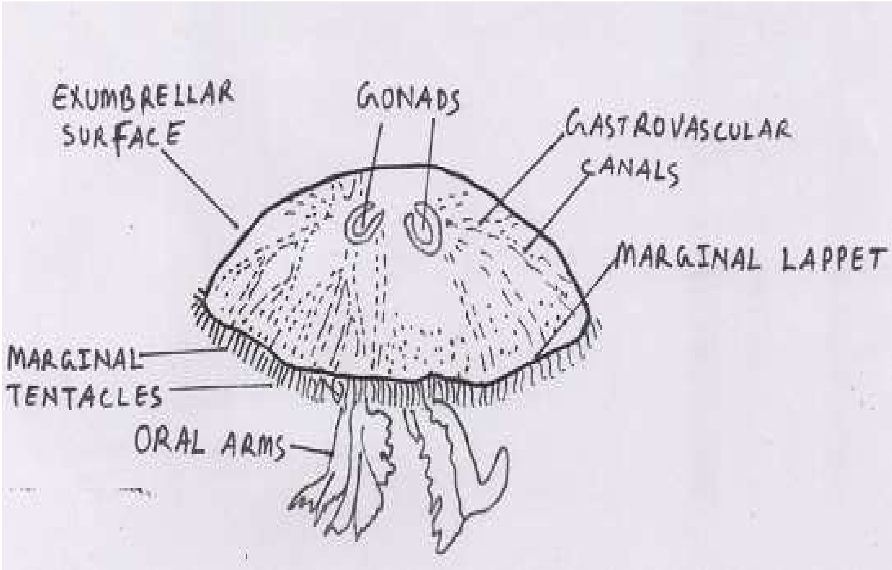


Fig.6 Aurelia

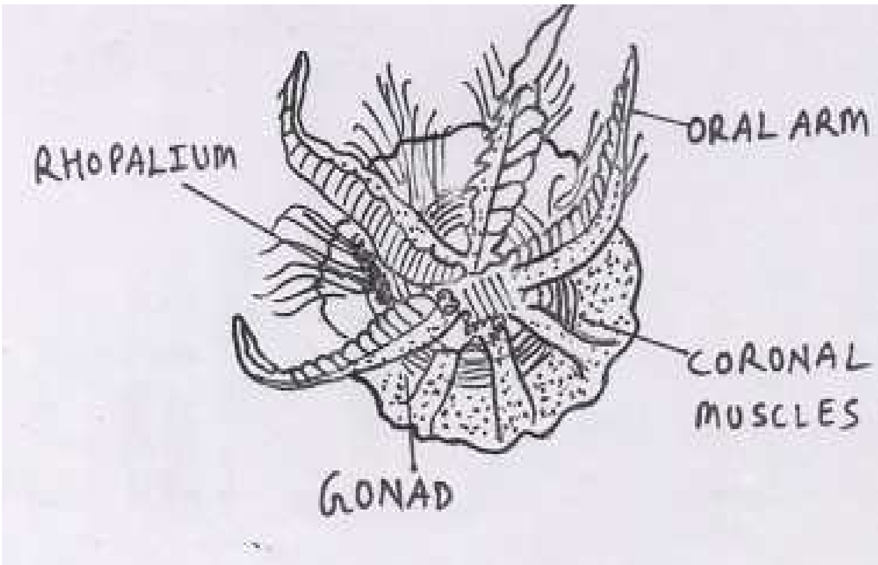


Fig.7 Cyanea

- **Order(e):** Rhizostomae
  - Free-swimming Scyphozoa found in shallow water of tropical and subtropical oceans.
  - Bell-shaped usually hemispherical, without marginal tentacles.
  - Typically 8 or more tentaculocysts.
  - No central mouth but the oral arms is fused with several small mouths.
    E.g. Rhizostoma (Fig.8) and Stomolophus.

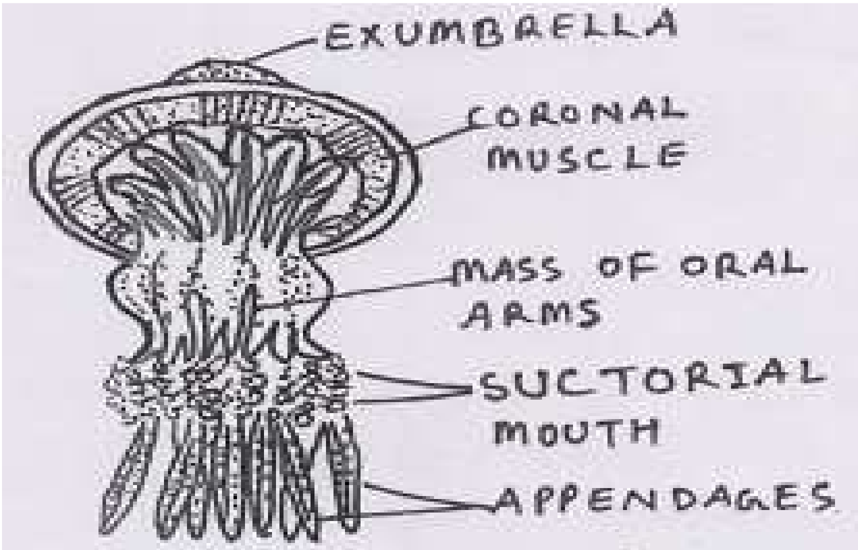


Fig.8 Rhizostoma

Class 3.Anthozoa (Actinozoa):

(Gr.Anthos- flower + zoios- animal)

- They are exclusively marine, may be solitary or colonial.
- All are polyp forms, nomedusae.
- They have gastro-dermal gonads.
- Gasto-vascular cavity is divided into completed and incomplete septa.
- Skeleton either external or internal.
- Nervous system prepared by typical nerve net without a concentrated central nervous system.
- Fertilisation is external.

These are divided into three subclasses:

- **Subclass 1.Octocorallia (Alcyonaria)**
  - They are exclusively colonial.
  - These are found in polyp form with 8 pinnate tentacles and 8 septa.
  - Eight complete mesenteries are present.
  - Polyps are dimorphic in some forms.

- They include six orders:-

❖ **Order(a):** Stolonifera

- The stolonifera are inhabitants of shallow waterin the tropical and temperate area.
- The polyps arise independently from a creeping motor stolon.
- The skeleton of separate calcareous spicules or absent.\
  E.g. *Tubipora* (Fig.9) and *Clavularia*

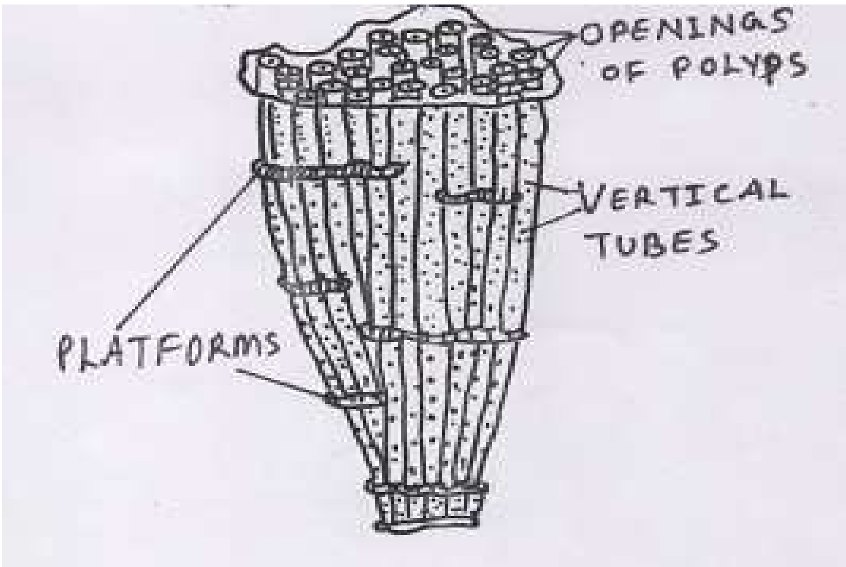


Fig. 9 Tubipora

❖ **Order (b):** Telestacea

- Lateral polyps on simple or branched stems arising from a creeping base.
- Skeletal consists of spicules fused by calcareous.
  E.g. *Telesto*.

❖ **Order(c):** Alcyonacea

- Colony mushroom-shaped.
- Polyps are dimorphic in some forms (Autozooides and Siphonozooides)
- Polyps proximally embedded in a fleshy mass or coenenchyme.
- Skeleton of separate calcareous spicules.
  E.g. Soft corals and *Alcyonium.*

❖ **Order(d):** Coenothecalia

- Polyps embedded and connected by solenial tubes.
- Skeleton massive, calcareous and blue-green from iron-salts.
  E.g. *Heliopora* (Blue coral).

❖ **Order(e):** Gorgonacea

- Colony usually of plant like branching forms bearing short polyps.
- Axial-skeleton composed of horn-like Gorgonin.

- It is commonly known as sea fans.
- Separate or fused calcareous spicules or both.
  E.g. *Gorgonian* (Fig.10) and *Corallium* (Fig.11).

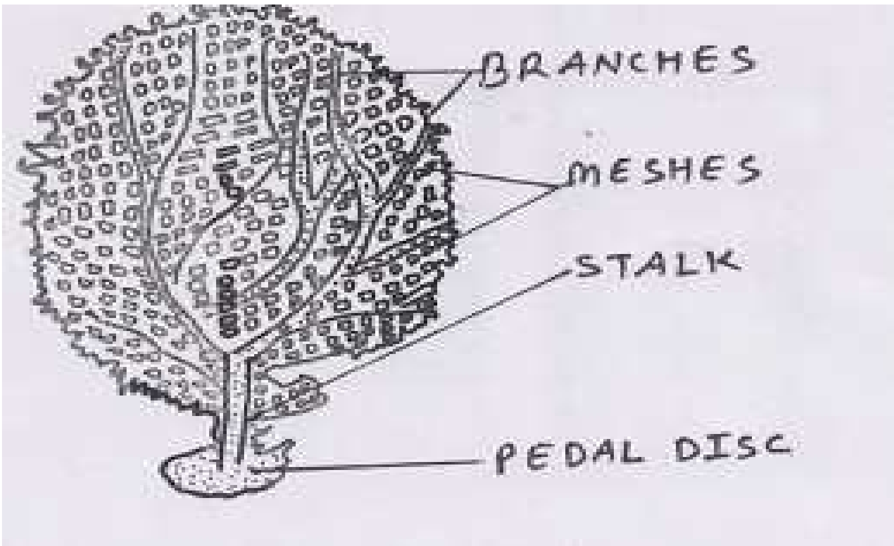


Fig.10 Gorgonia

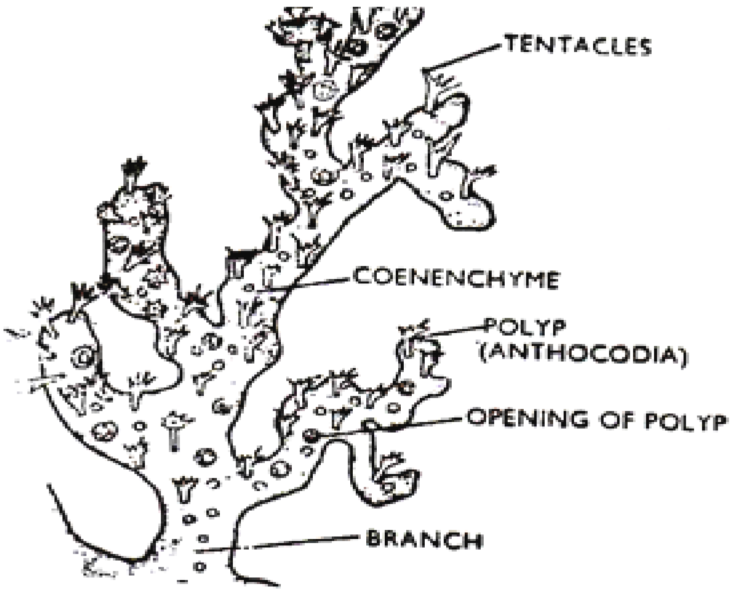


Fig.11 Corallium

❖ **Order(f):** Pennatulacea

- Colony elongated, sessile.
- Lower part embedded in mud.
- Upper parts consist of very long axial polyp with lateral branches bearing dimorphic polyps.
- Axial skeleton of separate calcareous spicules or horny substance.
  Eg. *Pennatula* (Fig.12) and *Renilla* (Sea pansy).

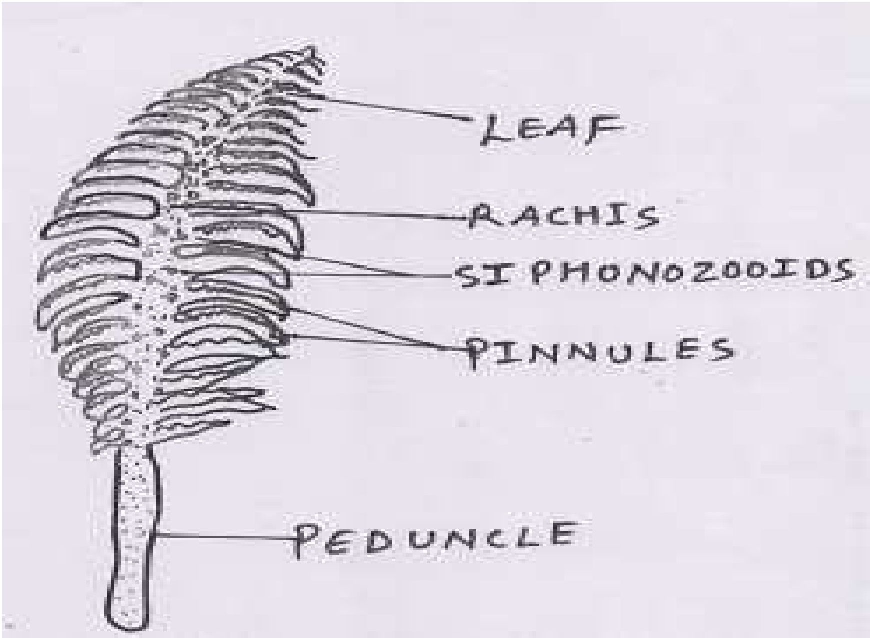


Fig.12 Pennatula

- **Subclass 2. Hexacorallia (Zoantharia)**
  - They may be solitary or colonial.
  - The tentacles are usually unbranched, numerous arranged in the multiple of 5 to 6 but never 8.
  - Endoskeleton is calcareous type. Polyps are monomorphic.
  - They included five orders:

❖ **Order (a):** Zoanthidea

- They may be solitary or colonial.
- No skeleton but body wall may contain calcareous bodies.
- Polyps are small in size.
- Mesenteries are paired.
  E.g. *Zoanthus* and *Epizoanthus*

❖ **Order (b):** Actiniaria

- Colonial or solitary.
- Skeleton absent.
- Tentacles and mesenteries are numerous.
- Large sized solitary anemones.
- Body muscular, often with an aboral pedal disc.

Ex. Sea-anemones (Fig.13), Metridium and Actinia.

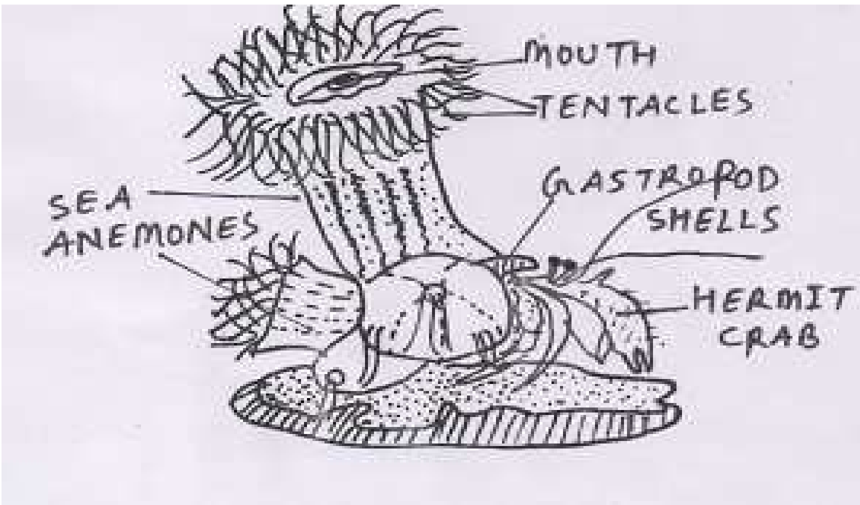


Fig.13 Sea-anemones

❖ **Order(c):** Ceriantharia

- Long, solitary, anemones like form living in sea bottom.
- Body smooth and cylindrical.
- Without pedal discs and skeleton.
- Tentacles numerous, arranged in to whorls- oral and marginal.

E.g. Cerianthus.

❖ **Order (d):** Antipatharia

- Antipatharia showed plant like colonial forms.
- It is found in the deep sea
- Tentacles and mesenteries comparatively few (6 to 24) in number.
- Skeleton as branched, chitinoid axis.

E.g. Black corals and Antipathes.

❖ **Order (e):** Madreporaria

- Generally found in colonial forms.
- Exoskeleton is hard, compact, often massive and calcareous.
- Polyps are small living in cup like cavities on exoskeleton.

E.g. True or stony corals, Astraea (Fig.15) and Acropora or Madrepora (Stag Hor n coral, Fig.14).

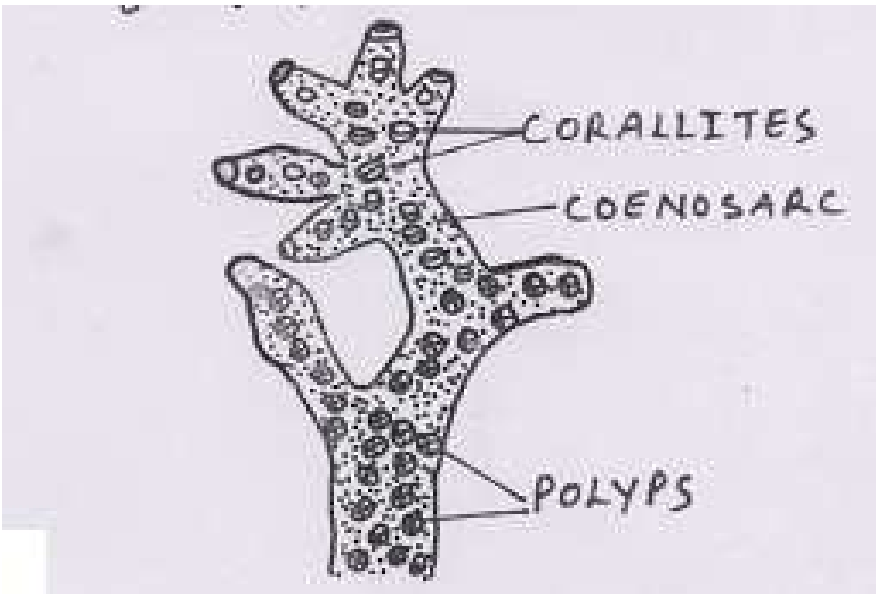


Fig.14 Madrepora

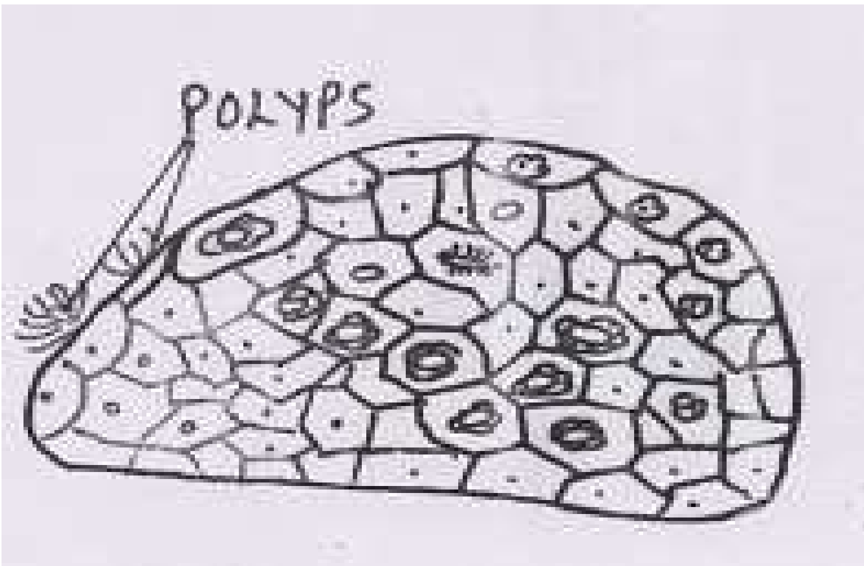


Fig.15 Astraea

- **Subclass 3.** Tabulata
  - These include extinct colonial anthozoans with heavy calcareous skeletal tubules containing horizontal platforms or tubulae.

  E.g. Favosites and Halysites.

4.4- Aurelia with special references to:-

4.4.1-Reproduction:

Aurelia (A jelly-fish):

Jelly-fishes are animals which belong to class Scyphozoa of Phylum Coelenterata. In this class, medusa is dominant and conspicuous zooids in life cycle while polypoid form is restricted to a short larval stage.

Aurelia aurita

A jelly-fish is not a true fish which is a vertebrate animal with a backbone.

Systematic position:

PHYLUM COELENTERATA
CLASS SCYPHOZOA
ORDER SEMAEOSTOMAE
FAMILY ULMARIDAE
GENUS AURELIA
Species aurita

Habit and Habitat:-

- Aurelia aurita is also popularly known as "moon-jelly".
- It is cosmopolitan jelly-fish, occurring in warm and temperate seas all over the world.
- It lives in coastal waters singly or in large shoals.
- It is found either floating with water currents and waves or swimming feebly by the contraction movements of its bell.
- It is carnivorous.

External Features:-

(a)Shape

Aurelia aurita resembles to a hydrozoan medusa.
The medusa of Aurelia aurita is flattened, bowl or saucer-shaped gelatinous structure called the umbrella (Fig.16).

(b)Size

The size is usually 4-12 inches in diameter.

(c)Colour

The umbrellar is almost transparent and bluish-white reddish or pinkish gonads.

(d)Structure

- The structure is distinctly divided into a slightly convex upper surface and a concave lower surface (Fig.16).

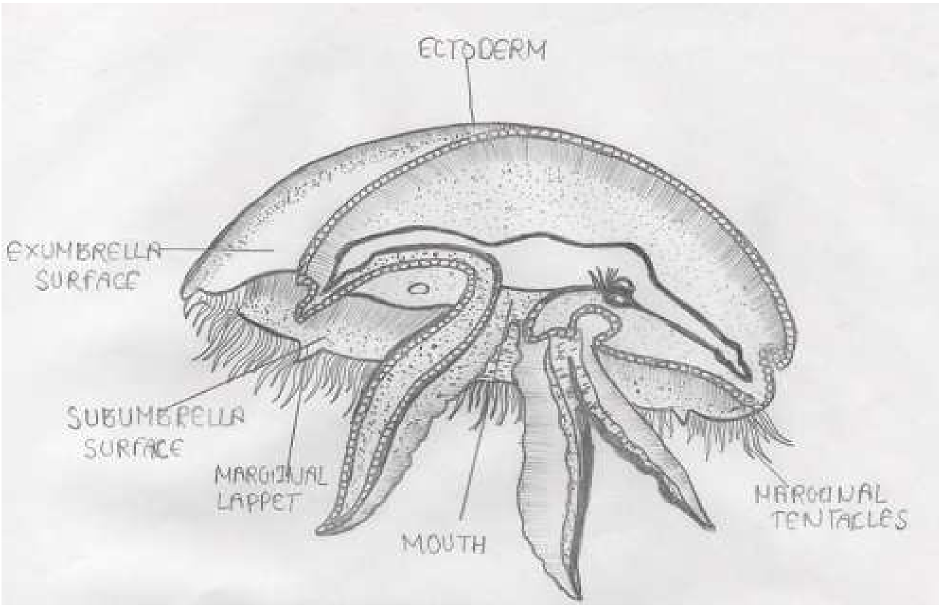


Fig.16 Aurelia Aurita (Side View)

- The convex surface is known as exumbrellar surface and concave surface is known as subumbrellar.
- The margin of umbrella is circular which is broken by eight notches.
- Each notch carries a sense organ, the tentaculocyts or rhopalium, protected by two leaves- like processes the marginal lappets.
- The marginal flap is known as velarium or pseudovelum.
- The true velum is not present in Aurelia.
- Muscles and nerve ring is absent in Aurelia.
- The following structures are found on the subumbrellar surface:-.

(i) Manubrium- In the centre of the subumbrellar surface, there is well developed but short and inconspicuous manubrium bearing a large squarish mouth.

(ii) Oral arms-The four corners of the mouth are drawn into four long delicate oral arms, Each arm bears a ciliated groove.

(iii) Subgenital pits- Situated ventrally between the oral arms and at a short distance from the mouth are four rounded apertures which lead into four subgenital pits.

(iv) Gonads- The gonads are four horse shoe-shaped patches of red or pink colour occupying inter-radial position.

Internal Anatomy:

(A) Body wall

The body wall is diploblastic, having the ectoderm, endoderm and mesogloea.

(1) Ectoderm- The ectoderm or epidermis covers the bell or umbrellar all around.
It has the columnar epitheliomuscular cells, nerve cells, sensory cells, which produce mucus. The manubrium and oral arms are also lined by epidermal cells.

(2) Endoderm- The endoderm or gastrodermis has columnar ciliated epithelial cells, they have no muscle processes, and the endoderm lines the enteron except the gullet.

(3) Mesogloea-It forms the bulk of body.

- It forms a thick layer between epidermis and gastrodermis.
- It is not structureless.
- It contains numerous branching elastic fibers and wandering amoeboid cells.
- This type of mesogloea is known as collenchyma.

(B) Muscular System

- It is very well-developed and confined to subumbrella surface.
- It is formed of both striated and non-striated muscle fibres.
- The muscle fibres are arranged longitudinally in the tentacles, manubrium and oral arms but are radial and circular in the umbrella.
- The rapid and rhythmic contraction of these muscle processes brings about swimming movements in Aurelia.

(C) Gastro-vascular System

- The mouth leads into the short gullet within the manubrium which finally opens into a four lobed spacious stomach.
- The digestive system has also taken over the work of distribution of digested food.
- Hence a distinct circulatory system is absent and this system is called gastro-vascular system.

(D)Nervous System

- The nervous system forms a subumbrella plexus and group of eight rhopalial ganglia.
- The subumbrella plexus froms special radial thickenings.

- The marginal nerve ring is either absent or faintly developed.

(E) Sense Organs

- Sense organs of Aurelia are eight rhopalia or Tentaculocyst situated in the eight marginal notches.
- Several sense organs are localized near the tentaculocyst.
- There are two olfactory pits as depression, one on the ex-umbrella and the other internal to the Tentaculocyst, their sensory epithelium is olfactory.

(F) Reproductive Organs

- The male and female sex organs are borne on separate sub umbrella which are similar in appearance.
- The gonads are horse –shoe-shaped, plaited or frilled structures of brilliant pink or reddish violet colour shining externally through semitransparent membrane of umbrella.

Reproduction and Life History:

- *Aurelia aurita* is dioecious, that is, the male and female sexes are separate but there is no sexual dimorphism.

Sex organs:

- Testes and ovaries are similar in appearance.
- A medusa has four horse-shoe-shaped gonads lying on the floor of stomach periphery, that is, one in each gastric pouch.
- They are reddish violet in colour.
- On maturity, ova and sperms break into the gastro-vascular cavity and pass out of mouth with the outgoing water current.
- The ova or eggs are lodged in the frills of oral arms.

4.4.2- Development of *Aurelia*

Fertilization:

The male and female gametes are formed separately in different medusae of *Aurelia aurita.* Spermatozoa, swimming about in water, reach the ova and fertilize them either in stomach of female or in the frills of oral arms (Fig.20) thus, fertilization is either external or internal.

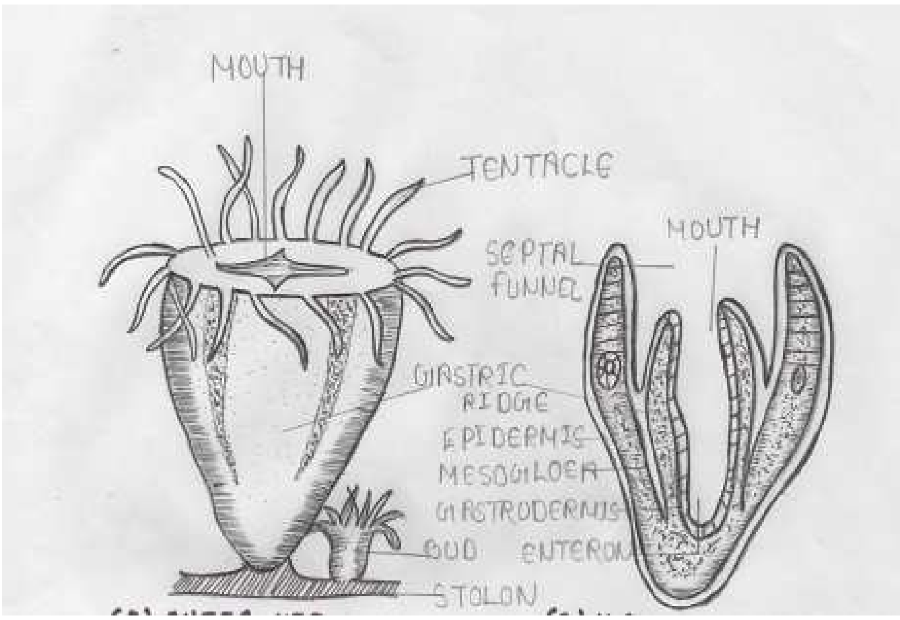
Formation of Planula larva:

- Frills of oral arms serve as temporary brooding of members.

- Here, each fertilized egg or zygote undergoes early development into a ciliated larval stage, called planula.
- The zygote undergoes holoblastic and equal segmentation to produce a solid ball-like morula. Soon it is transformed into a single –layered blastula, enclosing a central fluid-filled cavity or blastocoel.
- Two-layered gastrula develops by invagination, having an outer ectoderm and an inner endoderm lining an enteron cavity, with its blastopore or gastral mouth not completely closed.
- Thus, it differs from the gastrula of Hydrozoa (e.g. Obelia) which develops by a process of delamination and multipolar ingression of cells into blastocoel having no blastopore.
- The embryo now elongates, its outer cells become ciliated, blastopore closes and the typical planula larva is formed.
- At this stage, masses of planula are visible as minute patches on the oral arms of female individual (Fig.20).

Development of planula into Scyphistoma:

The ciliated planula eventually escapes and, after a short free-swimming existence, attaches itself to a stone or seaweed by its brood anterior, aboral end (Fig.17).



(A) Outer view (B)V.S Throughinter-Radius

Fig.17 Scyuphistoma Larva of Aurelia

Cilia are lost and a mouth opens at its free distal end where blastopore had closed. The larva now becomes elongated and metamorphosed into a small trumpet-shaped or hydra-like polyp, about

5mm high. Its proximal part is narrowed into a stalk-like organ, attached to the substratum by an adhesive basal disc.Tentacles bud out around the mouth. First four tentacles are perradial, subsequent four inter-radials and then 8 adradial in position. Thus, 16 long and slender tentacles are formed. Mouth becomes square in outline and its edges become elongated to form a short manubrium. The larva now looks like a trumpet-shaped polyp or Hydra, and is called hydratuba or young scyphistoma (Gr.Skyphos- cup + Stoma- mouth, Fig.20). Endoderm of its enteric cavity is raised into four interradial longitudinal gastric ridges or **taenioles,** characteristic of Scyphozoa, which divides the enteric cavity into four perradial **diverticula or pouches.** Simultaneously, the ectoderm between mouth and tentacles also becomes invaginated as four interradial funnel-like depressions, known as septal funnels or infundibula, which sink into 4 gastric ridges. Scyphistoma feeds and grows up to 12 mm in height and may survive in this stage for several months.

Formation of Ephyra (Strobilation):-

In autumn and winter, scyphistoma undergoes a remarkable process of budding or transverse fission of oral end, called strobilation. Distally, body develops a series of ring–like transverse constrictions or furrows which gradually deepens so that the organism resembles a pile of minute saucers or discs placed one above the other. At this stage, scyphistoma with a segmented body is called a strobili and each of the segments is called an ephyra larva. The ephyra are connected together by muscular strands. As they grow older, their muscular strands contract violently and break at intervals. So one by one the distal ephyra are pinched off from the parent strobili, which turn over, and swim away as little medusa or jelly-fish.
About a dozen ephyra are formed in a single strobilation. When food is plentiful and temperature is low, several ephyra are produced in one time (Poly disc strobilation).When food is scarce and temperature is high, a single ephyra is produced at a time (Mono disc strobilation).When all ephyra get detached, the base unsegmented part of scyphistoma grows new tentacles and continues to live as a polyp or hydratuba. It may live for several years, feeding, growing and by budding in summers,but producing ephyra by strobilation in winters.Under ecceptional circumstances the whole schiphistoma may be metamorphosed into a single adult Aurelia,without forming ephyra(Fig.18).

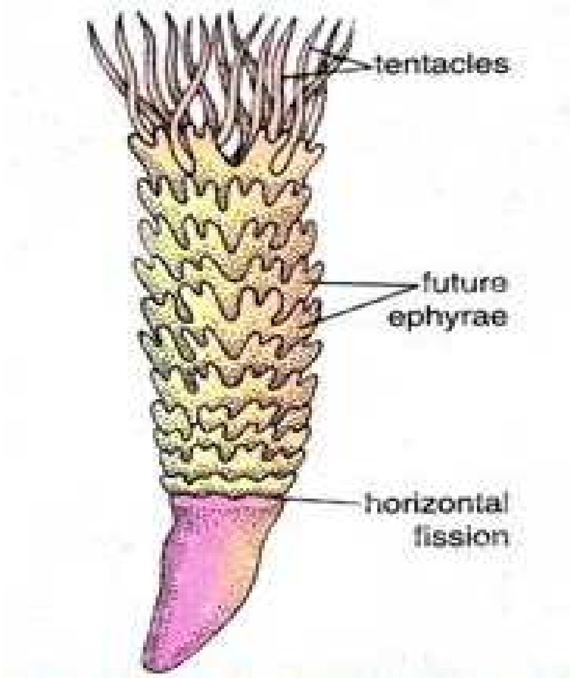


Fig.18 Aurelia: A Strobila

Ephyra:

A newly released ephyra is a microscopic gelatinous creature, about 1mm in diameter and with a well-developed tetramerous symmetry. The edge of its umbrella is greatly fluted, being produced into eight bifid-lobes or arms (4 per and 4 interradial), separated by 8 deep adradial Indentations or clefts. Distal extremity of each lobe in deeply notched to form a pair of primary lappets. Notch or groove between lappets is a sensory recess or niche bearing a short tentacle, which becomes tentaculocyst or rhopalium.Ephyra, contains a small segment of stomach of scyphistoma with gastric ridges.Ephyra swim actively in sea water feeding on minute organisms, such as protozoans, which are caught by lappets and transferred to mouth (Fig.19).

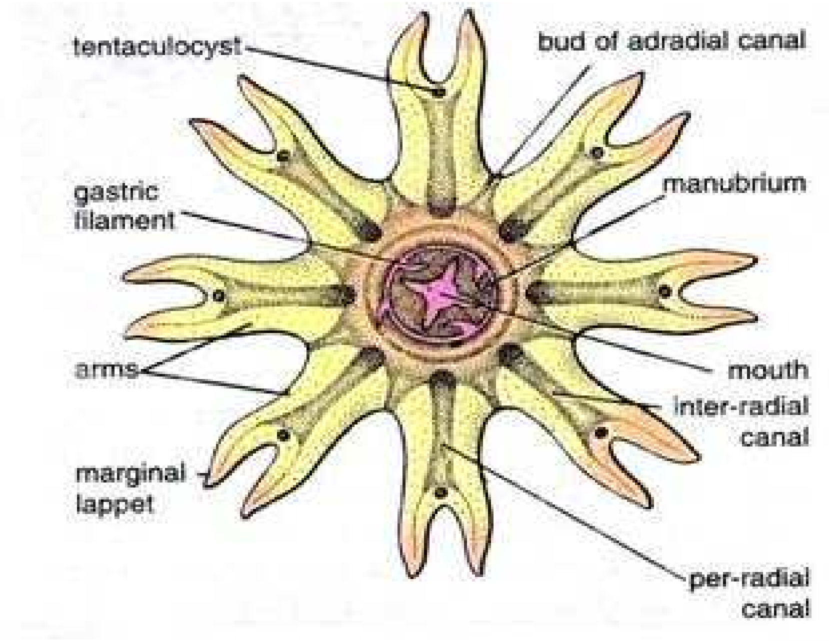


Fig.19 Aurelia: A free Ephyra

Metamorphosis:

As growth proceeds, mesogloea increases enormously, so that two layers of endoderm (gastrodermis) fuse to form a solid gastro-dermal lamella, except in regions of gastro vascular canals. Adradial regions grow more rapidly, gradually filling up their wide clefts, so that the umbrella of eight rayed ephyra become circular and saucer-shaped, as in an adult medusae. With the appearance of 4 oral arms and numerous marginal tentacles, ephyra is finally transformed into adult Aurelia.An ephyra formed in winter becomes a sexually reproducing adult medusa by spring or summer.

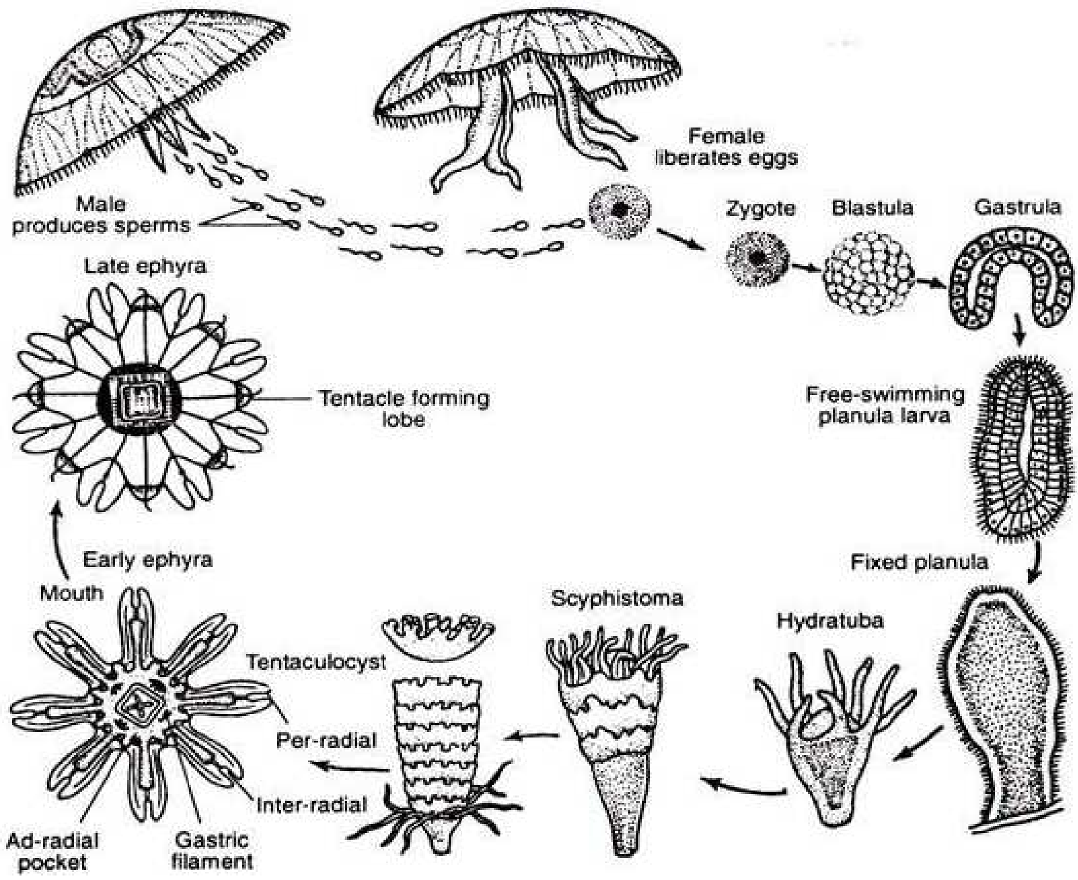


Fig.20 Different stages of development in Aurelia

The stages in the life history of Aurelia (Fig.20) are:-

Male and Female medusae⟶ gametes⟶ zygotes ⟶ ciliated planula larvae

↓

Adult Male and Female⟵medusae⟵ephyra ⟵scyphistomae ⟵hydratubae

Alternation of Generation:

Life history of Aurelia exhibits the phenomenon of "alternation of generation" since the sexual medusoid form always alternates with the asexual polypoid from.The fee-swimming adults Aurelia (medusoid form) represents sexual generation and reproduces by the formation of gamates.The fertilized ovum develops into a fixed polypoid scyphistoma through a free swimming planula larva. The polypoid scyphistoma represents asexual generation and reproduces asexual by budding.

4.4.3- Polymorphism:-

Meaning of polymorphism:

Occurrence in the same species of more than one type of individuals, which differ in form and function, is known as polymorphism (Gr., Polyps- many or several + Morphe- form). This ensures an efficient division of labor between the several individuals.

Two basic forms:

In hydrozoa (or coelenterates), which may be single or colonial, there occur two main types of individuals or zooids-polyps and medusa.

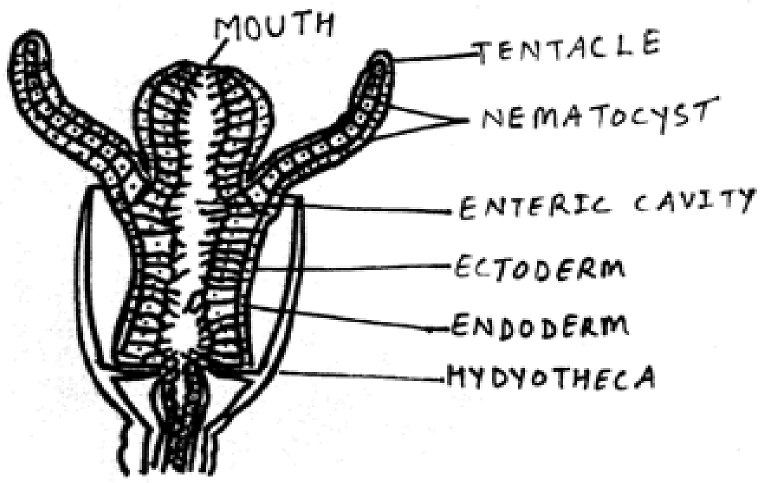


Fig. 21 Obelia :V.S of Polyp

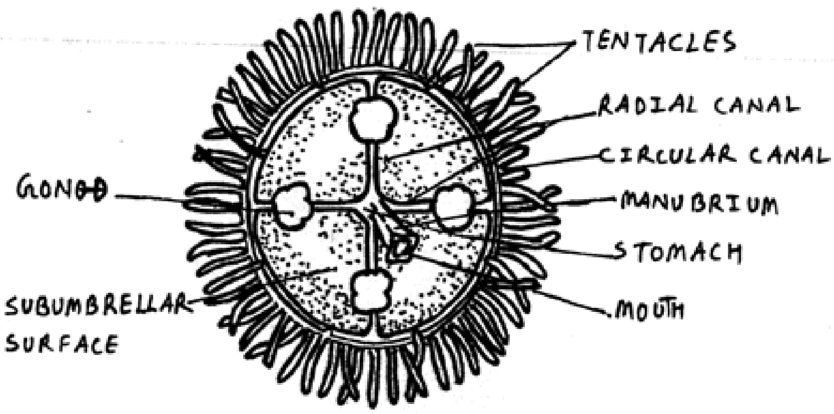


Fig.22 Medusa in Oral View

Patterns of polymorphism:

Degree of polymorphism varies greatly in different groups of Hydrozoa.

1. Dimorphic- simplest and commonest pattern of polymorphism is exhibited by many hydrozoan colonies like obelia, tubularia, etc. They have only one type of zooids (individuals). Gastrozooids or hydranths are concerned with feeding, while gonozooids or blastostyles with asexual budding forming sexual medusa or gonophores. Such colonies, bearing only two types of individuals are called dimorphic, and the phenomenon is termed dimorphism.

2. Trimorphic- some forms, like plumularia, are trimorphic. Besides gastrozooids and gonozooids, they also possess a third type of individuals, the dactylozooids.These are functionally non-feeding and defensive polyps bearing batteries of nematocysts.

3. Polymorphic- coelenterates having more than three types of individuals are called polymorphic. Polymorphism is found in the incrusting colony of *Hydractinia* (Fig.27) and *Calycophoran or Siphonophora* (Fig.23) with five types of polyps, each performing a specialized function. These are

(i) Gastrozooids for feeding,

(ii) Spiral dactylozooids for protection,

(iii) Long sensory tentaculozooids with sensory cells,

(iv) Skeletozooids as spiny projections of chitin, and

(v) Gonozooids or reproductive individuals, bearing male or female gonophores (sporosacs) or medusa for sexual reproduction.

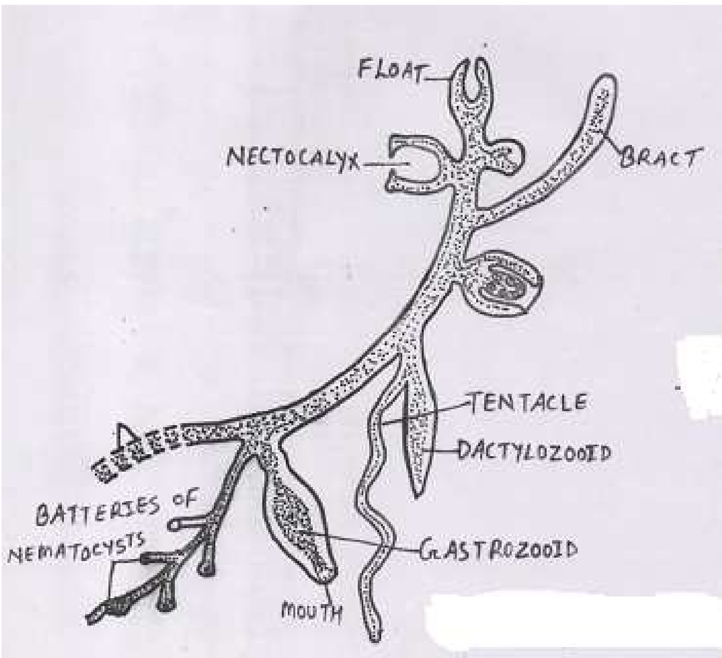


Fig.23 Calycophoran

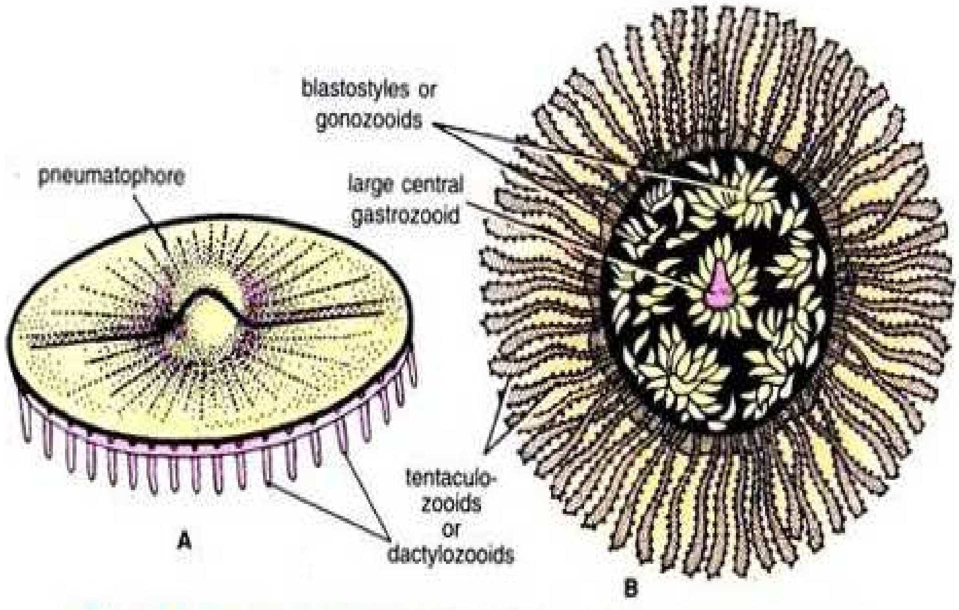


Fig.24 Porpita (A) Dorsal (B) Ventral

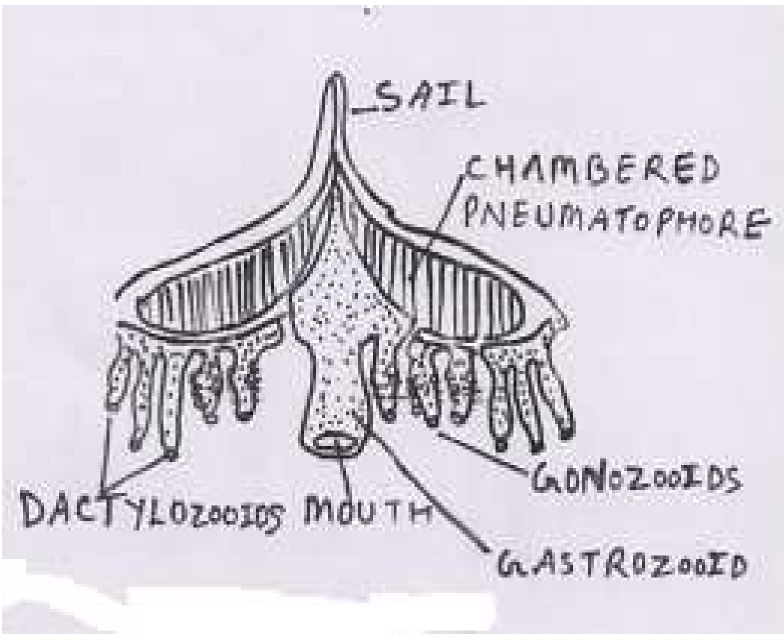


Fig.25 Vellella

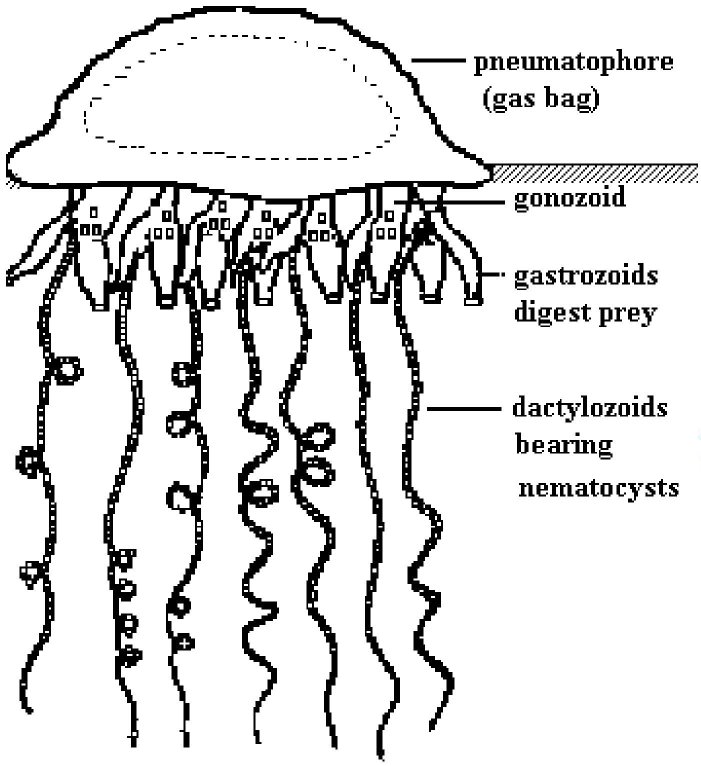


Fig.26 Physalia

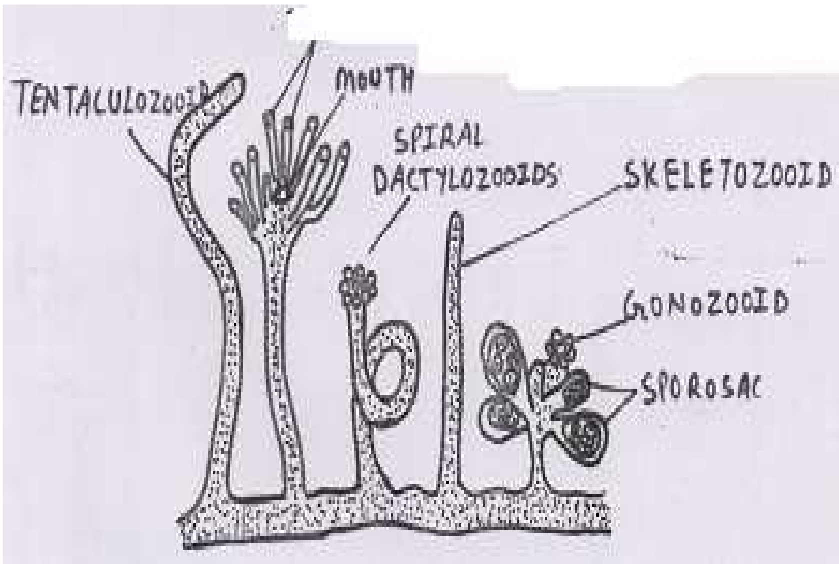


Fig.27 Hydractinia

Extreme examples of polymorphism are seen in the pelagic or swimming colonies of the orders siphonophora (Diphyes, Halistemmia, Stephalia, and Physalia,) and chondrophora (Porpita, and

Velella,). As in Hydractinia, both polypoid and medusoid individuals, specialized for various vital functions, occur in the same colony.

Polymorphism reaches its peak in siphonophora.

(a) **Modifications of polyps-** Polypoid individuals include:

(1) Gastrozooid or feeding polyp with a mouth and a long tentacle.

(2) Dactylozooid or protective polyp without mouth and usually with a long basal tentacle.

(3) Gonozooid or reproductive polyp which produces sexual medusa or gonophores.

(b) Modifications of medusa- The medusoid individuals are of the following types:

(1) Nectophore or nectocalyxor swimming zooid with a muscular bell without manubrium or tentacles.

(2) Pneumatophore or float as a bladder-like medusa filled with secreted gas.

(3) Phyllozooid or bract, usually leaf-like and studded with nematocysts, serving for protection of other zooids.

(4) Gonophore bearing gonads, which may be either male, producing sperms, or female producing ova.

Importance of polymorphism:

Polymorphism is essentially a phenomenon of division of labour. Different functions are assigned to different individuals, rather than to parts or organs of one individual. Thus, polyps are concerned with feeding, protection and asexual reproduction, while medusas are concerned with sexual reproduction.

4.5- A brief account of coral and coral reefs and there importance:-

Corals:-

Meaning of coral

Coral animals or corals are marine, mostly colonial, polypoid coelenterates, looking like miniature sea anemones and living in a secreted skeleton of their own. Their calcareous or horny skeleton is also commonly known as coral. Some corals grow into massive, solid structures; others form large, branched colonies. Most of the corals belong to the class Anthozoa and the few to class Hydrozoa of phylum coelenterate.

Structure of coral polyp

1. Soft structure

A typical coral polyp from a colony is a small organism about 10 mm long and 1 to 3 mm in diameter. A basal disc is absent because the basal region of polyp is surrounded by a calcareous exoskeleton. Oral disc bears numerous tentacles, in several rows around an elongated, oval or circular mouth. Pharynx or stomodaeum is short and without siphonoglyphs. Mesenteries are restricted to the upper part of coelenteron and mesenterial filaments contain only one glandular lobe bearing nematocysts. Body wall is without cinclides and nematocyst bearing structures (acontia). Muscles are poorly developed while little is known about nervous system.Living polyps are found only on surface layers of coral masses. They feed at night both by raptorial and suspension feeding. When not feeding, they withdraw into cup-like cavities of skeleton.

2. Structure of coral skeleton

Skeleton of solitary coral is known as corallite. It is a calcareous exoskeleton secreted by epidermis. In a colonial coral, corallites of individual polyps fuse together to form a skeletal mass, called corallum. Each corallite is like a stony cup with a basal part or basal plate, and a cup wall or theca, enclosing the aboral portion of polyp. Cavity of cup contains a number of vertical radiating ridges called sclerosepta, proceeding from theca towards the centre of cup. Inner ends of sclerosepta are fused to form an irregular central skeletal mass or columella.

Types of corals in different groups

1. Hydrozoan corals

Order hydrocorallinaincludes few genera, like millepora, stylaster and distichopora, which are colonial and secrete massive branched calcareous exoskeletons.These are found in coral reefs with other corals. Skeleton is secreted by a modified epidermis, called calicoblastic layer. Living within the skeleton occur two types of polyps, large feeding gastrozooids and defensive dactylozooids.

2. Octocorallian corals

(a)**Order** alcyonaceaincludes marine, colonial and soft corals. A well-known genus is alcyonium, popular as “dead man’s fingers” because of its resemblance to a human hand. It has an endoskeleton of separate calcareous spicules embedded in a massive mesogloea or coenenchyme.

(b)**Order** stolonifera includes the organ pipe coral, tubipora musica, widely distributed on coral reefs in warm waters. Skeleton is made of mesogloeal calcareous spicules forming parallel and vertical tubes, each occupied by one polyp, and connected together by lateral platforms. Skeleton is dull red in colour due to presence of iron salts.

(c)**Order** coenothecalia includes a single genus heliopora, commonly known as blue coral.
Its massive calcareous, skeletonor corallium is secreted by polyps living in large, erect, cylindrical solenialtubes on the surface of skeleton.

3. Hexacorallian corals

Order madrepora includes stony corals, which are the principal builders of coral reefs. While some of them are solitary, most are colonial, assuming a great variety of forms.

(a) Solitary corals

Fungia (Fig.13), flabellum, etc., are the solitary corals or cup corals. The corallite is disc-like or mushroom shaped in form and measures 5 mm to 25 cm across.

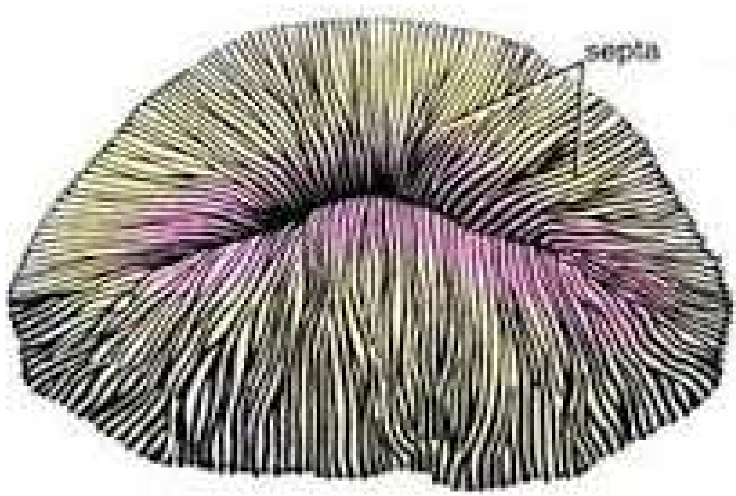


Fig.28 Fungia

(b) Colonial corals

Most of stony corals are colonial with plate –like, cup-like, spherical, or vase-shaped skeleton. Typical examples of colonial medreporarian corals are acropora, oculina, favia, madrepora, etc. Some of the colonies are branched.

Coral Reers

Coral colonies grow continuously in size by budding of polyps and often form extensive masses, known as coral reefs. According to T.Wayland Vaughan(1917), a coral reef is a ridge or mound of limestone, the upper surface of which is near the surface of sea and which is formed chiefly of CaCO3 secreted by coral polyps. Principal builders of coral reefs are stony corals (madreporaria), but other important contributers are the hydrocorallines and alcyonarians. Coralline algae and foraminiferan protozoa also take part in the formation of coral reefs.Reef building corals require warm shallow waters (normally above 20C). They are therefore limited to the Indo-pacific, the central western pacific, and the carabian regions north of Bermuda. About 50 species of corals contribute in the formation of reefs along the Florida Keys and in the West-Indies.

Kinds of coral reefs

The coral reefs are of three kinds, depending on how they are formed.

1. Fringing reefs

Coral reefs lying close to the shores of some volcanic islands or pert of some continent are termed fringing reefs. Fringing reefs may extend out to a distance of a quarter mile from the shore with the most active zone of the coral growth facing the sea. This seaward zone is commonly called the edge or front. A shallow water channel, 50 to 100 meters broad, lies between the reef-edge and shore at low tide, water of channel recedes at quickly exposing a flat bottom surface, called reef flat. It is largely composed of coral sand, mud dead and living coral colonies and other animals (Fig.29).

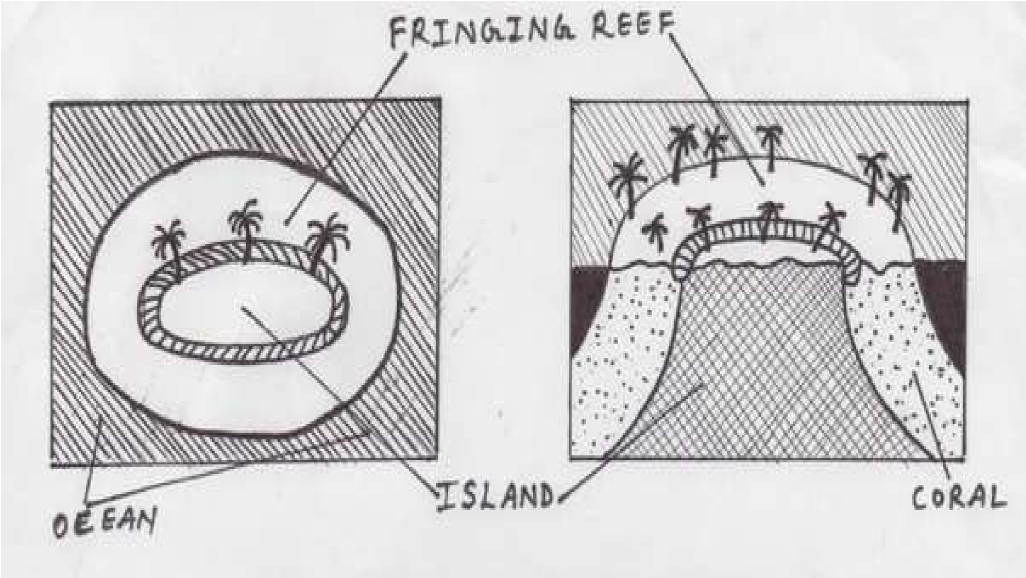


Fig.29 Fringing Reef

2. Barrier reefs

Barrier reefs are like fringing reefs but they are located some distance away from the shore.
The stretch of water, separating the barrier reef from land, may be half a mile to 10 miles or more in width. It is called a lagoon. It is 10 to 50 fathoms deep and suitable for navigation.
Most notable example of barrier reefs is the Great Barrier Reef along the north- eastern coast of Australia. It is about 2000 km long and upto 150 km from shore (Fig.30).

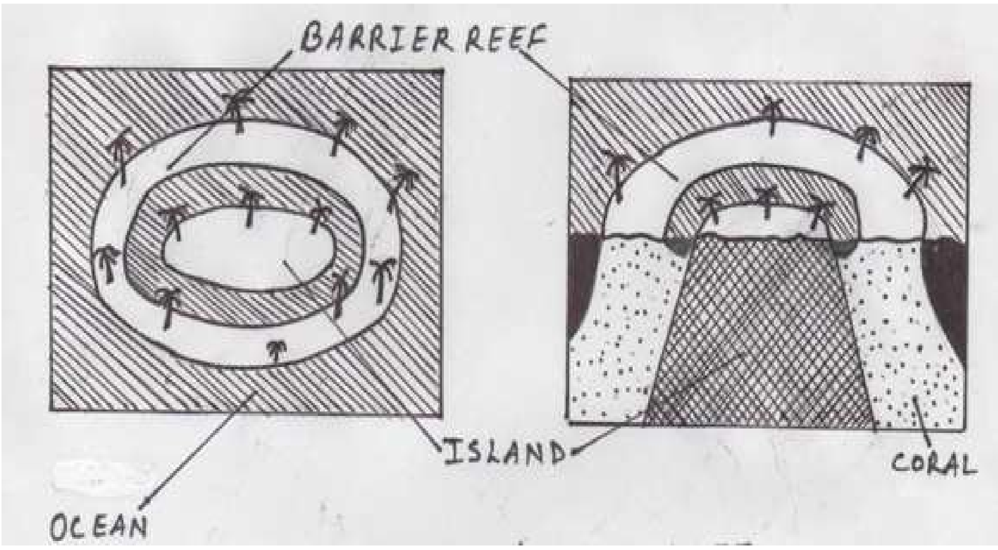


Fig.30 Barrier Reef

3. Atoll

An atoll is also termed a coral island or lagoon island. It is a ring-like or horse-shoe shaped reef that encircles a lagoon but not an island. The lagoon varies from a few to about 90 km across.
It may be complete or broken by a number of channels, of which only a few are navigable.
Outer side of the reef slopes off rather steeply into the depth of ocean. The atoll of Bikine, famous for atomic and hydrogen bomb tests, lies in the Pacific Ocean (Fig.31).

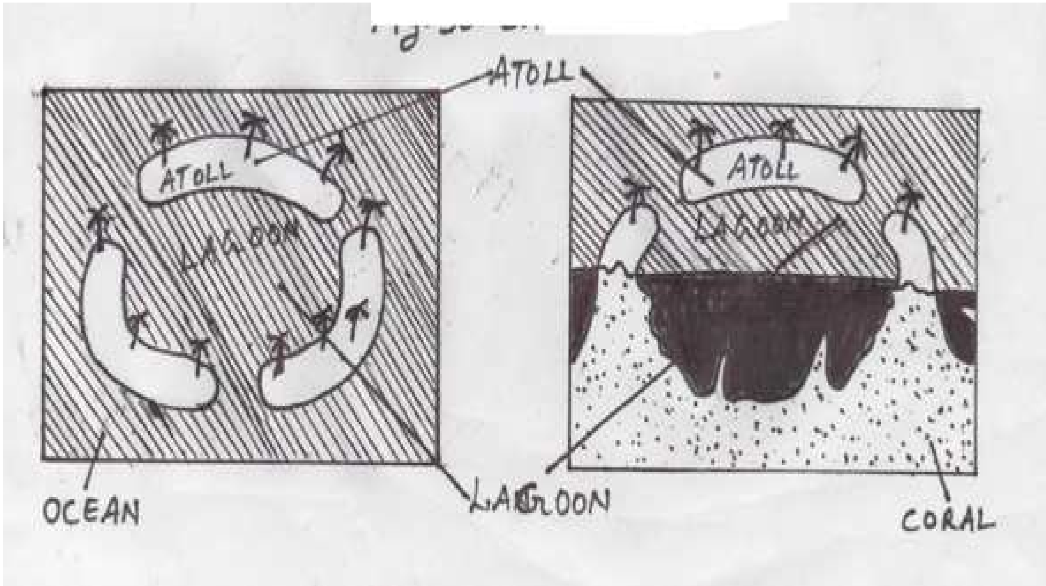


Fig.31 Atoll Reef

Theories of coral reefs formation

Since the reef building coral are littoral in their habitat and cannot grow below 150 feet, it is difficult to explain the great vertical thickness often attained by the coral reef. Several theories have been put forward by many scientists from time to time. A few important ones are as follows.

Darwin-Dana theory of subsidence-

During his expedition in 1931, Darwin noticed that in the region where coral reefs are found now, a sinking of land had taken place in past. He, therefore, assumed that the corals started their growth as fringing reef around the sloping shores of an island in shallow tropical sea.
By subsidence of the shore of that island they became barrier reef with a lagoon in between.
The rate of subsidence ought to have been equal to the rate of coral growth so that they have kept the surface of the reef in level with that of the ocean. The sinking island becomes smaller and smaller and finally disappeared leaving its ring –shaped contour marked in an atoll.Darwin

assumed a general sinking of the entire Pacific floor which appears to be incredible. The modern concept is viewed by supposing an independent sinking of each landmass.

Submerged bank theory

According to recent scientists the corals grow to form reef on flat pre-existing surfaces during or after their submergence. This submergence is brought about by the erosion and denudation of an island both above and below water. On complete replacement of the island by a submerged plateau the builders will produce an atoll.

Daly's glacial –control theory

According to Daly's glacial –control theory, during the last glacial period the formation of ice caps lowered the ocean level by 60 to 70 meters below the present surface. Waves cut the shores to make flat platforms suitable for growth of coral. As the ice caps melted and temperature rose, corals began to grow on these platforms and rose upwards with rising ocean levels, and all type of reef were formed on the pre-existing platform. There is evidence that coral reef are growing today on submerged land and the foundation of reef are now at a much greater depth than they were when corals first began to grow.

Observation of living coral shows that their rate of growth is from 5mm to 20cm per year, thus a 50 meter deep reef could be formed in less than 8,000years and all the known reefs could have been built in less than 30,000 years. Some boring made in coral reef showed that the rested on level platform, but some other boring showed that reefs had no underlying platforms but had only sand and shell below them.

Economic importance of coral reefs:-

Corals of the remote geological past formed reef structures.They were highly favourable sites for accumulation of petroleum deposits. Thus coral reefs are of much importance to oil industry. Large quantities of corals are shipped every year for the curio trade. The coral reefs serve as habitats for many plants and animals like sponges, molluscs, echinoderms, fishes, etc. Some coral reefs are used for habitations by man as well. Some corals are highly prized for their decorative value. *Corallum rubrum* is considered to be a precious coral stone in India and china and treated as auspicious. The red coral and organ pipe coral are used in some indigenous system of medicine in India Chunks of coral skeleton belonging to species porites are used as building materials. Coral skeleton serve as raw material for the preparation of lime, mortar and cement because of their calcium carbonate and magnesium carbonate content. Coral reefs serve as good nursery grounds for commercially important fishes. Reef fish varieties are more colourful than others.

4.6-Summary

- Phylum Cnidaria (formely known as coelenterata) includes about 9000 species.
- Some are found in fresh water, but the greater numbers are marine.Coelenteratas is metazoa or multicellular animals with tissue grade of organisation.
- Body radial or bi-radially symmetrical with oral-aboral axis. They are diploblastic animals.
- Coelenterate animals are represented by two morphologically different types of individuals, polyps and medusa. They are all aquatic, mostly marine and some freshwater (eg. Hydra).
- Coelenterate animals are usually carnivorous. The coelom, excretory, circulatory and respiratory organs are absent. Anus is absent.
- Locomotion is brought about by smooth muscle fibers.
- Nervous system consists of one or more networks or nerve cells and neurites located in the ectoderm and endoderm.
- Sense organs are ocellii and statocysts.
- Skeleton either calcereous or horny and external or internal but absent in few.
- Reproduction is both asexual and sexual methods.
- Asexual reproduction occurs by budding and sexual reproduction by the formation of gametes.
- The stages in the life history of Aurelia are:

  Male and Female medusae⟶ gametes⟶ zygotes ⟶ ciliated planula larvae

  ↓

  Adult Male and Female⟵medusae⟵ephyra ⟵scyphistomae ⟵hydratubae
- Polymorphism (Gr., Polyps- many or several + Morphe- form) is essentially a phenomenon of division of labour.
- A coral reef is a ridge or mound of limestone, the upper surface of which is near the surface of sea and which is formed chiefly of CaCO3 secreted by coral polyps.
- Reef building corals require warm shallow waters (normally above 20C). About 50 species of corals contribute in the formation of reefs along the Florida Keys and in the West- Indies.
- The coral reefs are of three kinds, depending on how they are formed (a) fringing reefs (b) barrier reefs and (c) atoll.

4.7- Glossary

Aboral –	Opposition the mouth.
Alternation of generation-	Alternate succession of sexual and asexual generation in the life cycle of a organism.
Amoeboid –	Cell movements resembling those of the amoeba.
Anatomy-	Study of the structure of animal and plants.
Anus –	Posterior opening of the digestive tract.
Atoll-	Horse shoe or ring-like island consisting of a belt of coral reef surrounding a central lagoon.
Budding –	A form of asexual reproduction.
Calcereous-	Containing lime.
Carnivorous-	Feeding on other animal.
Cilia –	Hair like projection.
Cleavage-	Series of early division of an egg into many cells.
Coelenterata-	Phylum (Cnidoblast structures)
Coelom-	Body cavity lined with tissue of mesodermal origins in which the digestive and other organs.
Colony-	Group of individuls.
Dactylozooids-	Sensory polyp of Hydrozoa.
Dioecious-	Having the male and female reproductive organs in separate individule.
Diploblastic-	Derived from two embryonic germ layer, ectoderm and endoderm.
Embryo-	Young animal that is passing through its developmental stages.
Endoderm-	Inner most layer of the early embryo which gives rise to the lining of the digestive tract.
Excretion-	Discharge of metabolic wastes.
Fertilization-	Union of a mature ovum and a mature sperm to form zygote.
Fringing reefs-	Coral ridge build up from ocean bottom.
Gamete-	A mature reproductive cell.
Gastro-vascular –	Serving the function of both digestion and circulation.
Gonozooid-	Reproductive polyp of Hydrozoa.
Holoblastic-	Cleavage in which an entire egg cell divides.
Invagination-	Infoulding of any part.
Locomotion-	Movement.

Manubrium-	A structure projecting from the middle of the sub-umbrellar surface of the medusa and bearing the mouth at its free end.
Mesogloea –	Non-cellular jelly like substance lying between the ectoderm and endoderm.
Metagenesis-	Alternation of sexual with an asexual generation in reproduction in the life cycle of a coelenterate, eg.Obelia.
Metamorphosis-	Structural changes.
Metazoa-	All multicellular animal in which there is a differentiation of the body cells as opposed to the unicelluler animal.
Morula-	Solid ball of cells resulting from eggs cleavage.
Nematocysts-	One of the stinging capsules found in the coelenterates; Each is
]	produced by a single cell.
Oral –	Pertaining to the mouth.
Ovary-	Female gonad.
Planula -	The ciliated free –living larval form of coelenterates.
Pneumatophore-	Air–filled float of siphonophoran hydroids.
Polymorphism –	Occurence of several forms in a single species.
Polyp-	A tubular coelenterates form.
Reproduction-	Production by an organism of others of its kinds.
Respiration-	Use of oxygen by cell.
Sessile-	Attached, not free-moving, sedentry
Sexual dimorphism-	Phenomenon of two sexes of a given species differing in secondary
characters.	
Solitary-	Living alone, not a member of the colony
Statocyst-	Organ of equilibrium in animal.
Statolith-	Solid body within a statocyst.
Stomodaeum-	Anterior portion of the alimentary canal with ectoderm. It is also Known as foregut.
Strobilation-	Budding in segmented of sessile scyphozoan coelenterate larve resulting in cutting off following free swimming ephyral larve.
Tentacles –	A flexible arm-like extension from the body of many invertebrates

	such as hydra used in grasping and movement.
Tentaculocyst –	Sense organs of some coelenterates.
Testis-	Sperm formation gland.
Zooid-	One of the members of a hydroid or siphonophore colony.
Zygote –	The product of the union of two gametes of any type.

4.8- Self assessment question

1. What are corals and their importance?
2. What are the components of coral reefs?
3. What is polymorphism?
4. What are the various types of coral reefs?
5. Describe the life history of Aurelia.
6. Write notes on:
 (a) Justify that coelenterates are at tissue level of body organization.
 (b) Generalised polyp and medusa.
7. on basis of which characters is the classification of Coelenterates based?

4.9-References

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Tun, K., Chou, L. M., Cabanban, A., Tuan, V. S., Philreefs, Yeemin, T., Suharsono, Sour, K. and D. Lane (2004). Status of coral reefs, reef monitoring and management in Southeast Asia, 2004. Pp 235-275 in C. Wilkinson (ed.). Status of Coral Reefs of the World, 2004 (Vol 1) Townsville, Australia: Australian Institute of Marine Science.

4.10-Suggested Readings

(a). Invertebrate Zoology, Author - E. L. Jorden and P. S. Verma.
(b). A text book of Invertebrate Zoology, Author –Dr. S. N. Prasad.
(c). Biology of the Invertebrate Zoology, Author –Jan A.Pechenik.
(d). Invertebrate Zoology, Author –Ruppert, Fox and Barnes.
(e). Invertebrate Zoology, Author –D.T.Anderson.
(f). Invertebrate Zoology, Author –Joseph G.Engeman and Robert W.Hegner.
(g). Invertebrate Zoology, Author –Fatik Boran Mondal
(h). Morden text book of Zoology Invertebrate, Author –R.L.Kotpal.
(i). Invertebrate Zoology, Author –Paul A.Meglitsch and Frederick R. Schram
(j). Text book of invertebrate Zoology, Author – G.S.Sandhu.

4.11-Terminal Questions

1. Write short notes on:
   (a) Coral reefs.
   (b) Fringing reef.
   (c) Barrier reef.
2. What is corallite? Discuss coral reefs, in brief?
3. Write notes on:
(a) Generalised polyp and medusa.
(b) Corallite.
(c) Types of coral reefs.
4. How are coral reefs formed?
5. Differentiate between Atoll, barrier reef and fringing reef?
6. Write the outline classification of Phylum Coelenterates?

Multiple choice questions

1. Nematocysts are found in
(a) Porifera [ ] (b) Platyhelminthes [ ] (c) Coelenterata [√] (d) Annelida [ ]

2. The function of nectocalyces in acoelenterate colony is

(a) Locomotion [√] (b) Digestion [ ] (c) Respiration [ ] (d) Reproduction [ ]

3. Bermuda is a

(a) Fringing reef [ ] (b) Coral island [√] (c) Atoll reef [ ] (d) Barrier reef [ ]

4. The exoskeleton of the colony is

(a) Corallum [√] (b) Corallite [ ] (c) Columella [ ] (d) None of these [ ]

5. Division of labour between several individuals is known as

(a) Vital activity [ ] (b) Labour division [ ] (c) Polymorphism [√] (d) Poly-functions [ ]

6. Polymorphism occurs in

(a) Termite [ ] (b) Certain ants [ ] (c) Certain snail [ ] (d) Coelentrates [√]

7. Which zooid is generally motile?

(a) Polyp [ ] (b) Medusae [√] (c) Both [ ] (d) None [ ]

8. Gastrozooid, gonozooid and dactylozooid are the characteristics of

(a) Dimorphic [ ] (b) Trimorphic [√] (c) Polymorphic [ ] (d) All of these [ ]

9. Modification of polyps is:-

(a) Gastrozooid [ ] (b) Dactylozooid [ ] (c) Gonozooid [ ] (d) All [√]

10. Modification of medusa is exhibited by

(a) Phyllozooid [ ] (b) Nectophore [ ] (c) Pneumatophore [ ] (d) All [√]

11. Corallite is

(a) An animal [ ](b) An individual [ ](c) A coelenterate [ ](d) Skeleton of a solitary coral[√]

12. Prototheen is a

(a) Nutritive secretion [ ] (b) Skeleton rudiments [√] (c) Larvae [ ] (d) Exoskeleton.[ ]

13. Most important example of barrier reef is

(a) Florida keys [ ] (b) West Indies [ ] (c) Great Barrier Reef [√] (d) None [ ].

UNIT: 5 PHYLUM- PLATYHELMINTHES

Contents

5.1-Objectives

(1) Understanding the general characters of Platyhelminthes and classification up to the order level.

(2) Study of *Fasciola* with references to structure, reproduction and parasitic adaptations.

5.2- Introduction

The phylum Platyhelminthes was coined by Gegenbaur in 1859. It includes the simplest animals that are bilaterally symmetrical and triploblastic (composed of three fundamental cell layers). These are also known as the flatworms. Flatworms have no body cavity other than the gut and lack an anus; the same pharyngeal opening both takes in food and expels waste. Because of the lack of any other body cavity, in larger flatworms the gut is often very highly branched in order to transport food to all parts of the body. The lack of a cavity also constrains flatworms to be flat; they must respire by diffusion, and no cell can be too far from the outside, making a flattened shape necessary.

Flatworms are once divided into three groups. The free-living Turbellaria include the *planarian dugesia*, shown above; these are found in the oceans, in fresh water, and in moist terrestrial habitats, and a few are parasitic. The **Trematoda**, or flukes, are all parasitic, and have complex life cycles specialized for parasitism in animal tissues. Members of one major taxon of flukes, the Digenea -- which includes the human lung fluke which pass through a number of juvenile stages that are parasitic in one, two, or more **intermediate hosts** before reaching adulthood, at which time they parasitize a **definitive host**. The **Cestoda**, or tapeworms, are intestinal parasites in vertebrates, and they also show anatomical and life history modifications for parasitism. Platyhelminths have practically no fossil record. A few trace fossils have been reported (Alessandrello et al., 1988), and fossil trematode eggs have been found in Egyptian mummies and in the dried dung of Pleistocene ground sloth.

5.3-General Characters of Platyhelminthes

- Bilaterally symmetrical with definite polarity of anterior (head) and posterior (tail) ends
- Triploblastic, i.e., body derived from three embryonic germ layers; ectoderm, mesoderm and endoderm.

- Dorso – ventrally flattened.
- Usually with a well- defined ventral surface bearing mouth and gonophores.
- Free- living commensal or parasitic forms.
- Tissue- organ grade of organization, i.e., body cells aggregate into definite tissues and tissues make up organs.
- Body unsegmented (except in class Cestoda).
- Acoelomate, i.e., without any body cavity or true coelom.
- Spaces between various organs filled with special mesodermal tissue, the mesenchyme or parenchyma.
- Adhesive structures like hooks, spines and suckers, and adhesive secretions common in parasitic forms.
- Epidemis cellular or syncytial, frequently ciliated. Absent in some.
- Muscular system of mesodermal origin.
- Longitudinal, circular and oblique muscle layers beneath epidermis.
- Digestive system branched and incomplete without anus. Altogether absent in Acoela and Cestoda.
- Skeletal, respiratory and circulatory system are wanting.
- Excretory system includes lateral canals and proto-nephridial (flame cells). Absent in some primitive form.
- Nervous system primitive, ladder- like. Comprises a pair of anterior ganglia with longitudinal nerve cords connected by transverse nerves.
- Sense organs simple. Eye- spots or photo receptors in free living forms.
- Mostly monoecious (hermaphrodite) with complex reproductive system.
- Well- developed gonads, gonoducts and accessory organs.
- Eggs mostly devoid of yolk.
- Yolk produced separately in yolk or vitelline glands.
- Fertilization internal may be cross or self.
- Development direct or indirect.
- Usually indirect in endoparasites with a complicated life cycle involving many larvae and hosts.

5.4-Classification of Platyhelminthes

A. Class - Turbellaria (Gr., *Turbella*- a little stirring) - The class Turbellaria includes free-living freshwater planarians (E.g. Dugesia).

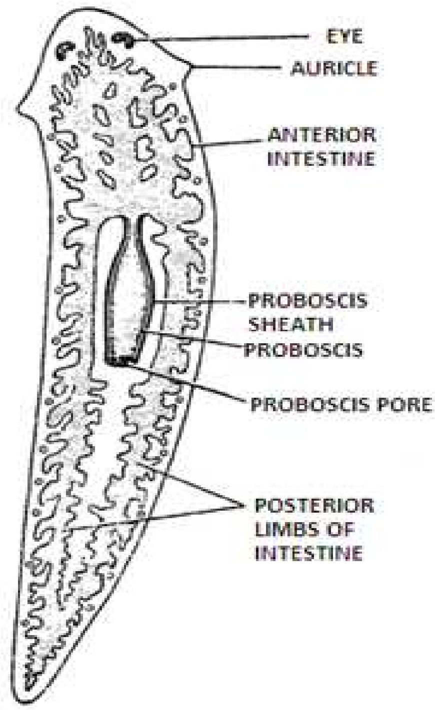

Fig.1 Dugesia

Same marine forms and a few parasite forms, whose beautiful colors serve as a warning of their toxicity to would-be predators, as well as the more drab freshwater planarians (Dugesia, Fig.-1). Some Turbellaria can swim by undulations of the body margins, but most of them glide gracefully over surfaces along a trail of mucus, pushed by **cilia** on their ventral surface.

- Usually non – parasitic, free – living worms are called planarians.
- Terrestrial marine or freshwater.
- Body unsegmented, flattened and covered with ciliated cellular or syncytial epidermis, containing mucus secreting cells and rod-shaped bodies called rhabdites.
- Mouth ventral. Intestine preceded by muscular pharynx.
- 5Suckers absent.
- Tango, chemo and photoreceptors common in free- living.

- Mostly hermaphroditic.
- Some reproduce asexually, sexual and by regeneration.
- Development usually direct.
- Life cycle simple.

Class Turbellaria divided into two orders:

1. **Order - Acoela**
    - Minute, exclusively marine, less than 2mm.
    - Ventral mouth; no muscular pharynx and without intestine.
    - Flame cells, definite gonads, gonoducts and yolk gland wanting.
    - Mostly free- living, found under stones, algae or on bottom mud.

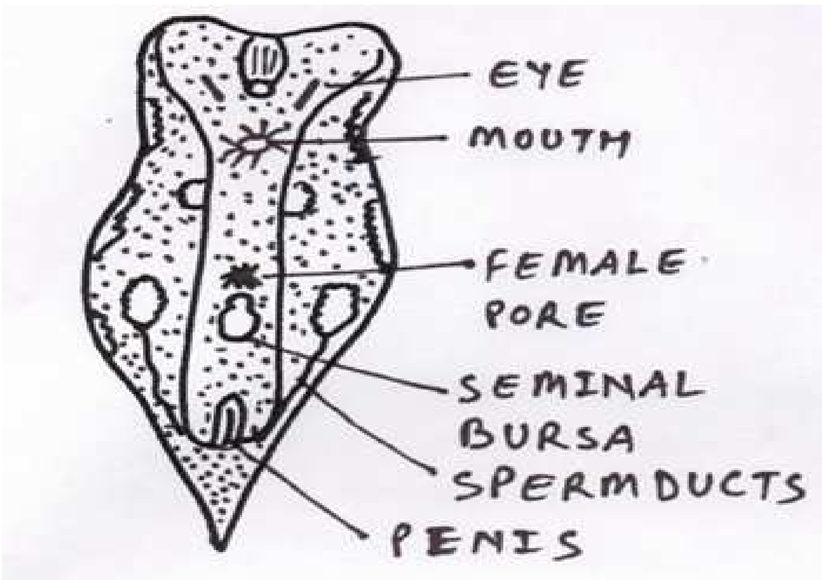

Fig.2 Covoluta

- Some dwell in intestine of sea- urchins and sea- cucumbers.
- Some coloured or brown by symbiotic algae.
  Example: *Convoluta (Fig.2, 3), Amphiscolops, Ectocotyle, Afronta.*

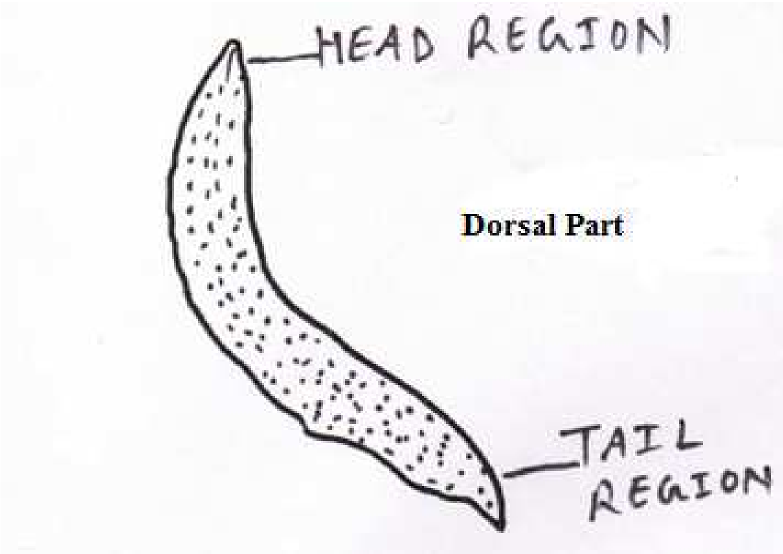

Fig.3 Convoluta

2. **Order - Rhabdocoela**
    - Small, usually less than 3mm.
    - Simple pharynx and sac- like intestine.
    - Proto-nephridial excretory system.
    - One or two gonads.
    - Yolk gland present or absent.
    - Marine, freshwater or terrestrial forms.
    - Free- living, commensal or parasitic forms.

Order –Rhabdocoela classified into following sub-order:-

1. Suborder-Notandropora

- Exclusively fresh water forms.
- Pharynx simple.
- Testis single compact mass, penis unarmed.
- Yolk glands absent.
- Asexual fission occurs with formation of chains of zooids.
  E.g. *Catenula*

2. Suborder- Opisthandropora

- Marine or freshwater forms.
- Testis compact and penis unarmed.
- Yolk glands absent.
- Found paired nephridia.

Eg. *Macrostomum and Microstomum.*

3. Suborder- Lecithopora

- Marine or freshwater and terrestrial forms.
- Pharynx bulbose.
- Separate ovaries.
- Yolk glands present.
- Mostly free living.
- Reproduction sexual.

  E.g. Mesostoma.

4. Suborder- Temnocephalida

- Freshwater ecto-commensal forms.
- Pharynx dolii form.
- Simple gonopore.

  Eg. *Temnocephala.*

3. Order -Alloecoela

- Moderate- sized, between 1and 10 mm.
- Pharynx simple, bulbous or plicate.
- Intestine straight or branched.
- Proto-nephridia paired, usually branched.
- Testes numerous.
- Penis papilla mostly present.
- Mostly marine, common in littoral sand and mud.
- Some freshwater and brakishwater forms.

Order –Alloecoela divided into four suborders.

1. Suborders- Archopora

- Marine forms.
- Pharynx plicate.
- Female reproductive organ primitive.
- Male copulatory apparatus.

  Eg. Proporoplana.

2. Suborder- Lecithoepitheliata

- Marine or freshwater and terrestrial forms.
- Pharynx simple or bulbose.
- Female ducts simple

- Yolk glands absent.

Eg. Prorhynchus and Geocentrophora.

3. **Suborder- Cumulata**

- Marine or freshwater forms.
- Pharynx plicate or bulbose.
- Penis unarmed.
- Yolk glands present.

Eg- Hypotrichina.

4. **Suborder- Seriata**

- **Several** Marine forms but some freshwater forms.
- Pharynx plicate.
- Intestine usually with lateral diverticula.
- Statocyst mostly present.
- Female reproductive system consists of separate ovaries.
- Yolk glands present.

Eg. Otoplana.

4. **Order - Tricladida**

- This is large size turbellarians.
- Size 2 to 60 cm in length.
- Mouth mid-ventral, pharynx plicate and intestine with three branches, each with many diverticula.
- Proto-nephridia as lateral networks with many nephridiopores.
- Testes numerous, ovaries two.
- Yolk glands present
- Marine, freshwater or terrestrial forms.

Order – Tricladida divided into three suborders:-

1. **Suborder- Maricola**

- Exclusively marine forms.
- A pair of eyes.
- Typical penis papilla.
- Only sexual reproduction.

Eg. - Ectoplana.

2. **Suborder- Plaudicola.**

- Mostly freshwater and some brackish water forms.
- Eyes two to many or some time completely absent.
- Sexual reproduction shows.

Eg. Planaria

3. Suborder- Terricola

- Terrestrial, tropical and subtropical forms.
- Body elongated.
- Eyes more than two.
- Bursa absent.
- Asexual reproduction shows.

Eg. Bipalium.

5. Order - Polycladida

- Moderate-sized, 2 to 20 mm.
- Pharynx plicate.
- Intestine highly branched.
- Gonads many, scattered.
- Yolk glands absent.
- Male and female gonopores separate.
- Marine, many bottom dwellers of littoral zone.

Order – Polycladida classified into two sub order:-

1. Suborder- Acotylea

- Pharynx vertical.
- Sucker absent.
- Tentacles nuchal type.
- Eyes absent.

Eg. Notoplana.

2. Suborder- Cotylea

- Pharynx tubular
- Sucker present
- A pair of marginal tentacles bearing eyes.

E.g. Thysanozoon (Fig.4)

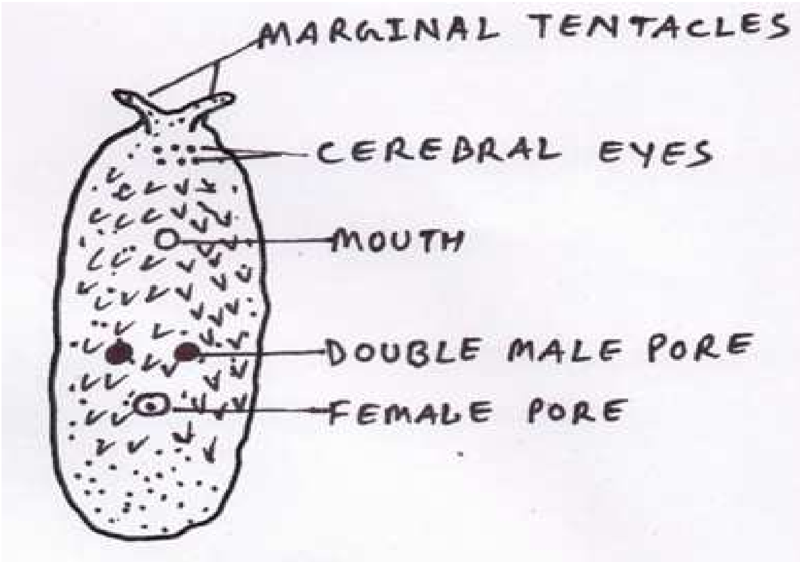

Fig.4 Thysanozoon

B. Class- Trematoda (Gr. *Tremta*- hole + *eidos*- form) – The class Trematoda, commonly called flukes, are unsegmented parasitic flatworms that usually parasitize a snail as an **intermediate** host (in which they reproduce asexually) and a human or other vertebrate as a **definitive** host (in which the worms mate and lay eggs). Many species have other hosts between these two, such as fish or frogs. Trematodes usually have a pair of suckers for crawling and clinging to the host's tissues. Many humans are infected with blood flukes, liver flukes, lung flukes, and other trematode parasites of great medical importance.

- 1 Ecto- or endoparasitic flatworm, called flukes.
- Body unsegmented, dorso-ventrally flattened, leaf like.
- Tegument thick but without cilia and rhabdites.
- Suckers and sometimes hooks present.
- Alimentary canal with anterior mouth, simple pharynx and two main branches.
- Three pairs of longitudinal nerve cords.
- Mostly monoecious (Hermaphrodite).
- Development direct (in ectoparasites) or indirect (in in endoparasites) with alternation of hosts.
- Life history simple or typical.
- Ovary single and testis two too many.

Class- Trematoda divided into three orders:-

1. Order - Monogenia

- Mostly ecto-parasitesim cold blooded aquatic vertebrates.

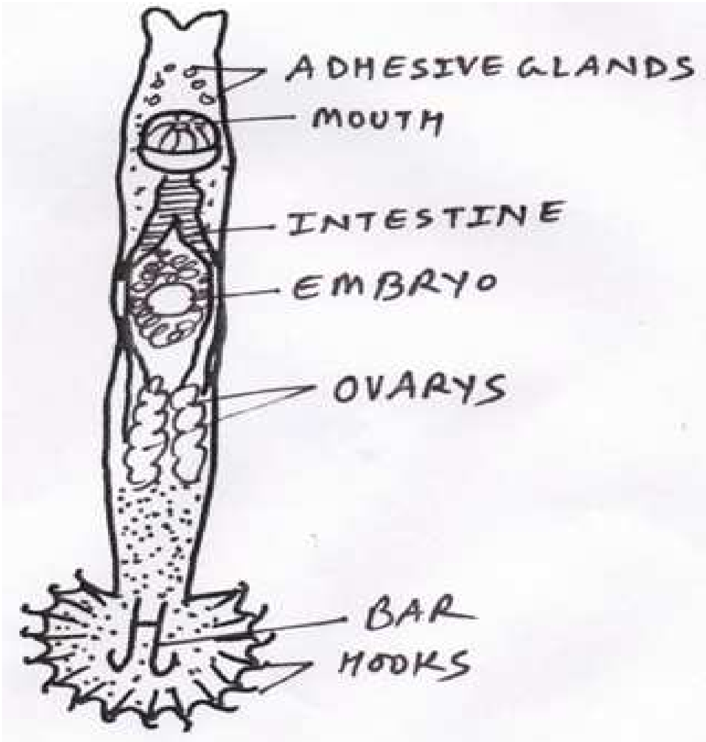

Fig.5 Gyrodactylus

- Posterior adhesive organ or opisthaptor with suckers armed with hooks or spines.
- Excretory pores two, situated anteriorly on dorsal side.
- Vagina one or two.
- Uterus small with a few shelled eggs.
- Only a single host in life cycle.
- Free swimming ciliated larva called onchomiracidium.
- One host in life cycle.
  E.g. Gryodactylus (Fig.5), Dactyogyrus, Polystoma, Diplozoon

2. Order - Digenea

- Mostly endoparasites in vertebrates and invertebrates.
- Two suckers, oral and acetabulam, both devoid of hooks.
- Single posterior excretory pore.
- No vagina.
- Uterus long with numerous shelled eggs.
- Life cycle complex with numerous larval stages in two to three intermediate hosts.

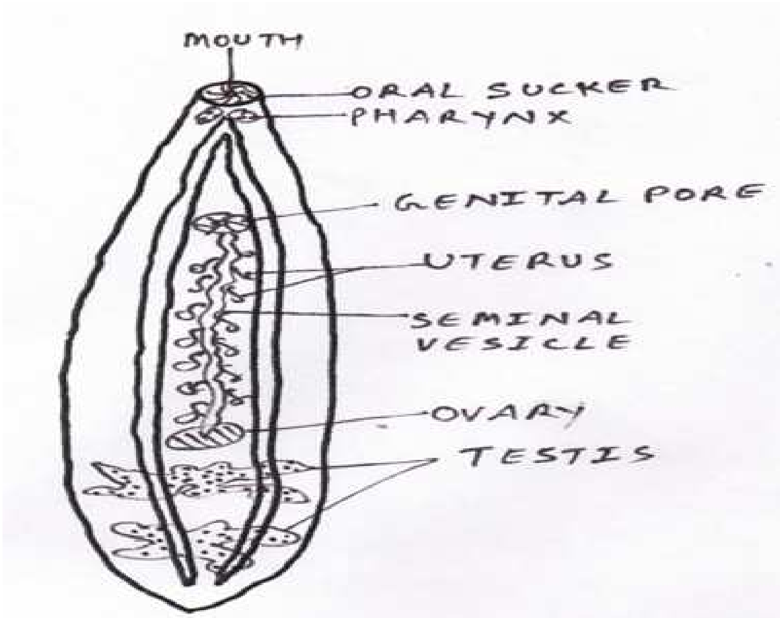

Fig.6 Opisthorchis Sinensis

- Larval forms reproduce asexually before metamorphosis.
- One to more intermediate hosts in life cycle.

Examples: Bucephalus, Fasciola hepatica (Fig.9), Fasciola gigantica (Fig.8) Param- phistomum, Paagonimus, Schistosoma (Fig.7), Opisthorchis (Clonorchis, Fig.6).

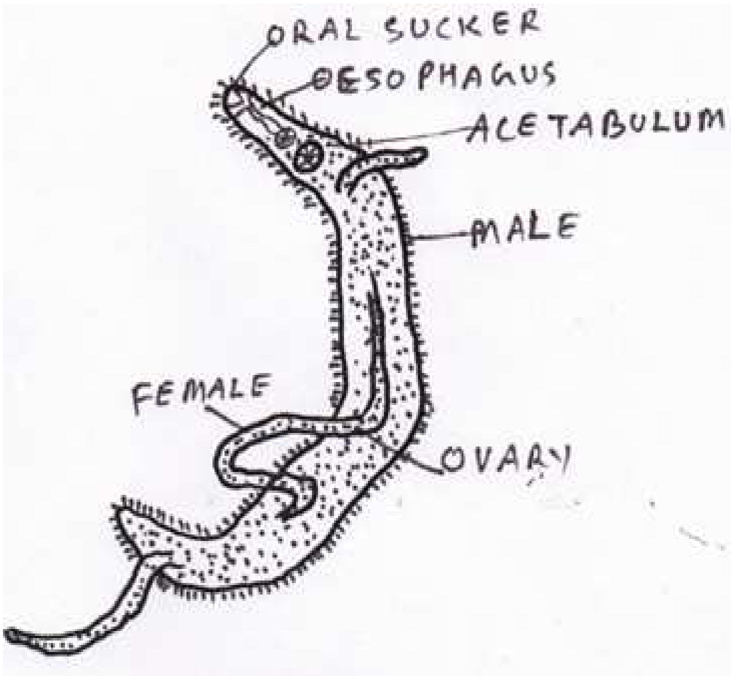

Fig.7 Schistosoma

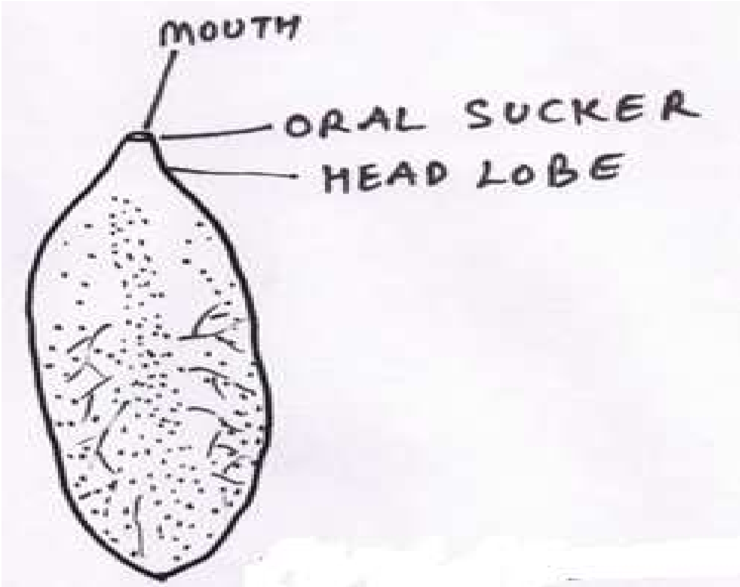

Fig.8 Fasciola Gigantica

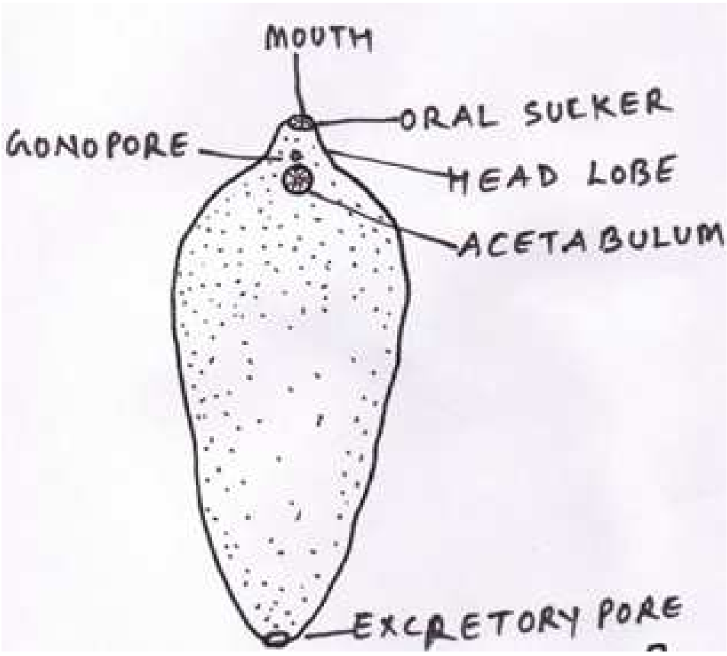

Fig.9 Fasciola Hepatica

3. Order - Aspidocotylea

- Oral sucker absent.
- Large ventral sucker subdivided into several suckers without hooks.
- Anterior end without paired adhesive structures.

- Only one testis in male system.

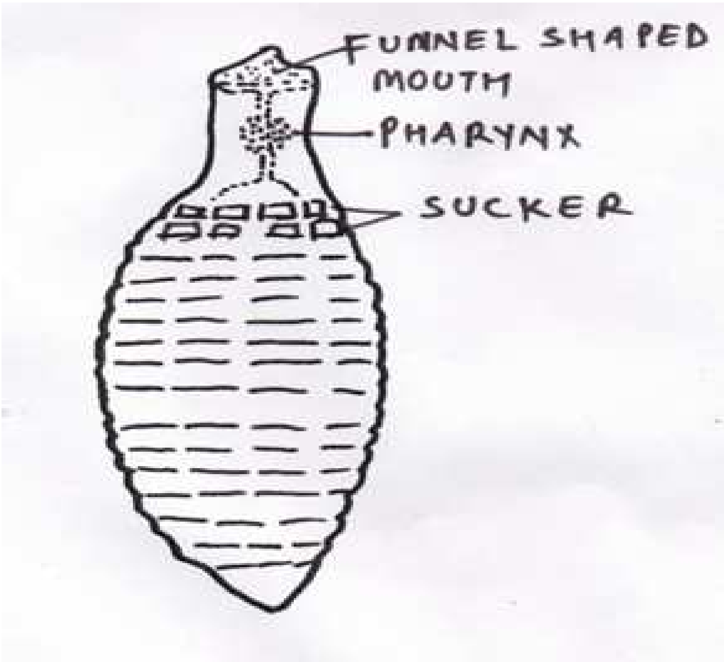

Fig.10 Aspidogaster

- Endoparasites in gut of fishes and reptiles.
- Nephridiopore single.
- Life cycle simple.

Example: Aspidogaster (Fig.10), Cotylapsis, Stichocotyle.

C. Class- Cestoda (Gr., *kestos*- girdle + *eidos*- form) - The Cestoda, commonly called tapeworms, is segmented, ribbon like parasites usually found as adults in the small intestines of vertebrate animals. Unlike the other classes, they have no digestive tract, they can absorb predigested nutrients from the host's intestine. The body consists of a long chain of segments, each with its own reproductive system. The anterior end is a knob-like holdfast called a scolex, equipped with suckers and often hooks for attachment to the host's intestine. In general, tapeworm infections are not as medically serious as trematode infections, but some tapeworms can be lethal.

- Endoparasitic flatworms, called tapeworms.
- Body segmented, elongate, flat, ribbon-like.
- Tegument with microvilli.

- Scolex (head) with suckers, or hooks, or both.
- No alimentary canal.
- No sense organs.
- Each mature segment or proglottid monoecious, with male and female organs.
- Life cycle complicated involving one or more intermediate hosts.
- Embryos with hooks.

Class- Cestoda classified into two subclasses:

A. Subclass - Cestodaria

- Body unsegmented, leaf- like, without scolex and strobila (monozoic or body undivided).
- Only one set of monoecious reproductive system.
- Larva lycophore with 10 hooks.
  Subclass – Cestodaria divided into two orders.

1. Order - Amphilinidea

- No suckers.
- Pharynx protrusible.
- Male genital pore and vegina situated posteriorly.
- Uterus coiled.
- Endoparasitic in coelom of primitive fishes.
  Example: *Amphilina*.

2. **Order- Gyrocotylidea**

- An anterior sucker and a posterior rosette- shaped adhesive organ present.
- Eversible proboscis at the anterior end.

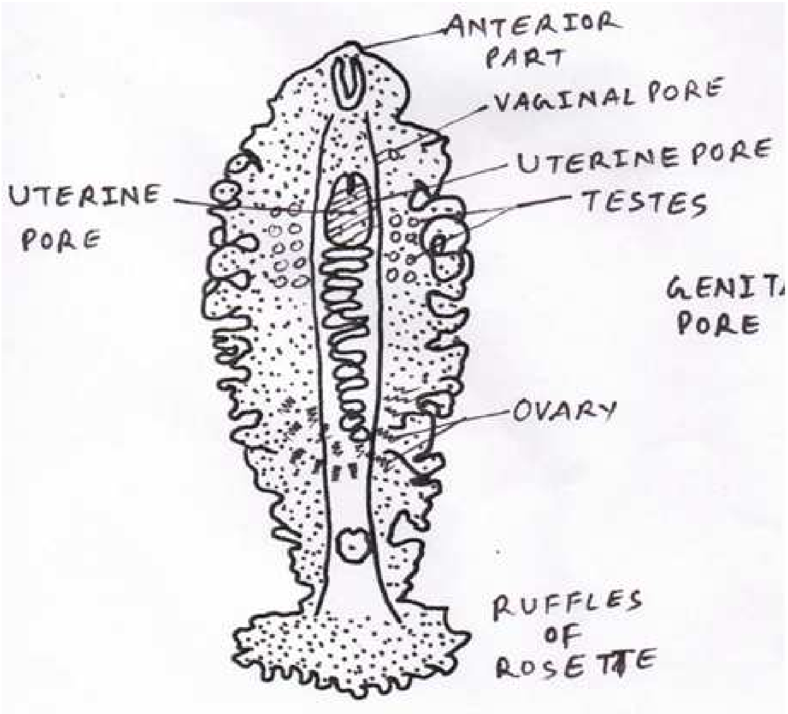

Fig.11 Gyrocotyle

- Endoprasites in chimaeroid fishes.
  Example: *Gyrocotyle (Fig11).*

B. Subclass - Eucestoda

- Body long, ribbon- like.
- Divided into scolex, neck and strobila with many proglottids (polyzoic).
- Mostly with several sets of monoecious reproductive organs.
- Larvae with six hooks.

Class- Eucestoda classified into eleven orders:-

1. Order - Proteocephalidea

- Scolex with 4cup- shaped suckers.
- Ovary bilobed.
- Utrus branched.
- Vitellaria scattered.
- Parasitic in freshwater fishes, amphibians and reptiles.
  Example: *Proteocephalus, Ophiotaenia.*

2. Order - Tetraphyllidea

- Scolex with 4 leaf - like bothria.
- Testes anterior to ovaries.
- Vitelline glands scattered.
- Parasitic in intestine of elasmobranches fishes.

Example: *Phyllobotheium.*

3. Order - Disculicepitidea

- Scolex with large cushion- like pad at anterior end.
- Female gonopore, anterior to male gonopore.
- Testes numerous.
- Uterus lobed.
- Endoparasites of Selachii.

Example: *Disculiceps.*

4. Order - Lacanicephaloidea

- Scolex divided by a transverse groove.
- Upper disc- like lower with 4 suckers.
- Vitellaria as two lateral bands.
- Intestinal parasites in elasmobranch fishes.

Example: *Lecanicephalum, Tetragonocephalum.*

5. Order - Pseudophyllidea

- Scolex with 2 to 6 bothridia.
- Testes numerous.
- Ovary bilobed.
- Vitellaria follicular.
- Parasitic in freshwater fisher (teleosts).

Example: *Dibothriocephalus, Haplobothrium.*

6. Order - Trypanorhyncha

- Scolex with 2 to 4 bothria and 4 spiny tentacles.
- Vitellaria in continuous layer in cortical parenchyma.
- Parasitic in elasmobranch fishes.

Example: *Tetrachynchus.*

7. Order - Cyclophyllidea (=Taenioidea)

- Scolex with 4 large deep suckers and hooks.

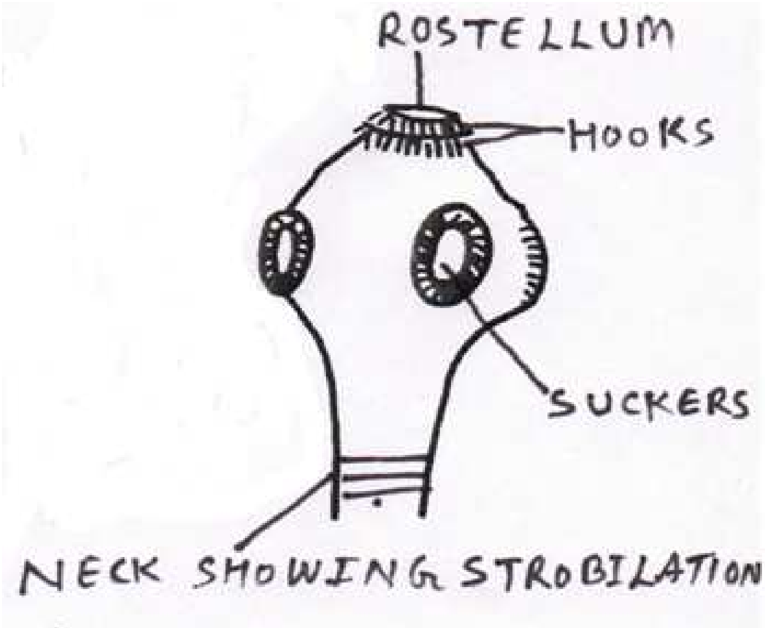

Fig.12 Head Region

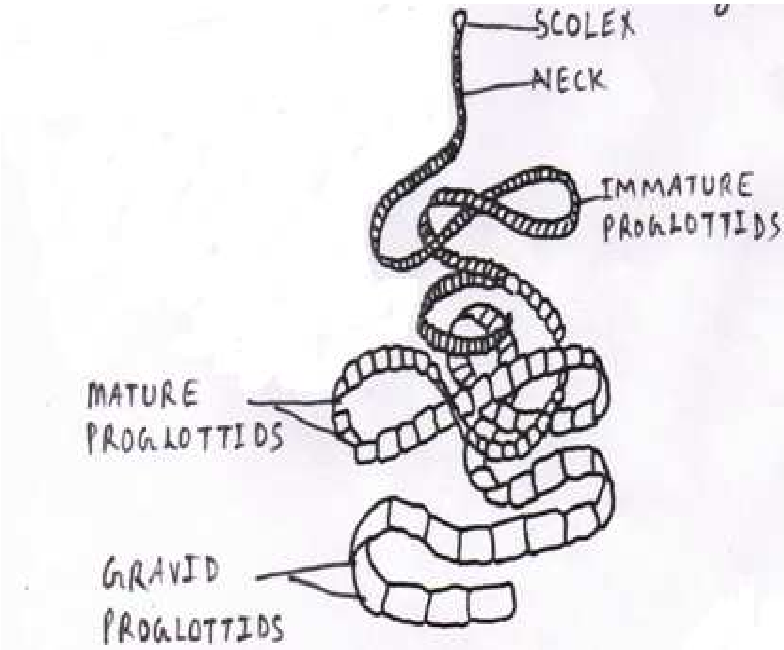

Fig 13 Teania Solium

- Ovary lobed.
- Uterus blind.
- Vitellaria follicular.
- Parasitic in amphibians, reptiles, birds and mammals.
  Example- *Taenia (Fig.13, 14), Moniezia, Echinococcus (Fig.14), Dipylidium, Hymenolepsis.*

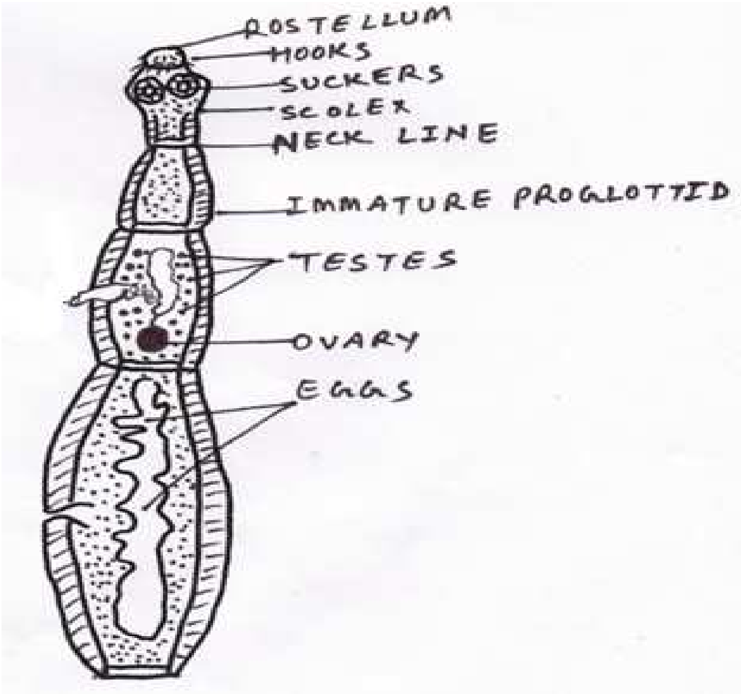

Fig.14 Echinococcus Granulosus

8. Order - Aphoridea

- Scolex with 4 suckers.
- Rostellum armed.
- No external segmentation.
- Ootype absent.
- Vitallaria absent or present.
- Sex ducts and genital apertures absent.
- Parasites in freshwater fishes of Japan.
  Example: *Nematoparataenia, Gastrotaenia.*

9. Order - Nippotaeniidea

- No scolex but well- developed erminal sucker.
- Proglottids few.
- Vitellaria few.
- Parasites in freshwater fishes of Japan.
  Example: *Nippotaenia, Amurotaenia.*

10. Order - Caryophyllidea

- Scolex without ture suckers or bothria.
- Eggs non- embryonated when laid.
- Parasites in fishes.

Example: *Caryophyllaeus, Archigetes, Glaridacris*.

11. Order- Spathebothridea

- Scolex without suckers or bothria.
- Testes are medullary.
- Ovary median.
- Parasites in primitive fishes.
  Example: *Spathebothrium.*

5.5- Study of *Fasciola*

Fasciola hepatica is a common liver fluke. Main species of Fasciola like *Fasciola hepatica* (Liver fluke- Sheep) and *Fasciola gigantica* (Liver fluke – Cattal) (Fig.15).

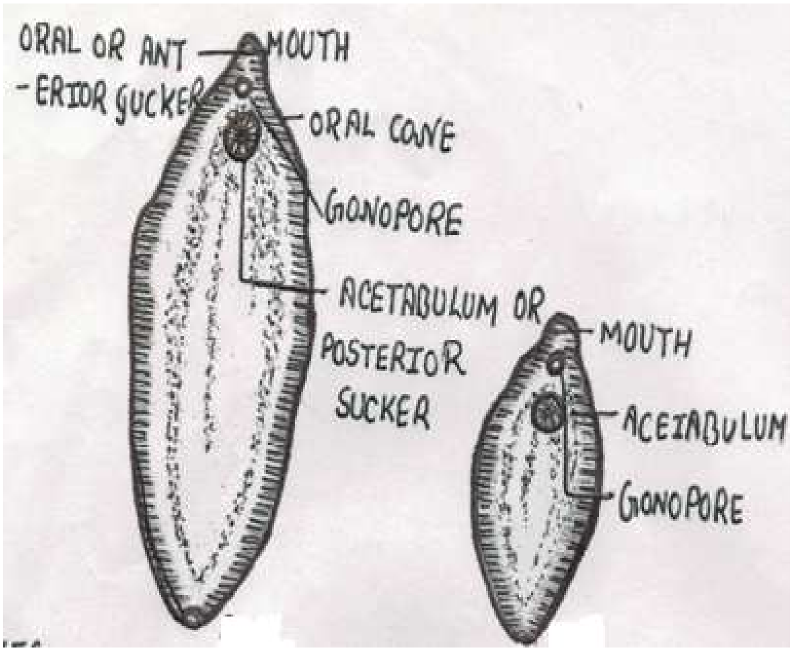

Fig.15 Liver Fluke: (A) Fasciola Gigantica (B) Fasciola Hepatica

Systematic Position:

PHYLUM - ASCHELMINTHES
CLASS - TREMATODA
ORDER - DIGENIA
GENUS - FASCIOLA
species - hepatica

Habit and habitat:

- *Fasciola hepatica* is a digenetic trematode.
- It is endo-parasite in the bill passage and liver of sheep and cattle and completes part of its life cycle in snail.
- It enjoys world-wide distribution.
- Its primary host is sheep and secondary host is freshwater snail.

External morphology:

Shape: Body is soft and fleshly. It is dorso-ventrally flattened and leaf like, somewhat oval in appearance.

Its anterior end is broad and rounded while posterior end is narrower and bluntly rounded.

Size: It is about 18-30mm long and 4-15mm broad.

Colour: The colour is slightly pinkish and the margins appear to be brownish or blackish. Internal organs are roughly visible because of transparent body wall.

5.5.1-Structure of *Fasciola Hepatica:*

- Head lobe or cephalic cone.
- The broad anterior end of body is produced into a conical projection.
- The head lobe or oral cone, cephalic cone.
- It bears mouth at its tip.

Suckers:

There are two suckers-

1. Anterior or oral sucker is cup-shaped and muscular.
    - It surrounds mouth. Its muscles rediate from the margin of mouth to the periphery.
    - Oral sucker is a suctorial organ. It helps in ingestion as well as in adhesion.
2. Posterior or ventral sucker is saucer-shaped.
    - It lies about 3-4mm from oral sucker mid ventrally.
    - It is without an aperture and is also known as acetabulum.
    - It is meant for attachment only.

Apertures:

- Mouth is terminal, situated on rhe tip of oral cone and is surroundd by oral sucker.
- Commmon gential Aperture or gonopore lies midventrally a little in front of acetabulum.
- A single excretory pore is situated midventrally at the posterior end.
- Opening of Laurer's canal appear temporarily during breeding season, a little anterior to the middle of body on the dorsal side.

5.5.2-Reproduction (Life cycle of Fasciola hepatica):-

Copulation:-

- Although *Fasciola i*s a hermphodite animal but cross fertilization occurs.
- The two flukes copulate inside the bile duct of host's body.
- The cirrus of one is inscrted into the opening of Laurer's canal of the other organism and the sperm along with the parasitic fluid make their way into the Laurer's canal, from where these move to the oviduct.
- Fertilization may also occur. Sperm enters the uterus of fluke through female gential aperture.

Fertilization:-

- The eggs are fertilized in the uterus or in ootype.
- The fertilize eggs are deposited with yolk cells produced by vitelline gland and are encircled by chitious shell or egg capsule.
- A single fluke may produce about 2, 00,000 eggs in about 11 years and 30,000 eggs per year.

Eggs:-

- The fully formed fertilized capsulated eggs are inside the uterus.
- The first cleavage is complete but unequal and produced (i) a small geanular propagatory cell and (ii) a large somatic or ectoderm of larva.
- The propagatory cell further divided into two types of cells propagative cells and somatic cells. The somatic cells after division from larval body structure.
- The propagatory cells form the germ cells. Within 9-15 days, the embroyinc development is complete and a ciliated marcidium larva is formed.

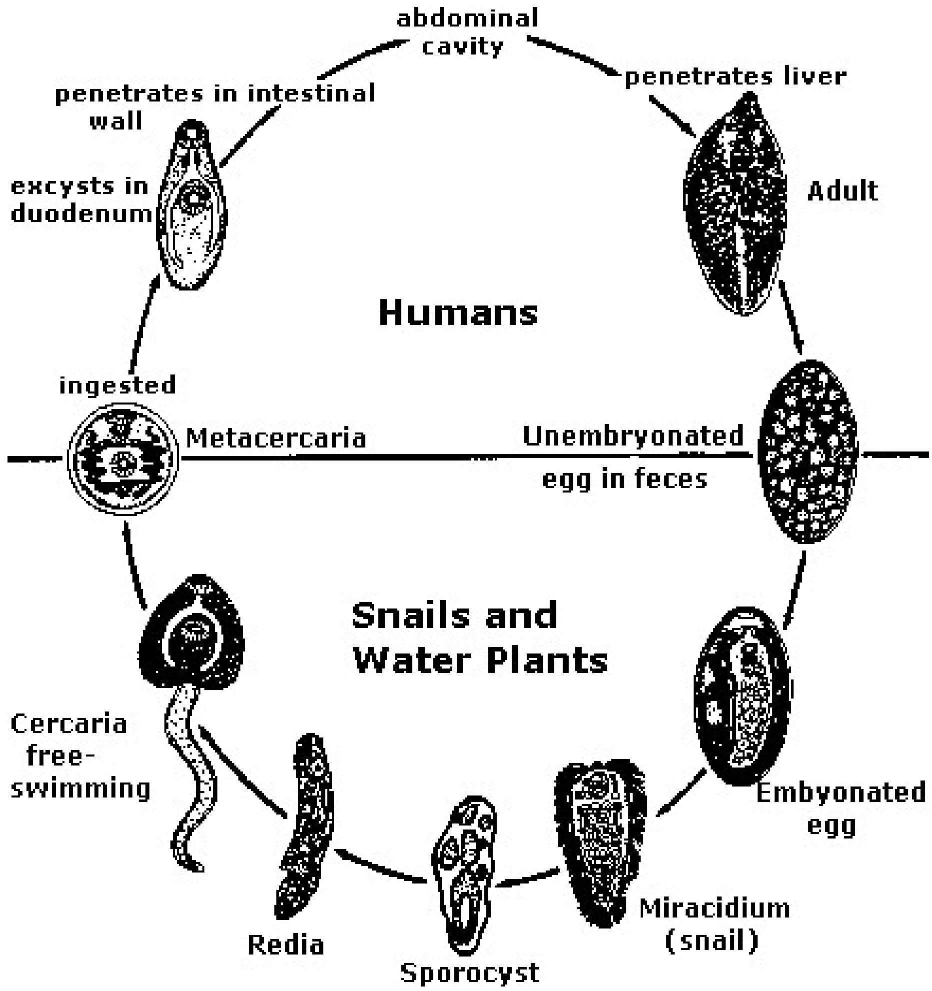

Fig.16 Life cycle of Fasciola Hepatica

Segmentation and early development:-

- Segmentation and cleavage start even when the eggs are inside the uterus.
- The first cleavage is complete but unequal and produces (i) a small granular propagatory cell and (ii) a large somatic or ecto-dermal cell.
- Repeated division of the somatic cell further from ectoderm of larva.
- The propagatory cell further divides into two types of cell- propagative cells and somatic cells.
- The somatic cells after division form larval body structures.
- The propagatory cells form the grem cells. Within 9-15 days, the embryonic development is complete and a ciliated miracidium larva is formed.

Hatching:-

- Further development occurs only when capsule reaches water or moist area.
- In contact with water, the operculum of egg capsule opens and ciliated marcidium larva hatches out. It swims in water actively.

Larval stage of Fasciola hepatica:-

Miracidium larva- It is the first larval stage in the life cycle of *Fasciola hepatica.*
It swims actively in water in search of secondary host, the snail of genus, Limnaea.

External Structure:-

- Miracidium of Fasciola is about 0.07mm long, oval or conical. Its broad anterior end is apical lobe or apical papilla or terebratorium.
- It bears opening of (i) a pouch like multinucleated apical gland and (ii) a number of unicellular penetration gland.

Miracidium larva:-

Miracidium larva does not feed. It swims actively in search of its secondary host.
In case it fails to reach the host, it dies within 24 hours. If it finds the snail, it penetrates through snail's soft skin or respiratory tissue dissolving larval secretion of penetration glands makes a minute opening in the host tissue.

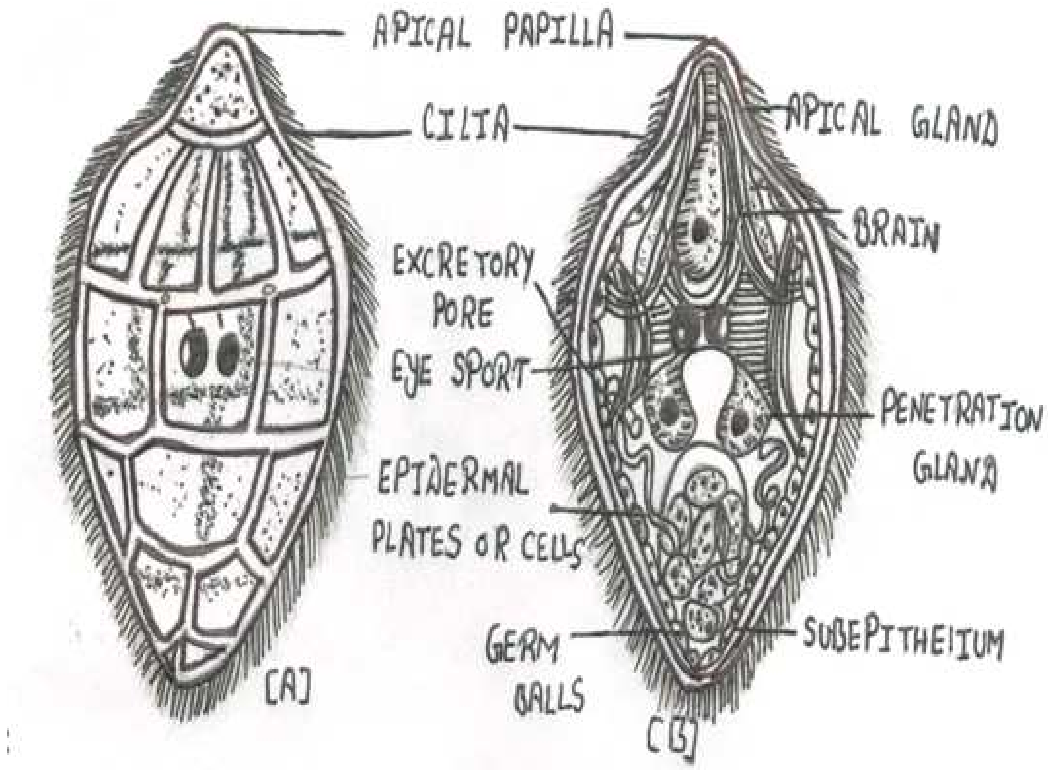

Fig.17 Miracidium Larva of Fasciola (A)External structure(B) Internal structure

Inside the host tissue, miracidium throws off ciliated epidermis, penetrates deeper to reach the lymph vessels or pulmonary chamber. Here it changes into second larval stage, the sporocyst larva.

Sporocyst larva:-

- Miracidium lose its apical gland, penetrated gland, brain, eyespot and change into a sac-like sporocyst larva.
- It looks like an elongated sac about 0.7mm long.
- Their body walls retain all the layers of miracidium's body wall except the ciliated epithelium.
- It consists of a thin cuticle, a layer of circular and longitudinal muscles.
- The wide interior is occupied by the protonephridia and germ cells. Each protonephridium now consist of two flame cells.
- These open on the surface by a common pore. A rudimentary gut is also found.

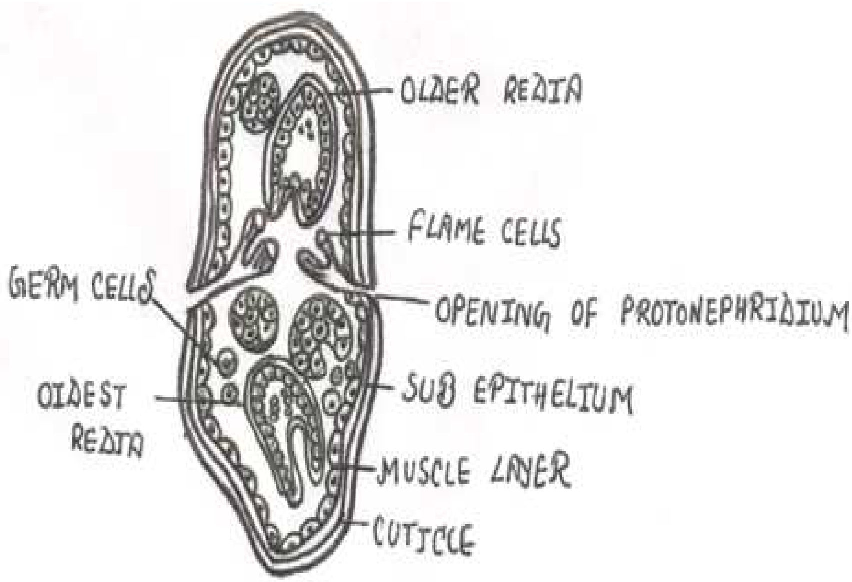

Fig.18 F.Hepatica:-Sporocyst larva of Fasciola

The germ cells undergo repeated division to produce redia larvae, but may also produce daughter sporocysts. A single sporocyst may contain 5-18 redia.

Redia larva:-

- It is an elongated and cylindrical sac.
- It comes out by the rapture of sporocyst.

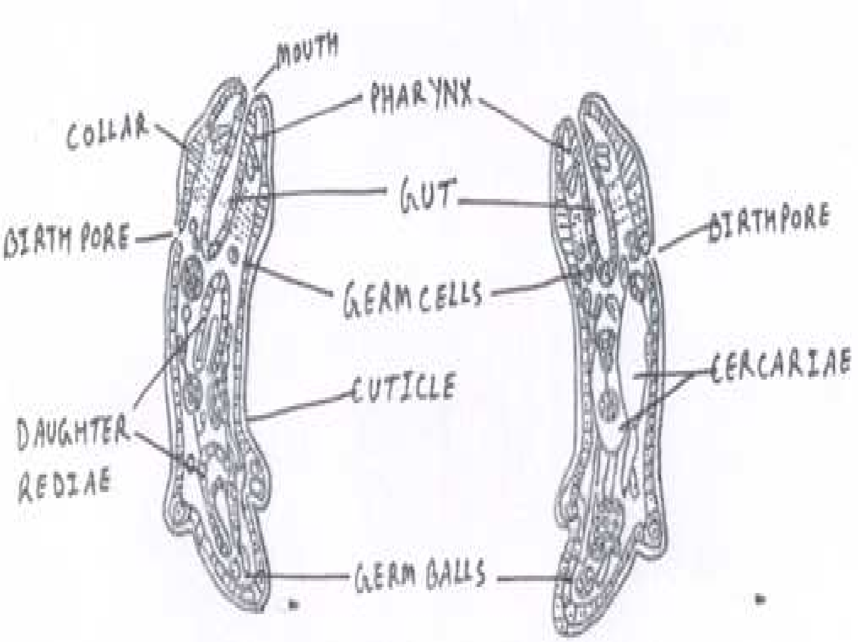

Fig.19 Redia Larva of Fasciola

It is covered with a thin cuticle secreted by sub epithelium. At the anterior end a small mouth, a muscular suctorial pharynx with unicellular pharyngeal glands and small gut. Slightly posterior to the pharynx, the anterior end is surrounded by a muscular band like collar and just behind it is the birthpore. A pair of conical projection, the procruscular or lappets is present at the posterior end. The interior of the body is filled with loose parenchyma, through which are found groups of germ cells called germ balls and highly branched flame cells. Their excretory ducts open through the paired excretory pore. The germ balls present inside redia give rise to generation of daughter rediae in summer months and produced cercaria Larvae in autumn.

Cercaria larva:-

A fully formed cercaria larva possesses a flattened heart-shaped body with a long contractile tail. Its body surface covered with thin cuticle with backwardly directed spines. The anterior end bears mouth, muscular pharynx, oeso-phagus and bifid intestine. The mouth is surrounded by oral sucker. A vebtral sucker or acetabulum is also present between the two limbs of the intestine.There are numerous flame cells. A small excretory duct arise from the bladder and opens to the exterior by excretory pore situated at the base of the tail. A number of unicellular cystogenous glands are situated below the large body wall.

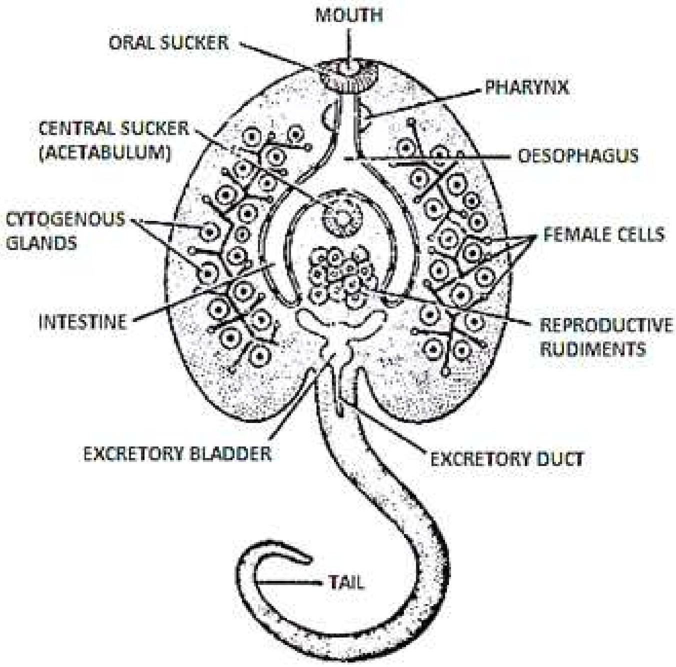

Fig.20 Cercaria Larva of Fasciola

Their secretion forms the cyst around the larva when it is converted into metacercaria. Groups of germ cells are also present.When mature the cercaria leaves the redia through birthpore it also wriggles out of the snail body. It swims in water for some time and finally settles down on the blade of some aquatic weed. It sheds off the tail and a cyst is formed by the secretion of cystogenous gland. Thus a metacercaria is formed.

Metacercaria:

The metacercaria is somewhat rounded with thick outer covering of cuticle in the from of cyst. The Cystogrenous cells of the cercaria disappear and the flame cells increase in number.

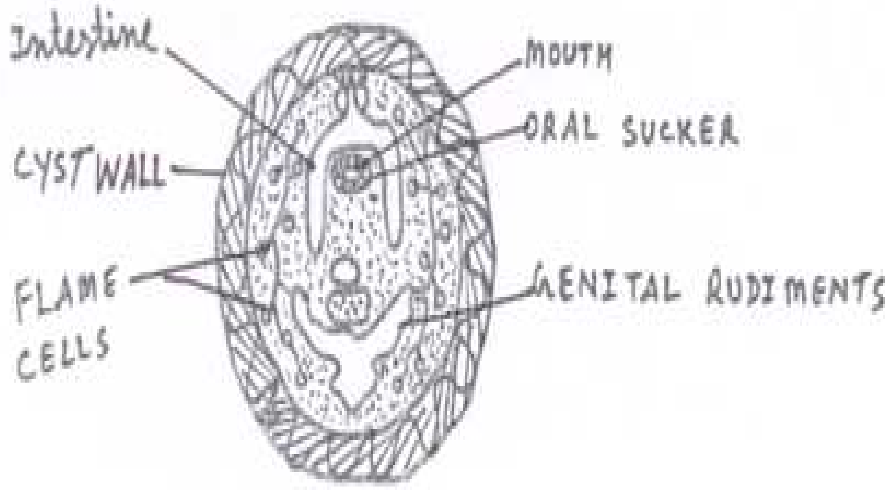

Fig.21 Metacercaria Larva of Fasciola

Infection to the final host:

The metacercaria enters the final host, the sheep, when it grazes on the aquatic weeds and reaches the intestine. In the intestine the cyst is dissolved by the action of digestive enzymes and young fluke comes out. It reaches the liver through the hepatic portal system and starts its existence inside the bile passage.

Infection:-

- The vertebrate host (sheep, goat, etc.) gets the infection by grazing on grass, leaves and other vegetation to which metacercaria cysts are attached.
- The invertebrate host (snail) acquires infection when a miracidium, at random, established contact with a suitable part of its body (Fig.22).

Pathogenesis or Symptoms:

- Infection of invertebrate host (snail) result in a partial or complete destruction of the affected site, which is preferably the digestive gland (liver) or gonad.
- In case of heavy infection, snail considerably increases in size.
- Of significant economic important is the effect of *F. hepatica* on its vertebrate, host whose bile ducts as well as liver may be damaged.
- In bile ducts, it causes inflammation and hepatits, resulting in loss of its epithelium and thickening of wall, followed by calcification and formation of gall stones.
- Heavy infection upset the normal metabolism of liver. This due to haemorrhage caused and irritation inflicted by cuticular spines. The disease thus cused is called liver-rot or fascioliasis. Symptoms of liver-rot are more acute in lambs than in sheep, appear about a month after infection.

- Frequently, death may soon result due to cerebral apoplexy. However, if the host survives few weeks of infection, it falls a victim to acute anaemia and falls even at mild contact.

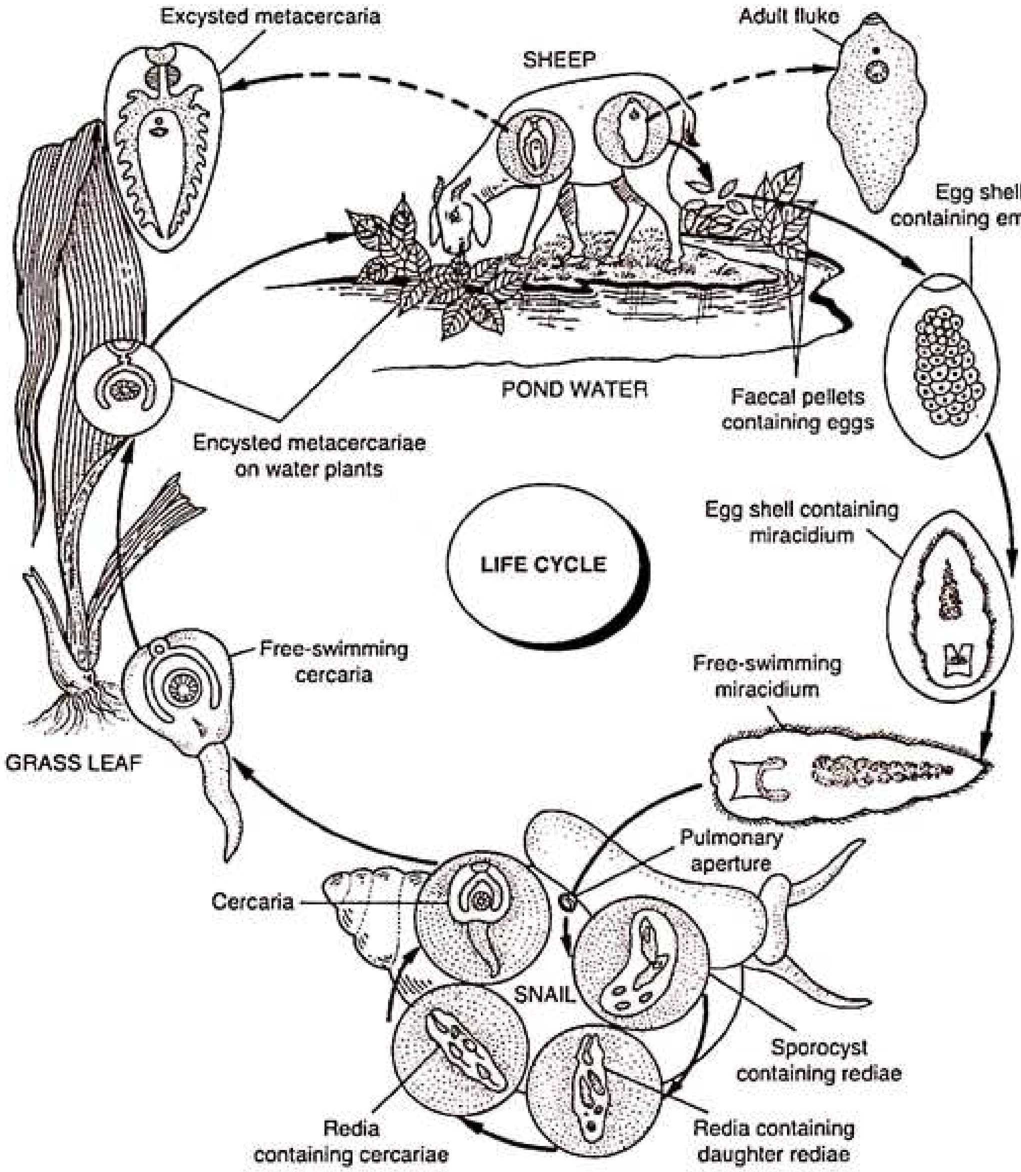

Fig.22 Life cycle of F.Hepatica

- Its appetite declines, rumination (chewing the cud) becomes irregular and at times there is fever and increase in respiratory activity.

- Conjunctiva becomes whitish-yellow, and dry and brittle wool falls off. After three months of infection comes the fatal period.
- Large oedemas or swelling (‘’watery poke’’) appear on jaws. Lactation and breeding are greatly reduced.
- Rarely does the host survive this period. In case it does, the fluke may migrate to the duodenum and finally escape to the outside world with faces.
- When this happens, or when fluke somehow dies in situ, the host recovers considerably.
- Infection by *F. hepatica* takes a huge toll of sheep annually.
- In England it caused the death of about one and a half million sheep in 1830 and about double in number in 1879-80.
- Ireland lost 60 percent of its flocks in 1882.

Therapy or treatment:

- Treatment of infection is not easy because it is difficult to introduce drugs in bile passages of infected sheep.
- Anti-helminth drugs such as hexachloroethane, carbon tetrachloride, filcin, emetine hydrochloride, phenothiazine and tetrachlorothane are being employed or treating case of liver-rot.
- These drugs are fairly effective in killing stages of the parasite in liver.

Prophylaxis or Prevention:

It is better to prevent infection by control of the vector or intermediate host. Preventive measures include:-

- Killing heavily infected sheep.
- Destroying eggs and manure of infected sheep.
- Feeding infected sheep with salt and little dry food.
- Killing or checking snail population.
- Snail is killed by adding copper sulphate solution in ponds and ditches or by draining their pastures as they are unable to survive long dry periods.
- Ducks feed on snails and can be usually employed in removing their population. Breeding of snails can be avoiding infection by consuming thoroughly washed and adequately cooked vegetables.

5.5.3-Parasitic Adaptation of Fasciola:-

- Liver fluke has undergone great modification, morphologically as well as physiologically, to suit its existence as an end parasite in the bile ducts of sheep.
- Outer tegument is thick, permeable to water, but enzyme-resistant, so that parasite is not digested by digestive juices of the host.

- Locomotary organs are absent as not required by adult. However, free swimming larvae, such as marcidium have cilia and cercaria has a locomotary tail.
- Oral sucker, acetabulum and spines of body wall of adult worm serve as organs of attachment in the host's body.
- Alimentary canal is without anus as there is no undigested food for egestion.
- Suctorial phyranx helps in sucking bile etc. and much branched intestine serves to distribute digested food to all parts of the body.
- Adult lacks circulatory, respiratory and sensory organs as they are not needed.
- Nervous system is poorly developed for the same reason. However, free swimming miracidia has sensory eye sport.
- Respiration is anaerobic as free O2 is not available.
- Reproductive system is highly developed.
- Number of eggs produced is enormous (about 200,000 eggs per fluke). This is necessary to offset several hazards resulting in great mortality.
- Resistant egg shells around zygote provided further safety from unfavorable environmental condition.
- Hermaphroditism ensures self-fertilization even in the absence of another companion for copulation. It is necessary of the species.

Liver rot:-

When sheep are infected by the liver fluke Fasciola hepatica, the liver sheep is seriously affected in structure and function. This disease is known as ''Liver rot'', or "Fascioliasis''.

5.6- Summary

The phylum name was coined by Gegenbaur in 1859. The simplest animals that are bilaterally symmetrical and **triploblastic** (composed of three fundamental cell layers) are the Platyhelminthes, the flatworms. Flatworms were once divided into three groups. A. **Class - Turbellaria B. Class- Trematoda C. Class- Cestoda**.The class -**Turbellaria** includes all free-living members of the phylum, as well as a few **parasites.** It includes many marine forms, whose beautiful colors serve as a warning of their toxicity to would-be predators, as well as the more drab freshwater planarians.

The class-**Trematoda**, commonly called flukes, are unsegmented parasitic flatworms that usually parasitize a snail as an intermediate host (in which they reproduce asexually) and a human or other vertebrate as a definitive host (in which the worms mate and lay eggs).The class-**Cestoda**, commonly called tapeworms, are segmented, ribbon like parasites usually found as adults in the small intestines of vertebrate animals. Platyhelminths have practically no fossil record. A few trace fossils have been reported that were probably made by platyhelminths (Alessandrello et al., 1988), and fossil

trematode eggs have been found in Egyptian mummies and in the dried dung of Pleistocene ground sloth.

- *Fasciola hepatica* is a common liver fluke.
- Main species of Fasciola like *Fasciola hepatica* (Liver fluke- Sheep) and *Fasciola gigantica* (Liver fluke – Cattal).
- *Fasciola hepatica* is a digenetic trematode.
- It is endo-parasite in the bill passage and liver of sheep and cattle and completes part of its life cycle in snail.
- Its primary host is sheep and secondary host is freshwater snail.

Shape: - Body is soft and fleshly. It is dorso-ventrally flattened and leaf like, somewhat oval in appearance.

Size: - It is about 18-30mm long and 4-15mm broad.

Colour: - The colour is slightly pinkish and the margins appear to be brownish or blackish. Internal organs are roughly visible because of transparent body wall.The eggs are fertilized in the uterus or in ootype. *Fasciola i*s a hermphodite animal but cross fertilization occurs. The fully formed fertilized capsulated eggs are inside the uterus. The first cleavage is complete but unequal and produced (i) a small geanular propagatory cell and (ii) a large somatic or ectoderm of larva. Segmentation and cleavage start even when the eggs are inside the uterus. The first cleavage is complete but unequal and produces (i) a small granular propagatory cell and (ii) a large somatic or ecto-dermal cell. Repeated division of the somatic cell further from ectoderm of larva.

Larval stage of Fasciola hepatica:-

Miracidium larva: -

- It is the first larval stage in the life cycle of *Fasciola hepatica.*
- It swims actively in water in search of secondary host, the snail of genus, Limnaea.
- Miracidium larva does not feed. It swims actively in search of its secondary host.
- In case it fails to reach the host, it dies within 24 hours.

Sporocyst larva:-

- Miracidium lose its apical gland, penetrated gland, brain, eyespot and change into a sac-like sporocyst larva.
- It looks like an elongated sac about 0.7mm long.

Redia larva: -

- It is an elongated and cylindrical sac.
- It comes out by the rapture of sporocyst.

Cercaria larva: -

- A fully formed cercaria larva possesses a flattened heart-shaped body with a long contractile tail.

- Its body surface covered with thin cuticle with backwardly directed spines.
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Metacercaria:-

- The metacercaria is somewhat rounded with thick outer covering of cuticle in the from of cyst.
- The Cystogrenous cells of the cercaria disappear and the flame cells increase in number.

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- The metacercaria enters the final host, the sheep, when it grazes on the aquatic weeds and reaches the intestine.

Infection:-

- The vertebrate host (sheep, goat, etc.) gets the infection by grazing on grass, leaves and other vegetation to which metacercaria cysts are attached.
- The invertebrate host (snail) acquires infection when a miracidium, at random, established contact with a suitable part of its body.

Pathogenesis or Symptoms:-

- Infection of invertebrate host (snail) result in a partial or complete destruction of the affected site, which is preferably the digestive gland (liver) or gonad.
- In case of heavy infection, snail considerably increases in size.
- Significant economic important is the effect of *F. hepatica* on its vertebrate, host whose bile ducts as well as liver may be damaged.

Treatment: -

Anti-helminthes drugs such as hexachloroethane, carbon tetrachloride, filcin, emetine hydrochloride, phenothiazine and tetrachlorothane are being employed or treating case of liver-rot.

Prophylaxis or Prevention:-

- Killing heavily infected sheep.
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- Feeding infected sheep with salt and little dry food.
- Killing or checking snail population.

Parasitic Adaptation of *Fasciola:-*

1. Liver fluke has undergone great modification, morphologically as well as physiologically, to suit its existence as an end parasite in the bile ducts of sheep.
2. Locomotary organs are absent as not required by adult. However, free swimming larvae, such as marcidium have cilia and cercaria has a locomotary tail..
3. Adult lacks circulatory, respiratory and sensory organs as they are not needed.
4. Nervous system is poorly developed for the same reason. However, free swimming miracidia has sensory eye sport.

5. Reproductive system is highly developed.
6. Number of eggs produced is enormous (about 200,000 eggs per fluke).
7. Hermaphroditism ensures self-fertilization even in the absence of another for copulation. It is necessary of the species

5.7-Glossary

Acoelomate-	Without a coelom animal.
Bilaterally symmetrical-	The arrangement of the body parts so that the right and left halves are mirror images of each other.
Endo-parasites-	Parasite living within the body of its host.
Fertilization-	Fusion of a mature ovum and a mature sperm to form zygote.
Habitat-	Environment in which an animal lives.
Hepatic –	Pertaining to the liver.
Hermaphrodite-	an individual possessing both male and female reproductive organs.
Host-	organism that provides food, shelter and other benefits.
Metamorphosis-	Structural changes, e.g. larva change into the adult stage.
Monocious-	Having both male and female reproductive organ.
Pathogenesis-	The production of offspring from unfertilised eggs.
Penis -	Male organ of copulation for conveying sperms to the female genital tract.
Papilla –	Any small nipple – shaped projection.
Platyhelminthes-	The flatworms such as planaria.
Proglottids –	Tapewarm segment.
Regeneration-	Replacement by growth of a part of the body that has been lost.
Renette-	In some nematodes, an excretory cell with short tube attached.
Triploblastic-	Derived from three primary germ layers- ectoderm, mesoderm and endoderm.

5.8 - Self assessment question

1. Write the summary of the life history of *Fasciola hepatica*?
2. Write the important parasitic adaptations of *Fasciola*?
3. What is the mode of respiration in *Fasciola hepatica*?
4. How does excretion take place in *Fasciola hepatica*?
5. Explain the structure of the body wall in *Fasciola.* Draw and mention some adaptive features.

5.9-References

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Suggested Readings

(a) Invertebrate Zoology, Author - E. L. Jorden and P. S. Verma.
(b) A text book of Invertebrate Zoology, Author –Dr. S. N. Prasad.
(c) Biology of the Invertebrate Zoology, Author –Jan A.Pechenik.
(d) Invertebrate Zoology, Author –Ruppert, Fox and Barnes.
(e) Invertebrate Zoology, Author –D.T.Anderson.
(f) Invertebrate Zoology, Author –Joseph G.Engeman and Robert W.Hegner.
(g) Invertebrate Zoology, Author –Fatik Boran Mondal
(h) Modern text book of Zoology Invertebrate, Author –R.L.Kotpal.
(i) Invertebrate Zoology, Author –Paul A.Meglitsch and Frederick R. Schram
(j) Text book of invertebrate Zoology, Author – G.S.Sandhu.

5.11 - Terminal Questions

1. Give an account of the life history of *Fasciola hepatica*.
2. What are adaptations? Explain with reference to the structure of Fasciola *hepatica*...
3. Where is Fasciola *hepatica occurence? Give an account of its structure.*
4. Describe reproductive organ of *Fasciola hepatioca*? (Only diagrammatic).
5. Describe the various larval form s of *Fasciola hepatioca.*
6. What do you understand by alternation of generation or digenetic life cycle?
7. What is the infective stage of Fasciola for sheep?
8. Where Fasciola found /
9. Which organism is the secondary host of fasciola?
10. To which larva does miracidium larva give rise to?
11. What is miracidium?
12. What are flame cells?
13. Where can you locate flame cells?
14. Enumerate, in brief, the parasitic adaptations of Fasciola hepatica?

Multiple choice questions:-

1. Liver fluke belongs to class
(a) Cestoda [ ] (b) Nematoda [ ] (c) Termatoda [√] (d) Turbellaria [ ]

2. Fasciola hepatica is found in
(a) Intestine of Sheep [ ] (b) Stomach of Sheep [ ] (c) Liver of sheep [√] (d) None of them [ ]

3. Fasciola hepatica is
(a) Free living [ ] (b) Ectoparasite [ ] (c) Endoparasite [√] (d) Ecto and endoparasite [ ]

4. Which of the following infects the snail in life cycle of Fasciola?
(a) Cercaria [ ] (b) Miracidium [√] (c) Redia [ ] (d) Metacercaria [ ]
5. Which of the following stage in the life cycle of Fasciola is infective stage for sheep?
(a) Cercaria [ ] (b) Miracidium [ ] (c) Redia [ ] (d) Metacercaria. [√]
6. The intermediate host in the case of liver fluke of is
(a) Snail [√] (b) Man [ ] (c) Pig [ ] (d) Fly [ ]
7. The correct sequence of various larvae in liver fluke is
(a) Miracidium, sporocyst, redia, cercaria, metacercaria [√]
(b) Miracidium, sporocyst, cercaria, metacercaria, redia [ ]
(c) Cercaria, sporocyst, redia, miracidium, metacercaria [ ]
(d) Sporocyst, redia, miracidium, cercaria [ ]
8. Larva of Fasciola hepatica that bores into snail is
(a) Cercaria [ ] (b) Hexacanth [ ] (c) Miracidium [√] (d) Redia [ ]
9. The aperture present at posterior end of Fasciola hepatica
(a) Anus [ ] (b) Excretory pore [√] (c) Genital apertures [ ] (d) Cloacal aperture. [ ]
10. Laurer's canal is present is
(a) Fasciola [√] (b) Taenia [ ] (c) Ascaris [ ] (d) Cockroach [ ]
11. During its life cycle, Fasciola hepatica infects its intermediate host and primary host at the following larval stages respectively
(a) Redia and miracidium [ ]
(b) Cercaria and redia [ ]
(c) Metacercaria and cercaria [ ]
(d) Miracidium and metacercaria. [√]
12. In fasciola, miracidium develops into the next stage inside
(a) Bulinus [ ] (b) Limnaea truncatula [√] (c) Pila globosa [ ] (d) Planorbis [ ]
13. Planorbis and Limnaea are the intermediate hosts of Fasciola?
(a) Faciola [√] (b) Schistosoma [ ] (c) Trichinella [ ] (d) Echinococcus [ ]
14. Which of the infective stage to primary host of Fasciola?
(a) Miracidium [ ] (b) Sporocyst [ ] (d) Metacercaria [√] (d) Cercaria [ ]
15. Which of the following larval stage of Fasciola does not produce several larvae?
(a) Sporocyst [ ] (b) Secondary redial [ ] (c) Primary Redial [ ] (d) Cercaria [√]

16. Which layer of Dugesia contains rhabdites?
(a) Epidermis [√] (b) Circular muscle [ ] (c) Parenchyma [ ] (d) Cuticle [ ]
17. Miracidium is one of the stages in the development of
(a) Fasciola hepatica [√] (b) Taenia solium [ ] (c) Ascaris lumbricoides [ ]
(d) Planaria [ ]
18. In Fasciola, the region where the shell gland opens into is the
(a) Oviduct [ ] (b) Ovovitelline duct [√] (c) Uterus [ ] (d) Oocyte. [ ]
19. Fasciola hepatica is a parasite that lives in the
(a) Intestine of sheep [ ] (b) Liverof sheep [√] (c) Spleen of sheep [ ] (d) Pancreas of sheep. [ ]
20. In Fasciola, the germ cells of redia gives rise to
(a) Daughter Cercaria [ ] (b) Daughter Sporocyst [ ] (c) Daughter Redia [√]
(d) Daughter Metacercaria. [ ]
21. Liver fluke is not affected by enzymes of host because of
(a) Cuticle [√] (b) Suckers [ ] (c) Epidermis [ ]
(d) Hooks. [ ]
22. The stage of life history the liver fluke when it infects the primary host is
(a) Redia [ ] (b) Cercaria [√] (c) Sporocyst [ ] (d) Cysticercus. [ ]
23. Which stage of Liver fluke infects the intermediate host?
(a) Redia [ ] (b) Cercaria [√] (c) Miracidium [ ] (d) Sporocyst [ ]
.
24. Primary host of Fasciola is:-
(a) Man (b) Pig (c) Sheep [√] (d) Dog
25. For attachment, Fasciola has:-
(a) Four suckers and hooks [ ] (b) Two suckers [√] (c) Two suckers and hooks [ ] (d) Hooks only. [ ]
26. Correct sequence of larval stages during development of Fasciola is
(a) Miracidium, Redia,, Sporocyst, and Metacercaria [ ] (b) Cercaria, Miracidium, Sporocyst and Metacercaria [ ] (c) Miracidium, Sporocyst, Redia, Cercaria and Metacercaria [√] (d) Redia, Cercaria, Metacercaria and Sporocyst. [ ]
27. In Fasciola, germ balls of Redia give rise to
(a) Daughter sporocyst [ ] (b) Daughter Cercaria [ ] (c) Daughter Redia [√] (d) Metacercaria. [ ]
28. Which is the first stage of larva of Fasciola?
(a) Miracidium [√] (b) Sporocyst [ ] (c) Redia [ ] (d) Cercaria [
29. Fasciola has
(a) Salivary gland [ ] (b) Pharyngeal gland [√] (c) Gastric gland [ ] (d) Intestinal gland. [ ]
30. The cause of 'liver rot' in sheep
(a) Dugesia [ ] (b) Fasciola [√] (c) Taenia [ ] (d) Schistosoma [ ]

UNIT: 06 PHYLUM- ASCAHELMINTHES

Contents

6.1-Objective:-

(1) Understanding the general characters of Ascahelminthes and classification up to the order level.
(2). Study of *Ascaris lumbricoides* with references to structure, reproduction and parasitic adaptations.

6.2-Introduction:-

There are several groups of animals in which the space inside the body is a pseudocoel. It is not a true coelom because it is not lined with mesodermal epithelium, and represents a persistent embryonic blastocoel. These groups of animals are known as pseudocoelomates (presence of a cavity, the pseudocoel, between the gut and body wall), and they are often placed within a single super phylum aschelminthes. Gegenbaur (1859) created a group nemathelminthis to place some pseudocoelomates animal. The name aschelminthes was proposed by grobben (1910), in place of the older name nemathelminthes. It has been derived from two Greek words: askes - cavity + helmins – worm.

6.3- GENERAL CHARACTERS AND CLASSIFICATION:-

6.3.1-GENERAL CHARACTERS:-

- Mostly aquatic, free living or parasitic.
- Usually small, even microscopic. Some reach a meter or more in length.
- Body slender, vermiform, unsegmented, flator cylindrical, bilaterally symmetrical and triploblastic.
- Organ system grade of body organization.
- Head not distinctily formed with well-defined sense organs.
- Body wall with a syncytial or cellular epidermis externally covered with thick cuticle of scleroprotein.
- Cilia absent except anterior cilia of rotifers.
- Musculature includes mostly longitudinal fibres.
- Body cavity pseudocoel not lined by mesoderm.
- Digestive canal complete with mouth, specialized pharynx, straight non-muscular intestine and posterior or anus.
- No circulatory and respiratory systems.
- Excretory system is of protonephridia and canals.
- Cloaca is present in some species.
- Nervous system of cerebral ganglia, or of circumenteric nerve ring with anterior and posterior nerves.
- Mostly dioecious. Male usually smaller then female.

- Gonads and ducts single or double.
- Eggs with chitinous shell. Cleavage is determinate and spiral.
- Development usually direct with no larval stages, or indirect with a complicated life history.

6.3.2-CLASSIFICATION OR MAJOR GROUPS:-

Aschelminthis includes one very large group (nematoda) and four smaller groups (rotifera, gastrotricha, kinorhyncha and nematomorpha). According to some zoologists such as l.h.hyman (1951), aschelminthis is regarded as a distinct phylum, and the various groups included in it as classes. However, others treat different groups as separate phyla and the name of aschelminthis as a superphylum or without any taxonomic rank. Modified classification was proposed by storer and usinger (1971).

Such an approach has been followed in the following in the scheme of classification.

1. class-rotifera
(gr., rota - wheel + ferre - to bear)

- Microscopic animals found in ponds, lakes and streams, rarely in oceans.
- Body wall thickened into stiff plates or lorica into which head may retreat.
- Anterior end with ciliary disc or corona (wheel organ), used for feeding and locomotion.
- Post –anal tail or with two toes and adhesive glands for attachment.
- Body musculature includes longitudinal and transverse muscle bands and strands.
- Digestive system with a grinding organ, mastax, lined internally by strong cuticle.
- Excretory system of proto-nephridia and two proto-nephridial tubes which empty into a bladder.
- Nervous system of three major ganglia and nerves.
- Sensory organs antennae and eye spots.
- Males smaller than females.
- Parthenogenesis common.
- No larval stage.

  Examples: philodina, asplanchna, rotaria, epiphanes (=hydatina).

Class rotifera divided into following three orders.

A). order- monogonontea

- Males small in size.
- Male showed degenerate nature.
- One testis found in male.

  Eg. Mytilina.

b). order- bdelloidea

- Swimming or creeping forms.
- Male showed degenerate.
- Pedal glands more than two.

  Eg. Rotifera and philodina.

c). order- seisonacea

- body elongated
- Gonads found in the paired form.

  Eg. Seison.

2. class- gastrotricha (gr., gaster- stomach + trichos- hair)

- Microscopic, marine and fresh water.
- Body wall with cuticle bearing short, covered, dorsal spines.
- Corona absent cilia on ventral surface for locomotion.
- Posterior end forked and with adhesive tubes and glands for attachment.
- Body musculature includes six pairs of longitudinal muscles.
- Mouth surrounded by bristles.
- Pharynx tri-radiate and muscular.
- Excretory system with two proto-nephridia.
- Nervous system with a saddle –shaped ganglion and two lateral nerves.
- Dioecious or monoecious.
- Fresh water females parthenogenetic.
- Development direct.
- Young and adult alike.

Class gastrotricha divided into following two orders:-

a). order- chaetonotoidea

- Fresh water forms seen.
- One paired proto-nephridia found.
- Reproduction by parthenogenesis.

  Eg. Chaetonotus.

b). order- macrodasyoidea

- Marine worm like.
- Proto-nephridia absent.
- Parthenogenesis type reproduction seen.

  Eg. Macrodasys

3. CLASS - Kinorhyncha (=Echinodera) (Gr., kineo- to move + rhynchos- beak)

- Marine, microscopic worm like animals.
- Superficial segmentation of body into 13 or 14 overlapping rings.
- Body surface with spiny cuticle but no cilia.
- Mouth cone or head protrusible and covered with scalids.

- A pair of adhesive tubes in front part of the ventral surface.
- Pseudocoel with fluid containing anoebocytes.
- A nerve ring with ventral cord with a ganglion in each zonite.
- Eyespots in some.
- Digestive system complete, with salivary glands.
- Dioecious gonads as a pair of tubular sacs.
- Penial spicules in males.
- Fertilization internal.
- Metamorphosis with several larval stages.

Class kinorhyncha divided into following two orders:-

a). order-homalorhagida

- Head and neck both.

  Eg. Trachydemus.

b). order- cyclorhagida

- Only head ring is protrusible.

  E.g. *Echinoderes.*

4. CLASS- Nematomorpha (Gr,.Nema- thread + Morphae- shape)

- Hair worms, found in fresh water. One genus marine.
- Body long, slender and cylindrical.
- Cuticle thick bearing small papaillae. Epidermis cellular, single layered.
- Digestive system complete in larva but degenerates in non-feeding adults. Cloaca present.
- Pseudocoel mostly filled with parenchyma.
- No circulatory, respiratory and excretory systems.
- Nervous system with a circumentric nerve ring and a mid ventral nerve cord.
- Dioecious, gonads and gonoducts paired. Oviducts also open into cloaca.
- Juveniles parasitic in grasshoppers, crickets and other insects.

Class nematomorpha divided into following two orders:-

A). Order- Cordioidea

- Swimming bristles are wanting.
- Gonads paired.

  Eg. Paragordius

B). Order- Nectonematoidea

- Marine forms.
- Swimming bristles are arranged in two rows.
- One gonad found.

  Eg. Nectonema.

5. CLASS- Nematoda (Gr., Nema-thread + Eidos- form)

- Aquatic, terrestrial or parasitic roundworms.

- Body elongated, cylindrical and unsegmented.
- Body wall with thick cuticle, cellular or syncytial epidermis and longitudinal muscule cells in four bands.
- No cilia, circulatory and respiratory systems.
- Digestive system complete with muscular pharynx and glands.
- Excretory system of glandular organs, canals or both.
- Nervous system with circumenteric ring and anterior and posterior nerves.
- Sense organs simple.
- Dioecious. Male with penial spicules and smaller them female.
- Gonads one or two. Male gential ducts lead into cloaca, female genital duct with a separate opening.
- Fertilization internal. Development usually direct.
- No asexual reproduction or regeneration.

Class nematoda divided into following eighteen orders.

a).order- enploidea

- Cuticle not ringed.
- 10-12 bristal in one or two circlets.
- Anterior end with 6 labial papillae.

  Eg. Enoplus

b). order-dorylaimoidea

- Cuticle smooth with bristles.
- Rear part of pharynax enlarged.

  Eg. Dorylaimius

c). order-mermithoidea

- Head sense organs reduced to papillae, generally 6.
- Amphids cyathiform or reduced.
- Pharynx long and blind.
- Intestine also blind.

  Eg. Mermis.

d). order-chromadoroidea

- Aquatic nematodes with smooth or ringed cuticle.
- Pharynx with a posterior bulb.
- amphid sprial

  Eg. Paracytholaimus.

e). order-araeolaimoidea

- Cuticle smooth rarely with bristles.
- Labial papillae present.

  Eg. Plectus.

f). order-monhysteroidea

- Cuticle smooth or slightly ringed.
- anterior end with 4, 6-8 bristles
  Eg. Cylindrolaimus

g). order-desmoscalecoidea
- Marine nematodes.
- Cuticle heavily ringed.
- Anterior end with 4 bristles.
  Eg. Tricoma.

h). order-rhabditoidea
- Free living or parasitic nematodes.
- Pharynx with posterior bulb.
- Caudal glands absent.
  Eg. Rhabditis

i). order-rhabdiasoidea
- Smooth nematodes without definite pharyngeal bulb.
- Hermaphrodite nature and sometimes parthenogenesis also occurs.
  Eg. Rhabdias

j). order-oxyuroidea
- Pharynx with a posterior bulb.
- Females with a long pointed tail.
- Male with one or two equal spicules.
  Eg. Enterobius (fig.4a and 4b)

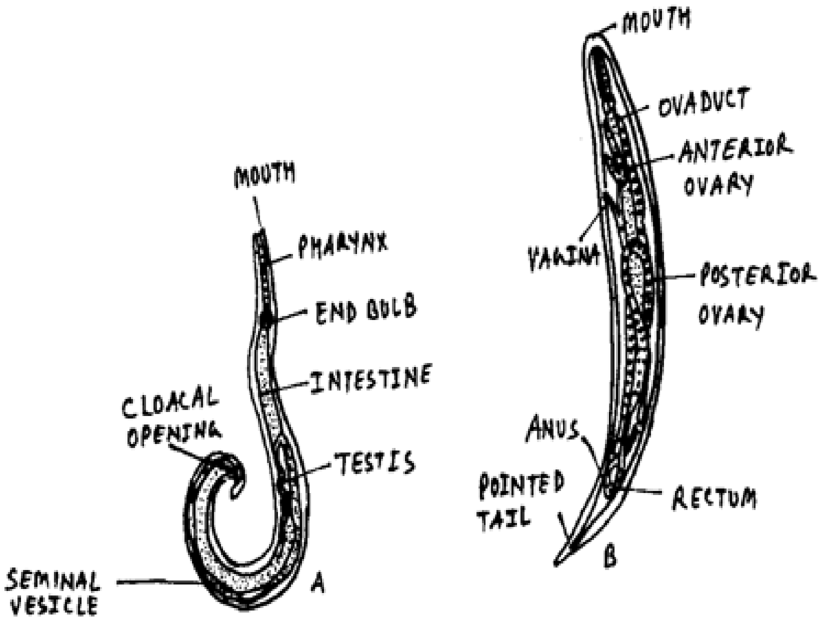

Fig.1: Enterobius Vermicularis: (A) Male (B) Female

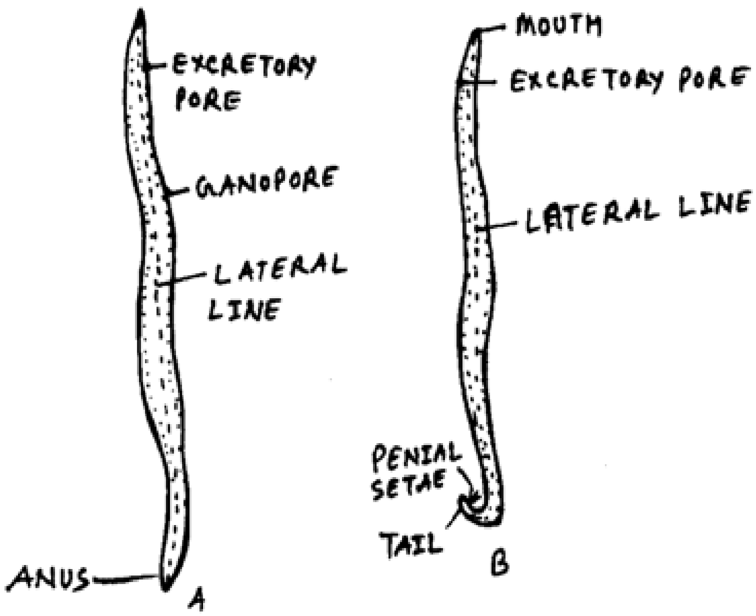

Fig.2: Ascaris lumbricoides: (A) Female (B) Male

k). order-ascaroidea

- Mouth surrounded by three prominent lips.
- Pharynx without posterior bulb.
- Buccal capsule absent.
- Tail of female blunt.
  Eg. Ascaris (fig.2a and 2b)

l). order-strongyloidea

- Mouth without conspicuous lips.
- Pharynx without bulb.
- Males with copulatory bursa, Eg. Ancylostoma (fig.3a and 3b)

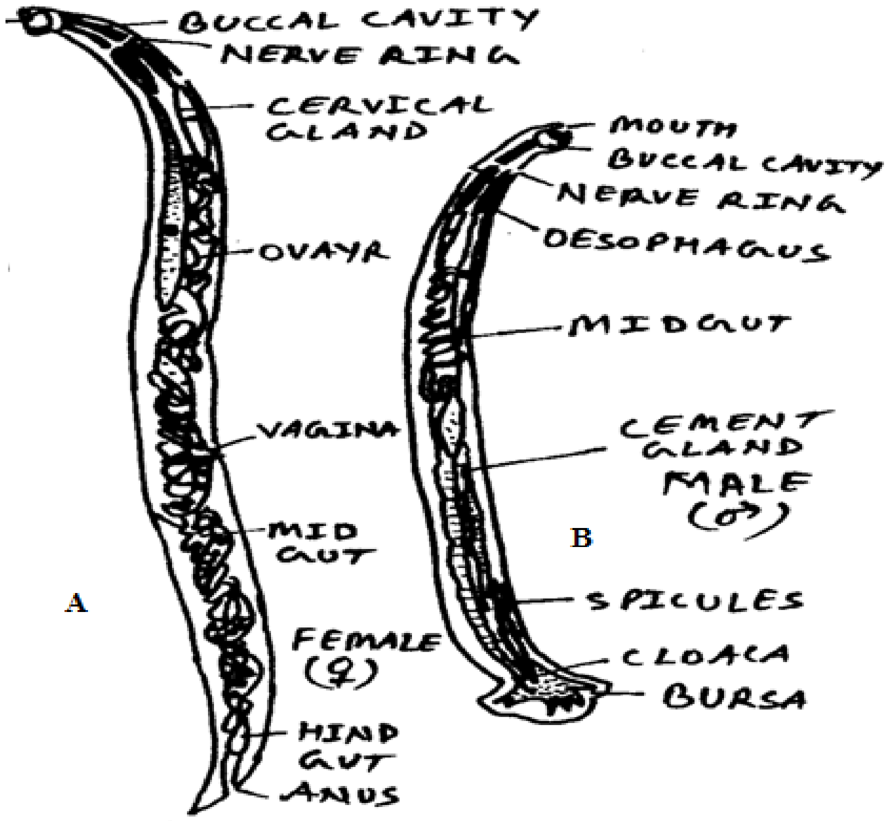

Fig.3 (A) Ancyclostoma Duodenal (Female)
(B) Ancyclostoma Duodenal (Male)

m**).** order-spiruroidea

- Mouth with two lateral lips.
- Pharynx without bulb.
- Males with bursa.

Eg. Rictularia

n). order-dracunculoidea

- without definite lips
- Pharynx as in spiruroidea.
- Vulva usually not functional.

Eg. Dracunculus.

o). order-filarioidea

- Lips absent in filiform worms.
- Buccal capsule small.
- Vulva anterior in female.

Eg. Wuchereria (fig.4).

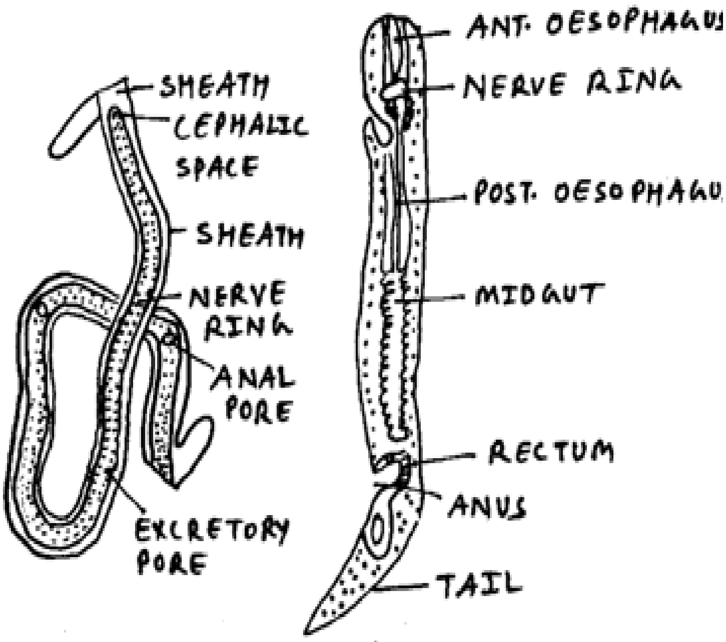

Fig.4 Wuchereria Larva

p). order-trichinelloidea

- Mouth without lips.
- Pharynx slender.
- Body filiform anteriorly.
  Eg. Trichinella (fig.5a and 5b).

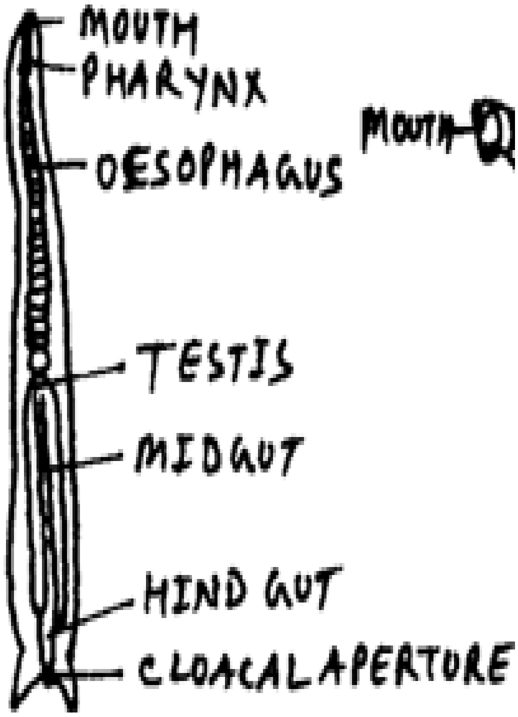

Fig.5 (A) Trichenella Spiralis (Male)

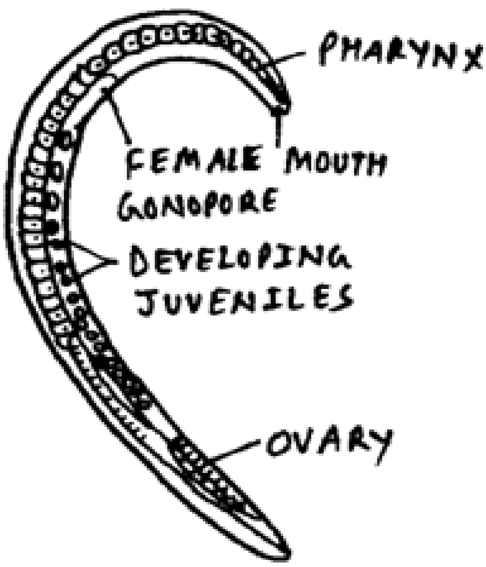

Fig.5 (B) Trichenella Spiralis (Female)

q). order-dioctophymoidea

- Mouth without lips surrounded by 6-12 papillae.

- Males with muscular brusa.
  Eg. Dictyophyme**.**

6.4 Study of Ascaris:-

6.4.1-Structure:-

<u>Life history of *Ascaris lumbricoides*</u>

Systematic Position

PHYLUM ASCHELMINTHES
CLASS NEMATODA
ORDER ASCAROIDEA
<u>GENUS</u> *<u>ASCARIS</u>*
<u>Species</u> *<u>lumbricoides</u>*

Habit and Habitat:-

- *Ascaris lumbricoides* commonly known as round worm.
- *Ascaris* is largest nematode parasite in the human intestine.
- It is cosmopolitan nematode parasite.
- A billion people are estimated to be infected with roundworm.
- The adult worms live in a small intestine of infected persons.
- It is found more commonly in children than in adults.
- As many as 800 to 1500 adult worms may inhabit a single host.

External Features:-

Shape:-

- Body is elongated, cylindrical and vermiform.
- It is a large size nematode showing sexual dimorphism.
- Sexes are separate.
- The female is larger than the male **(Fig.6A and 6B)**.

Size:-

- The female length measures 20-40 cm in length and 6-8 mm to width.
- The male is 15-30 cm long and 2-4 cm wide.

Coloration:-

- Fresh specimens are pale pink or flesh coloured become white outside the body.

Morphology:-

Anterior End:-

- The anterior end of the body bears a terminal triangular opening, the mouth **(Fig.6C, 6D and 6E)**.
- It is bounded by three rounded rasping lips; one of them is mid–dorsal and two are ventro –lateral or sub–ventral.
- The mid dorsal lip is broadly elliptical with central forked and fleshy core.
- It is beset with a circle of four minute sensory papillae.

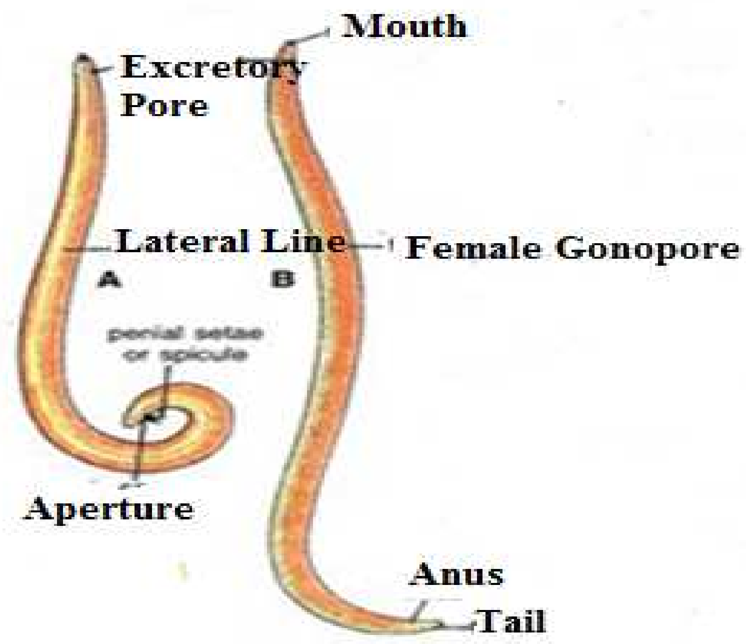

Fig.6 .1 Ascaris lumbricoides, Adult worm in lateral (A) Male (B) Female

- The two latero-ventrals are also provided with forked fleshy cores and bear two rows of sensors papillae each with two papillae.
- These are also provided with special sensory structures, the amphids.
- The sensory papillae are tango receptors and the amphids are chemo-receptors.
- The inner edges of the lips are finely toothed.
- Slightly behind the anterior end and situated mid ventrally is a small excretory pore.
- In female the gonopore is situated at about anterior 1/3rd of the body.

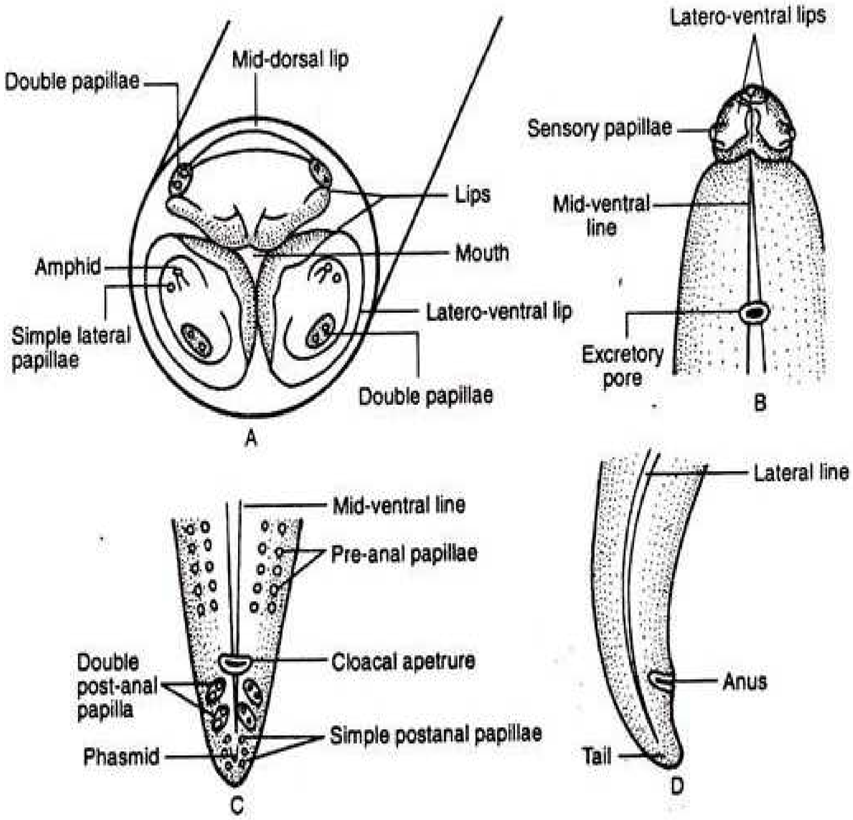

Fig.6.2 Ascaris lumbricoides: (a) face view of mouth & lips
(b)Anterior end of ventral view (c) Posterior end of female in side view
(d)Posterior end of male in ventral view

Posterior End:-

- The posterior part of the body exhibits sexual dimorphism.
- It is straight in male **(Fig.6G)** and sharply curved in female **(Fig.6F)**.
- It bears anus as a transverse slit in female and a cloacal opening in male.
- Two spicules or penial setae sometimes project out from a cloacal opening.
- The part of the body behind the anus or cloacal opening is known as tail.
- In male, it carries 50 pairs of pre-anal and 5 pairs of post-anal papillae **(Fig.6H)**.

Body wall:-

The body wall is formed of following three layers:-

1. Cuticle 2. Epidermis 3. Muscle layer

1. Cuticle- It is a thick, tough, wrinkled and transparent outer most layer of the body wall.

- It is continuous with the cuticular lining of the pharynx and rectum.

- The cuticle is not chitin.
- It is soluble in KOH.

2. Epidermis-

- Below the cuticle is a syncytial epidermis with many nuclei but no cell walls. The number of epidermal cells is small.
- Fat and glycogen reserves are abundantly found in the epidermis.

3. Muscle layer-

- Internal to epidermis and lying between the epidermal chords is the body wall musculature consisting exclusively of a single layer of longitudinal fibres running along the length of the body.
- Special muscles occur in the pharynx, vagina of female, and in connection with the spicules of the male.

Body Cavity:-

The space between the body wall and alimentary canal is not a coelom but a pseudocoel. It is formed by the breakdown of connective tissue cell. Pseudocoel has fibrous tissue and fixed cells called coelomocytes or giant cells. Pseudocoel is filled with a clear, protein-rich fluid, the pseudocoelomic fluid which distributes digested food and transports various metabolites (Fig.7A and 7b).

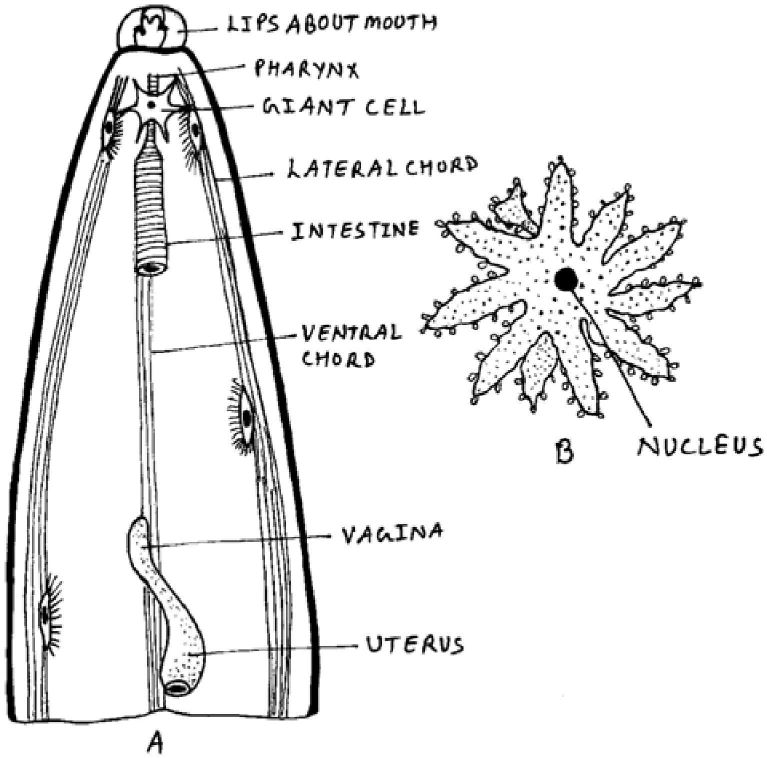

Fig.7 Ascaris lumbricoides (A) Position of giant cell (Pseudocoelomocytes) in pseudocoel. (B) Single pseudocoelomocytes Enlarged

Digestive System

The digestive system is very simple consisting of a) mouth b) esophagus or pharynx c) intestine d) rectum **(Fig.8A, B, C and D)**.

a). Mouth- The mouth is a tri-radiate aperture situated at the anterior tip surrounded by three lips or labia.

b). Pharynx-

- The pharynx is a small cylindrical chamber with thick and muscular walls formed of radially arranged muscules.
- Its cavity has a tri-radiate appearance and is lined by cuticle.
- In the pharyngeal wall are embedded two palmately branched subventral oesophageal glands and a pinnately branched dorsal oesophageal glands.

c). Intestine –

- It is a long, thin walled, dorsoventrally flattened tube which is devoid of muscles.

- The intestinal wall is formed of a single layer of elongated columnar cells lined externally by a basement membrane and a thin layer of cuticle.
- The free inner margin of each cell is produced into several fingers–like projections, the microvilli (Kessel et.al., 1961).
- They form sort of tightly packed brush borders which increase the surface area.

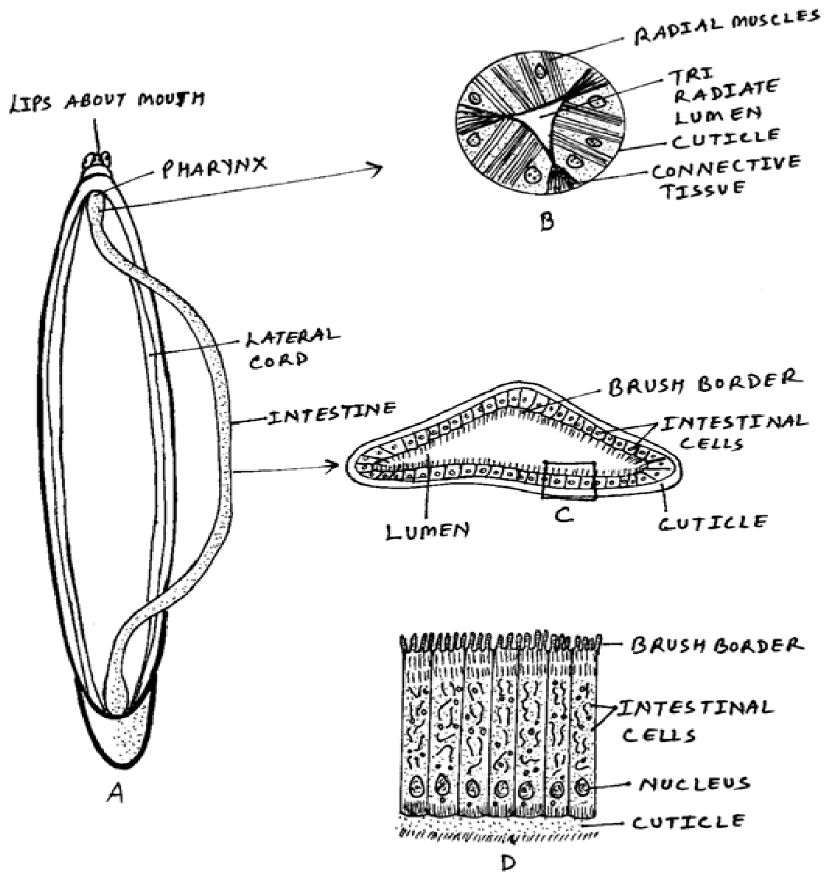

Fig.8 Ascaris: (a) Alimentary canal (b) Pharynx in T.S (c) T.S of Intestine (d) a portion of Intestinal wall showing brush border

d) Rectum-

- It is the distal narrow part of the intestine having comparatively thick walls.
- The wall of the rectum consists of tall columnar cells and is lined externally by the muscle layer and internally by cuticle.
- In male, rectum opens into the cloaca which also receives the ejaculatory duct.
- In female, it opens to the exterior by a transverse slit-like anus.
- In the rectum are larger unicellular rectal glands, 3 in the female and 6 in the male.

Respiratory System:-

- There are no respiratory organs in *Ascaris*.
- The parasites carry on anaerobic respiration as the oxygen content in the intestine of host is very poor.
- It obtains energy by the breaking down of glycogen into Co_2 and fatty acids which are excreted though the cuticle like those of flatworm parasites, eg. *Fasciola.*

Excretory System:-

- In marine nematodes, the excretory system consists of one or two large renette gland cells lying ventrally in the pseudocoel near the junction of the pharynx and intestine.
- The excretory system is in the shape of H.
- It consists of two longitudinal canals running one in each lateral line.
- The two canals are connected anteriorly by a transverse canal in the form of network and open on the ventral side by a single excretory pore.
- The excretory system has no internal opening, cilia, flame cells or nephridia.
- The nitrogenous waste chiefly comprises urea which diffuses into the pseudocoelomic fluid.
- The excretory canal are said to secrete this urea which is eliminated through excretory pore.
- Some ammonia and urea are also passed out along with the faecal matters.
- Ascaris excretes more urea when water is scarce.

Nervous System:-

- The nervous system of Ascaris is well developed and complicated.
- The nervous system is hypodermal and consists of a circumpharyngeal ring or nerve ring and nerves originating from it.
- The circumpharyngeal nerve around the pharynx consists of a number of cephalic ganglia. These are:

(a) Six papillary ganglia

b). Two ventral ganglia

c). Two sub-dorsal ganglia

d). Two dorsal ganglia

Nerves:-

- Six nerves are issued anteriorly from the nerve ring to the various sense organs of the anterior part of the body.
- Eight nerves arise posteriorly from the nerve ring. These are

a). A dorsal nerve

b). A ventral nerve

c). Paired dorsal-ventral nerves

d). Paired ventro-lateral nerves

e). Paired lateral nerves

Of these the dorsal and ventral nerves run through the dorsal and ventral lines upto the posterior part of the body.

Sense Organs

- Due to parasitic mode of life, Ascaris has developed sense organs which are very simple.
- The only sense organs are the sensory labial papillae and amphids present on the oral lips.

6.4.2-Reproductive System:-

- In Ascaris, like other nematodes, sexes are separate, i.e., dioecious.
- Sexual dimorphism found in Ascaris.
- The male is smaller in size than the female; its tail is curved, while females' tail is straight.
- It bears cloaca and a pair of spicules or penial setae but female possesses anus and spicules absent, male possesses pre-anal and post-anal papillae which are absent in female.
- The male system is reduced to a single tube but the female system is double.

Male Reproductive Organs

The male reproductive organs are-

a). Testis-

- Testis is monorchic, i.e., single in Ascaris but it may be diorchic, i.e., two testis in some nematodes.
- The testis of Ascaris is a long, thread-like and coiled tube **(Fig.9A, B, C, D and E)**.
- Cytoplasmic rachises are developing sperms.

b). Vas deferens-:-

- The testis continues distally into a short and thick coiled tube of the same diameter, the vas deferens.
- It is very short and leads into the seminal vesicle.

c). Seminal vesicle:-

- The seminal vesicle is a wide tube present in the posterior 1/3rd part of the body.
- It joins the ejaculatory duct.

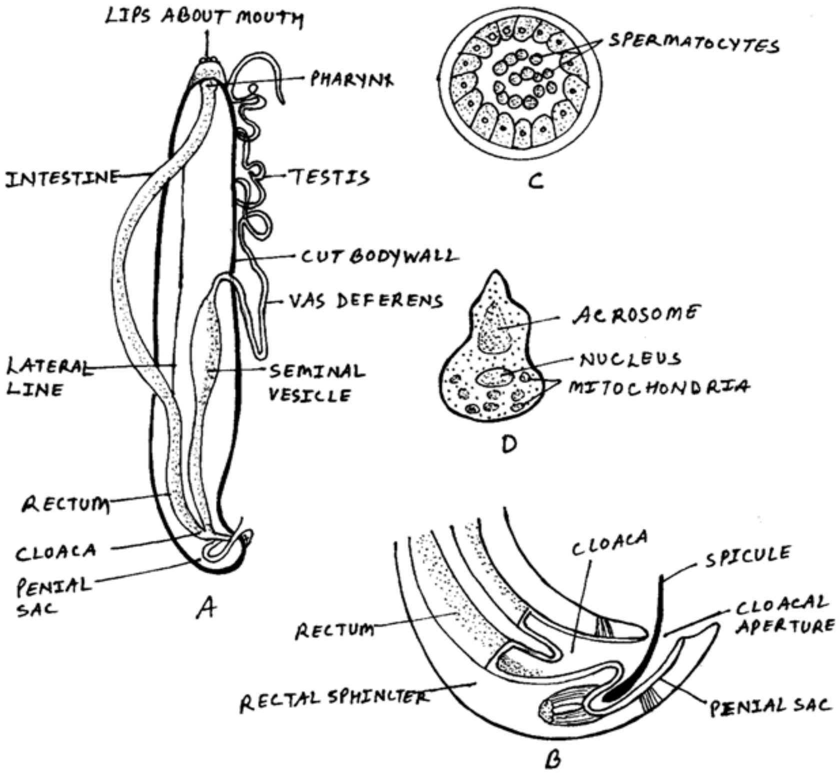

Fig.9 Ascaris lumbricoides (a) Male Reproductive system
(b)Posteror end of male Ascaris (c) T.S of vas deferens (d) a male sperm

d)Ejaculatory duct-

- The **seminal** vesicle narrows at its posterior end to form a short, but muscular ejaculatory duct which opens into the rectum to form the cloaca.
- This duct bears a numbers of prostatic glands whose secretion helps in copulation.

e) Penial setae –

- The penial setae are paired muscular pocket –like outgrowths from the dorsal wall of cloaca.
- The penial setae help the transference of sperm during copulation.

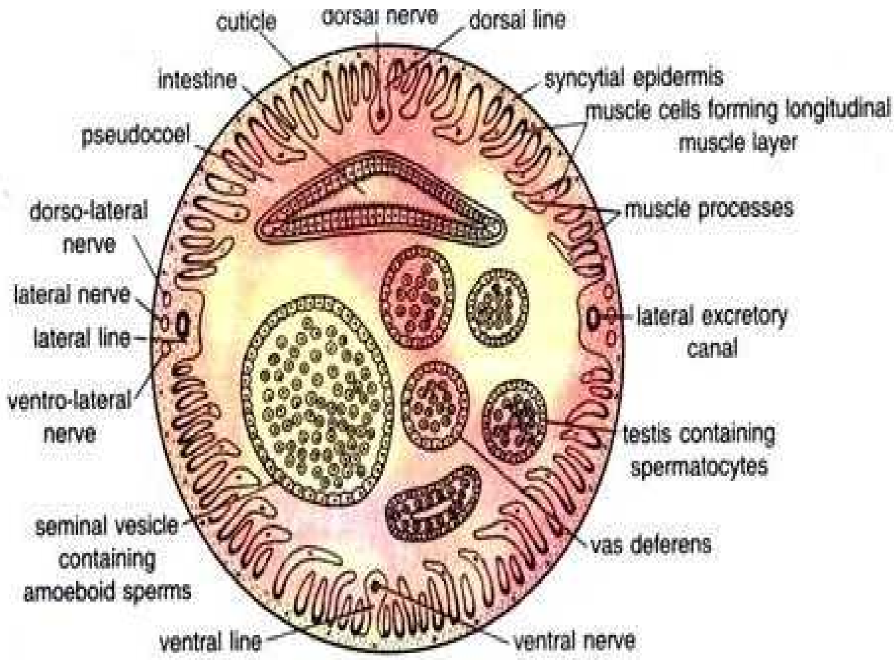

Fig.9-E Ascaris: T.S of Mature Male

Female Reproductive Organs:-

The female reproductive organ are-

a). A pair of ovaries

b). A pair of oviducts

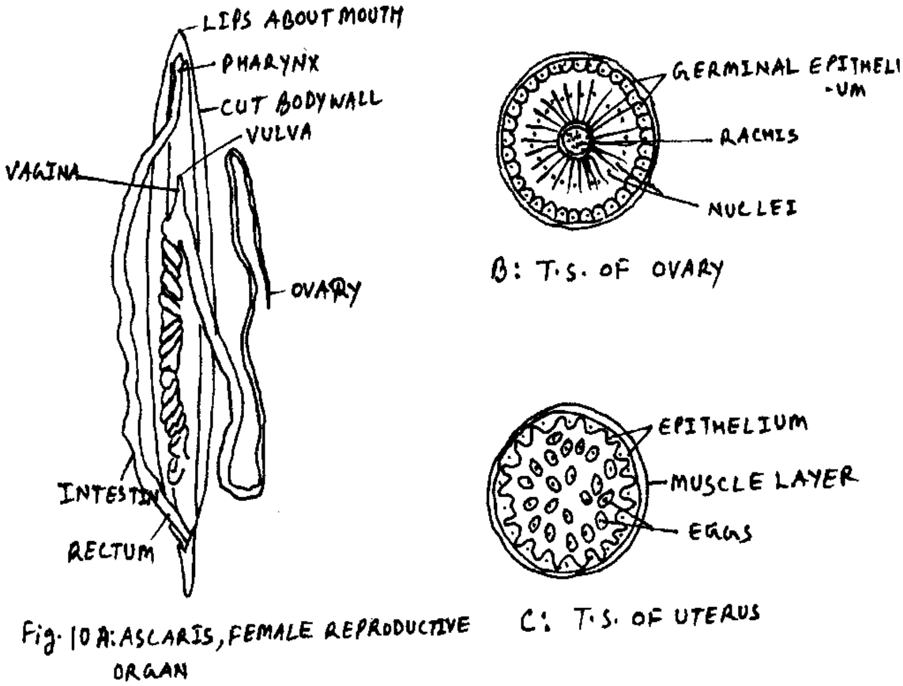

Fig 10 Ascaris Female Reproductive organs

c). Two uteri

d). A vagina

a) Ovaries- The paired ovaries of Ascaris are long, thread-like and highly twisted tube like and terminate blindly in the pseudocoel.

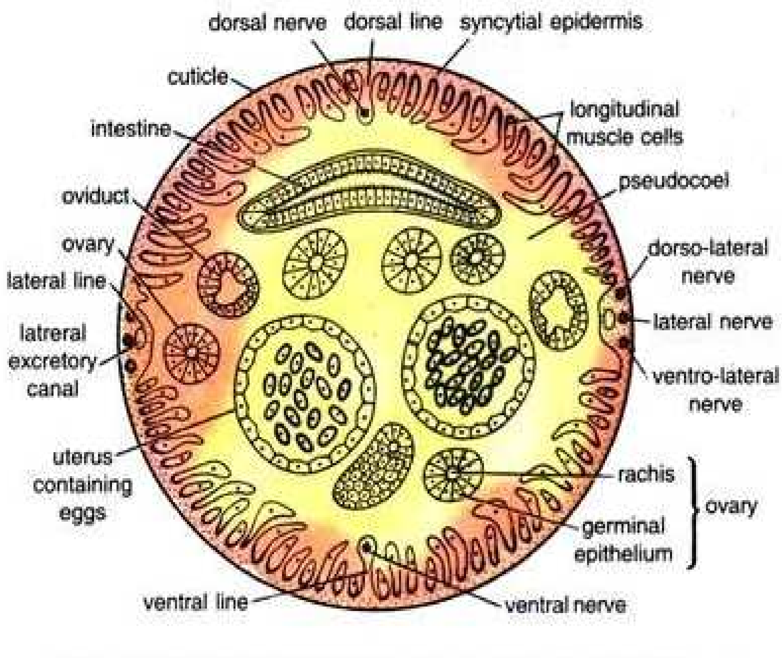

Fig.10-D Ascaris: T.S of Mature Female

b). Oviducts- The oviducts are two thin ducts very similar to the ovaries **(Fig.10A, B, C, & D)**. These open into the uteri.

c). Uterus- Each oviduct leads into a long, wide and much coiled uterus, having muscular wall.

d). Vagina-

- The two uteri and open into a short median, muscular vagina lined with cuticle.
- The vagina opens by a transverse gonopore or vulva which lies mid-ventrally about 1/3 of the length from the anterior end.

Life History of *Ascaris:-*

Ascaris is an intestine parasite of man. Its life history is simple and its completed is one host (monogenetic) only.

1. Copulation-

The male and female organisms copulate inside the host intestine and sperm are passed into the vagina.

2. **Fertilization-**

- These move through uterus and fertilised the eggs.
- Eggs are fertilized in the oviduct or in upper part of uterus.

- The fertilized eggs are surrounded with highly resistant, chitinous egg-shell and an irregular coat of albumin.

3. Egg Laying-

- The eggs are laid in the host intestine.
- These are deposited out along with host faces.
- A female Ascaris is recorded to lay as many as 27,000,000 eggs.
- One female may lay from 15,000 to 2, 00,000 eggs daily.

4. Eggs nature-

- Eggs of Ascaris are about 40-75 (microns) in size and elongated eplliptical or oval in form.
- The eggs become stained yellowish or brown in the intestine.
- These are enclosed in thick, transparent, chitinous egg shell and a coarsely laminated albumin coat.
- The covering is resistant to chemicals and environmental changes.
- These eggs can remain dormant for years together in unfavorable environmental conditions.

6.4.3-. Early development:-

- The stage of early embryonic development, say the cleavage or segmented, start in the soil.
- The pattern of cleavage is spiral and determinate.
- The fertilised eggs undergo two cleavages to form four cells or blastomeres.
- The first division is transverse producing an upper dorsal cell AB and a lower ventral P_1 **(Fig.11)**.
- The lower cell divides horizontally into upper cell EMST and lower cell P_2. Thus the four –celled embryo has T-shaped appearance.
- The P2 cell shift towards right and comes to lie in front of the upper cell EMST. The A and B cells divide together into right and left cells and by further divisions form the ectoderm of the embryo.
- The EMST and P2 cells divide into E, MST, P3, and C cells. The off springs of cell E form the endoderm, while the descendants of EMST constitute the mesoderm and a part of ectoderm.
- The cell P3 divides into P4 and D. The cell C and D divide and contribute to the ectoderm and mesoderm.
- The cell P1 divides into G1 and G2 and forms the primordial germ cell.\

- Thus blastula stage is attained. It undergoes gastrulation by invagination and finally develops into an active juvenile, representing the rhabditoid stage.

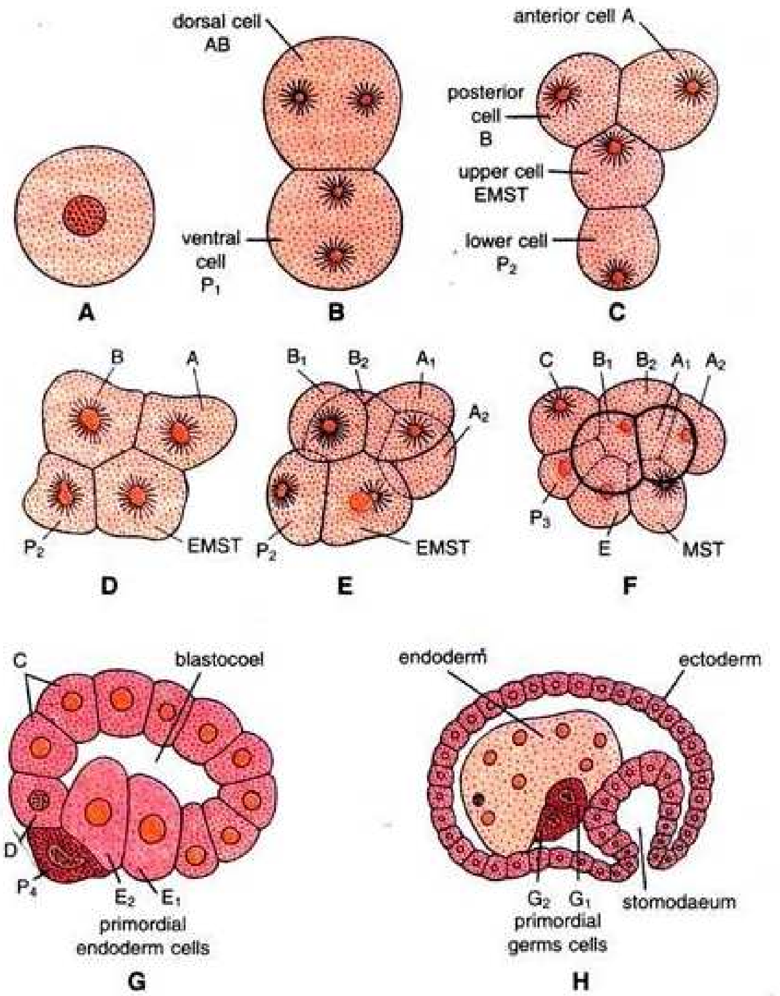

Fig.11 Ascaris: Stage of Development.(a) Zygote (b)Cell stage (c) 4-cell stage(T- shaped)(d) 4-cell stage (rhomboidal) (e) 6-cell stage (f) 8-cell stage (g) median sagittal Section through blastula (h) median sagittal section through the embryo after invagination of stomodaeaum & the primordial germ cell.

Under favorable condition of temperature, moisture and oxygen supply, it requires 10-14 days to reach the 2nd stage larva. After a week or so it moults inside the egg shell and changes into the second stages larva.

The hatching and further development of the larva is possible only if the egg enters the final host.

4. Infection-

- There is no secondary host in the life history of *Ascaris.* (Fig.12)
- The infection to final host is effected when the eggs are swallowed accidentally along with contaminated food, water or raw vegetables.

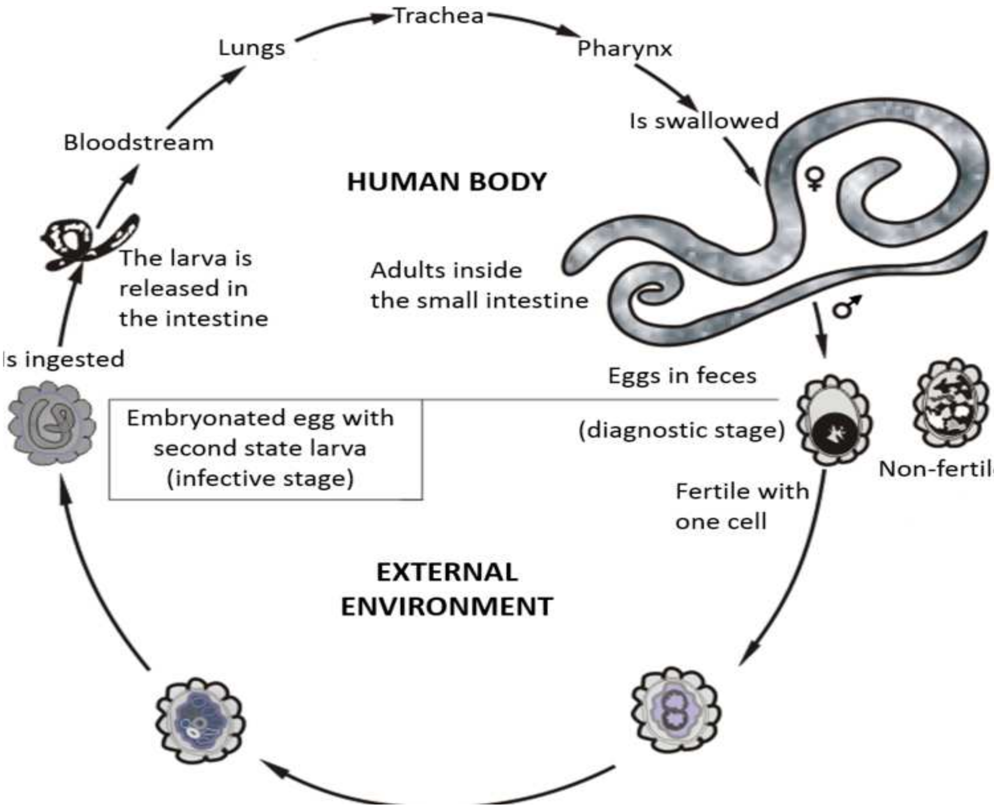

Fig.12 Ascaris: Life Cycle

- On reaching the duodenum the 2^{nd} stage rhabditoid larva hatches out of the egg.
- The larva is about 0.2 to .3 mm long with a well developed canal, nervous system and the excretory system.
- Before setting down into the intestine this larva pursues a migratory course through the host body and moults twice.

Primary Migration:

- The 2^{nd} stage larva after hatching out of the egg penetrates the mucous membrane of the intestine and enters the blood stream.
- It is carried to the liver through hepatic portal circulation and from liver it reaches the heart.

- The pulmonary artery, them, carries it to the lung.
- Here it settles down in the capillaries or alveoli for some time and undergo two moulting one after the other.
- It attains a size of about 1-2mm. After moulting, it again starts its migration.

Secondary Migration:

- Here they grow and moult to become 3rd stage larvae which moult again to become 4th stage larvae.
- From alveoli the larva travels along the trachea into the pharynx.
- It irritates the pharyngeal wall and causes coughing.
- With coughing it is swallowed and reaches the intestine inside the intestine it moults for the last or the 5th time and assumes the organization of the adult.
- Within 6-10 weeks it becomes sexually mature.
- They grow into adult males and females and attain sexual maturity. The total life of the parasite in the host averages only nine months to a year.

The life history of *Ascaris lumbricoides* can be represented as:

Adult male and female→ fertilisied eggs pass out→ larvae develop in egg shell

↓
Swallowed by man
↓
Intestine where juveniles hatch
↓
Bore through intestine
↓
Mesenteric veins
↓
Hepatic portal vein
↓
Liver
↓
Grow into adults Hepatic vein
↑ ↓
Intestine where fourth moulting occurs Postcaval vein
↑ ↓
Oesophagus Right side of heart
↑ ↓
Glottis Pulmonary artery
↑ ↓
Trachea ←Bronchus ←Bronchioles←alveoli where third moulting occurs←Lungs

Pathogenesis or Parasitic Effects:-

1. Not only the adult but also the larvae pursuing the migratory course are pathogenic.

2. The larvae inside the lungs cause inflammation and produce severe and fatal pneumonia. Sometimes their presence causes fever, anaemia, leucocytosis and eosinophillis.

3. The mature worms, of course, are not very fatal and in some cases these do not even disturb the life activities. But when present in large numbers these are responsible to cause abdominal discomfort and acute colic pain.

4. Diarrhea and slight temperature may also be caused.

5. These may accumulate in several hundreds and block the intestine or the appendix causing appendicitis.

6. By destroying the intestinal wall these produce peritonitis.

The toxins liberated by the worm cause delirium, convulsions, coma and general nervousness.In general, presence of Ascaris leads to stunt growth and poor memory of the host.The disease caused by Ascaris is generally known as ascariasis.

Diagnoses:-

1. by serological tests.
2. By barium x-ray the presence of the worm in the intestine can be detected.
3. By examine stoll for eggs of the worm.

Treatment:-

1. Piperazine salt is the ideal drug administered for Ascaris.
2. A single dose cures 60-75% of the infection.
3. Other drugs include Thiabendazole, Mebenedazole, Carbamazine and Tetramizole.

Prevention or Prophylaxis

To avoid the infection of Ascaris the following measures should be taken:
1. The use of raw vegetables and contaminated water should be avoided.
2. Sanitary toilet and effective sanitary disposal of faeces should be provided.
3. Raw stems, leaves, fruits and roots, which have been grown by the use of night soil, fertilizer, should be thoroughly washed and properly cooked.
4. Children should be asked to wash their hands carefully and properly before handling the food.
5. Proper hygienic measures should be adopted and sanitary education should be given to the people.

6.5- Summary:-

The name aschelminthes was proposed by grobben (1910), in place of the older name nemathelminthes. It has been derived from two greek words: askes - cavity + helmins – worm. Mostly aquatic, free living or parasitic. Usually small, even microscopic. Some reach a meter or more in length. Body slender, vermiform, unsegmented, flat or cylindrical, bilaterally symmetrical and triploblastic. Body cavity pseudocoel not lined by mesoderm. Digestive canal complete with mouth, specialized pharynx, straight non-muscular intestine and posterior anus. No circulatory and respiratory systems. Excretory system of protonephridia and canals. Nervous system of cerebral ganglia, or of circumenteric nerve ring with anterior and posterior nerves. Mostly dioecious. Male usually smaller then female. Gonods and ducts single or double. Eggs with chitinous shell. Cleavage determines and spiral. Developmant usually direct with no larval stages, or indirect with a complicated life history.

Aschelminthis includes one very large group (nematoda) and four smaller groups (rotifera, gastrotricha, kinorhyncha and nematomorpha). According to some zoologists such as l.h.hyman (1951), aschelminthis is regarded as a distinct phylum, and the various groups included in it as classes. However, others treat different groups as separate phyla and the name of aschelminthis as a superphylum or without any taxonomic rank. Modified classification was proposed by storer and usinger (1971).

Ascaris lumbricoides, commonly known as round worm. It is largest nematode parasite in the human intestine. It is found more commonly in children than in adults. It is a large size nematode showing sexual dimorphism. The female length measures 20-40 cm in length and 6-8 mm to width. Fresh specimens are pale pink or flesh coloured body. The body wall is formed of following three layers: a). Cuticle b). Epidermis c). Muscle layer. There are no respiratory organs in *Ascaris*. The parasites carry on anaerobic respiration as the oxygen content in the intestine of host is very poor. The excretory system is in the shape of H. *Ascaris* excretes more urea when water is scarce. A female Ascaris is recorded to lay as many as 27,000,000 eggs. Eggs of Ascaris are about 40-75 (microns) in size and elongated eplliptical or oval in form. The eggs become stained yellowish or brown in the intestine. No secondary host in the life history of *Ascaris.* The *Ascaris* larvae inside the lungs cause inflammation and produce severe and fatal pneumonia. Sometimes their presence causes fever, anaemia, leucocytosis and eosinophillis. Piperazine salt is the ideal drug administered for Ascaris.

6.6- Glossary:-

Adaptation- the fitness of an organism for its environment.
Anus- posterior opening of the digestive tract.
Bilateral symmetry- the arrangement of the body parts so that the right and left halves are mirror images of each other.
Blastocoel- cavity of the blastula
Bronchiole- tiny air tube in the lung.
Bronchus- one of the two main air passages on the trachea.
Caudal – pertaining to the tail.
Ceavage- series of early division of an egg into many cells.
Chemo-receptors- organs or neuron sensitive to specific chemical changes.
Chitin – a complex organic substance.
Cilia- hair like projection.
Cleavage - series of early division of an egg into many cells.
Coelom - body cavity lined with tissue of mesodermal origins in which the

digestive and other organs.
Copulation- sexual union of two individuals.
Cytoplasm- protoplasm of a cell exclusive of the nucleus.
Dioecious- having the male and female reproductive organs in separate

Individule. Eplliptical or oval in form.
Excretion- discharge of metabolic wastes.
Faeces- the indigestible, unabsorbed residue of digestion.

Female reproductive organs
Fertilization- union of a mature ovum and a mature sperm to form zygote.
Ganglion- group of mass of nerve cell bodies.
Gonad – reproductive organ (ovary or testis).
Hepatic – pertaining to the liver.
Hermaphrodite- an individual possessing both male and female reproductive organs
Host- organism that provides food, shelter and other benefits.
Ingestion- the act of taking the food into the mouth.
Locomotion- movement involving the organism as a whole.
Lorica- protective covering secreted by certain organism.
Mesoderm- the middle layer of embryonic cells, between the ectoderm and endoderm.
Metamorphosis - structural changes, eg. Larva change into the adult stage.

Monoecious – having both male and female reproductive organ.
Nephridium- tubular excretory structure characteristic of many invertebrates,

Such as the animal.
Nerve- bundle of nerve fiber.
Nerve cord – cord of neuron and ganglia forming part of a central nervous system.

Ovary- female gonad
Oviduct- a tube that conveys eggs from ovary to uterus or to exterior.
Papillae- small nipple shaped projection
Parasitic- organism that lives during the whole life cycle upon or within

Another organism and from which it derives nourishment.
Parthenogenesis- the production of offspring from unfertilised eggs.
Pedal – pertaining to the feet.
Penis- male organ of copulation for conveying sperms to the female genital tract.

Pharynx – anterior portion of the digestive tract between the mouth cavity and oesophagus.

Protonephridium- excretory organ of certain invertebrates with closed inner end

Branched.
Pseudocoel- a body cavity not completely lined with mesoderm as found in

Round worms.
Rotifers- phylum of microscopic pseudocoelomate animals.
Saliva- secretion of the salivary gland.
Salivary - pertaining to the saliva-secretion gland of the mouth.
Sense organ- an organ sensitive to a particular type of stimulus.
Sensory cell - cell that is very sensitive to stimuli, receptor.
Sexual dimorphism- phenomenon of two sexes of a given species differing in

secondary characters.
Spicule- One of much solid structure that composed the structural

framework of a spong.
Taxon- the category of animal classification.
Taxonomic – science that deals with the classification of organisms.
Triploblastic- derived from three primary germ layers as ectoderm, mesoderm and endoderm.

Valve-	any structure that limits or closes an opening.
Vas deferens-	duct that carries sperms away from the testis.
Ventral –	pertaining to the belly, away from the back or opposite of dorsal.

6.7-Self assessment question:-

1. What kind of parasite is Ascaris and it is the causal organism of which disease?
2. Which medicines are used for the treatment of Ascaris?
3. Write notes on: pseudocoel; Muscle cell?
4. Explain briefly the parasitic adaptations of Ascaris?
5. Give a few features of rhabditiform larva of Ascaris?

6.8-References:-

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Mongin. (1770)*. Sur un ver trouvé sous la conjunctive à Maribarou, isle Saint-Dominique.* J. Med. Chir. Pharm. 32**:**338-*339.*

Roberts, Larry S.; Janovy, John Jr. (2009). Foundations of Parasitology, Eighth Edition. United States: McGraw-Hill.

6.9-Suggested Readings:-

(a) Invertebrate Zoology, Author - E. L. Jorden and P. S. Verma.
(b) A text book of Invertebrate Zoology, Author –Dr. S. N. Prasad.
(c) Biology of the Invertebrate Zoology, Author –Jan A.Pechenik.
(d) Invertebrate Zoology, Author –Ruppert, Fox and Barnes.
(e) Invertebrate Zoology, Author –D.T.Anderson.
(f) Invertebrate Zoology, Author –Joseph G.Engeman and Robert W.Hegner.
(g)Invertebrate Zoology, Author –Fatik Boran Mondal
(h) Morden text book of Zoology Invertebrate, Author –R.L.Kotpal.
(i) Invertebrate Zoology, Author –Paul A.Meglitsch and Frederick R. Schram
(j) Text book of invertebrate Zoology, Author – G.S.Sandhu.

6.10-Terminal Questions:-

1. What kind of coelom is found in Ascaris?
2. What are distinguishing features of male and female Ascaris?
3. How many lips surround the mouth of Ascaris?
4. Which is the infective stage of Ascaris for man?
5. Where is anus situated in Ascaris?
6. Draw labelled diagrams only :-

(a) T.S. Male Ascaris.
(b) T.S.Female Ascaris.

Multiple choice questions:-

1. Which type of body cavity is found in Ascaris?
(a) Gastrovascular [ ] (b) Pseudocoelom [√] (c) Coelom [ ] (d) None of these [ ].
2. In life cycle of Ascaris, the juvenile hatches out of egg in
(a) Lung [ ] (b) Liver [ ] (c) Intestine [√] (d) None of these [ ].
3. The mouth of Ascaris lumbricoides is bound by three lips of which
(a) One is median and two are lateral [ ] (b) One is dorsal and two are ventral [ ]
(c) Two are dorsal and one is ventral [ ] (d) One is median and dorsal and two are ventrolateral [√].
4. Normal life span of Ascaris is
(a) 9-12 weeks [ ] (b) 9-12 months [√] (c) 9-12 years [ ] (d) 3-4 months [ ] .
5. Ascaris has well developed
(a) Nervous system [ ] (b) Reproductive system [√] (c) Receptors [ ] (d) Digestive system [ ].

6. Ascaris is not
(a) Endoparasite [ ] (b) Monogenetic [ ] (c) Free living [√] (d) Dioecious [ ].
7. Respiration in Ascaris is
(a) Aerobic Respiration [ ] (b) Anaerobic Respiration [√] (c) Both [ ] (d) None of these [ ].
8. Ascaris, being a parasite possesses reduced sense organs called
(a) Amphids [√] (b) Penial setae [ ] (c) Penial papillae [ ] (d) Post-anal papillae [ ].
9. Infection of Ascaris usually occurs by
(a) Contaminated water and vegetables [√] (b) Eating imperfectly cooked pork [ ]
(c) Tse-tse fly [ ] (d) Mosquito bite [ ].
10. The space between alimentary canal and body wall in Ascaris is
(a) Paracoel [ ] (b) Haemocoel [ ] (c) Pseudocoel [√] (d) Gastrocoel [ ].
11. Special feature of sperms of Ascaris is
(a) With tail [ ] (b) More than one tail [ ] (c) Without tail [√] (d) Largest [ ].
12. In Ascaris, how many juveniles are formed from fertilised egg up to adult?
(a) 1 [ ] (b) 2 [ ] (c) 3 [ ] (d) 4 [√].
13. Female reproductive organs of Ascaris are
(a) Protandrous [ ] (b) Polydelphic [ ] (c) Didelphic [√] (d) Monodelphic [ ]
14. Ascaris completes its life cycle:-
(a) Only in human [√] (b) Human and sheep [ ] (c) Human and mosquito [ ] (d) Human and cow [ ].
15. Female Ascaris can be differentiated from male Ascaris by
(a) Straight posterior end [√] (b) Curved posterior end [ ] (c) Smaller size [ ]
(d) Genital papillae. [ ].
16. During development, Ascaris needs
(a) One intermediate host [ ] (b) Two definite hosts [ ] (c) No intermediate host [√]
(d) No definite host [ ].
17. From the egg of Ascaris, first larva hatches in
(a) Uterus of female Ascaris [ ] (b) Outside the body of host [ ] (c) Stomach of host [ ].
(d) Intestine of host [√].
18. The first juvenile larva of Ascaris is known as
(a) Miracidium larva [ ] (b) Microfilariae [ ] (c) Rhabditiform larva [√] (d) Filiform larva [ ]
19. Amphids upon the lips of Ascaris are
(a) Organs of smell and chemoreceptor [ ] (b) Secrete saliva [ ] (c) Sense organs [ ].
(d) Adhesive organs [√].
20. Which type of excretory canal system is present in Ascaris?
(a) C-shaped [ ] (b) J-shaped [ ] (c) H-shaped [√] (d) W-shaped [ ]
21. In Ascaris, the reserve food is stored as glycogen and fats in
(a) Intestine [ ] (b) Muscles [ ] (c) Hypodermis or epidermis [√] (d) All of these [ ] .

22. The mammiliated eggs of Ascaris are enclosed in
(a) One layered membrane [ ] (b) Two layered membrane [ ] (c) Three layered membrane [√] (d) none of the above [ ] .
2. Sheathed microfilaria normally circulate at night
(a) In the arteries [ ] (b) In the caval veins [√] (c) In the peripheral blood vessels [ ] (d) Deep in the lymph vessels [ ].
24. The final moult in juvenile of Ascaris occurs in
(a) Lung [ ] (b) Intestine [√] (c) Liver [ ] (d) None of these [ ].
25. When egg of Ascaris is swallowed by man, it settles in intestine after
(a) Three days [ ] (b) One week [ ] (c) Two weeks [√] (d) Three weeks [ ].
26. While migrating, the larva of Ascaris takes its 4^{th} moult in
(a) Intestine [√] (b) Liver [ ] (c) Lungs [ ] (d) Heart [ ] .
27. In which of these animals, the syncytial epidermis follows the cuticle?
(a) Fasciola [ ] (b) Ascaris [√] (c) Taenia [ ] (d) Earthworm [ ].
28. Pineal setae are present in
(a) Earthworm [ ] (b) Ascaris [√] (c) Cockroach [ ] (d) None of these [ ].
29. The pseudocoelom of Ascaris is
(a) An intracellular space in mesodermal cells [ ] (b) A space between few mesodermal and endodermal cells[√] (c) A space in between botryoidal tissue [ ] (d) Intercellular space between false mesodermal cells [ ].
30. Ascaris has a body cavity which is
(a) Intracellular [ ] (b) Pseudocoel [√] (c) Intercellular and pseudocoel [ ] (d) Highly obliterated by cells [ ].
31. Ascaris has no
(a) Cephalisation [√] (b) Alimentary canal [ ] (c) Receptors [ ] (d) Larva [ ].
32. Maximum number of eggs released by single female Ascaris in any day is
(a) 2,000 [ ] (b) 20,000 [ ] (c) 5,000 [ ] (d) 2, 00,000 [√].
33. Final moult in life cycle of Ascaris takes place in
(a) Soil [ ] (b) Lung [ ] (c) Intestine [√] (d) Intestine before migration [ ].
34. Ascaris is
(a) Host [ ] (b) Bisexual [ ] (c) Dioecious [√] (d) Digenetic [ ].
35. Infective stage of Ascaris for new host is
(a) I stage juvenile [ ] (b) Embryonated egg [√] (c) II stage juvenile [ ] (d) Larva after I moult [ ].
36. Embryonated egg is
(a) Shelled egg [ ] (b) Shelled zygote [ ] (c) Shelled II stage juvenile [√] (d) II stage juvenile [ ]
37 .The stage hatched from the ingested egg of Ascaris is called
(a) Bladder worm [ ] (b) Hexacanth [ ] (c) Maggot [ ] (d) Rhabditiform larva [√]
38. The lips of Ascaris are

(a) Denticulate [√] (b) Smooth [ ] (c) Cartilaginous [ ] (d) Bony [ ] .

39. The correct statement for Ascaris is that it has

(a) Diploblastic body [ ] (b) Segmented body [ ] (c) Radial symmetry [ ] (d) Denticulate lips [√].

40. Excretory organs in Ascaris are

(a) Nephridia [ ] (b) Kidneys [ ] (c) Flame cells [ ] (d) None of these [√].

41. Two sexes of Ascaris can be identified as

(a) Posterior end of female is straight [ ] (b) Anal papillae are found in male [ ]

(c) Female has vulva [ ] (d) All of these [√].

42. Penial setae arise from

(a) Cloaca of male [√] (b) Anus of female [ ] (c) Vulva of female [ ] (d) None of these [ ].

43. In Ascaris, eggs are fertilised in

(a) Oviduct [√] (b) Uterus [ ] (c) Vagina [ ] (d) Outside human body [ ].

44. Eggs of Ascaris passed out of host's body are

(a) Unfertilised [ ] (b) Fertilised [ ] (c) Fertilised and shelled [ ] (d) With a larva [√].

UNIT 07: PHYLUM- ANNELIDA

Contents

7.1-Objectives:-

(1) Understanding the general characters of Annelida and Classification up to order level.

(2) Study of *Nereis* with special reference to structure, reproduction and development.

(3) Study of Metamerism and Parasitic adaptations in *Hirudinaria*.

7.2-Introduction:-

Name of phylum Annelida was first coined by Lamarck (1801) for the higher segmented worms (Gr., annulus - little ring + eidos - form). Annelids are elongated, bilaterally symmetrical and highly organized animals, in which the organs have grouped in to definite systems. Appearance of metamerism represents their greatest advancement, so that they are called segmented worms in order to distinguish them from flatworms (Platyhelminthes) and roundworms (Nematodes) whish are not segmented. Their paired appendages, when present, are never jointed. Their coelom, nephridia and cephalization are better developed than those of the un-segmented worms.

They are the first animals to have a closed vascular system. Nervous system is fundamentally similar to that of Arthropoda and embryology is not much different from that of mollusca.

7.3 General Characters and classification of Annelida

7.3.1-General Characters of Annelida:-

- Mostly aquatic, some terrestrial.
- Burrowing or tubicolous.
- Some commensal and parasitic.
- Body elongated, bilaterally symmetrical, triploblastic, truly coelomate and matamerically segmented into similar metamers.
- Epidermis of a single layer of columnar epithelial cells, covered externally by a thin cuticle.
- Body wall dermo-muscular.
- Outer muscle fibres circular, longitudinal.
- Locomotory organs are segmentally repeated chitinous bristles, called setae or chaetae, embedded in skin. May be borne by lateral fleshy appendages or parapodia.
- Coelom, true, schizocoelous. Mostly well developed except in leeches.
- Usually divided into compartments by transverse septa.
- Coelomic fluid with cells or corpuscles.

- Digestive system straight and complete.
- Digestion entirely extracellular.
- Blood vascular system is closed.
- Respiratory pigmants either haemoglobin or erythrocruorin dissolved in blood plasma.
- Respiration by moist skin or gills of parapodia and head.
- Excretory system consisting of metamerically disposed coiled tubes, called nephridia.
- Nervous system with a pair of cerebral ganglia (brain) and a double ventral nerve cord bearing ganglia and lateral nerves in each segment.
- Sensory organs include tactile organs, taste buds, statocysts, photoreceptor cells and sometimes eyes with lenses in some.
- Hermaphroditic or sexes separate, cleavage pattern spiral and determinate.
- Larva, when present, is a trochophore.
- Regeneration is common.

7.3.1-.Classification of Annelida:

Modern classification of phylum Annelida was proposed by Fauchold (1977) and Parker (1980). About 8,700 known species of annelid are divided into four main classes, primarily on the basis of the presence or absence of parapodia, setae, metamers, and other morphological features.

A. Class – Polychaeta (Gr., poly- many + chaite- hair)

- Chiefly marine, some in fresh water.
- Segmentation internal and external.
- Head distinct with eyes, palps and tentacles.
- Setae numerous, on lateral parapodia.
- Clitellum absent.
- Sexes separate.
- Gonads temporary and in many segments.
- Trochophore larva present.

Polychaetes are divided into two subclasses, Erranitia and Sedentaria (Fauvel, 1959).
However, according to Dab (1963), this subdivision is artificial and not a natural one.

1. Subclass – Erranitia

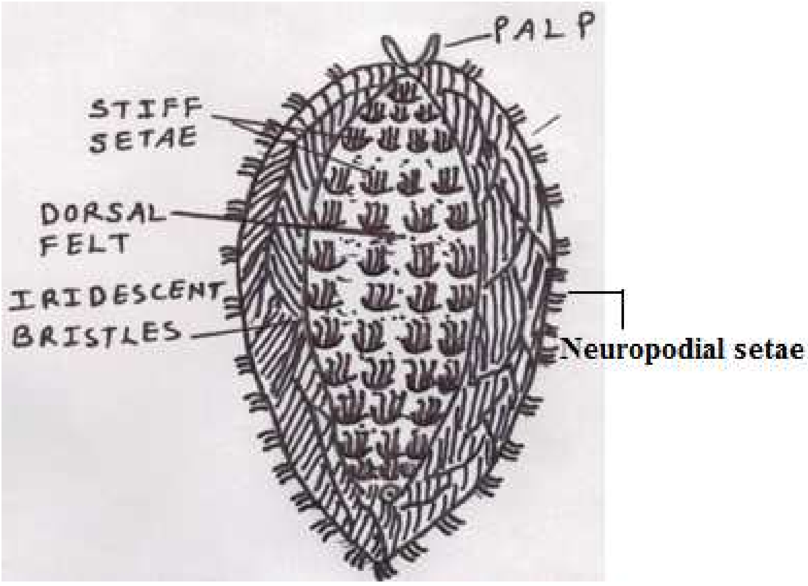


Fig.1Aphrodote

- Free-swimming, crawling, burrowing or tube-dwelling and predatory polychaetes.
- Segments numerous and similar, except for head and anal region.
- Prostomium distinct with sensory structures.

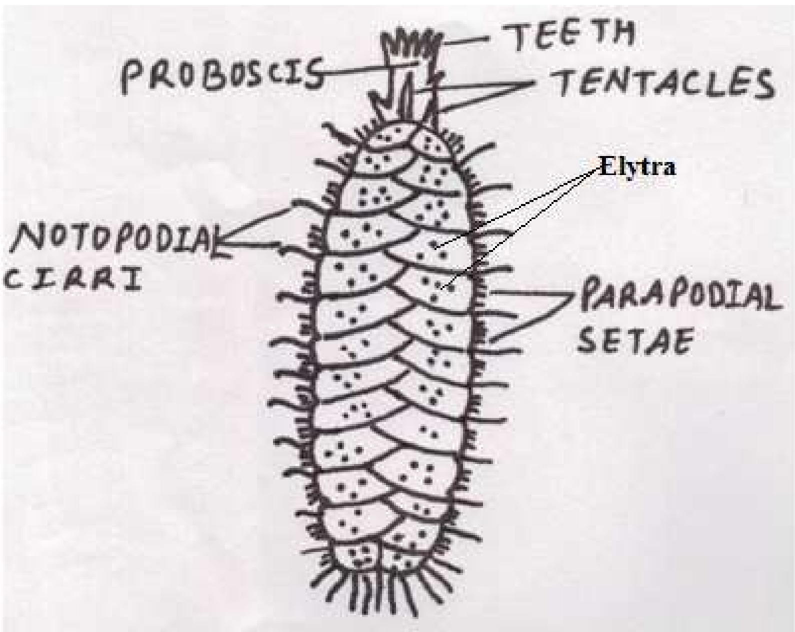


Fig.2 Polynoe

- Parapodia with acicula and compound setae.
- Pharynx protrusible, enlarged and usually with jaws and teeth.
  Examples: Aphrodite (sea mouse, Fig.1), Polynoe (Fig.2), Phyllodoce, Tomopteris, Syllis, Nereis, Glycera, Eunice, Diopatra, Histriobdella.

2. Subclass - Sedentaria

- Sedentary polychaetes living in burrows or tubes.
- Body made of two or more regions, with dissimilar segments and parapodia.
- Prostomium small.
- No acicula and compound setae.
- Pharynx without jaws and teeth.

Examples: Chaetopterus (Fig.3), Arenicola (Fig.4), Owenia, Sabella, Sabellaria, Terebella (Fig.5), Amphitrite (Fig.6), Pomatoceros, Spirorbis, Serpula.

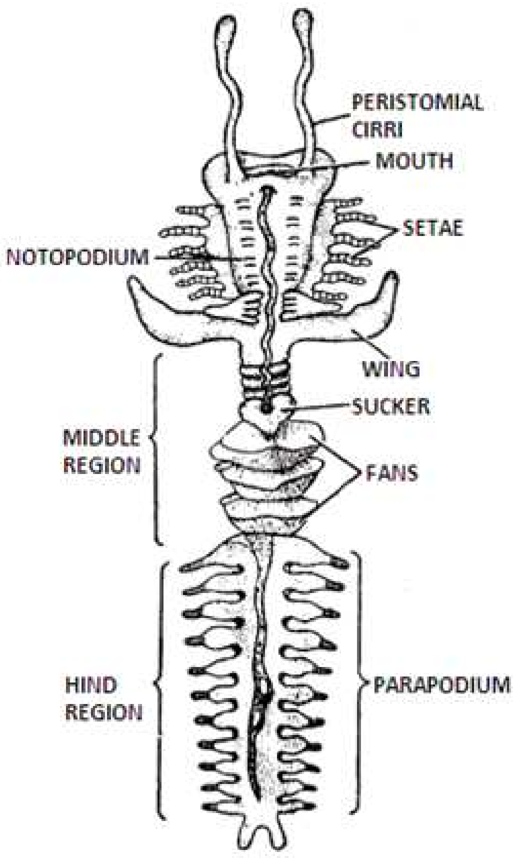


Fig.3 Chaetopterus in Dorsal View

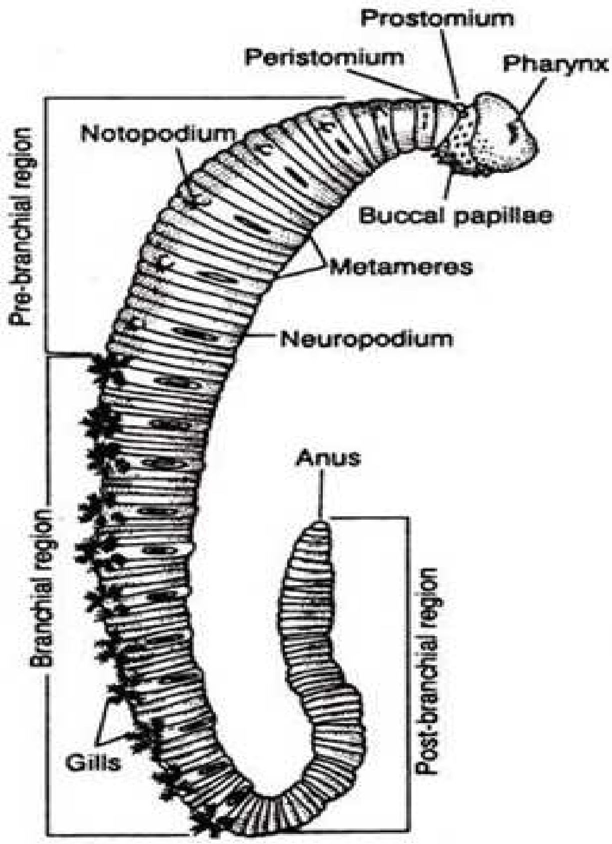


Fig.4 Arenicola

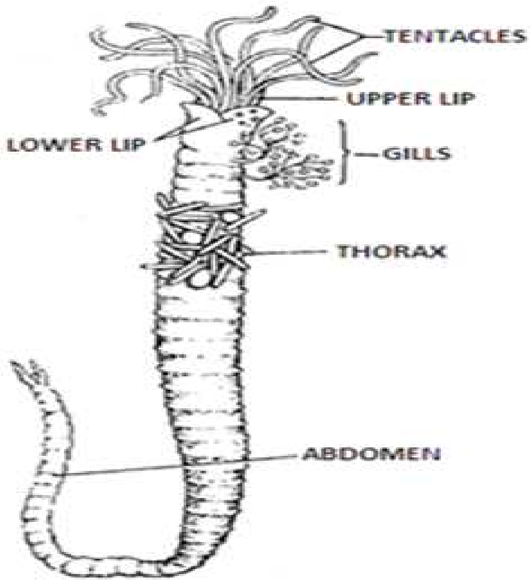


Fig.5Terebella

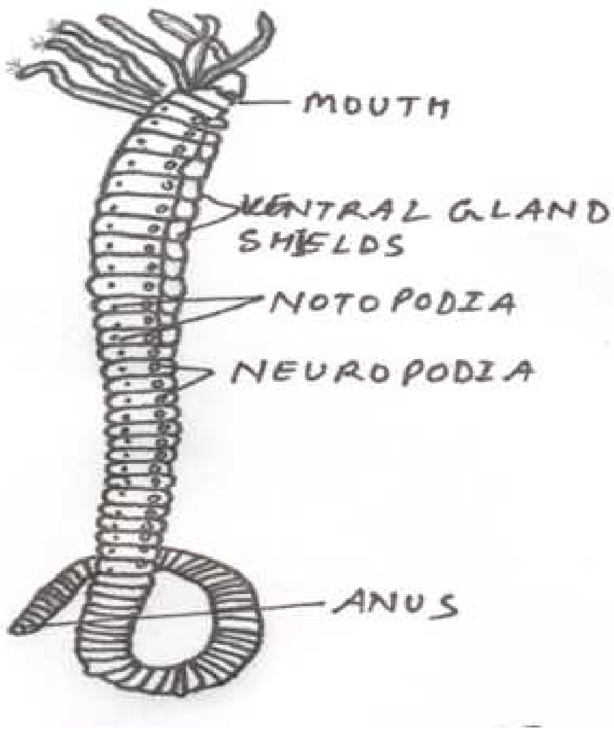


Fig.6 Amphitrite

2. Class - Oligochaeta (Gr., oligos- few + chaite- hair)

- Mostly terrestrial, some in fresh water.
- Segmentation internal and external.
- Head distinct, without sensory organs.
- Setae few, embedded in skin.
- Parapodia absent.
- Glandular clitellum present for cocoon formation.
- Hermaphroditic.
- Testes anterior to ovaries.
- Fertilization external (in cocoon); development direct, no larval stages.

1. Order - Plesiopora plesiothecata

- Mostly aquatic.
- Male gonopores on segment immediately following that which contains testes.
- Spermathecae in the testes-containing segments, or nearby.

Examples: Aelosoma, Nais, Dero, Chaetogaster, Tubifex (Fig.7).

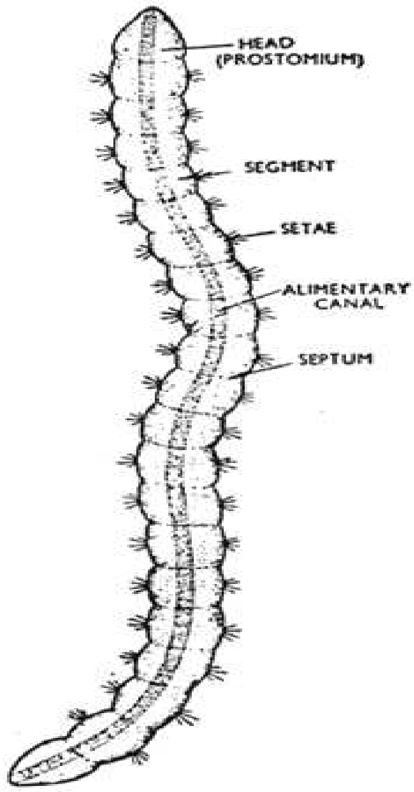


Fig.7 Tubifex

2. Order - Plesiopora prosothecata

- Spermathecae far anteriorly to the segment containing testes.

  Examples: Enchvtraeus.

3. Order - Prosopora

- Mostly aquatic.
- Male gonopores on the same segment containing testes, or on segment containing the second pair of testes.

  Example: Branchiobdella (parasitic).

4. Order - Opisthopora

- Mostly terrestrial earthworms.
- Male gonopores some distance behind the testes-containing segments.

  Examples: Lumbricus (Fig.8), Eisenia, Pheretima, Megascolex, Allolobophora, Dendrobaena.

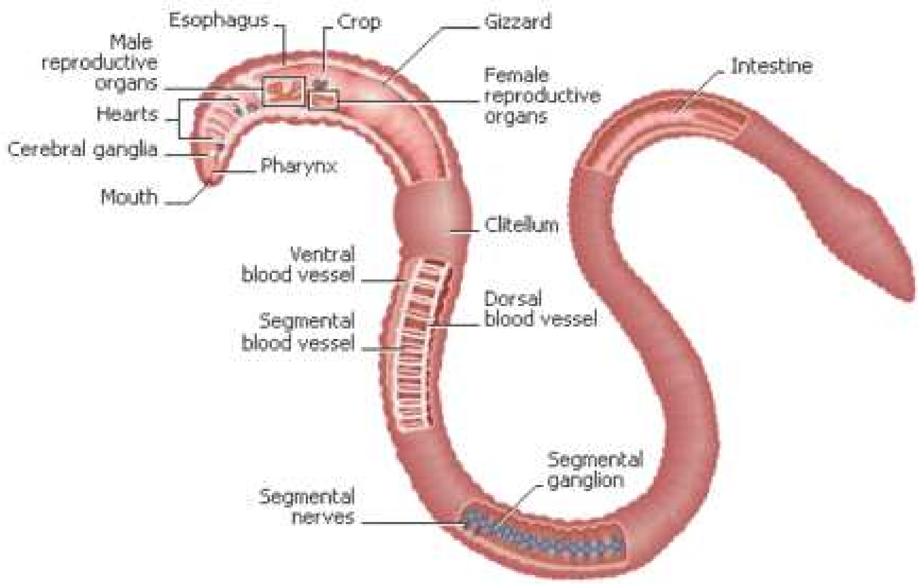


Fig.8 Lumbricus

3. Class – Hirudinea (L., hirudo- leech)

- Freshwater, marine or terrestrial.
- Generally ectoparasitc, blood-sucking and carnivorous.
- Body with fixed number of segments (33).
- Each segment subdivided externally into annuli.
- Segmentation external without internal septa.
- Parapodia and setae absent.
- Both anterior and posterior ends of body with suckers.
- Coelom much reduced due to its filling by botryoidal tissue, and forms haemocoelomic sinuses.
- Hermaphroditic with one male and one female gonopore.
- Fertilization internal.
- Development in cocoons, direct without larval stages.

1. Order - Acanthobdellida

- Primitive without anterior suckers, proboscis and jaws.
- Setae present in 5 anterior segments.
- Coelom with compartments.

Example: A single Russian genus and species (Acanthobdella) parasitic on salmon.

2. Order - Rhynchobdellida

- Only aquatic leeches, ectoparasitic.
- A protrusible proboscis with no jaws.
- Coelom without compartments.
- Bloodvasculare system separated from coelomic sinuses.

- Blood colourless.

3. Order - Gnathobdellida

- Aquatic or terrestrial.
- Ectoparasitic blood-sucking leeches.
- Pharynx non-eversible with 3 pairs of jaws.

Examples: Hirudo, Hirudinaria, Haemadipsa.

4. Order - Pharyngobdellida

- Terrestrial and aquatic.
- Some predaceous.
- Pharynx non-protrusible.
- No teeth but one or two style may be present.

Examples: Erpobdella, Dina.

4. Class - Archiannellida (Gr., arch- First)

- About one dozen genera of small, marine worms of unknown affinities.
- Segmentation chiefly internal.
- No parapodia and setae.
- Sexes usually separate.
- Usually trochophore larva.

Example: Polygordius, Dinophilus, protodrilus.

7.4-Nereis with special reference to:-

7.4.1- Structure:-

<u>NEREIS OR NEANTHES (A CLAMWORM)</u>

Nereis is a typical polychaete genus, living in burrows in sand or mud, often with clams. A reason for which its species are commonly known as clamworms or sandworms.

Systematic position:-

PHYLUM ANNELIDA
CLASS POLYCHAETA
SUBCLASS ERRANTEA
<u>GENUS</u> <u>NEREIS</u> OR <u>NEANTHES</u>
<u>Species</u> <u>virens</u>

Ecology:-

Nereis is a cosmopolitan marine polychaete, usually found on sandy shores between tidemarks.
Most of the time it lives in U-shaped burrows (up to 60cm), deep and coated with mucus.
Worm maintains constant water current through the burrow by dorso-ventral undulations of its body.
Worm is nocturnal and carnivorous.
During breeding season, the worm leaves its burrow permanently and swims about actively in surface layers of water.
At this stage it is known as heteronereis.

External Morphology

(1)Shape

Body is elongated, slender, bilaterally symmetrical, somewhat broad anteriorly and tapering posteriorly (Fig.9). It is slightly flattened dorso-ventrally, dorsal surface being convex, while ventral surface flat or even somewhat concave.

Size

Length of adult worm varies from a few to about 40cm or even more.

Colour

Different species are differently coloured and the colour may vary with age and sexual maturity.

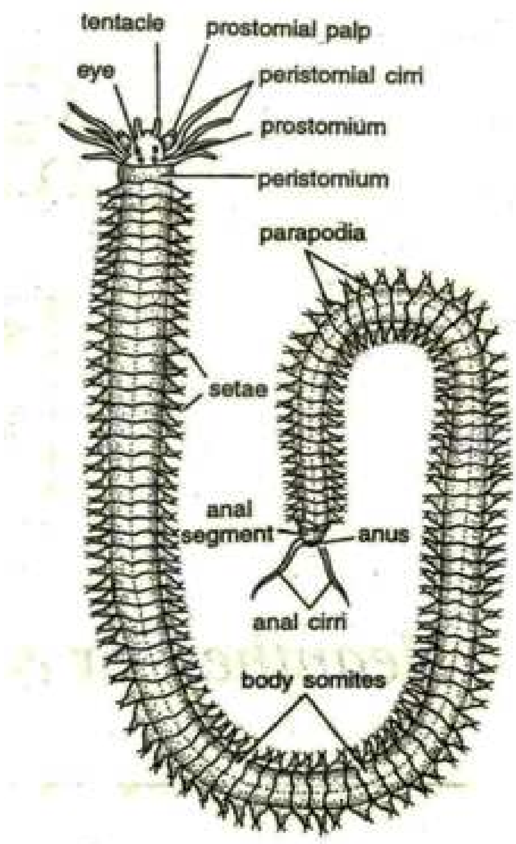


Fig.9 Nereis: External feature in dorsal view

N. pelagic is brownish, *N. cultrifera* is greenish and *N. virens* is steel-blue in colour.

(2) Body division

- Body is metamerically divided into a number of metameres or segments arranged in a linear series.
- Number of segments is fairly constant for a species; about 80 in *N. cultrifera* and *N. dumerilli* and about 200 in *N. virens.*

Three distinct regions can be identified in the body: head, trunk and pygidium.

(a) Head:

- Nereis possesses well-developed head corresponding to its active life and predaceous habit (Fig.10 and 11).
- It lies at the anterior end and consists of two parts: peristomium and prostomium.

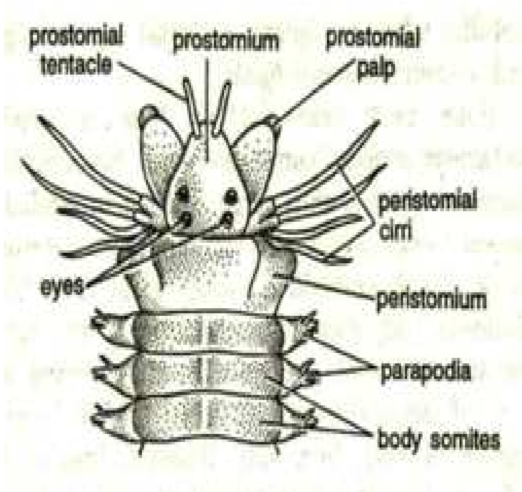
(b) Trunk:

- It comprises practically the entire body segment or pygidium.
- It consists of 80-200 similar segments, each broader than being long and characterized by the presence of a parapodium on each lateral side (Fig.12).

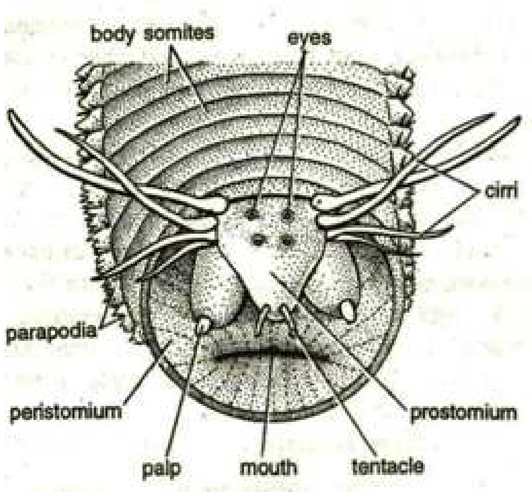
(c)Pygidium:

- This is represented by the last body segment, also known as tail or anal segment.

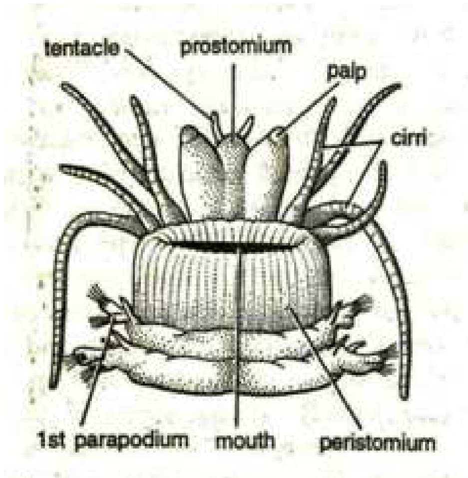
- It bears a terminal anus, a pair of long filamentous, ventral appendages, the anal cirri, and several minute sensory papillae.



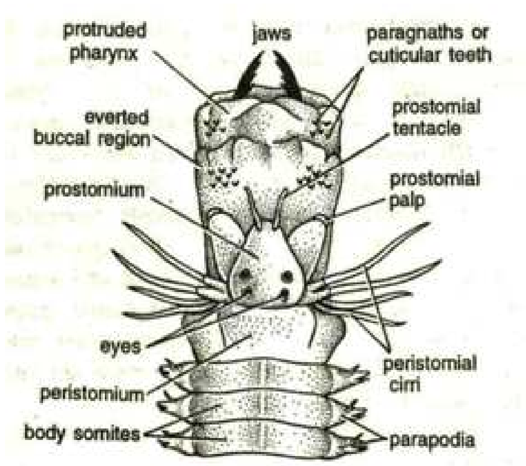
(A) Dorsal View



(B) Frontal View

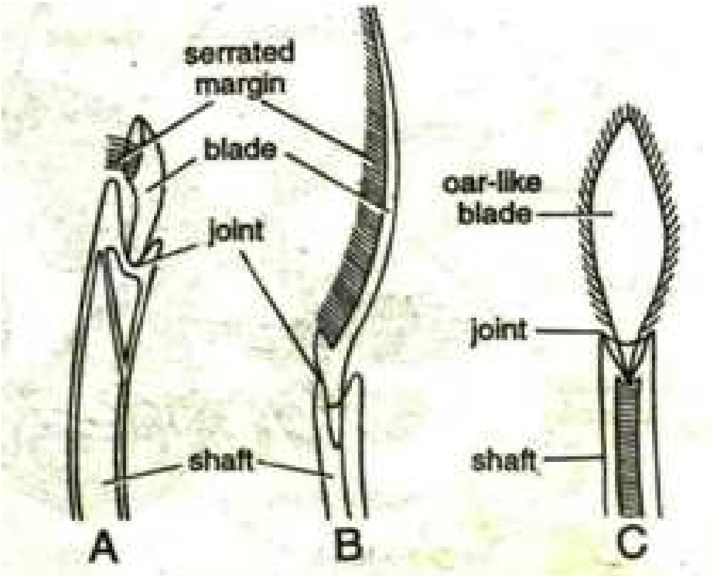


(C) Head in Ventral View



(D) Head in dorsal view with everted probosascis

Fig 10 (1)



Typical Long Bladed Oral shaped Heteronereis

Fig.10 (2) Nereis kind of setae

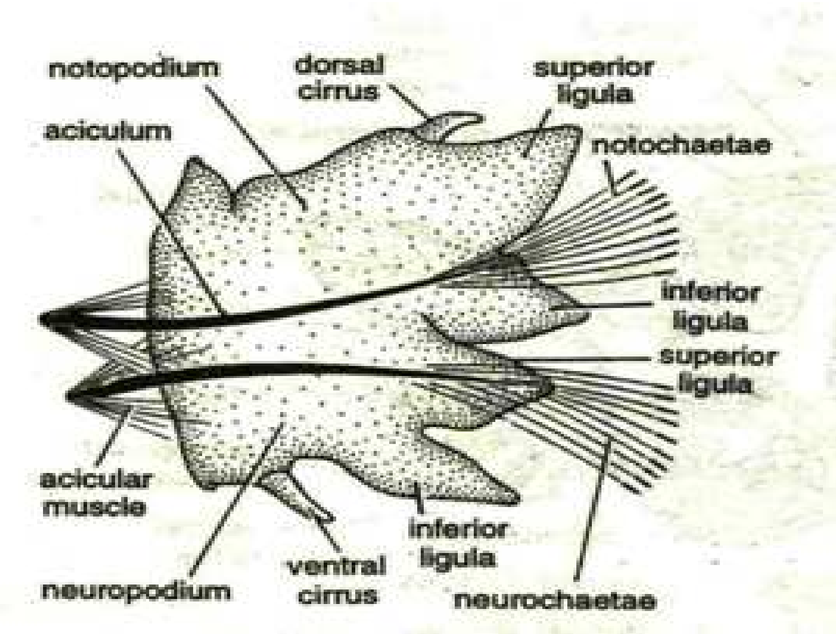


Fig 11 Nereis: Parapodium

Body Wall and Musculature:-

The body wall consists of four layers: cuticle, epidermis, musculature and peritoneum.

- **Cuticle:** It is the outermost, thin, tough and chitinous layer and is perforated by numerous minute openings of epidermal gland cells.

- **Epidermis:** It lies beneath cuticle and rests on a thin basement membrane. It consists of a single layer of tall columnar supporting cells and some scattered glandular and sensory cells. Epidermal gland cells secrete mucus.
- **Musculature:** Nereis has a well-developed musculature consisting of circular, longitudinal and oblique muscles. These are composed of unstriped muscle fibres.

Peritoneum:

- Muscles are lined internally by a thin, delicate layer of coelomic epithelium or peritoneum.
- This layer also lines the coelom externally and is thus also described as the somatic or parietal layer of coelomic epithelium.
- It secretes the coelomic fluid.

7.4.2-Reproductive System

Nereis is dioecious, i.e., sexes are separate. The gonads are neither permanent nor distinct. They are seasonal and develop only during the breeding season (summer months) (Fig.12).

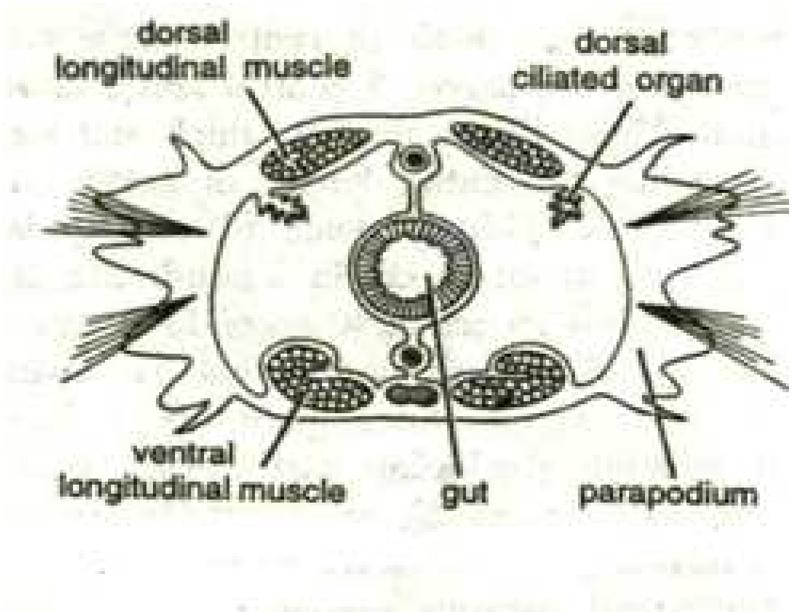


Fig 12 Nereis: T.S of a Segment to show the ciliated organs

Epitoky and Heteronereis:-

Epitoky is the formation of sexual individual or epitoke which differs from the parent non-sexual individual or atoke (Fig.15).

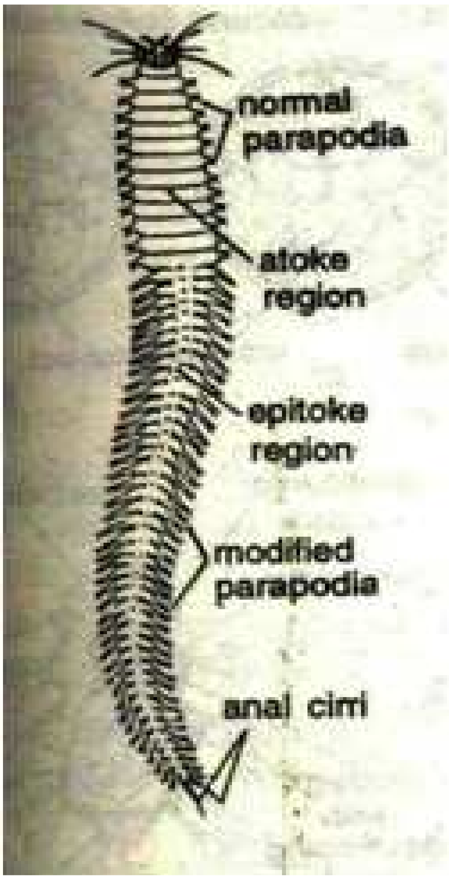


Fig 13: Heteronereis

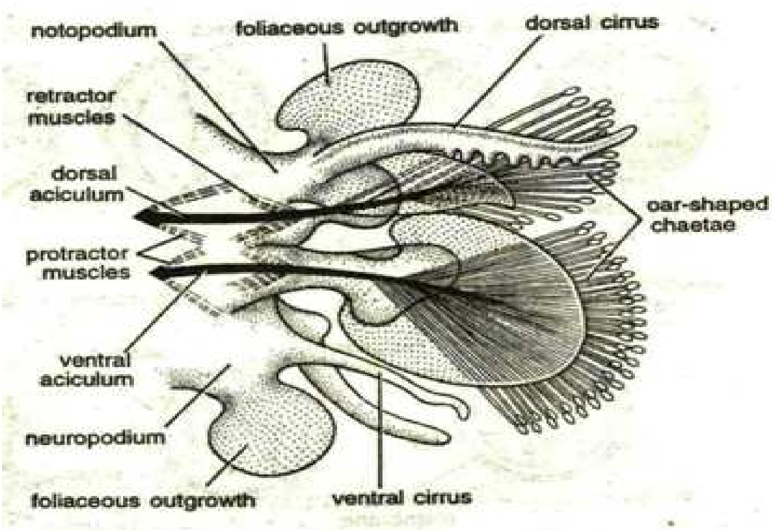


Fig 14 Parapodium of Heteronereis

- Heteronereis leaves the burrow, comes up at the surface of water and leads an active free swimming life.

- The eyes are highly sensitive to light.
- The peristomial cirri become longer.
- Parapodia of epitoke region become enlarged (Fig.15).

Significance of Heteronereis Stage:-

- Heteronereis is a sexual phase,
- Swims actively at the surface of sea –water. So, it discharges gametes too far off places in the sea and thus helps in the dispersal of species.

7.4.3- Development:-

Life-History of Nereis

(I) Swarming:-

- Sexually mature individuals or Heteronereis swim to the surface of sea water in order to shed sperms or ova. This ethos is called swarming.
- It generally occurs at night and some species, while swarming, perform a nuptial dance in which both mntales and females swim rapidly in a circle.
- Females produce a substance, called fertilium, which attracts the male and stimulates shedding of eggs.
- In case of *N. succinea*, males first swim to the surface and wait for females.
- When the latter appear, males swim around them shedding sperms. In response, the females get excited and shed ova.

(II) Fertilization:

- Fertilization is mostly external in *Nereis virens* and takes place in sea water.
- *Platynereis megalops* has an altogether different mechanism.
- The male wraps tightly around female, inserts his anus into her mouth and injects sperms.
- Gut of both having been eroded by phagocytes, sperms pass directly into coelom of female where fertilization of eggs occurs.
- Fertilized eggs are shed at once from the posterior end of the female's body.
- This mechanism of internal fertilization has probably evolved in *Platynereis megalops* because its eggs become unfertilizable just after 30 seconds contact with sea water.

(III) Development:-

Development of Nereis comprises three distinct periods (Fig.16)

(a) Pre-larval period:-

- Unfertilized egg of Nereis contains numerous yolk spherules and oil droplets.
- It is covered by a thick, radially striated membrane, called zona radiata, which in turn has another thin delicate membrane around it.
- Outside these membranes is a thick gelatinous coating.
- Soon after fertilization, zona radiata disappears, yolk spherules from animal pole move into vegetal pole (telolecithal condition), egg extrudes two polar bodies, and undergoes cleavage.
- First two cleavages of zygote are equal and vertical and results in four cells or blastomeres, lying in the same plane.

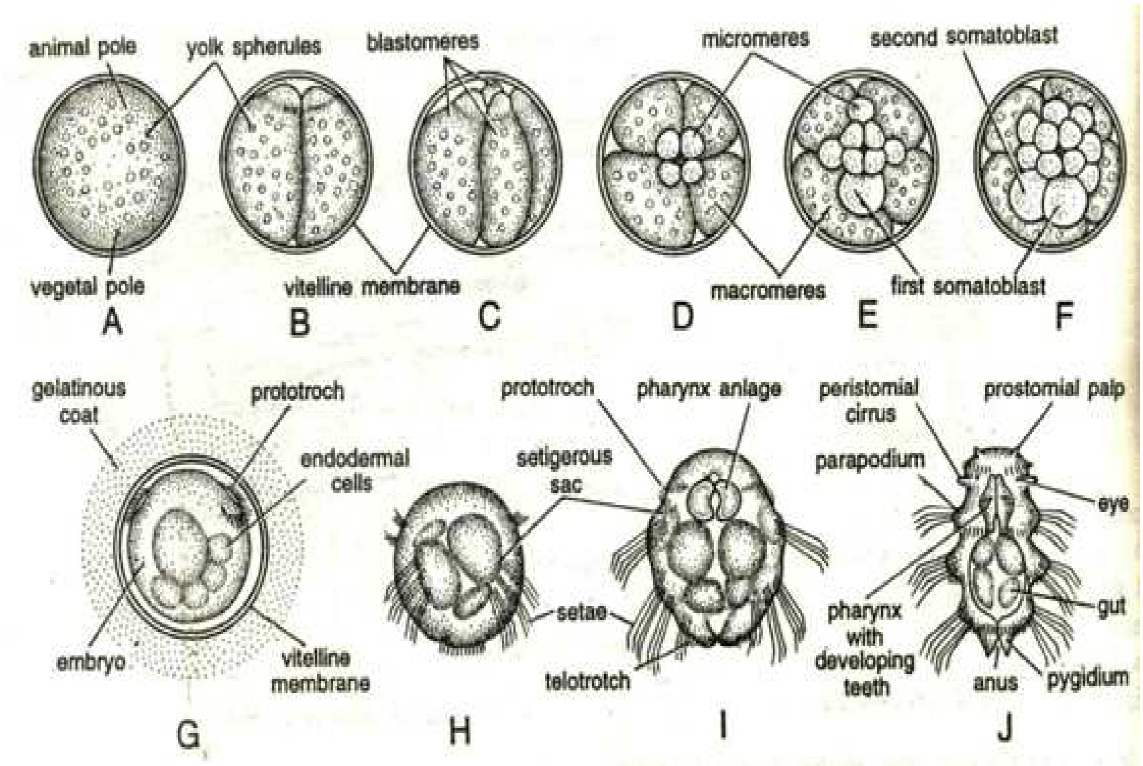


Fig: 15 Nereis: Stage in Development

- Cleavage is determinate.
- Third cleavage is unequal and horizontal.
- It produces four small, yolk free micromeres towards the animal pole and four large, yolky macromere's towards the vegetal pole.
- Fourth, fifth and sixth cleavages are also unequal and horizontal.

(b) Larval period –

- After gastrulation, ciliated embryo rapidly develops into a larval stage, called trochophora.
- After 24 hours of development, the trochophora structure begins to appe.

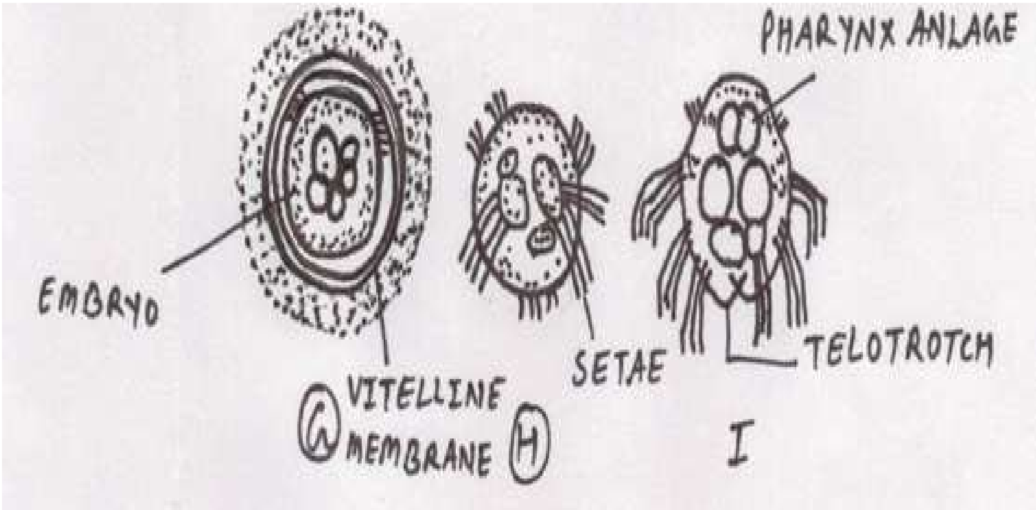


Fig: 16 Young trochophore before hatching, Post trchophore & older larva hatching Stage

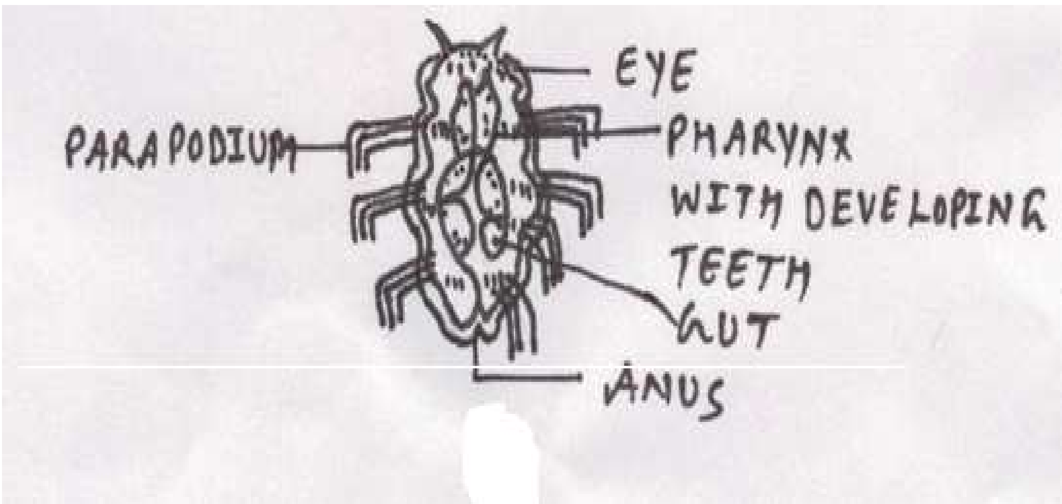


Fig: 17 later larvas after three week

(c) Post-larval period-

- Post trochophore larva swims actively for a few days and feeding on microorganisms (Fig.17).
- While swimming it undergoes metamorphosis to change into the adult.

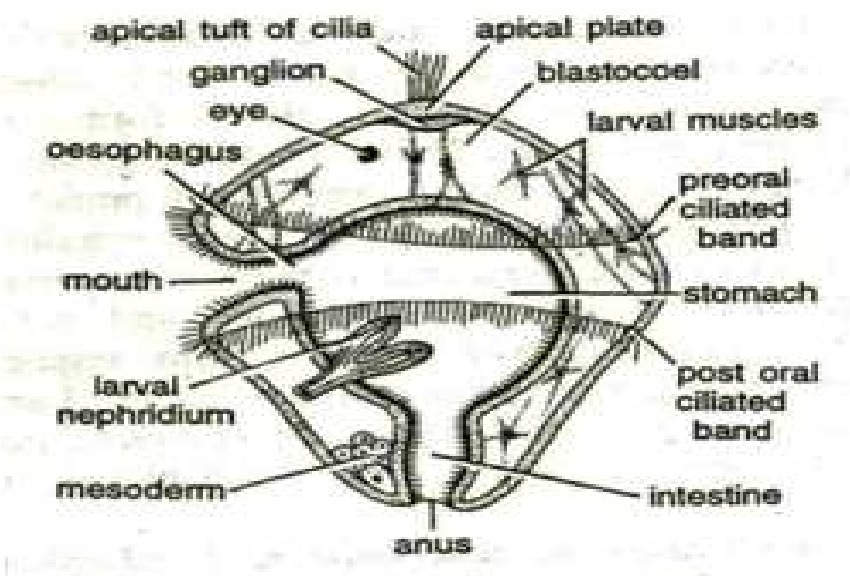


Fig: 18 A Typical trochophore Larva

- Its preoral apical portion develops into the prostomium of adult.
- First segment becomes the peristomium and the last segment the pygidium.
- Ciliary bands disappear and larva grows in size with the addition of new segments just in front of pygidium.
- In the burrow it grows further adding new segments and becomes the burrowing adult worm.

7.5- Metamerism and Parasitic adaptations in Hirudinaria

HIRUDINARIA GRANULOSA (The Indian Cattle Leech)

- Class Hirudinea comprises of leeches which are perhaps the most specialized annelids without parapodia and setae but with suckers.
- About 300 species of leeches are known to occur in the tropical and temperate parts of the globe. Most of them are freshwater, while some are marine or terrestrial.
- Most of leeches are ectoparasitic, living on the blood of vertebrates, while some are predaceous, feeding on worms, snails, insect larvae, etc.
- The genus Hirudinaria includes four species of Indian cattle leeches: *Hirudinaria viridis*, *H. javanica*, *H. manilensis* and *H. granulose.*

Hirudinaria granulose

Systematic Position

PHYLUM ANNELIDA
CLASS HIRUDINEA
ORDER GNATHOBDELLIDA
FAMILY HEIRUDINAE
GENUS HIRUDINARIA
Species granulose

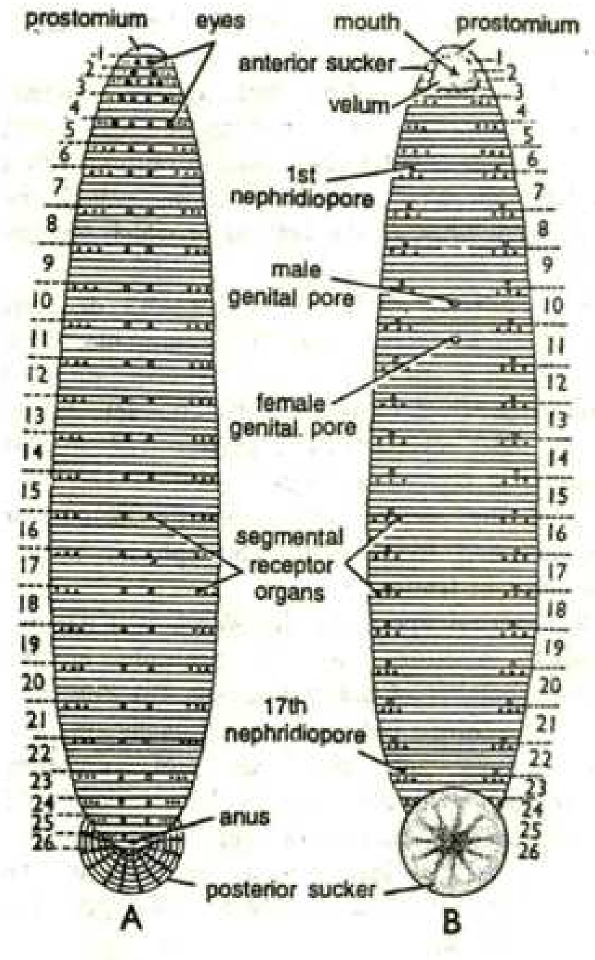


Fig 19 Hirudineria: External Feature (A) Dorsal view (B) Ventral View

Ecology:-

- *Hirudinaria granulose,* the Indian cattle leech, is found in India, Burma, Sri Lanka, Pakistan and Bangladesh.
- It occurs in fresh-water ponds, lakes, tanks, swamps and slow streams, where it either swim by vertical undulations or grips objects with its suckers and moves by looping.
- Like most ectoparasitic leeches, it has a blood-sucking (sanguivorous) habit, feeding on the blood of fish and frogs and also of cattle and men, who happen to enter the water inhabited by it.
- Though hermaphroditic, leeches copulate to bring about cross-fertilization.
- Eggs are deposited in cocoons.
- Body is elongated, dorso-ventral-flattened and vermiform with flat ventral and convex dorsal surfaces (Fig.18).
- Development is direct, i.e., there are no free larval stages in the life-history.

7.5.1-Metamerism in *Hirundinaria:-*

In annelids the body consists of segments arranged in a linear repetitive fashion. This linear repetition of body segment is called metamerism. Each section or part of the body is called segment, somite or metamer (Fig.20).

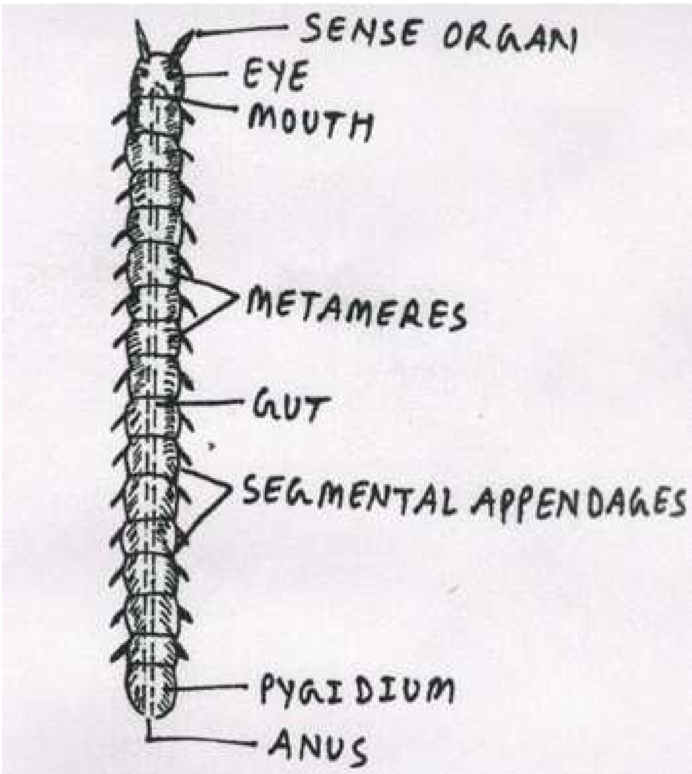


Fig: 20 Diagram showing metameric segmentation in an Annelid

Metamerism segmentation is first seen in animal kingdom in the body of annelids. In metameric segmentation, body is divided into numerous body segments externally by groove and internally by septa. All the segments or metameres are same age and have all body organs such as musculature, blood vessels, nerves, ganglia, excretory organs and gonods etc. In earthworm and Nereis even the coelom is divided into segmental compartments by inter segmental septa. But in annelids, the metamerism is limited to the trunk region of the body.The head with brain and sense organs is represented by prostomium and the terminal portion at the posterior end with anus is represented by pygidium.This two portions i.e., prostomium and pygidium are not true metameres. In annelids metameism is described as bring complete because all segments or metameres have segmented blood vessels, nerve, nephridia and coelom. Such segment also called homonomous.

Significance of Metamerism:-

a) Metamerism helps in locomotion in various ways. Annelids are able to locomotion like swimming and creeping by the help of the contraction of body wall muscles of body segments and coelomic fluid.
b) Coelomic fluid in coelomic chamber acts as an hydraulic skeleton during burrowing and swimming.
c) In higher classes like Arthropods and Chordates, each metamere of body is specialized for different functions. Hence, higher and complex animals evolved due to metamerism.

7.5.2-Parasitic Adaptations in *Hirundinaria*:-

Most leeches lead a semi-parasitic life, sucking blood of vertebrates.
Correspondingly, they show several parasitic adaptations in their habits, habitat and structure.

- **Habitat:**
  It inhabits fresh water ponds and pools visited frequently by men and cattle.
  Moreover, it prefers to live in shallow waters where it can easily hide under weeds, logs and stones.
- **Habits:**
  Its active swimming habit is ideal for searching the host and escaping from predators.
- **Shape:**
  Body is long, flattened and devoid of appendages, like parapodia, and hence suitable for aquatic life.
- **Slime gland:**
  These are present in body wall.
  Their secretion keeps the body moist and slippery to prevent desiccation and reduces friction during locomotion.

- **Suckers:**
  These serve as organs of locomotion and also provide firm adhesion to the host's body at the time of feeding.
- **Jaws:**
  The three jaws are specialized weapons for inflicting a painless triradiate wound on the host's skin for sucking blood.
- **Suctorial pharynx:**
  Mouth leads into a muscular pharynx connected with body wall by radiating muscles. Cavity of pharynx alternately expands and contracts to serve as a suction pump so that blood, oozing from the host's would, is sucked in.
- **Hirudin:**
  Slivary glands of leeches secrete an anticoagulating substance, called hirudin or anticoagulin, It prevents clotting of blood while the leech is taking its meal, thus ensuring a continuous supply of blood (vampire bats and hook worms also secretes a similar substance to facilitate their feeding).
- **Spacious crop:**
  Chances of getting a host are remote, so that supply of nutrient is very irregular and a matter of chance. Digestive tract is accordingly modified. At the time of single meal a leech obtains many times its own weight of blood, which is sufficient for several months or even a year. To accommodate this blood, the crop is spacious thin-walled elastic and capable of great dilatation. It is also produced into lateral pouches or storing pockets. It can, therefore, hold enough blood to last for months. However, some species that parasitize aquatic vertebrates remain attached to their hosts.

  Slow digestion:
  After a meal, leech drops off, remains torpid and digests blood at a very slow pace. Last chamber of crop opens behind into stomach through a sphinctered aperture, so that blood passes from crop into stomach with extreme slowness. Digestion of a "crop full of blood" takes many months and thus a single meal lasts for several months. For this reason also leeches lack elaborate digestive juices and enzymes.
- **Sense organs:**
  These are well-developed and provide the animal with greater opportunities of life.
- **Hermaphroditisim:**
  This doubles the rate of reproduction as, after copulation, both individuals lay eggs.
- **Development:**
  It takes place within the cocoon which serves as a protective covering.
  Further, development is quick, and completed within a fortnight to ensure the maintenance of a regular population.

7.6-Summary

Name of phylum Annelida was first coined by Lamarck for the higher segmented worms (Gr., annulus - little ring + eidos - form). Annelids are elongated, bilaterally symmetrical and highly organized animals, in which the organs have grouped in to definite systems. Appearance of metamerism represents their greatest advancement, so that they are called segmented worms in order to distinguish them from flatworms (Platyhelminthes) and roundworms (Nematodes) which are not segmented. Their paired appendages, when present, are never jointed. Their coelom, nephridia and cephalization are better developed than those of the un-segmented worms. They are the first animals to have a closed vascular system. Nervous system is fundamentally is similar to that of Arthropoda and embryology is not much different from that of mollusca.

Annelids mostly aquatic, some terrestrial. Burrowing or tubicolous. Locomotory organs are segmentally repeated chitinous bristles, called setae or chaetae, embedded in skin. May be borne by lateral fleshy appendages or parapodia. Blood vascular system is closed. Hermaphroditic or sexes separate cleavage spiral and determinate. Larva, when present, is a trochophore. Regeneration is common. Modern classification of phylum Annelida was proposed by Fauchold (1977) and Parker (1980). About 8,700 known species of annelid are divided into four main classes **(A. Class – Polychaeta; B. Class – Oligochaeta; C. Class – Hirudinea and D. Class - Archiannellida)**, primarily on the basis of the presence or absence of parapodia, setae, metamers, and other morphological features.

NEREIS:-

Nereis is a typical polychaete genus, living in burrows in sand or mud, often with clams. A reason for which its species are commonly known as clamworms or sandworms. It is a cosmopolitan marine polychaete, usually found on sandy shores between tidemarks. Most of the time it lives in U-shaped burrows (up to 60cm), deep and coated with mucus. Worm is nocturnal and carnivorous. During breeding season, the worm leaves its burrow permanently and swims about actively in surface layers of water. At this stage it is known as heteronereis.

Body is elongated, slender, bilaterally symmetrical, somewhat broad anteriorly and tapering posteriorly. Length of adult worm varies from a few to about 40cm or even more. Different species are differently coloured and the colour may vary with age and sexual maturity. *N. pelagic* is brownish, *N. cultrifera* is greenish and *N. virens* is steel-blue in colour. Number of segments is fairly constant for a species; about 80 in *N. cultrifera* and *N. dumerilli* and about 200 in *N. virens.* Three distinct regions can be identified in the body: head, trunk and pygidium.
The body wall consists of four layers: cuticle, epidermis, musculature and peritoneum.

Life-History of Nereis:-

Sexually mature individuals or Heteronereis swim to the surface of sea water in order to shed sperms or ova. This behavior is called swarming.

↓

It generally occurs at night and some species, while swarming, perform a nuptial dance in which both males and females swim rapidly in a circle.

↓

Females produce a substance, called fertilizum, which attracts the male and stimulates shedding of eggs. When the latter appear, males swim around them shedding sperms. In response, the females get excited and shed ova.

↓

Fertilization is mostly external in *Nereis virens* and takes place in sea water. Fertilized eggs are shed at once from the posterior end of the female's body.

↓

Development of nereis comprises three distinct periods: (a). Pre-larval period : Soon after fertilization, zona radiata disappears, yolk spherules from animal pole move into vegetal pole (telolecithal condition), egg extrudes two polar bodies, and undergoes cleavage.

↓

First two cleavages of zygote are equal and vertical and results in four cells or blastomeres, lying in the same plane. Cleavage is determinate. Third cleavage is unequal and horizontal. It produces four small, yolk free micromeres towards the animal pole and four large, yolky macromeres towards the vegetal pole. Fourth, fifth and sixth cleavages are also unequal and horizontal.

↓

After gastrulation, ciliated embryo rapidly develops into a larval stage, called trochophora. After 24 hours of development, the trochophora structure begins to appear.

↓

Post trochophore larva swims actively for a few days and feeding on microorganisms. While swimming it undergoes metamorphosis to change into the adult.

↓

Its preoral apical portion develops into the prostomium of adult.First segment becomes the peristomium and the last segment the pygidium. Ciliary bands disappear and larva grows in size with the addition of new segments just in front of pygidium.

↓

In the burrow it grows further adding new segments and becomes the burrowing adult worm.

Hirudinaria granulosa **(The Indian Cattle Leech):-**

About 300 species of leeches are known to occur in the tropical and temperate parts of the globe. Most of them are freshwater, while some are marine or terrestrial. Most of leeches are ectoparasitic, living on the blood of vertebrates, while some are predaceous; feeding on worms, snails, insect larvae, etc.The genus Hirudinaria includes four species of Indian cattle leeches: *Hirudinaria viridis*, *H. javanica*, *H. manilensis* and *H. granulose.Hirudinaria granulose,* the Indian cattle leech, is found in India, Burma, Sri Lanka, Pakistan and Bangladesh. It occurs in fresh-water ponds, lakes, tanks, swamps and slow streams, where it either swim by vertical undulations or grips objects with its suckers and moves by looping. Like most ectoparasitic leeches, it has a blood-sucking (sanguivorous) habit, feeding on the blood of fish and frogs and also of cattle and men, who happen to enter the water inhabited by it.Though hermaphroditic, leeches copulate to bring about cross-fertilization. Eggs are deposited in cocoons. In annelids metameism is described as being complete because all segment or metameres have segmented blood vessels, nerve, nephridia and coelom. Such segment also called homonomous

Parasitic Adaptations in *Hirundinaria*:-

Most leeches lead a semi-parasitic life, sucking blood of vertebrates. Correspondingly, they show several parasitic adaptations in their habits, habitat and structure.

Habitat: - It inhabits fresh water ponds and pools visited frequently by men and cattle.Its habitat thus most favorable for sure food supply.

Habits-:-Its active swimming habit is ideal for searching the host and escaping from predators.

Shape: Body is long, flattened and devoid of appendages, like parapodia, and hence suitable for aquatic life.

Slime gland: Their secretion keeps the body moist and slippery to prevent desiccation and reduces friction during locomotion.

Suckers: - These serve as organs of locomotion and also provide firm adhesion to the host's body at the time of feeding.

Jaws: - The three jaws are specialized weapons for inflicting a painless triradiate wound on the host's skin for sucking blood.

Hirudin: - Slivary glands of leeches secrete an anticoagulating substance, called hirudin or anticoagulin,

Spacious crop: - Chances of getting a host are remote, so that supply of nutrient is very irregular and a matter of chance.

Slow digestion- After a meal, leech drops off, remains torpid and digests blood at a very slow pace. Digestion of a "crop full of blood" takes many months and thus a single meal lasts for several months.

Sense organs- These are well-developed and provide the animal with greater opportunities of life.

Hermaphroditisim -This doubles the rate of reproduction as, after copulation, both individuals lay eggs.

Development-It takes place within the cocoon which serves as a protective covering.

Further, development is quick, and completed within a fortnight to ensure the maintenance of a regular population.

7.7-Glossary:-

Acicula: Needle like bristles within parapodium of polychaete.

Adaptations: The fitness of an organism for its environment.

Habitat: Environment in which an animal lives.

Anticoagulating: Substance that prevents the coagulation of blood.

Anticoagulin: An anticoagulant substance.

Appendages: Portion of body that projects and has a free end such as limbs.

Arthropoda: An invertebrate animal having an exoskeleton, a segmented body, and jointed appendages.

Bilaterally symmetrical: The arrangement of the body parts so that the right and left halves are mirror images of each other.

Blastomeres: A type of cell produced by cleavage of the zygote after fertilization which is an essential part of blastula formation.

Blood-sucking: An animal that sucks blood, eg. a leech or mosquito.

Carnivorous: Flesh eating animals.

Cerebral ganglia: In invertebrates, one of a pair of ganglia (or fused median ganglion) situated in the head or anterior portion of the body.

Chitin: A complex organic substance or a polysaccharide protein, forming the exoskeleton of arthropods and some other animals.

Clamworms: are an important food source for bottom-feeding fish and crustaceans, though they can protect themselves by secreting a mucus substance.

Cleavage: Series of early divisions of an egg into many cells.

Clitellum: A thickened glandular portion of the body of an earthworm or other annelid, used in the formation of cocoon.

Coelom: the body cavity lined with tissue of mesodermal origin in which the digestive and other organs lie.

Coelomate: COELOMATE animals or Coelomata (also known as eucoelomates — "true coelom") have a fluid filled body cavity called a coelom.
Columnar epithelial cells: are epithelial cells whose heights are at least four times their width.

Corpuscles: a minute body or cell in an organism, especially a red or white cell in the blood of vertebrates.

Cosmopolitan: of universal occurrence.

Dermo-muscular: pertaining to skin and muscles.

Ectoparasitc: Parasite that lives on the outside of the body of its host.

Embryology: The study of the development of an organism.

Epidermis: The outer cellular layer of the cells covering the external surface of the body.

Erythrocruorin: is a large oxygen-carrying protein, whose molecular mass is greater than 3.5 million Daltons.

Excretory system: is a passive biological system that removes excess, unnecessary materials from the body fluids of an organism, so as to help maintain internal chemical homeostasis and prevent damage to the body.

Fertilization: Union of the mature ovum and mature sperm to form zygote.

Flatworms: Flatworm, also called platyhelminth, any of the phylum Platyhelminthes, a group of soft-bodied, usually much flattened invertebrates.

Ganglia:	Group of mass of nerve cell bodies.
Haemocoelomic:	a body cavity (as in arthropods or some mollusks) that normally contains blood and functions as part of the circulatory system.
Haemoglobin:	is the protein molecule in red blood cells that carries oxygen from the lungs to the body's tissues and returns carbon dioxide from the tissues back to the lungs.
Hermaphroditic:	An individual possessing both male and female reproductive organs.
Hirudin:	An anticlotting agent that prevents blood clots from traveling through the bloodstream to clog up a vessel. It is a naturally occurring peptide in the salivary glands of leeches.
Homonomous:	Having the same features or functions.
Locomotory:	Related to the movement of an organism.
Megalops:	the larval stage of marine crabs immediately prior to and resembling the adult stage.
Metamerism:	Conditions where the body of an animal is made up of a succession of homologous parts.
Mollusca:	Non-segmented, schizocoelomate phylum.
Nephridia:	is an invertebrate organ which occurs in pairs and performs a function similar to the vertebrate kidney.
Nocturnal:	Active at night.
Parapodium:	flattened, Paired appendages on the body segments of many polychaete annelids that help in locomotion.
Peristomium:	is the second body segment in an annelid worm's body in the anterior end. It is directly behind the prostomium and contains the mouth.

Pharynx:	Anterior portion of the digestive tract between mouth cavity and oesophagus.
Photoreceptor cells:	Light sensitive cells or organs.
Platynereis:	is a genus of marine annelid worm. The species PLATYNEREIS dumerilii is used in development biology to study development
Predaceous:	predatory.
Proboscis:	Tubular extension of the nose, lips or pharaynx. the extended beak-like mouth parts of insects.
Prostomium:	Anterior portion of the first segment of the annelids such as earthworms overhanging the mouth region.
Pygidium (plural pygidia):	is the posterior body part or shield of crustaceans and some other arthropods, such as insects and the extinct trilobites. It contains the anus and, in females, the ovipositor.
Regeneration:	Replacement by growth of a part of body that has been lost.
Roundworms:	Roundworms, or nematodes, are parasites that can infect people. they usually live in the intestines.
Sanguivorous:	organisms feeding on blood.
Schizocoelous:	Body cavity formed by the splitting of the embryonic mesoderm.
Segmented worms:	Annelids.
Setae or chaetae:	Bristles such as those embedded in the body wall of the earthworm.
Spermatheca:	seminal receptacles in some female insects.
Statocysts:	organs of equilibrium and balance in some animals like *Palaemon*.

Swarming: move somewhere in large numbers.

Tactile organs: Organ pertaining to sense of touch.

Taste buds: are sensory organs that are found on the tongue and allow us to experience tastes that are sweet, salty, sour, and bitter.

Triploblastic: derived from three primary germ layer- ectoderm, mesoderm and endoderm.

Triradiate: having three rays or radiating branches.

Trochophore: Free swimming marine ciliated larva.

Tubicolous: (of a marine worm) living in a tube.

Vascular system: also called the circulatory system is made up of the vessels that carry blood and lymph through the body.

7.8- Self assessment question:-

(1)Write down the note on Segmentation of Hirudinaria?
(2) Note on Botryoidal tissue?
(3) Write down the note on Coelom of leech?
(4) Write down the note on ciliated organ?
(5) Write down the note on Formation of ootheca in Hirudinaria?
(6) Note on Parasitic adaptive features of Hirudinaria?
(7) Describe briefly about the annelids?
(8)What is hypodermic impregnation? In which genera is this phenomenon found?
(9). Give only the outline classification of phylum Annelida?
(10) Write short notes on:
(1) Aphrodite (2) Chaetopterus (3) Amphritrite (4) Sabella (5) Lumbricus (6) Pontobdella (7) Bonellia (8) Sipunculus (9) Myzostoma.
11. Draw fully labelled diagrams.
(1) T.S. body wall of Hirudinaria. (2) Botryoidal tissue.

7.9-References:-

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7.10-Suggested Readings:-

(a). Invertebrate Zoology, Author - E. L. Jorden and P. S. Verma.
(b). A text book of Invertebrate Zoology, Author –Dr. S. N. Prasad.
(c). Biology of the Invertebrate Zoology, Author –Jan A.Pechenik.
(d). Invertebrate Zoology, Author –Ruppert, Fox and Barnes.
(e). Invertebrate Zoology, Author –D.T.Anderson.
(f). Invertebrate Zoology, Author –Joseph G.Engeman and Robert W.Hegner.
(g). Invertebrate Zoology, Author –Fatik Boran Mondal
(h). Morden text book of Zoology Invertebrate, Author –R.L.Kotpal.
(i). Invertebrate Zoology, Author –Paul A.Meglitsch and Frederick R. Schram
(j). Text book of invertebrate Zoology, Author – G.S.Sandhu.

7.11-Terminal Questions

1. Write important adaptive features of Hirudinaria?
2. Describe the features indicating the adaptations of leech to lead an ectoparasitic life?
3. Which organs does the female reproductive system of leech comprise? Write the location of ovaries?
4. Write, in brief, about the mode of locomotion of leech?
5. Write a short note on haemocoelomic system of leech?
6. In how many classes is phylum Annelida divided?
7. Give the name of larvae of Annelida?
8. Name the kind of segmentation found in annelids?
9. What is the feeding habit of Hirudinaria?
10. How many testes are present in Hirudinaria?

Multiple choice questions:-

1. In leech locomotion occurs by
   (a). Setae [ ] (b) Parapodia [ ] (c) Undulating movements [√] (d) All of these [ ]
2. The saliva of leech contains an anticoagulant called
   (a) Histidine [ ] (b) Hirudin [√] (c) Heparin [ ] (d) Histamine [ ]
3. Coelom filled with connective tissue and botryoidal tissue has come across in
   (a) Earthworm [ ] (b) Nereis [ ] (c) Leech [√] (d) Ascaris [ ]
4. Which one of the following is an ectoparasite annelid
   (a) Hirudinaria [√] (b) Lumbricus [ ] (c) Pheretima [ ] (d) Ascaris [ ]
5. Botryoidal tissue is found in
   (a) Unio [ ] (b) Ascaris [(c) Hirudinaria [√] (d) Nereis [ ]
6. How many numbers of somites are present in the body of leech?
   (a) 20 [ ] (b) 40[ ] (c) 50 [ ] (d) 33 [√]
7. In leech the excretion is

(a) Uricotelic [ ] (b) Ammonotelic [√] (c) Ureotelic [ ] (d) None of these [ ]

8. Leech is
(a) Carnivorous [ ] (b) Omnivorous [ ] (c) Sanguivorous [√] (d) Herbivorous [ ]
9. Saliva of leeches contain an anticoagulant called
(a) Haemoglobin [ ] (b) Hirudin [√] (c) Heparin [ ] (d) Histamine. [ ]
10. Common cattle leech belongs to the genus
(a) Megascolex [ ] (b) Neanthes [ ] (c) Arenicola [ ] (d) Hirudinaria [√]
11. The saliva of leech has an anticoagulant called
(a) Heparin [ ] (b) Hirudin [√] (c) Chloragosomes [ ] (d) None of these [ ]
12. How many chambers are found in the crop of leech?
(a) Six [ ] (b) Eight [ ] (c) Nine [ ] (d) Ten [√]
13. Leech is a blood sucking animal, nutritionally, therefore leech is
(a) Herbivorous [ ] (b) Carnivorous [ ] (c) Sangivorous [√] (d) Omnivorous [ ]
14. In which segment do you find the ovisac in leech?
(a) 8^{th} [ ] (b) 11^{th}[√] (c) 15^{th}[ ] (d) 13^{th}[ ].
15. Which segment possesses nephridia in Hirudinaria?
(a) 7-10^{th} segment [ ] (b) 6-22 segments [√] (c) 10-20 segments [ ] (d) 7-18 segments [ ]
16. Female genital opening of Hirudinaria is present in
(a) Ist annule of 10^{th} segment [ ] (b) Ist annule of 11^{th} segment [ ] (c) 2^{nd} annule of 10^{th} segment [ ] (d) 2^{nd} annule of 11^{th} segment [√]
17. The posterior sucker of Hirudinaria is formed by the union of
(a) 1 segment [ ] (b) 7 segments [√] (c) 25 segments [ ] (d) 33 segments [ ]
18. The number of segments in Hirudinaria is
(a) 109 [ ] (b) 33[√] (c) 26 [ ] (d) Numerous [ ]
19. Anterior sucker of Hirudinaria is formed by the union of
(a) 1 segment [ ] (b) 3 segments [ ] (c) 7 segments [ ] (d) Prostomium and 3 segments [√]
20. In Hirudinaria space between body wall and canal is filled with the
(a) Botryoidal [√] (b) Connective tissue [ ] (c) Hoemocoelomic fluid [ ] (d) None [ ].
21. Hirudinaria is
(a) Herbivorous [ ] (b) Carnivorous [ ] (c) Omnivorous [ ] (d) Sanguivorous [√]
22. A temporary clitellum is formed in Hirudinaria's segments
(a) 7^{th},8^{th} and 9^{th}[ ] (b) 9^{th} to 11^{th}[√] (c) 11^{th} to 13^{th}[ ] (d) None [ ]
23. Number of annular receptor in each annulus
(a) 18[ ] (b) 18 on dorsal and 18 on ventral [√] (c) 9 [ ] (d) None of the above. [ ]
24. Hirudinaria contains
(a) Slime gland [ ] (b) Sucker gland [ ] (c) Clitellar gland [ ] (d) All the above [√]
25. Velum is present in
(a) Pheretima [ ] (b) Hirudinaria [√] (c) Ascaris [ ] (d) All the above. [ ]
26.In Hirudinaria there is no special organ for
(a) Digestion [ ] (b) Excretion [ ] (c) Respiration [√] (d) Reproduction. [ ]

27. Number of testes in Hirudinaria is:
(a) 10 pairs [ ] (b) 11 pairs [√] (c) 12 pairs [ ] (d) 13 pairs [ ].
28. How is phylum Anellida advanced over Nemathelminthes?
(a)Metameric segmentation [ ] (b) True coelom [ ] (c) Closed circulation [ ] (d) All of the above [√]
29. The animal bearing numeraous setae are kept in class
(a) Hirudinea [ ] (b) Oligochaeta [ ] (c) Polychaeta [√] (d) Onychophora [ ]
30. In which class of phylum Annelida one pair of ovaries and many pairs of testes are found?
(a) Polychaeta [ ] (b) Oligochaeta [ ] (c) Hirudinea (d) Archiannelida [ ]
31. Which one of these is the primary characteristic of phylum Annelida?
(a) Trochophore larva in life cycle [ ] (b) Metameric segmentation [√] (c) Excretion by flame cells [ ] (d) Body covered by ciliated epidermis. [ ]
32. Aphrodite is commonly known as
(a) Lung worm [ ] (b) Paddle worm [ ] (c) Sand worm [ ] (d) Sea mouse [√]
33. Larval form of Polychaeta is known as
(a) Tornaria [ ] (b) Glochidium [ ] (c) Trochophore [√] (d) Bipinnaria [ ].
34. Smooth blood worm is
(a) Aphrodite [ ] (b) Glycera [ ] (c) Hirudinaria [√] (d) Terebella [ ]
35. In Lumbricus, clitellum is present in segments
(a) 33 to 37 [√] (b) 22 to 27 [ ] (c) 54 to 60 [ ] (d) 46 to 56 [ ]
36. A triploblastic, bilaterally symmetrical, elongated and vermiform body is characteristic of
(a) Coelenterates [ ] (b) Arthropods [ ] (c) Annelids [√] (d) None of the above [ ]
37. Tube dwelling polychaetes are known as
(a) Burrowing [√] (b) Planktonic [ ] (c) Pelagic [ ] (d) Tubicolous [ ]
38. In Polychaeta, the nature of seta is
(a) Numerous [√] (b) Occur singly [ ] (c) Occur in bundles [ ] (d) Fused [ ]
39. Presence of coelom and metamerism are the most important characters in
(a) Helminths [ ] (b) Arhhropods [ ] (c) Annelids [√] (d) Coelenterates [ ]
40. The origin of the nephridium is
(a) Germinal [ ] (b) Ectodermal [ ] (c) Mesodermal [√] (d) Endodermal [ ]
41. Cuticle of annelids is
(a)Non-chitinous and albuminoid (b) Chitinous [√] (c) Chitinous albuminoid [ ] (d) Non chitinous [ ]
42. The body cavity of Hirudo is filled with
(a) Connective tissue [ ] (b) Parenchyma tissue [ ] (c) Botryoidal tissue [ ] (d) Coelomic fluid [√]
43. Tube within a tube body plan is found in
(a) Pheretima posthuma [ ] (b) Hydra [ ] (c) Rana tigrina [√] (d) Lepus cuniculus [ ]
44. Arenicola is commonly known as
(a) Lugworm[√] (b) Paddle worm[ ] (c) Sea pen [ ] (d) Potato worm. [ ]

45. Nereis is commonly known as
(a) Clam worm [√] (b) Earthworm [ ] (c) Skate sucker [ ] (d) Sea fan. [ ]
46. Sucking of human blood by the leech is called
(a) Blood sucking [√] (b) Phlebotomy [ ] (c) Autotomy [ ] (d) Phrynotomy [ ]
47. The coelom in Annelida is
(a) Pseudocoelic [ ] (b) Enterocoelic [ ] (c) Schizocoelic [√] (d) Acoelous [ ]
48. Lug worm is scientifically known as
(a) Nereis [ ] (b) Arenicola [√] (c) Aphrodite [ ] (d) Polynoe [ ]
49. Sabella is generally known as
(a) Rag worm [ ] (b) Scale worm [ ] (c) Peacock worm [√] (d) None [ ]
50. Which is known as blood worm?
(a) Terebella [ ] (b) Tubifex [ ] (c) Lumbricus [√] (d) Nereis [ ].
51. The 'Tubifex' is
(a) Blood parasite [ ] (b) Sand dweller [√] (c) Fresh water [ ] (d) Parasite [ ].
52. Medicinal leech is
(a) Hirudinaria [ ] (b) Hirudinaria japanica [ ] (c) Hirudo medicinalis [√]
(d) Hirudinaria viridis [ ]
53. Sipunculus is commonly known as
(a) Nut worm [ ] (b) Pea nut worm [√] (c) Peacock worm [ ] (d) None [ ]
54. The annelid larva is
(a) Bipinnaria [ ] (b) Trochophore [ ] (c) Cercaria [√] (d) None [ ]

UNIT 08: PHYLUM ARTHROPODA

Contents

8.1- Objectives

1. To understand different body parts and their functioning.
2. Detailed study of some important arthropoda.
3. Understading habitat of *Palaemon*.
4. Understanding the nervous system and reproductive system of *Palaemon*.

8.2- Introduction

Phylum arthropoda (Gr., arthros = joint + podos = foot) is the largest phylum and most varied in the animal kingdom. Von Siebold gave the name arthropoda. It includes well over one million described species and many million remain unstudied. Some of the more well-known arthropods include insects, crustaceans, spiders, scorpion and centipede as well as the fossil trilobites. Arthropods are mainly terrestrial but marine and freshwater species are also well known. Arthropoda varies tremendously in their habitats, life histories, and dietary preferences.

Arthropod bodies are divided into segments. However, a number of segments are sometimes fused to form integrated body parts known as tagmata. This process of fusion is called tagmosis. The head, thorax, and abdomen are examples of tagmata. Exoskeleton serves as protection and provides places for muscle attachment. Arthropods must molt because their exoskeletons don't grow with them. However, in most species some appendages have been modified to form other structures, such as mouthparts, antennae, or reproductive organs. Arthropod appendages may be either biramous (branched) or uniramous (unbranched). In insects, the anterior portion of the heart is extended into a tube that is called an aorta which directs the blood forward as it goes out into the body cavity. Arthropods have a well-developed, mesodermal, solid nerve cord, ventral and well-developed sense organs. They range in size from microscopic plankton to life-forms that are a few meter long. Arthropods primary internal cavity is known as hemocoel, which accommodates their internal organs, and through which their haemolymph - analogue of blood - circulates; they have open circulatory systems.

Respiration occurs in various ways for e.g. some species have gills, while others employ tracheae, or book lungs. The tracheal respiratory system consists of external openings called spiracles that are linked to a system of branched tubules which allow respiratory gases to reach internal tissues. Arthropods are characterized by a brain as well as a nerve ring around the area of the pharynx, in the oral cavity. A double nerve cord extends backwards along the ventral surface of the body, and each body segment is associated with its own ganglion, or mass of nerve cells. Generally, the sexes are separate in phylum arthropoda. Fertilization usually occurs internally, and most species are egg-laying. While some species exhibit direct development, in which eggs hatch as miniature versions of adults, other species pass through an immature larval stage and undergo a dramatic metamorphosis before reaching adult form. Arthropods contribute directly (as food) as well as indirectly (crop pollination) to human food supply chain. Some specific species are known to spread severe disease to humans, livestock, and crops.

8.3- GENERAL CHARACTERS

1. Arthropoda is bilaterally symmetrical, triploblastic and metamerically segmented animals.
2. Body can be divided into head, thorax and abdomen; head and thorax are often fused to form Cephalothorax.
3. Body is covered with a thick chitinous cuticle forming an exoskeleton.
4. Body segments usually bear paired and jointed appendages.
5. Coelom largely a blood-filled haemocoel.
6. Muscles are mostly striated, usually capable of rapid contraction.
7. Digestive tract is complete. The mouth and anus lie at opposite ends of the body.
8. Circulatory system is open with dorsal heart and arteries and blood sinuses.
9. Respiration through by general body surface, by gills in aquatic forms, by tracheae and by book lungs.
10. Nervous system has dorsal nerve ring.
11. Excretory organs are malpighian tubules (in insects) and green glands (in Crabs and prawn).
12. Cilia are absent from all parts of the body.
13. Sexes are generally separate.
14. Fertilization is internal, oviparous and ovoviviparous
15. Parental care is well marked in many arthropods.

8.4- CLASSIFICATIONS

Arthropoda is a heterogenous group including a wide variety of animals. Since there are divergent views concerning their phylogeny, therefore there is no definitive system for classifying this phylum. However we can still classify it under following:

Subphylum I: Trilobitomorpha (Gr., tria=three + lobos= lobe+morphe= form)

1. Mostly marine and bottom dwellers arthropods.

2. Fossil trilobites.

3. Body can be divided into 3 lobes by 2 longitudinal furrows.

4. Biramous appendages are there on all segments except the last one.

Examples: *Triarthrus*, *Dalmanites*

Subphylum II: Chelicerata (Gr., Chele= claw+ Keros=horn+ata=group)

1. Body differentiated into an anterior prosoma (cephalothorax) and an opisthosoma (abdomen).

2. There are six pairs of appendages. First pair is of preoral chelicerae with claws, one pair of pedipalps and four pairs are of walking legs.

3. Antennae and jaws are absent.

Subphylum Chelicerata has been divided into two classes:

Class1. Merostomata (Gr., meros = thigh + Stoma = mouth)

1. Marine and aquatic chelicerates.

2. Median, simple and lateral compound eyes.

3. Abdomen with 5 or 6 pair of appendages.

4. No malpighian tubules.

Subclass 1. Xiphosura (Gr., xiphos = sword + aura = tail)

1. Cephalothorax with a broad, horse-shoe shaped carapace.

2. Abdomen is unsegmented and ends in a long telson.

Examples: *Limulus* (king crab or horseshoe).

Subclass 2. Eurypterida (eurys = broad + pteryx = wing)

1. Extinct, marine and giant water scorpion.

2. Abdomen has twelve segments.

3. Cephalothorax is small.

Examples: *Eurypterus* and *Pterygotus*.

Class 2. Arachnida (Gr. Arachne = spider)

1. Terrestrial or aquatic.

2. It has simple and non compound eyes.

3. Cephalothorax (prosoma) with 2 chelicerae, 2 pedipalps and 4 pairs of walking legs.

4. Abdomen without appendages.

5. Respiration by tracheae, book lungs or both.

6. Excretory organs are malpighian tubules.

7. Dioecious, oviparous, courtship before mating.

Arachnida has been divided into following 10 orders:-

Order 1. Scorpionida (= True Scorpions)

1. Cephalothorax covered with carapace; abdomen differentiated into 7 –segmented mesosoma and 5-Segmented metasoma.

2. Respiration by 4 pair of book lungs.

Examples: *Palamnaeus*, *Buthus*, *Androctonus*.

Order 2. Pseudoscorpionida (False scorpions)

1. Tiny sized.

2. Cephalothorax covered with carapace, abdomen 11 segmented; sting and telson absent.

Examples: *Chelifer*, *Microcreagris*.

Order 3. Araneae (True Spiders)

1. Prosoma and opisthosoma are joined by a narrow pedicel.

2. Opisthosoma with 3 pairs of spinnerets. The Telson is absent.

Examples: *Achaearanea* (House spider), *Lycosa* (wolf spider), *Argiope* (writing spider), *Agelena* (funnel-web spider).

Order 4. Solifugida

1. False Spiders, Sun Spiders or Wind Spiders.

2. Prosoma is divided into a large anterior and a small posterior part.

3. Opisthosoma has 10 or 11-segments.

4. Chelicerae large form pincers; male with flagellum for sperm transfer.

Examples: *Galeodes* (Sun Spiders).

Order 5. Palpigradi

1. Small-sized microwhip scorpions.

2. Carapace formed of two plates.

3. Opisthosoma is 11-segmented.

Examples: *Koenenia*.

Order 6. Pedipelpi

1. Whip scorpions.

2. Abdomen 12- segmented. Last segment has a long flagellum.

3. Pedipalps large with terminal pincer.

Examples: *Mastigoproctus*, *Thelyphonus*.

Order 7. Amblypygi

1. Flattened scorpion-spiders.

2. Abdomen 12-segmented, Chelicerae moderate.

3. First pair of legs is long and sensory.

Examples: *Charinus*.

Order 8. Ricinulei

1. Rare, small and heavy bodied arachnids.

2. Chelicerae pincer-like.

3. Opisthosoma 6-segmented.

Examples: *Ricinoides*, *Crytocellus*.

Order 9. Opioliones

1. Spider-like harvest-men.

2. Body is elliptical.

3. Prosoma is broadly joined to opisthosoma.

Examples: *Phalangium*, *Leiobunum*.

Order 10. Acarina

1. Free-living or parasitic.

2. Body is small, oval and unsegmented.

3. Prosoma and opisthosoma are not differentiated.

4. Chelicerae and pedipalps are small.

Examples: *Sarcoptes* (Itchomite), *Ixodes* (sheep tick), *Dermacentor* (dog tick).

Subphylum III. Mandibulata (L. mandibula = mandible + ata = group)

1. Body can be divided into head, thorax and abdomen.

2. Head consists of one or two pairs of antennae, one and two pairs of maxillae and one pair of mandibles.

3. Compound eyes are common.

Subphylum mandibulata has been divided into six classes.

Class 1. Crustacea (Gr. Cursta = shell)

1. Crustacea are mainly aquatic (mostly marine, few freshwater) and few live in moist places on land.

2. Head joined with thorax to form cephalothorax.

3. Exoskleton is chitinous, hard and calcareous.

4. Head 5-segmented with 2 pairs of antennae, 2 pairs of maxillae and 1 pair of mandibles.

5. Respiration takes place through general body surface or gills.

6. Excretion by antennal glands.

7. Sexes are separate or united and development with nauplius stage.

Subclass 1. Cephalocarida

1. Body made of a horseshoe-shaped head and 19 trunk segments.

2. Eyes absent. Antennae short.

3. Hermaphrodite; life-histroy completes in a metanauplius larva.

Examples: *Hutchinsoniella*.

Subclass 2. Branchiopoda

1. Primitive, small-sized and mostly freshwater.

2. Trunk appendages leaf-like and serve for locomotion, respiration and feeding.

3. Antennules and 2^{nd} maxillae reduced or absent.

4. Abdomen ends in a pair of jointed or unjointed caudal styles.

Order 1. Anostraca

1. Fairy shrimps with nineteen or more trunk segments. Only anterior 11-19 segments bear appendages.

2. Eyes stalked and carapace absent.

Examples: *Artemia*, *Eubranchipus*.

Order 2. Notostraca

1. Tadpole shrimps with 25 to 45 trunk segments.

2. Carapace shield-like. Eyes sessile and styles jointed.

Examples: *Lepidurus*, *Apus*.

Order 3 Diplostraca

1. Clam shrimps and water fleas with a bivalved carapace. Carapace does not enclose the head.

2. Eyes sessile or fused. Styles unjointed.

Examples: *Daphnia*, *Cyzicus*.

Subclass 3. Ostracoda

1. Seed shrimps and small-sized mussel with poorly segmented body.

2. Trunk appendages 2 pairs and leg-like.

3. Antennae and antennules and large, used in swimming.

Order 1. Myodocopa

1. Carapace with anennal notches.

2. Antennae biramous.

Examples: *Cypridina.*

Order 2. Podocopa

1. Carapace unnotched. Two pairs of trunk appendages.

2. Antennae uniramous.

Examples: *Cypris*, *Darwinula*.

Order 3. Platycopa

1. Carapace unnotched. One pair of trunk appendages.

2. Antennae uniramous.

Examples: *Cytherella*.

Order 4. Cladocopa

1. Carapace unnotched.

2. Antennae biramous.

Examples: *Polycope*.

Subclass 4. Mystacocarida

1. Primitive and microscopic body.

2. Antennae and antennules prominent.

3. A single median eye present. Compound eyes absent.

4. Abdomen limbless and a pair of caudal styles.

Examples: *Derocheilocaris*.

Subclass 5. Copepoda

1. Body small, divisible into head, thorax and abdomen.

2. Compound eyes absent and median eye present.

3. Antennae smaller and antennules long.

Examples: *Cyclops*, *Ergasilus*, *Caligus*.

Sub-class 6. Branchiura

1. Fish lice; ectoparasites of skin and gill chambers of fishes and some amphibians.

2. Body dorso-ventrally flattened.

3. Head and thorax covered with carapace.

4. One pair of compound eyes present.

5. Antennae and antennules reduced.

6. First maxillae modified into suckers.

7. Abdomen unsegmented and bilobed.

Examples: *Argulus*, *Dolops*.

Sub-class 7. Cirripedia

1. Barnacles, sessile, attached or parasitic.

2. Carapace forms two folds of mantle and covered externally by calcareous plates.

3. Thoracic limbs 6 pairs, cirriform and biramous.

4. Antennae and compound eyes are absent in adult.

5. Antennules become cement glands for attachment.

6. Abdomen rudimentary with caudal styles.

Order 1. Thoracica

1. Hermaphrodite, non-parasitic and with or without stalk.

2. Mantle present with calcareous plates.

3. Thoracic appendages 6 pairs and ciriform.

Examples: *Lepas*, *Balanus*.

Order 2. Acrothoracica

1. Sessile; unisexual; bore into mollusc shells or corals.

2. Mantle reduced to a chitinous disc.

3. Trunk appendages 4 pairs and cirriform.

Examples: *Alcippe*, *Cryptophialus*.

Order 3. Ascothoracica

1. Parasitic in echinoderms and corals.

2. Mantle bivalve or saccular.

3. Appendages are absent but antennules remain present.

Examples: *Synagoga*, *Dendrogaster*.

Order 4. Apoda

1. Parasitic without appendages.

2. Mantle absent.

Examples: *Proteolepis*.

Order 5. Rhizocephala

1. Adult degenerate, parasitic and sac-like.

2. Peduncle forms root-like absorptive branches ramifying throughout host’s tissues.

Examples: *Sacculina*.

Sub-class 8. Malacostraca

1. Body large-sized and made of 19 segments.

2. Cephalothorax made of head and one or more thoracic segments.

3. Carapace well formed and absent.

4. Compound eyes sessile or paired.

5. Abdomen ends into telson; caudal styles absent.

Order 1. Nebaliacea

1. Primitive marine crustaceans.

2. Carapace bivalved with an adductor muscle.

3. Instead of 6, there are 7 abdominal segments.

Examples: *Nebalia*.

Order 2. Mysidacea

1. Marine crustaceans.

2. Body elongated, uropods form a fan-tail.

3. Carapace covers almost entire thorax.

Examples: *Mysis* (Opossum shrimp).

Order 3. Cumacea

1. Head and thorax greatly enlarged.

2. Carapace fused to 3 to 4 thoracic segments.

3. Abdomen narrows.

Examples: *Diastylis*, *Cumopsis*.

Order 4. Isopoda

1. Body dorso-ventrally flattened.

2. Head and 1 or 2 thoracic segments form cephalothorax.

3. Carapace absent.

4. Abdomen is usually short.

Examples: *Asellus*, *Oniscus*.

Order 5. Amphipoda

1. Mostly marine crustaceans.

2. Body laterally compressed.

3. Carapace absent; eyes sessile.

Examples: *Caprella*, *Gammarus*, *Cyamus*.

Order 6. Stomatopoda

1. Mostly marine forms.

2. Mantis shrimp; body flattened; carapace small.

3. Abdomen large, broader than cephalothorax.

4. Heart is elongated.

Examples: *Squilla*.

Order 7. Decapoda

1. Marine forms.

2. Carapace well developed.

3. First 3 pairs of thoracic limbs form maxillipedes.

4. Gills in 3 series present on thorax.

Examples: *Palaemon*, *Penaeus*, *Leucifer*, *Astacus*, *Hippa*, *corcinus*.

Class 2. Diplopoda (Gr., diplos = double + pous = foot)

1. Body elongated, cylindrical and divisible into 5 head segments and 4 thorax segments.

2. Mandibles and maxillae 1 pair.

3. Eyes simple and genital openings in the 3rd abdominal segment.

Sub-class 1. Pselaphrognatha

1. Minute millepedes with soft skin bearing rows of scale-like setae.

2. Trunk with 13 to 17 pairs of legs.

Examples: *Lophoproctus, Polyxenus*.

Sub-class 2. Pentazonia

1. Last two pairs of legs modified for clasping.

Examples: *Desmus*, *Glomeris* and *Glomeria*.

Sub-class 3. Helminthomorpha

1. Body flattened or cylindrical.

2. One pair of legs of the 7th segment in the male.

Examples: *Julus*, *Polyzonium*, *Apheloria*, *Polydesmus*.

Class 3. Chilopoda (Gr., Cheilos = lip + pous = foot)

1. Body dorso-ventrally flattened and divisible into head and trunk.

2. Head with 1 pair of antennae, 1 pair of mandibles and 2 pairs of maxillae.

3. First pair of legs modified into poison claws.

Subclass (1) Epimorpha

1. Development epimorphic.

2. Adults with 21 or more pairs of legs.

Examples: *Geophilus*, *Scolopendra*.

Subclass (2) Anamorpha

1. Adults with fifteen pairs of legs.

2. Development anamorphic, *i.e.* less number of segments in young than adults.

Examples: *Lithobius*, *Scutigera*.

Class 4. Symphyla (Gr., syn = together + phylon = tribe)

1. Body is slender and made of head and 15 to 22 trunk segments.

2. without eyes.

3. Genital pores located ventrally on the 4^{th} trunk segment.

Examples: *Hanseniella*, *Scutigerella*.

Class 5. Pauropoda (Gr., pauros = small + pous = foot)

1. Less than 2 mm long; eyes are absent.

2. Body divisible into head and 11-12 trunk segments.

Examples: *Pauropus*.

Class 6. Insecta (L., insectus = cut or divided) **Largest group of phylum Arthropoda.**

1. Body divided into head, thorax and abdomen.

2. Head with compound eyes (1pair), antennae (1 pair), mandibles (1 pair) and maxillae (2 pairs).

3. Mouthparts modified for different feeding habits.

4. Respiration by tracheae. Spiracles lateral.

5. Thorax bears 3 pairs of legs and 1 or 2 pairs of wings.

6. Excretion by Malpighian tubules.

7. Unisexual. Fertilisation is internal.

Subclass (1) Apterygota

1. These are primitve wingless insects.

2. Abdomen with cerci and style-like appendages.

3. Metamorphosis is reduced or absent.

Order1. Protura

1. Insects without wings.

2. No antennae, true eyes and metamorphosis.

Examples: *Acerantulus*.

Order 2. Collembola

1. No eyes, tracheae, Malpighian tubules.

2. Mouthparts chewing or sucking type.

3. Abdomen 6-segmented.

4. Metamorphosis absent.

Examples: *Achoruted*, *Sminthurus*, *Springtails*.

Order 3. Thysanura

1. Body covered with minute silvery scales.

2. Antennae long; mouthparts chewing.

3. Abdomen 11-segmented; telson long.

Examples: *Lepisma* (silver fish).

Sub-class 2. Pterygota

1. Wings present.

2. Abdominal appendages absent but cerci present.

3. Metamorphosis complete or incomplete.

Division (a) Exopterygota

1. Wings develop externally as buds.

2. Metamorphosis gradual. Young stages are nymphs

Order 1. Orthoptera

1. Wings 2 pairs. Forewings straight and leathery. Hindwings membranous and folded at rest.

2. Mouth parts chewing.

3. Prothorax large.

Examples: *Periplaneta* (Cockroach), *Poecilocercus* (Grasshoppers), *Schistocerca* (Locust), *Gryllus* (Cricket), *Mantis* (Praying mantis), *Carausius* (Stick insect) and *Phyllium* (Leaf insect).

Order 2. Isoptera

1. Wings 2 pairs. Held flat on back.

2. Mouthparts chewing.

3. Social insects with well developed caste-system.

Examples: *Termites* or white ants.

Order 3. Dermaptera

1. Forelibs small, leahery; hindwings large and semicircular.

2. Mouthparts chewing.

Examples: *Forficula* (Earwig).

Order 4. Ephemeroptera

1. Wings 2 pairs, membranous; forewings longer and triangular; hindwings smaller and rounded.

2. Adult mouth parts vestigial.

3. Abdomen carries long cerci and caudal filament.

Examples: *Ephermera* (Mayfly).

Order 5. Odonata

1. Wings 2 pairs and membranous.

2. Eyes very large.

3. Mouthparts chewing. Predaceous.

Examples: Dragon flies, Damsal flies.

Order 6. Plecoptera

1. Wings 2 pairs and membranous.

2. Antennae long.

3. Mouthparts of chewing type.

Examples: *Isoperla* (Stone-fly) and Perla.

Order 7. Psocoptera

1. Wingless or forewings larger than hindwings.

2. Antennae present.

3. Mouthparts of chewing type.

Examples: Book lice (wingless), Bark lice (winged).

Order 8. Mallophaga

1. Wings absent; body small; head large; eye degenerate; legs clasping.

2. Mouth parts of chewing type.

Examples: Bitings lice of mammals, bird lice.

Order 9. Anoplura

1. No wings; body broad and flat; head small.

2. Mouth parts piercing and sucking type.

3. Ectoparasites on mammals.

Examples: *Pediculus* (Human louse)

Order 10. Thysanoptera

1. Wings 2 pairs, fringed with long hairs.

2. Mouth parts rasping and sucking type.

Examples: *Thrips*.

Order 11. Hemiptera

1. Wingless or wings 2 pairs. Forewings thickened at base, membranous at tip.

2. Mouth parts of piercing-sucking type forming beak.

Examples: *Belostoma* (Giant water bug), *Cimex* (bedbug) and *Ranatra* (water scorpion).

Order 12. Homoptera

1. Wingless or 2 pairs of membranous wings.

2. Mouth parts form a piercing and sucking beak.

Examples: *Aphids*, *Cicadas* ans Scale insects.

Division (b) Endopterygota

1. Wings develop internally in pupal case.

2. Metamorphosis complete with larval and pupal stages.

Order 1. Neuroptera

1. Wings large and membranous.

2. Antennae long and cerci absent.

3. Mouth parts chewing type.

4. Larvae carnivorous. Abdominal gills in aquatic larvae.

Examples: *Crysopa* (Lacewing), *Myrmeleon* (Antlion).

Order 2. Coleoptera

1. Forewings leathery and hindwings membranous.

2. Antennae modified. Mouth parts chewing type.

Examples: Beetles.

Order 3. Mecoptera

1. Wings long, narrow and membranous.

2. Mouth parts chewing type and on a prolonged beak.

3. Tip of abdomen curved and sting-like in male.

Examples: *Panorpa* (scorpion-fly)

Order 4. Trichoptera

1. Wings long, hairy, folded roof-like over abdomen.

2. Antennae long.

3. Mouthparts rudimentary.

4. Larve pupates within a tube.

Examples: Caddis flies.

Order 5. Lepidoptera

1. Wings membranous, covered with overlapping scales.

2. Mouth-parts of sucking type.

3. Life-cycle includes caterpillar larva.

Examples: Butterflies, Moths.

Order 6. Diptera

1. One pair of wings; hindwings knob-like.

2. Mouth-parts of piercing-sucking type or sponging type.

3. Larva limbless and worm-like called maggot.

Examples: *Musca* (House fly), *Drosophilla* (Fruit fly), *Culex* (Mosquito).

Order 7. Hymenoptera

1. Two pair of wings that are membranous and hooked together during flight.

2. Mouth parts sucking or chewing type.

3. Some show social behavior.

Examples: *Apis* (Honey bee), ants, *Vespa* (Wasp).

Order 8. Siphonaptera

1. Small and laterally flattened. Secondarily wingless.

2. Mouth-parts of piercing-sucking type. Legs long, leaping.

3. Ectoparasites on birds and mammals.

Examples: *Pulex* and *Xenopsylla* (Fleas)

Other types of Arthropoda:-

1. **Limulus.** *Limulus* or king crab belongs to the subclass xiphosure and class merostomata of subphylum chelicerata (Fig 1). It is a large-sized marine animal, upto 60 cm long. It lives in shallow waters partly buried in the bottom mud. It feeds on worms, algae and mollusks. It is bilaterally symmetrical, triploblastic metamerically segmented animal with jointed appendages. The body is differentiated into prosoma and hinged opisthosoma. Prosoma bears a pair of 3-jointed chelicerae and 5 pairs of 6-jointed legs. First four legs are chelate; fifth is non-chelate. The 7th pair of appendages, chilaria are degenerate and of doubtful functions. (Yadav and varshney, 2015). The broad hexagonal opisthosoma is divisible into an anterior 6-segmented mesosoma and a posterior 3-

segmented metasoma. Excretion takes place through 4 pair of coxal glands. Sexes are separate. In breeding season males and females copulate in shallow water. Eggs, laid by females in holes in sand, are fertilized by sperms. *Limulus* is found along the eastern coast line of Asia and North America (Kotpal, 2005).

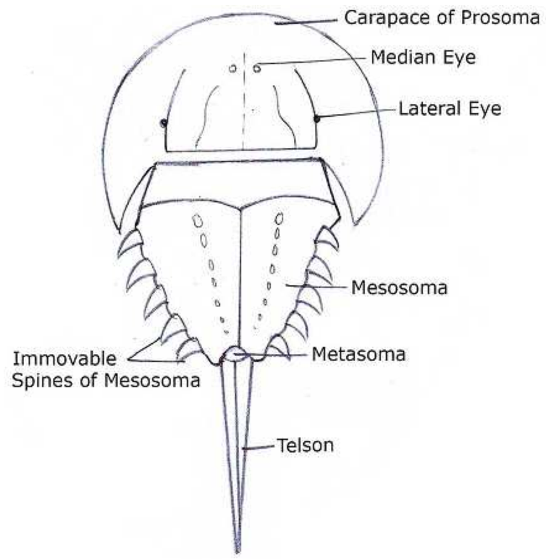


Fig. 1. *Limulus*

2. Aranea: *Aranea* belong to the order Araneae of class Arachnida. Body can be divided into prosoma and opisthosoma. Prosoma is covered by carapace that bears 8 simple eyes anteriorly. Ventrally prosoma bears 6 pair of appendages, a pair of chelicerae, a pair of pedipalps and 4 pair of walking legs. Opisthosoma bears spinnerets or spinning organs just anterior to the terminal anus. Respiration happens via book lungs or tracheae or both. Excretory organs are malpighian tubules. The silk secreted by most spiders is used for construction of egg sacs and for constructing webs to trap insects, as well as a guideline for males in finding sexual partners (Fig. 2).

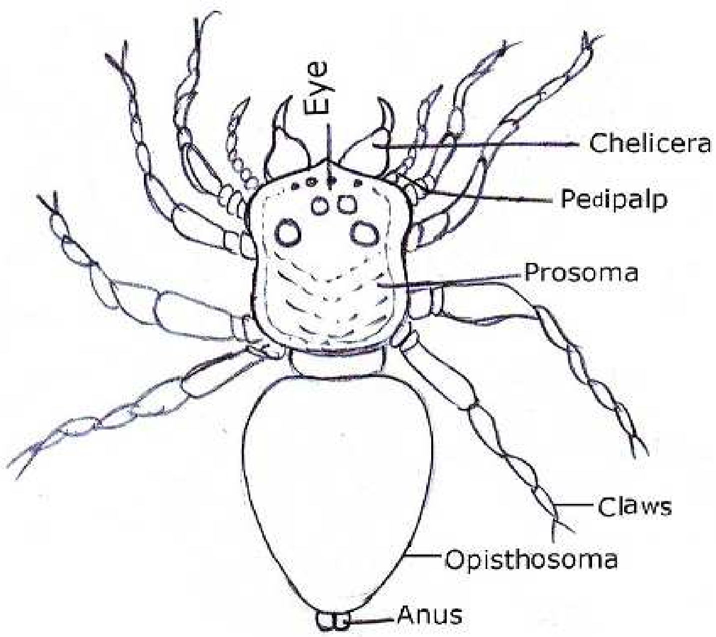


Fig. 2 Arenia

3. *Daphnia*: *Daphnia*, also called "water fleas", are found in order cladocera of subclass branchiopoda and are sometimes called cladocerans (Fig. 3). Body is about 2 mm long, oval, laterally flattened with a ventral beak on head and a sharp posterior caudal spine. *Daphnia* has a single compound eye and there are normally five or six appendages attached to the thorax. The body is compressed and enclosed in a flattened, transparent carapace. Antennules are much reduced and uniramous. *Daphnia* moves by beating its antennae which are moved by large muscles. They feed on algae, protozoa, bacteria, and decaying organic material. Most are filter feeders that consume phytoplankton which they remove from water using their setose thoracic appendages. A few are carnivores preying on other cladocerans. *Daphnia* swims by rapid jerks of its two large biramous antennae.

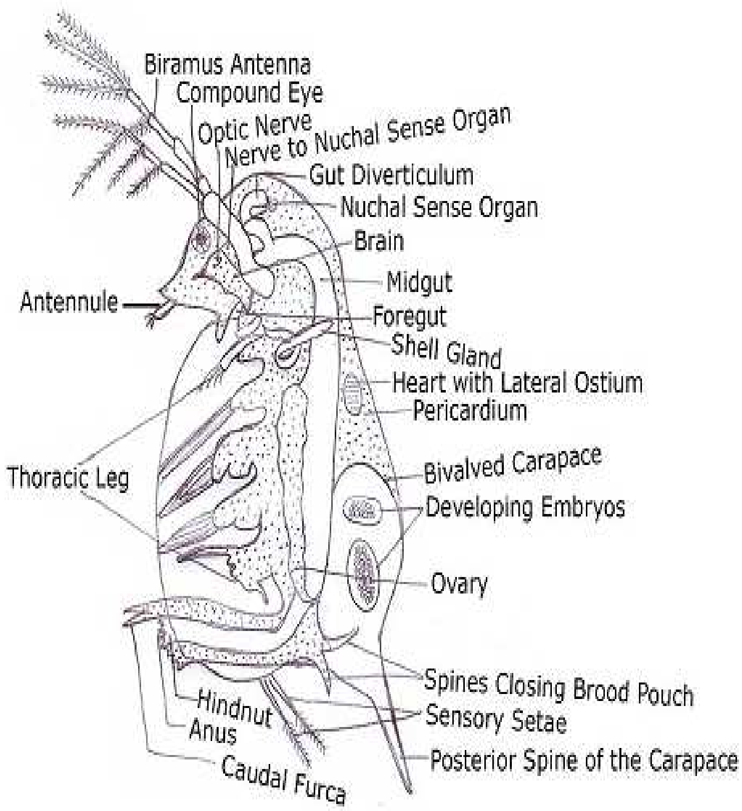


Fig. 3 *Daphnia*

4. *Cyclops*: The *Cyclops* is named after one-eyed monster of Greek legend. *Cyclops* is crustacean invertebrate with a hard outer shell. It is the most familiar copepod crustacean found in freshwater ponds. Pear-shaped or elongated body measures 1.5 to 5 mm in length. Head and first thoracic segment become fused to form cephalothorax, which is covered dorsally by a carapace. The cyclops has 5 pair of legs and a divided tail-like appendage called a furca. It is greenish, straw yellow, or grayish in color. It goes jerking through the water usually in very large numbers. The females carry the eggs in little side sacs and they multiply rapidly. The *Cyclops* is often seen near water fleas or *Daphnia*. Many water animals feed upon the *Cyclops*. It has a very important role in the food chain. *Cyclops* serves as intermediate hosts for the guineaworm of man (Fig. 4).

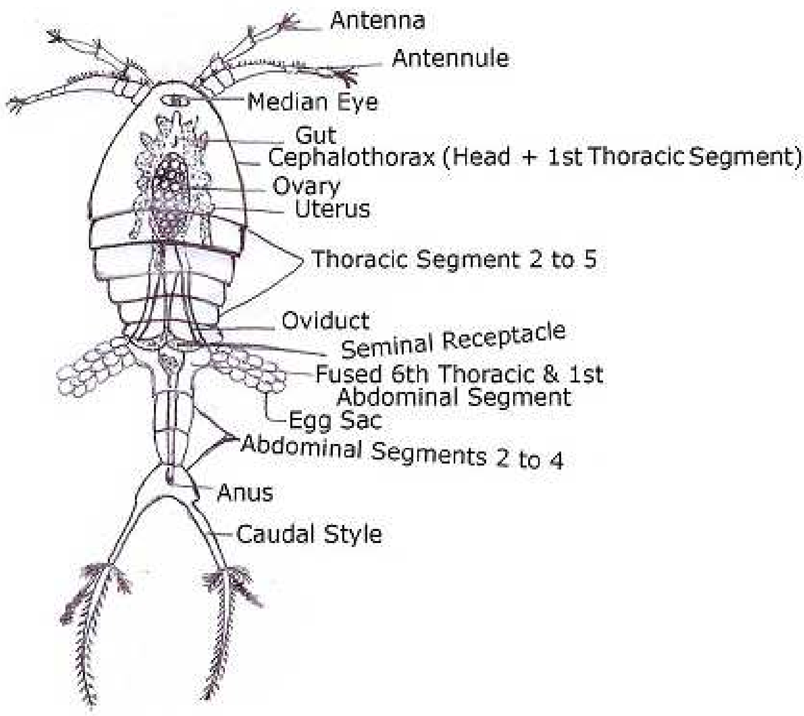


Fig. 4 *Cyclops*

5. *Lepas*: *Lepas* is commonly known as "ship or goose barnacle" (Fig. 5). It is a marine animal that inhabits warmer seas. It is found attached to ships and vegetation with the help of peduncle. *Lepas* is bilaterally symmetrical, triploblastic metamerically segmented animal with jointed appendages. The body is covered by a thick chitinous exoskeleton and by 5 calcareous plates-a pair of scuta, a pair of terga and a median dorsal carina. They feed upon minute organisms gathered from water and kicked into mouth by the thread like feet. It is bisexual. Development includes a free-swimming cypris larva (Yadav and varshney, 2015).

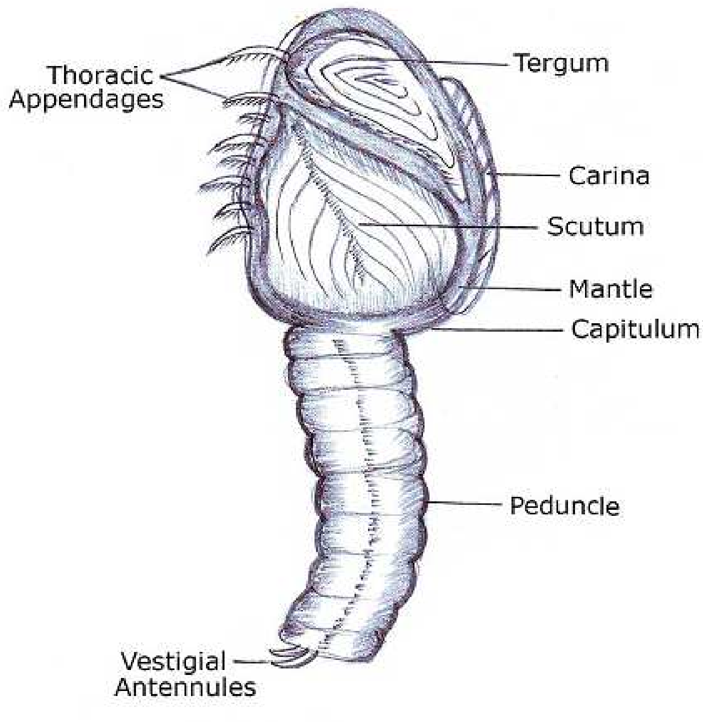


Fig. 5 *Lepas*

6. *Sacculina*: *Sacculina* is commonly known as root-headed barnacle. The adult looks like a large tumour or ovoid sax fastened to the abdomen of crab by a short stalk. Appendages, segmentation, sense organs and alimentary canal etc. are absent. The body is made up of two parts- a thin sac present on the ventral abdomen of the host crab and a peduncle. The female *sacculina* infects a crab. The male *sacculina* lives within the body of the female and fertilize its eggs. Larva is cirripede-nauplius (Fig. 6).

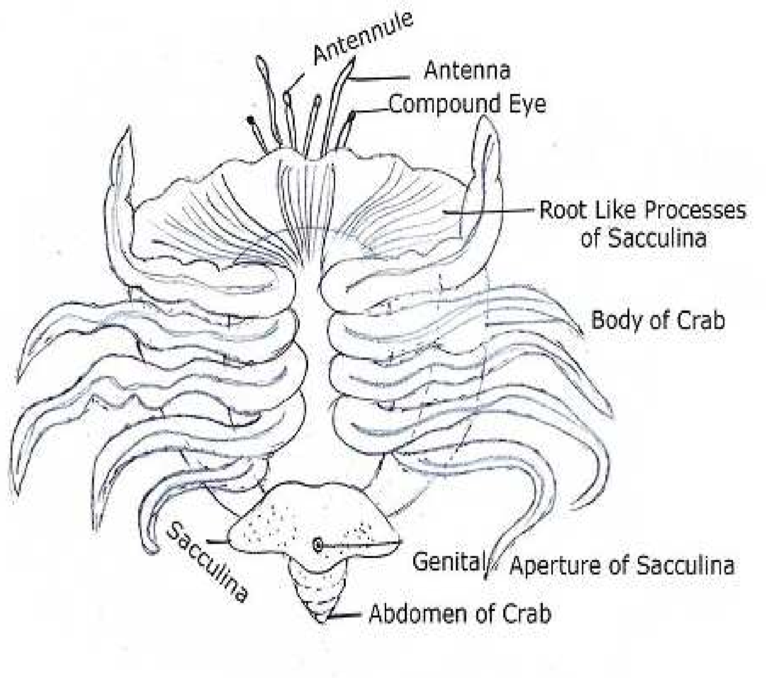


Fig. 6 ***Sacculina***

7. *Squilla*: *Squilla* is a large marine crustacean and belongs to order stomatopoda of subclass malacostraca (Fig. 7). *Squilla* is active, predatory and nocturnal; it catches hold of the prey with powerful maxillipedes. It is found in burrows in the sand or mud at the bottom of the sea. Body is bilaterally symmetrical, metamerically segmented, triploblastic, dorso-ventrally flattened and 25 cm long. Body is divisible into cephalic, thoracic and abdominal parts. Head bears a pair of stalked movable compound eyes, antennules and antennae. The thoracic region bears 5 pairs of maxillipedes and 3 pairs of walking legs. The second pair of maxillipedes is exceptionally large. The large abdomen is made up of 6 segments and each segment bears a pair of biramous pleopods. The last pair of pleopods are called uropod. It feeds on small fishes, crustaceans, molluscs etc..

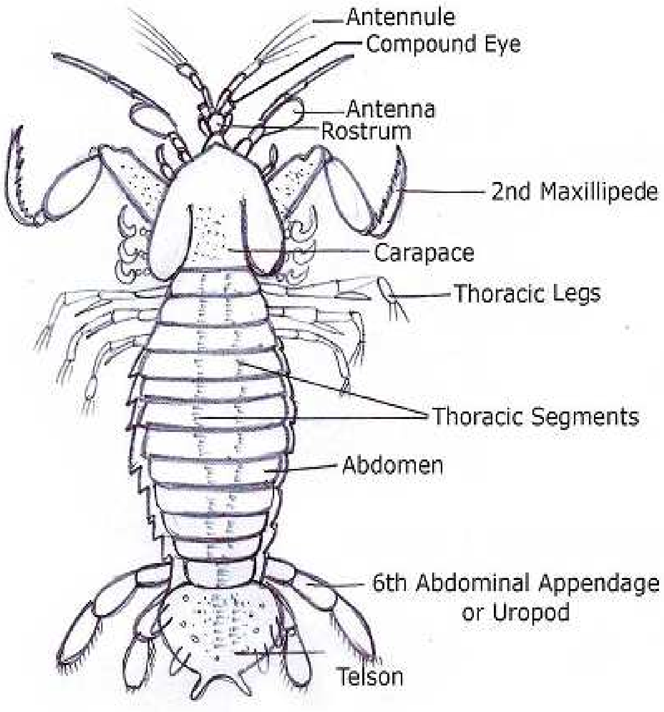


Fig. 7 *Squilla*

8. *Eupagurus*: *Eupagurus* is commonly known as 'hermit crab'. It is found inhabiting the empty shells of gastropods. It leads a commensal life. Cephalothorax is broad and flattened. Head bears a pair of stalked elongated eyes, a pair of large antennae and a pair of short antennules. Thorax bears 5 pair of legs. First, fourth and fifth pair of legs are chelate whereas rest of the legs are non chelate (Verma, 2015). Abdomen appendages of the left side are reduced while those of the right side are absent. *Eupagarus* is a peculiar crustacean having extreme modifications in order to adjust in the coils of molluscan shells (Fig. 8).

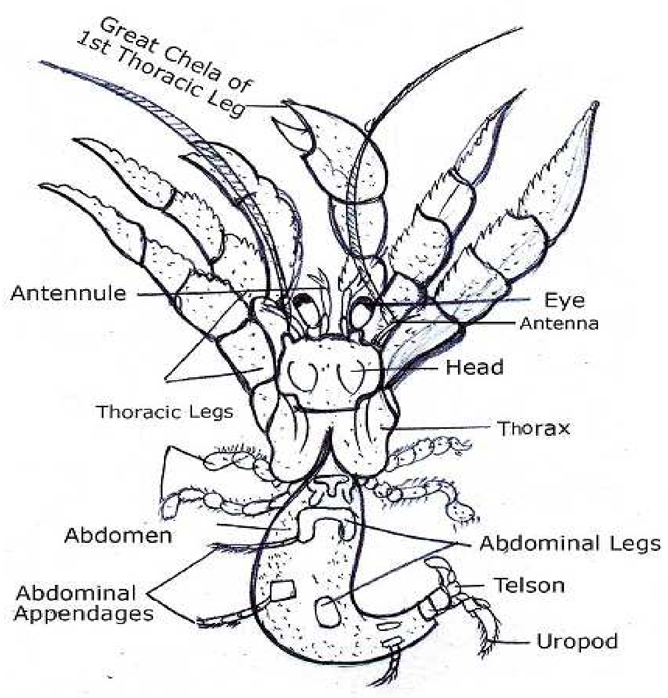


Fig. 8 Eupagurus

9. *Cancer*: *Cancer* is commonly called rock crab or true crab (Fig. 9). Body is dorso-ventrally compressed and consists of a cephalothorax and an abdomen. Cephalothorax is broader than long and is covered by a carapace. It bears small antennules, antennae, maxillipedes, compound eyes and thoracic legs. Mouth parts present on the ventral surface are covered by the flat, plate-like third maxillipedes. Fifth pairs of thoracic legs are present. The first pair is chelate where as the remaining are non-chelate. The eggs are carried about by the female attached to abdominal legs (Verma, 2015). Development is indirect through zoea and megalopa larval stages.

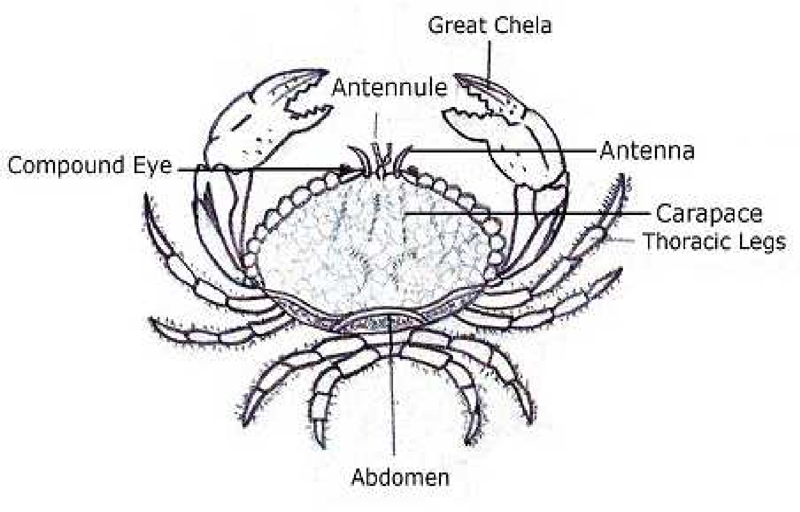


Fig. 9 *Cancer*

10. *Gryllus*: *Gryllus* belong to the order Orthoptera. *Gryllus* is the common house cricket which lives in damp warm places like under logs, boxes, and stones and in holes behind boods and crevices and in the kitchens. The body can be divided into head, thorax and abdomen. Head bears a pair of compound eyes and a pair of antennae which are filiform and longer than the body. Mouth parts are mandibulate and well-developed. Female possess a well-developed oviposterior that serves for depositing eggs in holes or crevices, devours all sorts of animal and vegetable matter such as clothing paper, skin, fruits and vegetables etc.

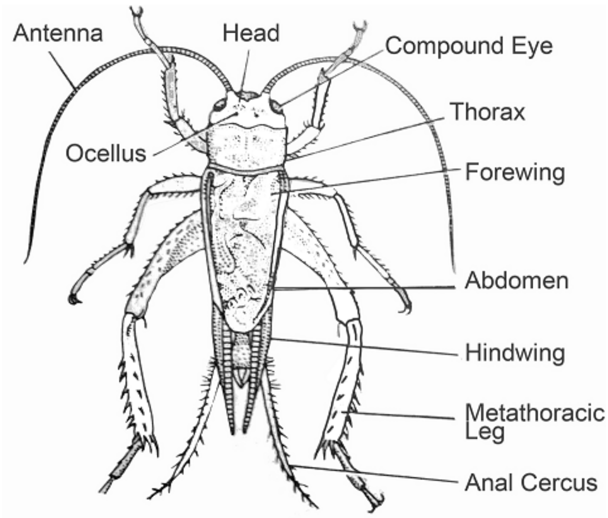


Fig.10 Gryllus

11. *Mantis*: *Mantis* is commonly called praying mantis (Fig. 10). The colour of *Mantis* is usually green. It is a large insect (5-10cm), with a small triangular head, a long prothorax and abdomen consisting of

10-segments. Wings are folded flat and overlap the sides of the body. It is found in areas of green vegetation. It feed voraciously on other insects. Female eats up the male after copulation. The female lays about 200 eggs in frothy mass which soon hardens into a waterproof egg case.

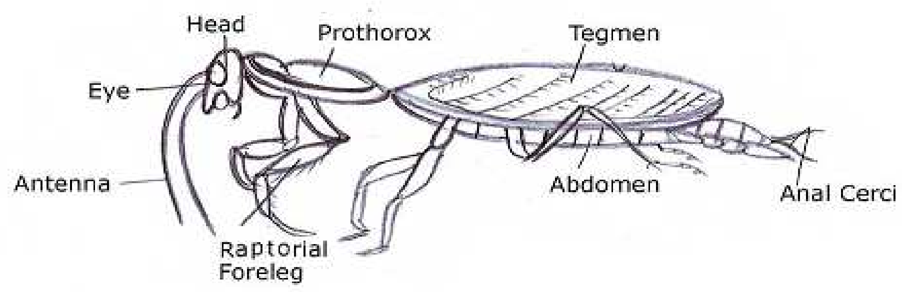


Fig. 11*Mantis*

12. *Carausius*: *Carausius* is commonly known as stick insect because it mimics a twig to escape enemies. *Carausius* is herbivorous and is found in tropical forests in thick vegetation. Body is elongated and slender and can be divided into head, thorax and abdomen. Head is small, bears a pair of antennae and a pair of small compound eyes. Thorax is elongated bearing pairs of long slender legs. Abdomen has 10 segments. Mouthparts are of chewing type. Sexes are separate. While male is small, winged and active, the female is large, sluggish and apterous (Fig. 11).

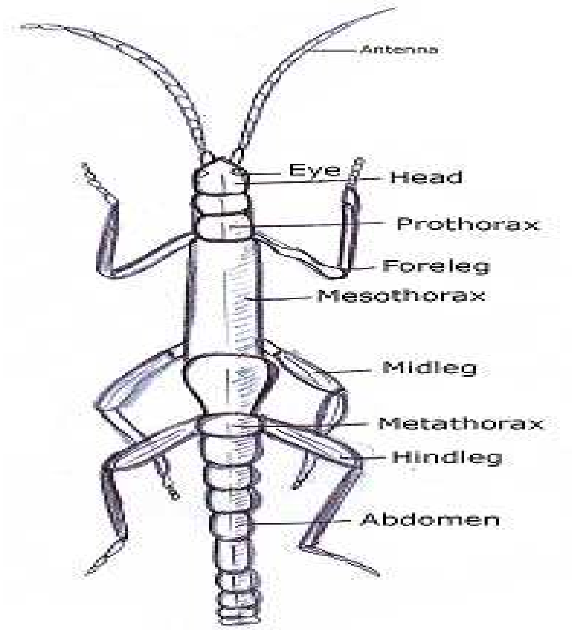


Fig. 12 Carausius

8.4 Palaemon (*Macrobrachium malcolmsonii)*

The Indian Freshwater Prawn

Systematic position

Phylum Arthropoda

Subphylum Mandibulata

Class Crustacea

Subclass Malacostraca

Order Decapoda

Genus *Palaemon*

Species *malcolmsonii*

Habits and Habitat:-

Palaemon is commonly known as prawn. It is found in freshwater streams, ditches, lakes, ponds, rivers and reservoirs. It is a nocturnal animal hiding at the bottom during the day and coming to the surface at night in search of food. It is omnivorous, feeding on small organisms, like algae, minute insects, mosses, debris etc. It walks slowly at water bottom with the help of its 10 walking legs and swims actively to the surface with the help of its 10 pleopods.

8.4.1- STRUCTURE

External Morphology

1. Shape and size. Body of *Palaemon* is elongated, spindle shaped and bilaterally symmetrical. The size of *Palaemon* varies from species to species. *P. malcolmsonii* found in Bengal, Tamilnadu and Central India and measures about 30 cm, *P. carcinus* varies upto 90 cm in length while *P. lamarrei* measure only 2.5-5.0 cm in length.

2. Colour. *Palaemon* species are of pale-yellow and greenish color with brown tinge or with orange-red patches. Preserved specimens become deep orange-red.

3. Body Divisions. Body of adult prawn is distinctly divided into 19 segments, all bearing jointed appendages. The body can be divided into two regions:

(1) Anterior Cephalothorax

(2) Posterior Abdomen

1. Cephalothorax. Cephalothorax is a large, rigid, unjoited, immovable and cylindrical structure. It consists of 13 segments, 5 of the head region, and 8 of the thorax region, all bearing jointed appendages (kotpal).

2. Abdomen. Abdomen is rounded dorsally and compressed laterally and consists of 6 movable segments and a terminal conical structure, called telson. Each abdominal segment bears a pair of jointed appendages called pleopods or swimmerets (Fig. 12) (Rastogi, 2015).

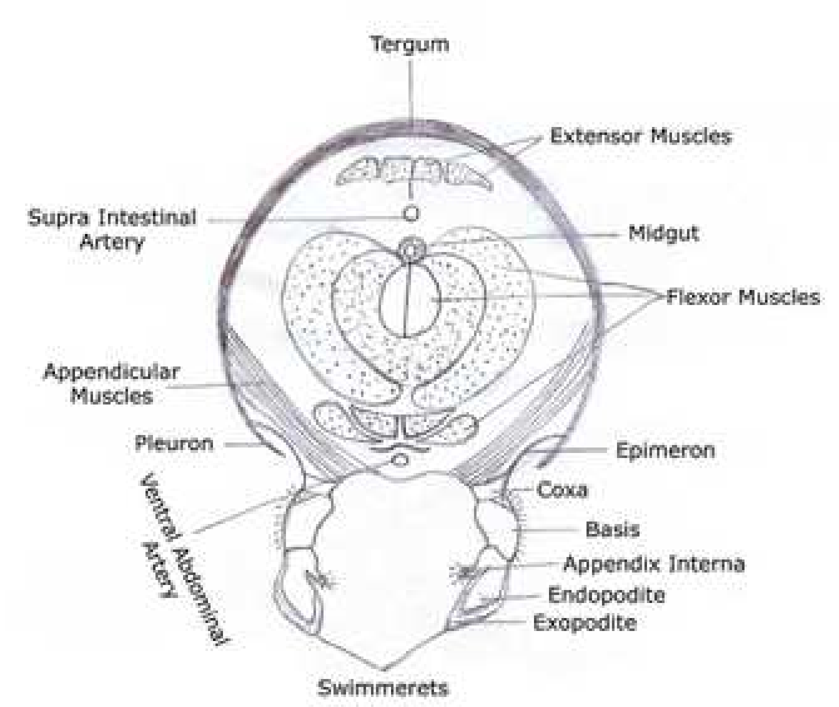


Fig.12 Palaemon T.S of Abdomen

4. **External Apertures**.

At the anterior end of cephalothorax is a mid-ventral slit-like aperture called mouth. Anus is a longitudinal aperture situated mid-ventrally at the base of telson. Renal apertures are paired apertures found on a papilla at the inner surface of coxa of antennae. Male genital apertures are present in male prawn on the inner surface of coxae of fifth pair of walking legs. Female genital apertures are present on the inner surface of coxa of third pair of walking legs. Openings of statocysts are present in the roof of precoxae of antennules. Body and appendages are covered by a hard protective calcareous shell or exoskeleton. Exoskeleton of arthropods is light-weight, tough and composed of structural polysaccharide called chitin. In *Palaemon*, each segment of body bears a pair of jointed appendages. Each appendage consists of a common base (or protopodite) bearing two rami - an inner or median endopodite and an outer exopodite. An appendage that is composed of two branches is known as biramous.

In prawn there are 19 pairs of appendages, 13 in cephalothorax and 6 in abdomen. Cephalothoracic appendages further include 5 pairs of anterior cephalic appendages and 8 pairs of posterior thoracic appendages.

(I) Cephalic Appendages: These are: (i) Antennules (ii) Antennae (iii) Mandibles (iv) Maxillulae and (v) Maxillae

1. Antennules: The antennules are attached, one on either side, below the base of eyes-stalks. The protopodite is three segmented due to the intervention of a large precoxa between coxa and the body.The precoxa is large and dorso-ventrally flattened and coxa is short and cylindrical (Fig. 13).

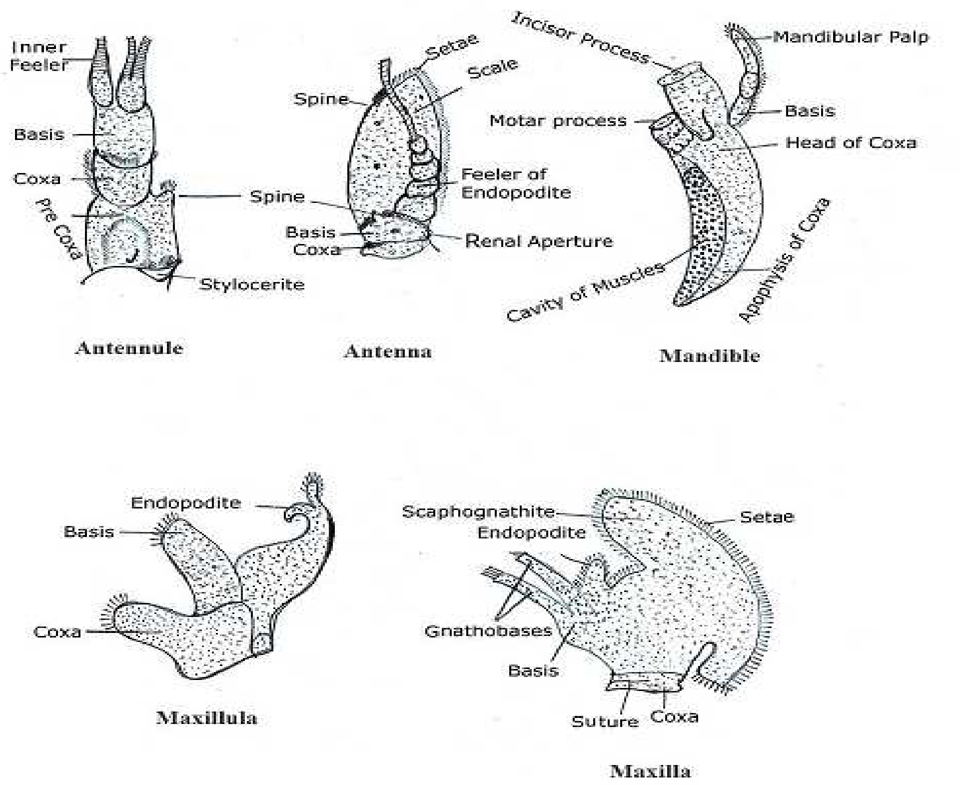


Fig. 13 ***Palaemon.*** **Cephalic appendages**

2. Antennae: The antennae lie, one on either side, just below the antennules. It consists of a protopodite, endopodite and exopodite. The protopodite is small, two segmented and swollen due to presence of excretory organ inside. Endopodite is represented by a many-jointed sensory feeler, while exopodite is in the form of a broad and leaf-like plate, the squama or scale.The antennae are sensory, excretory and balancing organs.

3. Mandibles: The mandibles are short, stout and highly calcified structures situated in the 3rd segment one on either side of mouth. It is differentiated into a triangular, hollow and spoon-shaped proximal part and a solid distal part of head. The latter can be further distinguished into inner molar process with 5 or 6 teeth and an outer incisor process terminating in three denticles. Mandibles constitute the biting jaws and are masticatory in function.

4. Maxillulae: These are small, delicate, thin and leaf-like appendages. Endopodite forms a curved process bifurcated at the apex. The exopodite is absent. Maxillulae help in the manipulation of food.

5. Maxillae: The maxillae are thin and leaf-like mouth appendages. The endopodite is quite small, while exopodite forms a large expanded, fan-shaped scaphognathite. Maxillae help in respiration and in the manipulation of food.

(II) Thoracic appendages

There are 8 pairs of thoracic appendages. Anterior appendages consist of first 3 pairs of maxillipedes or foot jaws and posterior appendages consist of 5 pairs of paraeopods or walking legs (Fig. 14).

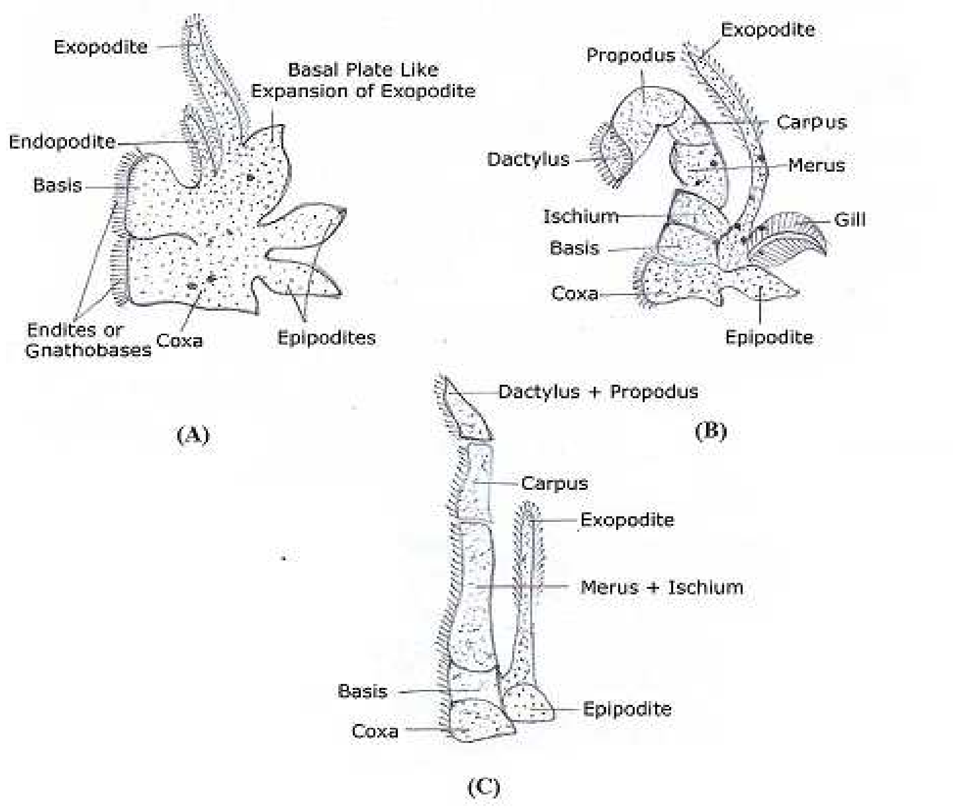


Fig. 14 ***Palaemon.*** **(A) First maxillipedes (B) Second maxillipedes (C) Third maxillipedes**

1. First maxillipedes. These are dorsoventrally flattened, thin, delicate, leaf-like structures present in first thoracic segment.The outer margin of coxa bears bilobed epipodite or the primitive gill. The basis carries a small endopodite and a long exopodite bearing setae along their whole length.

2. Second maxillipedes: Coxa bears an epipodite and a gill on its outer margin. The exopodite is unjointed and covered with setae but the endopodite is 5 segmented namely ischium, merus, carpus, propodus and dactylus. The last two podomeres are bent backwards and inwards and possess cutting margins.

3. Third maxillipedes: These are leg-like in appearance but possess same parts as 2^{nd} maxillipedes. Outer border of coxa bears an epipodite. Basis supports a long, slender and unsegmented exopodite covered with setae and a 3-jointed endopodite. The first podomere represents fused ischium and merus, the 2^{nd} carpus and the third represents fused propodus and dactylus.

4. Walking legs: The walking legs consist of a 2-segmented protopodite and 5-segmented endopodite. All the seven podomeres, namely the coxa, basis, ischium, merus, carpus, propodus and dactylus are arranged in a linear series and are movably hinged together. Unlike maxillipedes, they don't have any exopodite (Fig. 15).

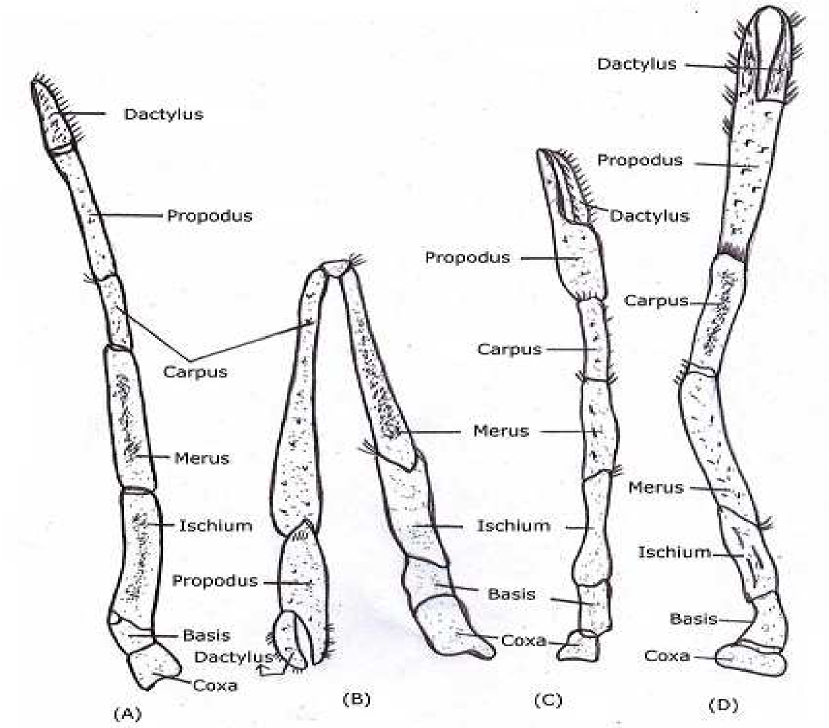


Fig. 15. ***Palaemon*. Thoracic legs**
(A) Typical or non-chelatae leg (B) First chelage leg
(C) Second chelate leg of female (D) Second chelate leg of male

1^{st} and 2^{nd} pair of walking legs: These are known as chelate legs due to the prolongation of propodus beyond its articulation and with dactylus to form a pincer-like or forcep-like structure. These are used to grasp the food and pass it to mouth (Rastogi, 2015).

3^{rd}, 4^{th}, and 5^{th} walking legs: These are typical nonchelate legs, 3^{rd} pair of walking legs in female and 5^{th} pair of walking legs in male bears the reproductive openings.

(III) Abdominal appendages

There are six pairs of abdominal appendages which are collectively known as pleopods or swimmerets. These help in swimming (Fig. 16).

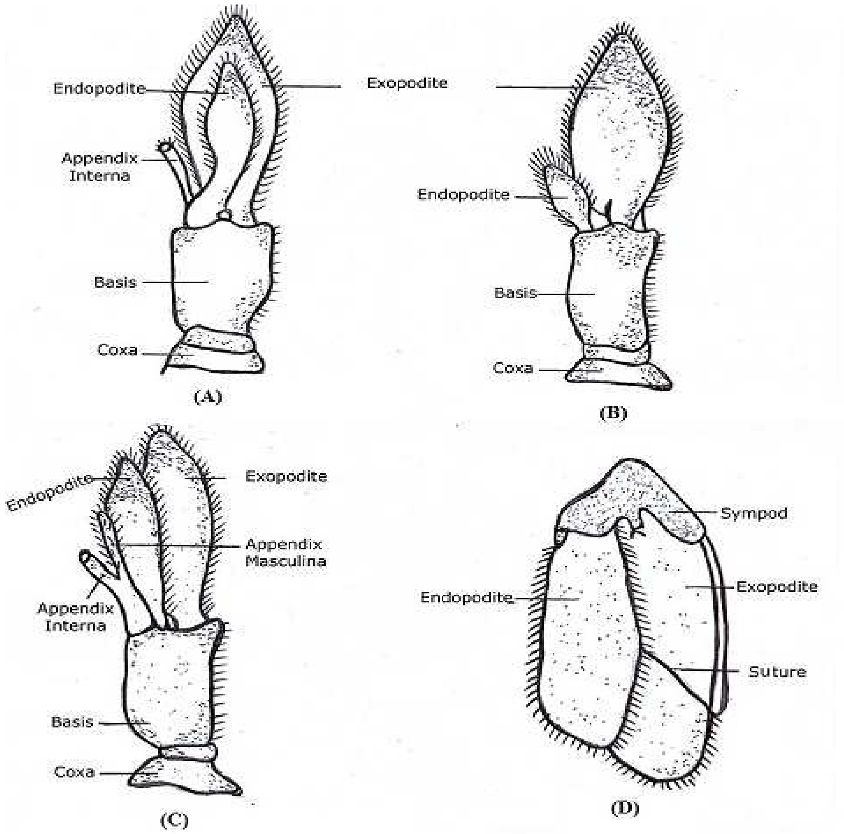


Fig. 16. ***Palaemon*. Abdominal appendages**
(A) Typical (B) First (C) Second of male (D) Uropod

1. First abdominal appendages: Endopodite is greatly reduced in size while appendix interna is absent.

2. Second abdominal appendages: The 2^{nd} pair of pleopods of male possesses an additional rod-like process (appendix masculine) in between the appendix interna and endopodite. Second pleopod of female is typical.

3. Third, fourth and fifth abdominal appendages: In a typical appendage, like the 3^{rd}, 4^{th} or 5^{th} pair, the protopodite consists of a ring-like coxa and a cylindrical basis. The basis bears flattened leaf-like smaller endopodite, and larger exopodite. Outer margin of basis and the free margins of exopodite and endopodite are fringed with setae.

4. Sixth abdominal appendages: The 6^{th} pair of abdominal appendages is called uropods. These are large, stoutly built structures present one on either side of telson. The coxa and basis are fused into a triangular sympod, bearing the oar-shaped endopodite and exopodite. Exopodite is bigger than the endopodite and partially divided in the middle by a transverse suture.

Nervous system of *Palaemon*:

1. Brain or supra-oesophageal ganglia: It is situated beneath the base of rostrum, in front of the junction of oesophagus with the cardiac stomach. The following nerves originate from the brain (Fig. 17).

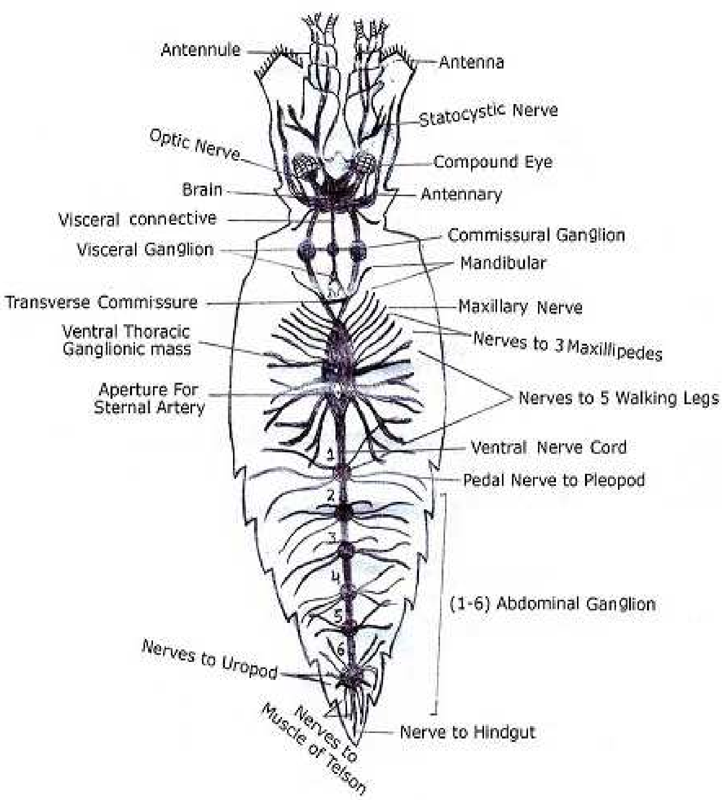


Fig. 17 Nervous system of Palaemon (prawn)

(I) Optic nerves: Optic nerves arise from the dorsal surface of the brain one on each side, and pass forwards and outwards in the eye stalks.

(II) Antennulary nerves: Antennulary nerves arising immediately behind and below the place of origin of optic nerves.

(III) Antennary nerves: Antennary nerves originate from the ventral surface of the brain. Each nerve runs obliquely downwards and forward to enter the base of antenna.

2. Circum-oesophageal commissures: Circum-oesophageal commissures arise from the hind end of the brain and run outwards and then downwards along the sides of the oesophagus and meet on the ventral side into suboesophageal ganglia which really form the anterior part of the extensive thoracic ganglionic mass. Each commissure presents a small commissural ganglion and a slender transverse commissure which connects the two circum-oesophageal commissures.

3. Ventral thoracic ganglionic mass: Ventral thoracic ganglionic mass is an elongated oval structure lying immediately above the thoracic sterna plates in the mid-ventral line. Following nerves originate from the ventral ganglionic mass:

(i) Mandibular nerves.

(ii) Maxillulary nerves.

(iii) Maxillary nerves.

(iv) Nerves to first, second and third maxillipedes.

(v) Neves to first, second, third, fourth and fifth pair of walking legs.

4. Ventral nerve cord: Ventral nerve cord lies in the mid-ventral line in the abdominal region. There are six abdominal ganglia which give nerves to appendages, muscles, uropods, telson and hindgut.

8.4.2- Reproductive system:-

The sexes are separate and sexual dimorphism is well marked.

1. The male is bigger in size than the female.

2. The abdomen of male is narrower than that of female.

3. The second chelate leg of male is longer, stronger and more spiny than one in female.

4. In male the second pleopod bears an additional process (appendix masculine) between endopodite and appendix interna.

5. The paired female reproductive apertures are situated on the inner side of coxa of 3^{rd} pair of walking legs and the male genital apertures are situated on the coxae of 5^{th} pair of walking legs.

6. In male, epimera of abdominal segments are smaller than that in female.

This external difference in the male and female organisms is called sexual dimorphism.

Male reproductive system:-

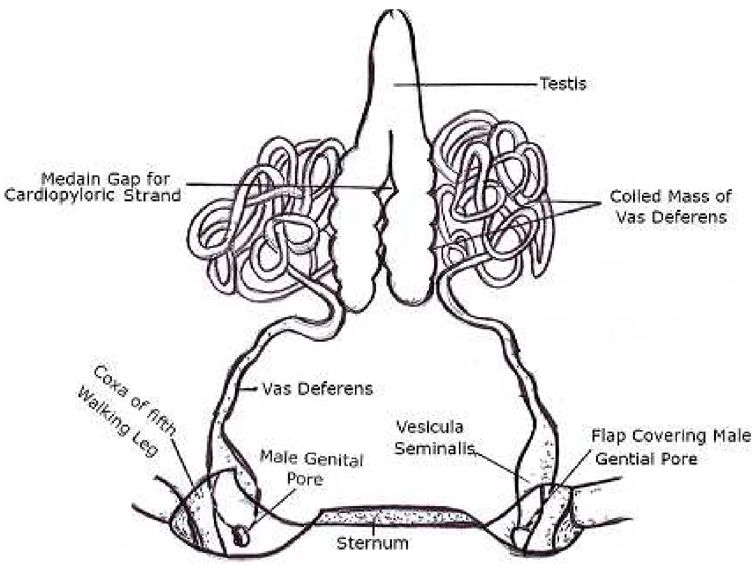
The male reproductive organs are:

1. Testis

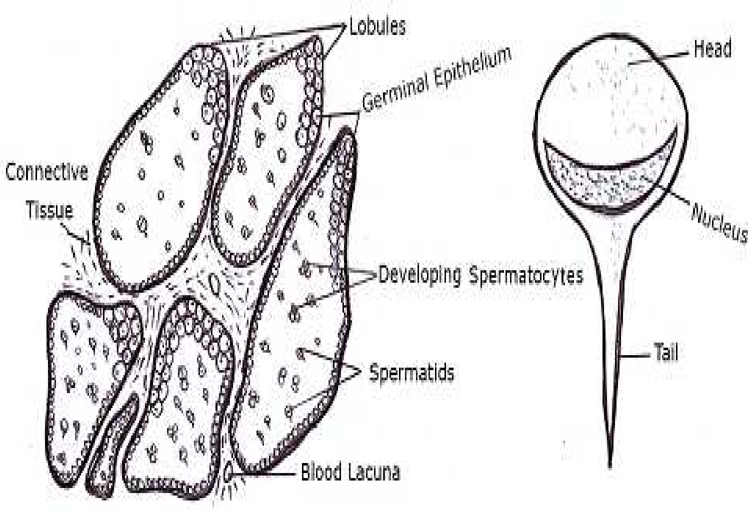
2. Vasa differentia

3. Vesicula seminalis

1. Testis: The testis is two in number and is soft, white and elongated. They fuse at their anterior ends to form a common lobe. The testis enclose a central space or gap which gives way to the cardiopyloric strand connecting the heart to the cardiac stomach. The testis consists of a large number of coiled, narrow, thin-walled seminiferous tubules embedded in connective tissue. Each seminiferous tubule is lined by a single layer of germinal epithelium. Each tubule is lined with germinal epithelium, the cells of which undergo spermatogenesis to form spermatozoa. A mature sperm consists of a rounded cytoplasmic body, containing a large, dark, crescentic nucleus, and a tail-like blunt process (Fig. 18).



A



B **C**

Fig. 18. Palaemon.

(A) Male reproductive organs

(B) A portion of testis in section showing seminiferous tubules

(C) A sperm

2. Vas deferentia: Vasa deferentia are a long coiled and narrow tube; the vasa deferens arises from each testis near its posterior end. It is differentiated into two parts - the proximal highly convoluted part (which emerges out of the testis) and the distal straight part (which runs vertically downwards between the abdominal flexor muscles and the thoracic wall). Each vas deferens reaching ventrally near the base of 5^{th} leg swells to form a club-shaped vesicular seminalis.

3. Vesicula seminalis: The vesicular seminalis acts as on organ of storage and contains sperms in the form of bundles. Each vasicula seminalis opens to the exterior through male genital apertures situated on the inner side of coxa of 5^{th} walking leg of its side. The genital pore is protected by a flap of integument.

Female reproductive organs: The female reproductive organs are:

1. 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 cardiopyloric strand. The size and shape of ovaries vary with age and the season of year. Each ovary consists of numerous rows of ova arranged radially and enclosed in a membranous capsule. Immature ova lie towards the centre while mature ova towards the surface of ovary (Kotpal). The ova are large nucleated cells with plentiful yolk contained as reserve food (Fig. 19).

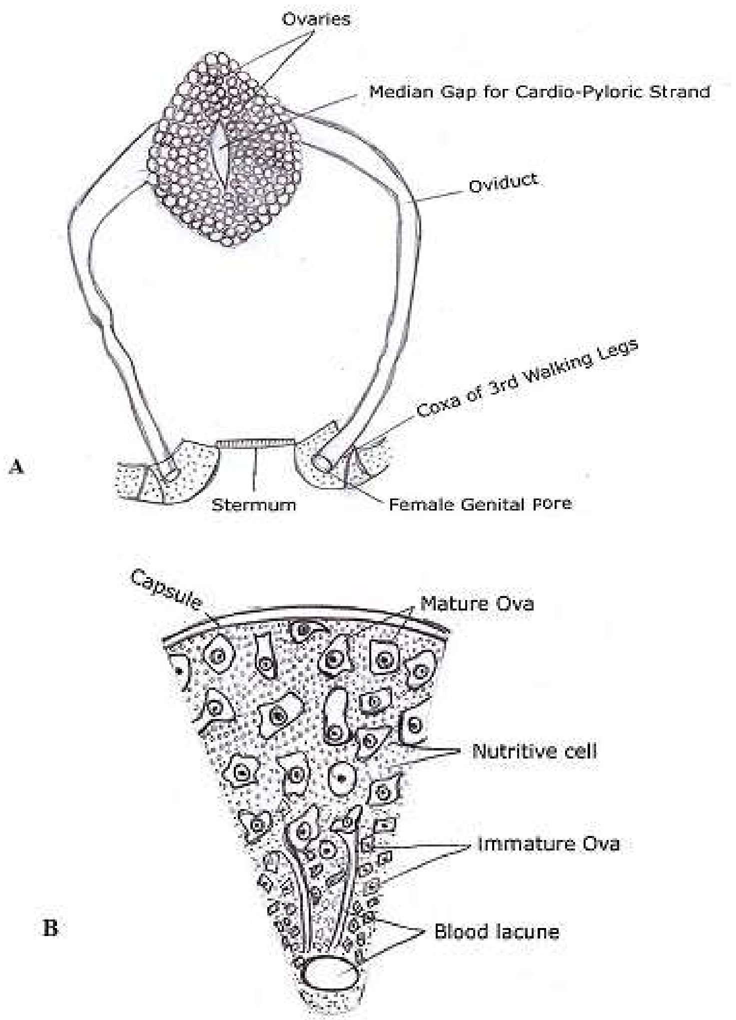


Fig. 19. ***Palaemon.***
(A) Female reproductive organs
(B) A portion of ovary in section (magnified)

Oviducts: From the middle of the outer surface of each ovary arises a short thin-walled tube known as oviduct. It opens outside through a female genital aperture on the inner side of the coxa of third walking leg of its side.

8.4.3- Life history and development:

1. Fertilization: Fertilization is external in *P. malcolmsonii.* It breeds during May, June and July. About two or three hundred mature eggs are laid by the female at one time in slimy stringe. The male deposits spermatophores near the genital opening of the female and the eggs get fertilized as they come out (Kotpal).

2. Development: Development is direct and the juveniles hatching out of the eggs resemble the adult except in size. The eggs hatch in 5 to 6 weeks and cling to the pleopods for some time. Prawns usually have a life span of 3 to 5 years.

8.5- Zoological importance of *Peripatus*

Peripatus belong to the phylum Onychophora (Gr., onyx=claw; pherein=to bear) and is considered to be a connecting link between Annelida and Arthropoda. *Peripatus* exhibits discontinuous distribution with its species scattered in most of the warmer parts of the world such as Australis, Africa, Central America, New Zealand, West Indies, Mexico, Malaya Archipelago and India. There are about 70 species in this phylum belonging to a few genera or possibly to one genus, *Peripatus*.

Habits and Habitat:

Peripatus is a terrestrial animal; living in moist places, in crevices of rocks, under stones, logs and bark and other dark and damp places where it is protected both from loss of water and also from the predatory arthropods. It is nocturnal in nature and predaceous and carnivorous in feeding habit.

External morphology:

Peripatus body is cylindrical, elongated and bilaterally symmetrical measuring 5-7 cm in length (Fig. 25). Outer covering or skin is velvety-like which is thrown into transverse wrinkles bearing numerous small papillae armed with spines. Head is not distinct. The anterior end bears a pair of antennae, a pair of simple eyes, a pair of jaws, and a pair of oral papillae. Mouth is ventral on the anterior side. Trunk bears a number of stumpy leg-like outgrowths (14-43 pairs) all along the length of the body (Fig. 26). There are unjointed and each one bears two claws. Anus lies at the posterior end of the body and behind the last pair of legs. Sexes are separate, fertilization is internal and the development is direct (Verma, 2015).

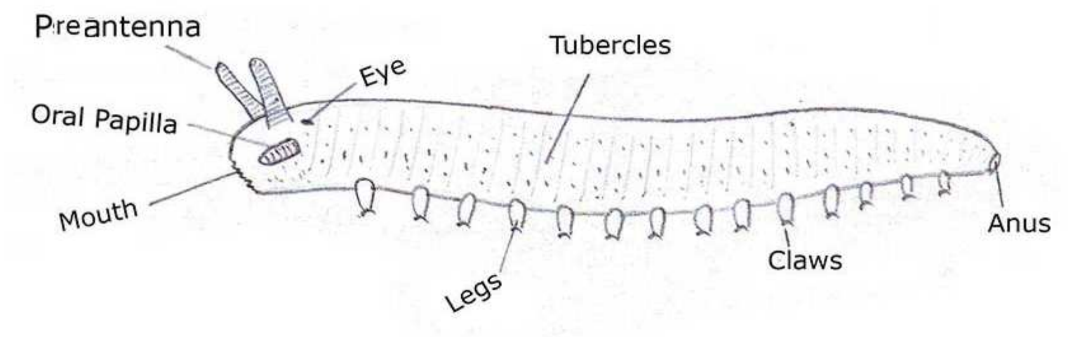
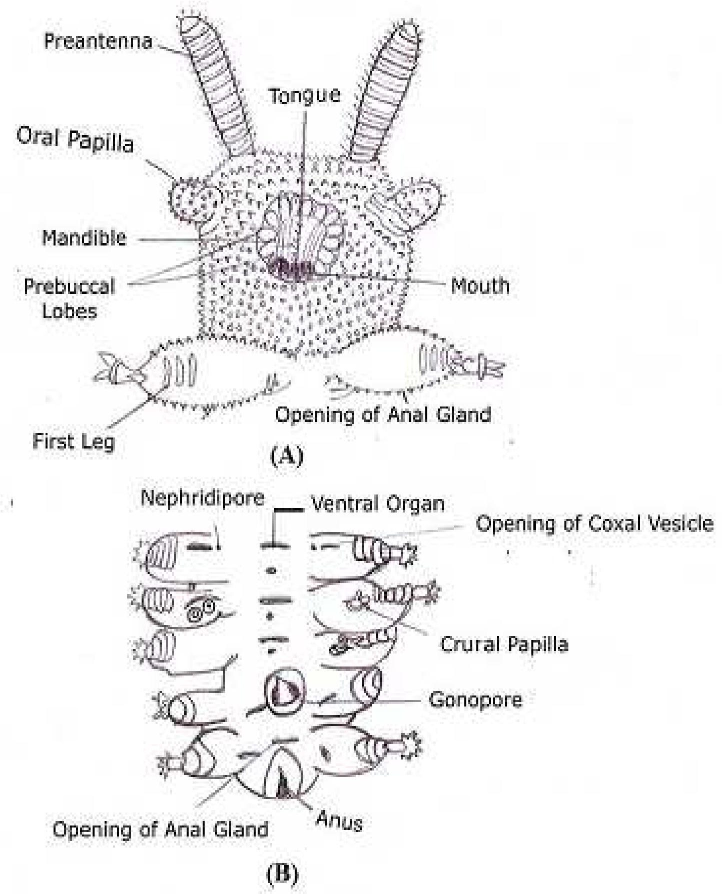


Fig. 25 ***Peripatus***



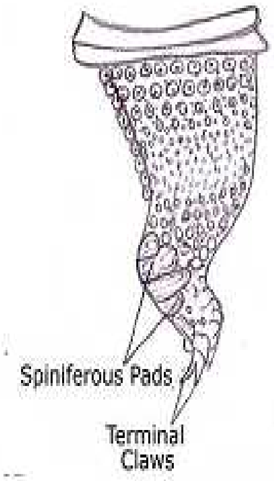


Fig. 26 *Peripatus* (A) Anterior end in ventral view (B) Posterior end in ventral view (C) A leg

Iternal morphology:

Body wall is dermomuscular and consists of cuticle, epidermis and dermis. Body cavity is in the form of haemocoel lined with epithelium. Mouth leads into alimentary canal via tongue (bearing sensory spines), pharynx, oesophagus, long stomach-intestine and a short rectum. Respiration happens via tracheae. Excretory organ consists of a pair of metanephridia containing ciliated funnel and nephrostome in each segment. Nervous system consists of a pair of suprapharyngeal ganglia or brain with two circumpharyngeal connectives and a pair of widely separated lateral longitudinal nerve cords connected together by transverse commissures. Ganglia on the cords are indistinct. Sensory organs are a pair of eyes near the base of antenna, taste spines on the lips and preoval cavity and tactile spines on the surface of tubercles. Female reproductive organs include a pair of ovaries, a pair of oviducts and a pair of uteri. The uteri join together to open outside through a common vaginal opening. The male reproductive organs have paired testes, seminal vesicles, vasa deferentia and genital opening (Fig. 27).

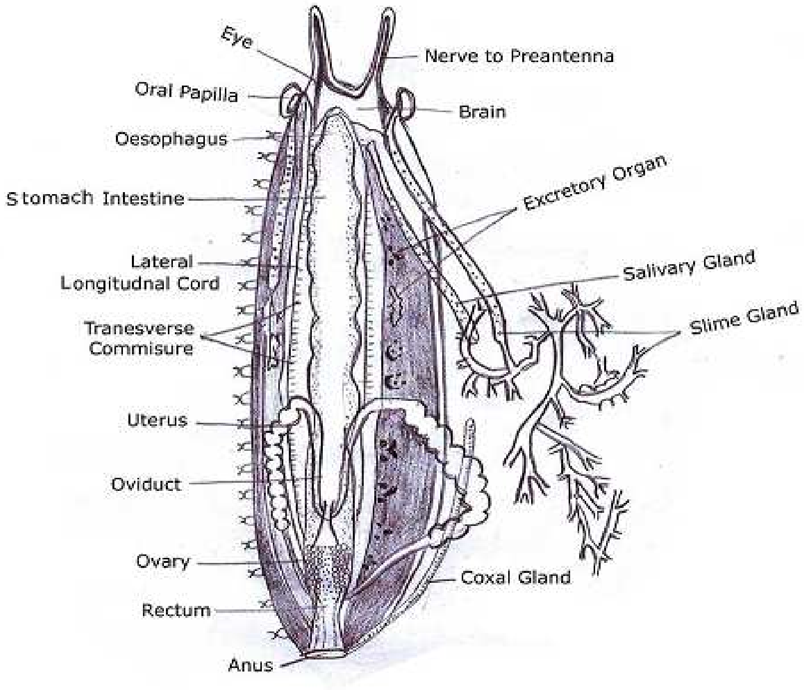


Fig. 27 *Peripatus* Internal structures

Affinities of *Peripatus*: Despite having no economic importance *Peripatus* is zoologically interesting because it exhibits both annelid and arthropod characteristics besides having peculiarities of its own.

Phyla characteristics those are similar to that of *Peripatus*:

(I) Annelidan characteristics:

1. Vermiform body and dermo-muscular body wall with underlying longitudinal muscles.

2. Absence of a true head.

3. Structure of the simple eyes as in polychaetes.

4. Legs are in the form of unjointed hollow stumpy outgrowths resembling to parapodia of annelids.

5. Locomotion happens via slow peristalsis as in earthworm.

6. Simple, straight alimentary canal with a terminal mouth and anus.

7. Presence of segmentally arranged nephridia.

8. Presence of cilia in the excretory and reproductive ducts.

(II) Arthopodan characteristics:

1. Cuticle has a thin deposit of chitin, like that of arthropods.

2. Presence of jaws, antennae, spines and claws.

3. Body cavity is haemocoel.

4. Locomotion by definite legs, having definite musculature and provided with claws.

5. Presence of a tracheal respiratory system.

6. Coelom reduced to small cavities and is present around the excretory and reproductive ducts.

7. Presence of modified nephridia.

8. Brain is large and typically arthropodan.

9. Reproductive organs and development is of arthropodan type.

Peripatus differs from other phyla in following ways:

(I) Onycophoran characteristics:

1. Body shows no or indistinct external segmentation.

2. Cuticle is rough and is covered with numerous velvety processes. These are not found in any other phyla.

3. Antennae not homologous to the antennae of other arthropods.

4. Three-segmented head of Peripatus shows a condition mid-way between that of annelid and arthropoda.

5. Eyes less complicated.

6. Single pair of jaws.

7. Non-jointed legs with claws.

8. Tracheal openings and irregular distribution of spiracles.

9. Ventral nerve cords widely separated and without ganglia.

10. Distribution of reproductive organs unique.

(II) Molluscan characteristics:

Peripatus was previously included with mollusca due to slug-like appearance of its body and ladder-like nervous system, as found in Amphineura and Prosobranchiata.

Taxonomic Position:

Onychophora have both annelidan and arthropodan characteristics. *Peripatus* is of great biological significance as it is regarded to be a connecting link between annelida and arthropoda. It appears to be more closely allied to arthropods than to annelids and arose as an offshoot from near the base of arthropod line.

Manton (1958) and other contemporary zoologists considered onychophora as a class of Arthropoda but others put it with annelids due to the absence of exoskeleton and jointed limbs, and due to the presence of certain annelidan characters. Strictly speaking *Peripatus* is neither an annelid nor arthropod, but has distinctive characteristics of its own. Therefore, onychophora is now-a-day treated as a separate phylum.

8.6- Mouth Parts of Insects

Insects feed on animals and plants in diverse ways and their mouthparts have become modified for those purposes. Important types of insect mouthparts can be described as follows:

Biting and chewing type: Biting-chewing mouthparts represent the most primivitve and unspecialised type which appeared in early insects in the course of evolution. This type of mouthpart is common among orthopteran insects such as grasshoppers, cockroaches and crickets (Fig. 20). Some other species like - termites, beetles, silver fish, earwigs, book lice, bird lice as well as some hymenoptera and many larval forms, specially the caterpillars of lepidoptera, falls under this category. This type of mouthparts consist of labrum (or upper lip), paired maxillae (first maxillae), labium (second maxillae), a pair of mandibles, epipharynx and hypopharynx. Maxillary palps act as sensory feelers to locate the food. Mandibles work by two set of muscles and masticate food with a teeth like process. *Ligula*, formed by paired and glossae paraglossae helps in pushing the food into pharynx.

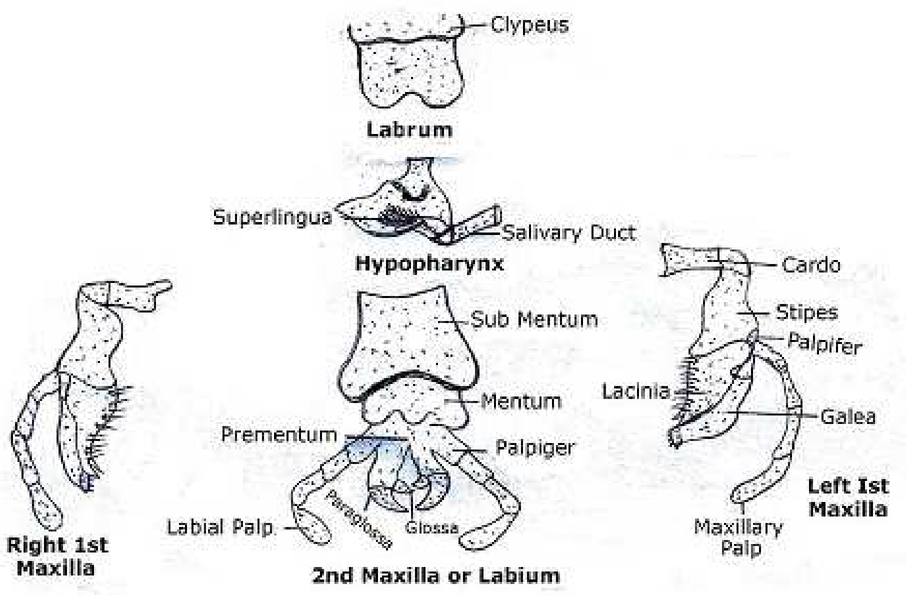


Fig. 20. Mouth parts of *Cockroach*

Piercing and sucking type: Piercing-sucking mouthparts are found in blood-sucking insects like mosquitoes, in bugs such as the bedbug and kissing bug, and in herbivorous insects such as aphids, which feed on plant juices. In this type the mandibles and maxillae resemble fine needles, meant for piercing the skin. Labium forms a hollow grooved channel which encloses these needles.

In mosquitoes the mouthparts consist of a long proboscis which has labium, forming an elongated, fleshy and mid-dorsally grooved tube. It encloses the needle-like stylets, formed by the modifications of the maxillae, mandibles and hypopharynx. Needle-like labrum is fused wih epipharynx and forms long covering of the open groove of proboscis. Two small labellae, at the tip of proboscis, are used as feelers and enables the mosquito to select appropriate part of its victim to attack. Mouthparts are well developed in female mosquitoes as they feed on blood (Fig. 21).

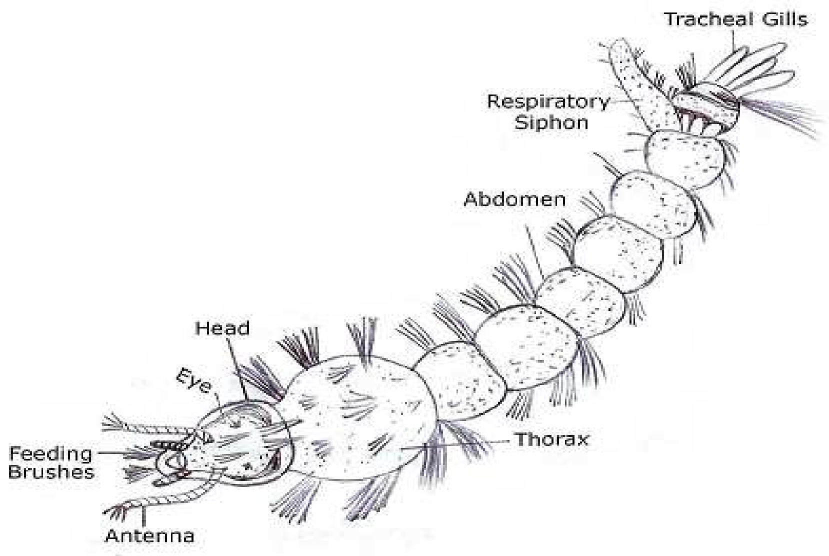


Fig. 21 Larva of *Culex*

Chewing and lapping type: Chewing-lapping mouthparts occur in honey-bees and bumble-bees (Fig. 22). Such mouthpart consists of a long tongue, which is formed from the glossae of the labium, ending in a spoon-shaped labellum. A temporary food channel is formed by the proboscis, galeae and labial palps fitting together. Through this food channel the liquid food flows up, assisted by the pumping action of the pharynx. Mandible and labrum helps in chewing the food.

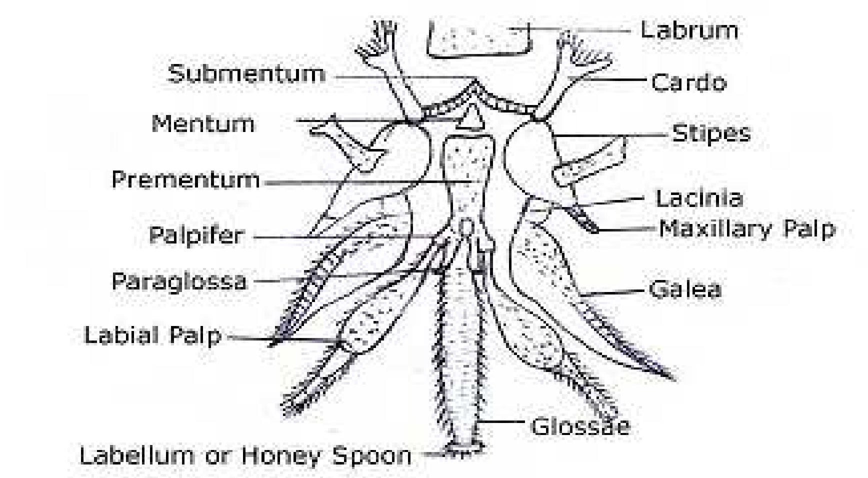


Fig. 22 Mouthparts of *Honeybee*

Sponging type: Sponging mouthparts are found in flies such as housefly. It helps in sucking up the liquified food. Flies having such mouthparts lack the cutting weapons of the insects that chew food. Mandibles are altogether absent, while the maxillae are represented only by two maxillary palps, each made of a single piece. Labium is greatly modified to form the so-called proboscis, which can be divided into three parts. (i) A proximal cone-like rostrum bearing the maxillary palps (ii) A middle haustellum with a mid-dorsal groove, serving as food passage and a ventral heart-shaped plate called theca (iii) A distal labellum consisting of two expanded lobes or labellae (Fig. 23).

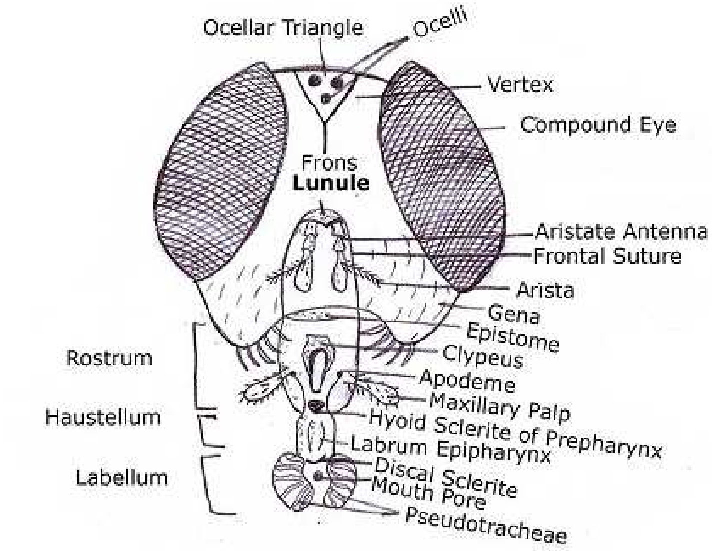


fig. 23 Head and mouthpart of housefly

Siphoning type: Siphoning type of mouthparts is found in butterflies and moths that feed on nectar (Fig. 24). In such mouthparts the maxillae form the main proboscis and not the labium. Mandibles and labium are much reduced, the maxillary palps are rudimentary and labium forms a triangular plate bearing labial palps. Galeae are much coiled and elongated, each forming a half tube, which makes complete tube when both are locked together. When not in use the proboscis is coiled beneath the head and it uncoils (to reach the nectar) during feeding process. It is the rise in blood pressure which uncoils the proboscis.

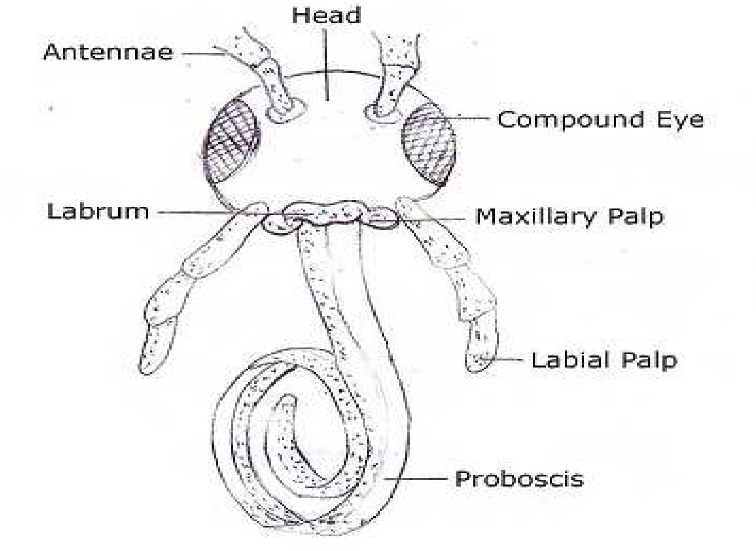


Fig. 24 Mouthparts of Butterfly

8.7- Social insects and their economic importance:

Social insects are any of the numerous species of insects that live in colonies and manifest three important characteristics – Group Integration, Division of labor & Overlap of Generations. Social insects, unlike the majority of insect species, live in organized groups. Social insects include wasps, bees, ants, termites etc. They reproduce cooperatively & share resources like food & shelter. These insects are differentiated into various castes based on their structure, function & behavior – like reproductives (e.g. Queen) and Steriles (e.g Workers and Soldier). Characteristically an insect society is formed of a parent or parents and a large number of offspring.

The individual members of the society are divided into groups, each having a specialized function and often exhibiting markedly different bodily structure. Some of the well known social insects are Gypsy moth (*Lymantria dispar dispar*- a pest of hardwood trees in North America), Corn earworm or cotton bollworm (*Helicoverpa zea* - a major agricultural pest), Indian meal Moth (*Plodia interpunctella* - a major pest of grain and flour), Codling moth (*Cydia pomonella* - a pest mostly of apple, pear and walnut trees), Light brown apple moth (*Epiphyas postvittana* - a highly polyphagous pest), Silkworm (*Bombyx mori* - for its silk), Wax moths (*Galleria mellonella*, *Achroia grisella* - pests of bee hives).

Social insects are among the most dominant and prolific of all organisms on earth. Social Insects are an important factor of the eco-system as well. The Social Insects are known to eat debris and left-over food so that the earth is not inundated with waste products As social insect groups grow, they evolve more differentiation between members but reintegrate into a more closely organized system known as eusocial. These are the most advanced societies with individual polymorphism, and they contain insects of various ages, sizes, and shapes. All the eusocial insects are included in the orders Isoptera (termites) and Hymenoptera (wasps, bees, and ants) (Wikipedia).

Termites:-

Termites belong to the order Isoptera and are eusocial insects. Termites are sometimes called white ants. They may resemble ants in size, but ants have a narrow waist and elbowed antennae while termites have a thick waist and antennae that resemble a string of beads. Ecologically, termites play an important role in the environment by helping to break down and recycle dead wood and other plant tissues. They become pests when their appetite for wood and wood products extends to human homes, fence posts, building materials, cardboard, and other valuable products. In tropical and subtropical forests where termites are abundant, railroads must use expensive metal ties because wooden ones are quickly destroyed.

The termites feed primarily on the cellulose and lignin found in plant cell walls; these compounds are the main ingredients of wood and all paper products. Termites cannot digest the cellulose directly so they rely upon symbiotic bacteria and protozoa living within their intestines to supply most of the enzymes needed for cellulose digestion.

The Termite Caste System: The termites live in a nest or colony of hundred, thousand, or even million. The colony consists of various groups of individuals having different functional roles according to a "caste system".

The worker caste is the largest group. They are blind and white in appearance. They navigate with their antennae rather than their eyes. These soft-bodied, wingless individuals perform all of the hard labor in the colony: they clean, maintain, and repair the nest, gather food and water and care for the young. They construct new tunnels and galleries using mud, saliva and faeces. Some of them may become soldiers or reproductives, but most will spend their entire lives as workers. Members of **the soldier caste** are larger in size but fewer in number than the workers. They are also wingless, but they have large heads with powerful jaws. They are pale yellow brown in color & have enlarged head & mandibles. Their enlarged jaws prevent them from feeding themselves and they rely upon workers to assist them in this task. Their job is to guard the nest site and protect it from attacks by ants or other invaders. In some species they have a large gland in the head that shoots defensive chemicals through a nozzle at the front of the head.

The reproductive caste always includes a king (male) and a queen (female) who are the parents of the termite family and founders of the colony. These are the only adult insects in the colony. The queen lays large numbers of eggs which develop into more workers and soldiers as the family grows. Large colonies with multiple reproductives may split into two or more daughter colonies, a process known as "budding". Termite queens have the longest lifespan of any insect in the world, with some queens living up to 50 years.

The termite's caste system is regulated by pheromones. Pheromones regulate how many members of each termite cast are produced or may regulate workers from becoming reproductive. More than 2000 different species of termites are known. These can be divided into two groups: those that live entirely within wood, and more advanced species that live in tunnel and nest in the soil. The primitive species often have specialized habitat requirements, nesting only in rotten, damp, or dry woods. Their colonies are rather small and persist only as long as the food resource lasts. All wood-dwelling termites produce distinctive waste pellets which are often the first sign of an active infestation. In contrast, the subterranean termites construct underground nests and have the ability to tunnel through the soil to find new food resources. Termites are a delicacy in the diet of some human cultures and are used in many traditional medicines. Several hundred species can cause serious damage to buildings, crops or forest plantations thereby incurring economic losses.

Ants:-

Ants are common insects with some unique capabilities. There are more than 10,000 species of ants in the family Formicidae -- all of them are eusocial. There are more species of ants than all other social insects combined. They are also the most ecologically diverse group in terms of distribution, life history, feeding strategies, and specialized adaptations. Like all insects, Ants have three distinct body parts – head, thorax & abdomen.

Ants are the most ecologically diverse of all social insects. The following list includes some of the more common groups.

• Harvester Ants usually live in arid environments and feed primarily on seeds. Many species build elaborate underground nests that may reach depths of six feet or more.

• Army ants are nomadic predators that do not have permanent nests. They include legionary ants which live in South America, and driver ants which live in Africa.

• Slave-maker ants raid the colonies of other species and steal worker larvae and pupae. Once the slaves mature, they work for their "owners" until they die.

• Leafcutter ants (also known as parasol ants) are gardeners. They chew up plant leaves into a pulp and use it to fertilize a fungus they grow for food in underground gardens.

• Weaver ants build nests in trees. Workers interlink their bodies, pull branches into position, and tie the leaves together with silk spun by their larvae.

• Honey-pot ants feed on honeydew excreted by aphids. Some workers engorge themselves with food reserves until their abdomens swell to the size of marbles.

• Fire ants are an invasive species with a very painful sting. They respond aggressively to any disturbance of their nest.

• Thief ants are very small. They raid the food supplies of larger ants and then escape through tunnels that are too small for the bigger ants to enter.

• Carpenter ants build their nests in wood. Unlike termites, they do not eat the wood but they may still cause serious damage to homes and other wooden structures.

Ants are social insects & are divided into three castes – Workers, Males & Queens. Workers are sterile, wingless females. Males are almost same sized as workers, winged and have a small head with proportionally large eyes. Their sole purpose is to mate with the new queens and they die shortly after mating. Queens are largest members of the colony, often 2-3 times larger than workers. Queens can live for very large number of years.

Regulation of caste in ants is not well-understood. Apparently, all female eggs are identical when laid. Whether they mature into minors, majors, soldiers, or new queens depends on the care and feeding they receive as they grow and mature.

Bees:-

Bees are flying insects and close relative of wasp and ants. A vast majority of these species are solitary and do not produce honey. One of the most important species of bees is honey bee, *Apis melifera.* Bees exhibit complete metamorphosis. The young and the adults look very different and have different diets also. The bee life stages are egg larva, pupa and adult. Bee castes consist of workers (sterile females), drones (fertile males) and queen. Workers have a typical life span of a month and are responsible for collecting the nectar. Unlike workers drones can't fly and don't gather food from the colony. The role of the drones is largely to fertilize new queens and die immediately afterwards. Drones typically live for about 50 days. Queens can be distinguished from others due to their large size. Queens have the longest life span of all the bees within the hive. Their major role is to lay eggs. A queen controls the social organization within her colony by means of a pheromone secreted from her mandibular glands. A typical honey bee colony consists of tens of thousands of sterile workers and hundreds of drones and only a single queen.

Some bees collect nectar and then convert it into honey. This process occurs in the bee's crop where sucrose in the nectar undergoes enzymatic conversion into glucose and fructose. The honey is regurgitated for storage or mixed with pollen and fed to developing larvae. Some bees have abdominal glands that secrete wax. This wax, alone or mixed with other substances, is often used for construction of the nest site. Several bee products are economically significant the two most significantly used around the world are honey and wax. Honey is used in many ways by man also as the chief source of natural sweet in preparing candies, cakes and bread, jellies, jams etc. It forms a very important food for patients of diabetes or for persons undergoing very strenuous physical exertion. Bee wax is made of secretion of worker bees' abdominal glands. It is a product of industrial importance. It is used in the manufacture of many items including cosmetics, lotions, ointments, face cream, shaving cream, toothpaste, carbon papers, pencils, protective coating, ink, candles, plasters, paints, furniture-polishes, boot-polishes and electric goods. It is also used in model and mould making and in printing industry.

The honey bee communicates the location of nectar bearing flowers to its co-worker by using special form of dance language. It begins by regurgitating and distributing nectar to bees waiting in the hive. Once her generosity has garnered an audience, the dancing begins. There are two types of bee dances: the round dance and the tail-wagging or waggle dance, with a transitional form known as the sickle dance. The round dance is used for food sources around 100 meters away from the hive or closer. In this dance form the bee distributes some nectar to its co-workers in the hive and begin running in a small circles, switching direction every so often. After the dance ends, food is again distributed and the dance may be repeated three or more times. As the food source becomes more distant the round dance is replaced by the waggle dance. The waggle dance is performed by bees foraging at food sources that are more than 100 meters from the hive. This dance, unlike the round dance, communicates both distance and direction. A bee that performs a waggle dance runs straight ahead for a short distance, returns in a semicircle to the starting point, runs again through the straight course, then makes a semicircle in the opposite direction to complete a full figure-eight circuit. The duration of the straight run, measured in seconds, is an indicator of the distance of the food source. The orientation of the dancing bee during the straight portion of her dance indicates the location of food source relative to Sun.

Wasps:-

A wasp is any insect (that is neither a bee nor an ant) of the order Hymenoptera and suborder Apocrita. Eusocial behavior among wasps is found only in certain members of the family Vespidae. This means that wasps are paraphyletic with respect to bees and ants, and that all three groups are descended from a common ancestor. Wasps are a diverse group, estimated at over a hundred thousand described species around the world, and a great many more as yet undescribed. Insects known as wasps include the sawflies, the parasitic wasps and the stinging wasps. Wasps are characterized by two pair of membranous wings and an ovipositor. Wasps have a complete metamorphosis with four stages in their life history: egg, larva, pupa, and adult. There are males and females of most species of wasps. However as with most species in the order Hymenoptera, males are normally produced from non-fertilized eggs in a developmental process known as parthenogenesis. Female wasps develop from fertilized eggs and are usually much more abundant than males. In some species, male wasps are not even known to occur (Wikipedia).

Although some wasps are solitary, i.e. just one adult female per nest, most live a social life. Solitary wasps are relatively small insects that build their nests in burrows in the ground or out of mud on an exposed surface. The nest is then provisioned with an insect or spider that has been paralyzed by stinging and upon which one or more eggs are laid. The prey serves as a living but immobile food for the developing larvae of the wasp. Although quite small, parasitic wasps can be rather abundant, and they can exert a substantial measure of control over the populations of their prey species.

In contrast, the social wasps are relatively large insects that live in colonies of various sizes. These wasps develop colonies with three castes: workers, drones and queens. Workers are infertile females that do the labour & protect their colonies from invaders using their stings. The drones are relatively short-lived fertile males and serve only to fertilize the queens. The queens are long-lived wasps, and their major function is to initiate a colony and then spend their life laying eggs. Once a colony is established, the eggs and young are tended by workers which are non-fertile female wasps that can be very numerous in large colonies. Social wasps cooperatively feed their developing young on a continuous basis, often with chewed-up insects and other animal-derived foods.

They can be divided into three groups:

• **Yellow Jackets**: They usually build nests in underground cavities, such as old rodent burrows.

• **Hornets:** Nests are always located above ground. Some species colonize hollow trees while others hang brood comb from a tree branch and surround it with paper walls for protection against the weather and natural enemies.

• **Common Paper Wasps:** Nests are typically found under sheltered overhangs where they are protected from wind and rain. Their colony could be as big as 100 wasps living together in a nest.

Wasps have a great economic value. They help control arthropod pests by preying on them thereby reducing use of pesticides. While yellow Jackets feed on dead insects, the Paper & Hornet wasps provide great pest control services by preying on live insects. Wasps are an important source of pollination of figs too.

8.8- Summary:-

Phylum arthropoda (Gr., arthros = joint + podos = foot) is the largest phylum and most varied in the animal kingdom. Arthropods are mainly terrestrial but marine and freshwater species are also well known. Arthropod bodies are divided into segments.

A number of segments are sometimes fused to form integrated body parts known as tagmata. This process of fusion is called tagmosis. The head, thorax, and abdomen are examples of tagmata. However, in most species some appendages have been modified to form other structures, such as mouthparts, antennae, or reproductive organs. Arthropod appendages may be either biramous (branched) or uniramous (unbranched).

Arthropods have a well-developed, mesodermal, solid nerve cord, ventral and well-developed sense organs. They range in size from microscopic plankton to life-forms that are a few meter long. Arthropods primary internal cavity is known as hemocoel.

Respiration occurs in various ways for e.g. some species have gills, while others employ tracheae, or book lungs. Generally, the sexes are separate in phylum arthropoda.

Fertilization usually occurs internally, and most species are egg laying. While some species exhibit direct development, in which eggs hatch as miniature versions of adults, other species pass through an immature larval stage and undergo a dramatic metamorphosis before reaching adult form. Some specific species are known to spread severe disease to humans, livestock, and crops.

Palaemon is commonly known as prawn. It is found in freshwater streams, ditches, lakes, ponds, rivers and reservoirs. It is a nocturnal animal hiding at the bottom during the day and coming to the surface at night in search of food.

It is omnivorous, feeding on small organisms, like algae, minute insects, mosses, debris etc. It walks slowly at water bottom with the help of its 10 walking legs and swims actively to the surface with the help of its 10 pleopods.

Body is elongated, spindle shaped and bilaterally symmetrical.The size of *Palaemon* varies from species to species. *P. malcolmsonii* measures about 25-40 cm, *P. carcinus* varies upto 90 cm in length while *P. lamarrei* measure only 2.5-5.0 cm in length.

Body of adult prawn is distinctly divided into 19 segments or somites, all bearing jointed appendages.

The body can be divided into two regions: (1) Anterior Cephalothorax (2) Posterior Abdomen. In prawn there are 19 pairs of appendages, 13 in cephalothorax and 6 in abdomen. Cephalothoracic appendages further include 5 pairs of anterior cephalic appendages and 8 pairs of posterior thoracic appendages.

The sexes are separate and sexual dimorphism is well marked. The male is bigger in size than the female. This external difference in the male and female organisms is called sexual dimorphism.

The male reproductive organs are: (1) Testes (2) Vasa differentia (3) Vesicula seminalis. The female reproductive organs are: (1) Ovaries (2) Oviducts. Fertilization is external in *P. malcolmsonii.*

It breeds during May, June and July. About two or three hundred mature eggs are laid by the female at one time in slimy stringe. The male deposits sperms near the genital openings of the female and the eggs are fertilized as they come out.

Important types of insect mouthparts can be described as follows: (1) Biting and chewing type (2) Piercing and sucking type (3) Chewing and lapping type (4) Sponging type (5) Siphoning type

Peripatus belong to the phylum Onychophora (Gr., onyx=claw; pherein=to bear) and is considered to be a connecting link between Annelida and Arthropoda.

Peripatus is a terrestrial animal; living in moist places, in crevices of rocks, under stones, logs and bark and other dark and damp places where it is protected both from loss of water and also from the predatory arthropods.

It is nocturnal in nature and predaceous and carnivorous in feeding habit. *Peripatus* body is cylindrical, elongated and bilaterally symmetrical measuring 5-7 cm in length. Outer covering or skin is velvety-like which is thrown into transverse wrinkles bearing numerous small papillae armed with spines.

Onychophora have both annelidan and arthropodan characteristics. *Peripatus* is of great biological significance as it is regarded to be a connecting link between annelida and arthropoda.

Social insects like termites, ants, bees and wasps dominate the environment in most terrestrial habitats.

Termites belong to the order Isoptera and are eusocial insects. Termites are a delicacy in the diet of some human cultures and are used in many traditional medicines. Several hundred species can cause serious damage to buildings, crops or forest plantations thereby incurring economic losses.

Ants are common insects with some unique capabilities. There are more than 10,000 species of ants in the family Formicidae -- all of them are eusocial. Ants are social insects & are divided into three castes – Workers, Males & Queens.

Bees are flying insects and close relative of wasp and ants. Bee castes consist of workers (sterile females), drones (fertile males) and queen.

Honey is used in many ways by man also as the chief source of natural sweet in preparing candies, cakes and bread, jellies, jams etc. The honey is a neutral, natural valuable tonic for human body.

Bee wax is made of secretion of worker bees' abdominal glands. It is a product of industrial importance. It is used in the manufacture of many items including cosmetics, lotions, ointments, face cream, shaving cream, toothpaste, carbon papers, pencils, protective coating, ink, candles, plasters, paints, furniture-polishes, boot-polishes and electric goods.

A wasp is any insect (that is neither a bee nor an ant) of the order Hymenoptera and suborder Apocrita.

They can be divided into three groups Yellow Jackets, Hornets and Common Paper Wasps.

8.9- Glossary:

Antenna.	The second cephalic appendage of copepods and branchiurans.
Antennule.	The first cephalic appendage of copepods and branchiurans.
Anterior.	Forward-moving end of animal.
Appendage.	A movable projecting part of the body.
Bilateral symmetry.	Symmetry with similarity on both sides.
Biramous.	Bearing two branches.
Carnivorous.	Meat or flesh-eating.
Cephalic.	Relating to or towards the head.
Cephalothorax.	The fused head and thorax.
Chelate.	Claw-possessing appendage.
Chelicera.	A pair of pincer-like head appendages of arachinids.
Fertilisation.	Union of a sperm with an ovum resulting in a zygote.
Gonopore.	The external opening of the reproductive system, the oviduct in the female and the vas deferens in the male.
Habitat.	Physical area of the occurrence of an animal species.
Hamocoel.	Coelom filled with blood.
Herbivorous.	Feeding on vegetation.
Integuments.	Covering of the body.
Larva.	An embryonic stage which is free living and self feeding and unlike the **parent**.
Lateral.	Relating to the side.
Maxilla.	The fifth and last pair of cephalic appendages.

Maxilliped.	The first pair of thoracic appendages, located on the last somite of the uniramous and typically modified for feeding or grasping.
Maxillule.	The fourth cephalic appendage. Historically referred to as the first maxilla.
Mouthparts.	The group of appendages near the mouth which are involved in feeding, comprising the paired mandibles, maxillules, maxillas, and maxillipeds.
Nocturnal.	Active at night.
Omnivorous.	Feeding on both plants and animals.
Organism.	A single complete living unit.
Oviparous.	Egg-laying animals.
Ovoviviparous.	Production of eggs that are retained and hatched within mother's body.
Plankton.	Minute free-floating organisms.
Posterior.	End of the body.
Segmentation.	Division of a body into more or less similar parts.
Species.	A population of interbreeding individuals.
Telson.	Terminal body part of certain arthropods.
Testis.	A male gonad.
Thorax -	the middle region of the body, comprising the seven postcephalic trunk somites from the maxillipedal to the genital.
Uniramous -	an appendage with a single ramus.
Ureotelic.	Animal whose nitrogenous excreta contain mainly urea.
Uricotelic .	Animal whose nitrogenous excreta contain mainly uric acid.
Viviparous.	An animal whose female gives birth to young.
Zygote.	Resultant of the fusion of male and female.

8.10- SELF ASSESSMENT QUESTIONS:

8.10.1- Long Answer type questions:

1. To describe the classification of arthropoda?
2. What is the economic importance of social insects?
3. What is the zoological importance of *Peripatus*?
4. Describe the mouth parts of insects?
5. Discuss the reproduction of *Palaemon*?
6. Write about the nervous system of *Palaemon*?

8.10.2- Short type questions:

1. What is the study of insects called?
2. Describe briefly Cancer?
3. Describe the various types of appendages of *Palaemon*?
4. Write about the general characters of arthropoda?
5. Write short notes on *Daphnia* and *Limulus*?

8.10.3-Fill in the blanks:

1. Division of the body into head, thorax and abdomen is a characteristic of……….

2. Bee-keeping is commonly known as……………

3. Lung books are the respiratory organs of…………….

4. *Musca domestica* is the zoological name of………..

5. Excretory product in an insect is…………..

Answer: (1) Insecta (2) Apiculture (3) Archinds (4) Housefly (5) Uric acid

Multiple Choice Questions:

(1) Metamerically segmented, bilaterally symmetrical animals bearing jointed appendages. These are characteristics of:

(a) Annilida (b) Helminths

(c) Arthropoda (d) Mollusca

(2) An animal without economic importance is:

(a) Honey bee (b) *Pheritma*

(c) *Peripatus* (d) Parasite

(3) *Peripatus* is connecting link between:

(a) Annelida and Platyhelminthes (b) Annelida and Mollusca

(c) Annelida and Arthropoda (d) Mollusca and Arthropoda

(4) *Peripatus* is:

(a) Herbivorous (b) Carnivorous

(c) Omnivorous (d) Parasite

(5) The excretory structure in *Peripatus* are:

(a) Nephridia (b) Malpighian tubules

(c) Coxal glands (d) Solenocytes

(6) Biting and chewing type of mouth parts occurs in:

(a) Grasshopper (b) Cockroarch

(c) Cricket (d) All

(7) Respiratory organs of crustaceans are:

(a) Gills (b) Lungs

(c) General surface (d) both gills and general surface

(8) Means of respiration in insects:

(a) Integuments (b) Blood gills

(c) Tracheal gills (d) Spiracular gills

(e) All

(9) The mouth parts of housefly are:

(a)Biting and chewing type (b) Sucking and sponging type

(c) Biting, sucking and lapping type (d) Piercing and sucking type

(10) Rearing of silkworm is known as:

(a) Aquaculture (b) Floriculture

(c) Sericulture (d) Apiculture

Answer: (1) c (2) c

(3) c (4) a

(5) c (6) d

(7) a (8) e

(9) b (10) c

8.11- References:

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UNIT 9:- PHYLUM MOLLUSCA

Contents

9.1 OBJECTIVES

1. The objective of this chapter is to understand the division of mollusca into different classes.

2. To understand different body parts and their functioning.

3. Detailed study of some important molluscs.

4. Understading habitat of *Pila*.

5. Understanding the nervous system and reproductive system of *Pila*.

9.2 INTRODUCTION

Phylum mollusca (L., molluscus, soft) includes soft-bodied invertebrate animals such as Octopods, snails, slugs, mussels, clams, oysters, tusk-shells, squids etc. The term mollusca were coined by Johnston. It is a diverse and widespread group, with about 112,000 species. Molluscs are the largest marine phylum, comprising about 23% of all the named marine organisms. Molluscs may be terrestrial or aquatic (freshwater or marine). They are found in all habitats - deserts, forests, lakes, rivers, abysses of sea, coral reefs, underground or even as parasite in the body of other animals. They may be found clinging to the rocks, crawling, and swimming, burrowing or even digging. They have diversified feeding habit and can be herbivores, carnivores or omnivores. They vary in size from giant squids (nearly 2m long) to little snails, a millimeter long. The largest of the molluscan classes is Gastropoda, which is represented by about 35,000 living and some 15,000 fossil species.

The three most universal features defining molluscs are - a mantle with a significant cavity used for breathing and excretion, the presence of a radula, and the structure of the nervous system. The "generalized" mollusc's feeding system consists of a rasping "tongue", the radula, and a complex digestive system. Although molluscs are coelomates, the coelom tends to be small, and the main body cavity is a hemocoel through which blood circulates; their circulatory systems are mainly open. The generalized mollusc has two paired nerve cords, or three in bivalves. Most molluscs have eyes, and all have sensors to detect chemicals, vibrations, and touch. The simplest type of molluscan reproductive system relies on external fertilization, but more complex variations occur. All produce eggs, from which may emerge trochophore larvae, more complex veliger larvae, or miniature adults.

Molluscan shells have always been economically important, having served as money in early days. They have been used in jewellery and buttons. *Octopus*, Scallops, oysters and squids are important food items. The scientific study of molluscs is called malacology.

9.3 GENERAL CHARACTERS AND CLASSIFICATION

9.3.1 General characters:-

1. Molluscs are essentially aquatic, mostly marine, few freshwater and some terrestrial animals.

2. Body is soft, bilaterally symmetrical, unsegmented and without jointed appendages.

3. Body can be divided into head, mantle, visceral mass and foot.

4. Body is commonly protected by an exoskeletal calcareous shell of one or more pieces, secreted by the mantle.

5. The head carries mouth, eyes and tentacles.

6. The mantle is a thick, muscular fold of body wall extended over the viscera and thus enclosing a space, the mantle cavity.

7. Visceral mass contains the visceral organs of the body in a compact form.

8. The foot is ventral in position and is usually thick and muscular being variously modified for creeping, ploughing and seizing but is absent in oysters.

9. Body cavity is haemocoel. The true coelom is generally limited to the pericardial cavity and the lumen of the gonads and nephridia.

10. Digestive system is complete. Digestive glands are liver or hepatopancreas. Radula is mostly present.

11. Circulatory system is closed type. Heart has one or two auricles and one ventricle.

12. Respiration direct or by gills or lungs or both. The respiratory pigment is haemocyanin.

13. Excretion is performed by nephridia or kidneys.

14. Nervous system consists of paired cerebral, pleural, pedal and visceral ganglia joined by longitudinal and transverse connectives and nerves.

15. Sexes are separating (dioecious) but some are hermaphrodita. Fertilization happens externally as well as internally.

16. Development is either direct or with metamorphosis through the trochophore stage called veliger larva.

9.3.2 CLASSIFICATION:-

Molluscs are classified into six classes according to their symmetry and also according to their food habits, shell, mantle, gill, nervous system, muscles and radula.

Class1. Monoplacophora (Gr., monos = one + plax = plate + pherein = bearing)

1. Body is bilaterally symmetrical and segmented. Mantle is dome shaped.
2. Shell is flattened and limpet-shaped with spirally coiled protoconch.
3. Foot is broad, flat and bears 8 pairs of pedal retractor muscles.
4. Five pair of gills which are in pallial grooves.
5. There are six pairs of nephridia out of which two are modified into gonoducts.
6. Intestine is highly coiled. Radula present in radular sac.
7. Heart consists of two pairs of auricles and a single ventricle.
8. Nervous system with longitudinal, pallial and pedal cords.

Examples: *Neopilina galatheae*.

Class 2. Amphineura (Gr., amphi = both + neuron = nerve)

1. Body elongated with reduced head.
2. Radula is present.
3. Shell as 8 dorsal plates or as spicules.
4. Foot is ventral, flat, large, and muscular.
5. Fertilization is external. Development happens via intermediate stage of trochophore larva.
6. Organisms are marine.

Subclass 1. Aplacophora

1. Body worm-like without shell and foot.

2. Radula is simple.

3. Calcareous spicules buried in cuticle.

4. A pair of bivalve ctenidia is present.

Examples: *Chaetoderma*, *Neomenia*, *Nematomerina*.

Subclass 2. Polyplacophora

1. Body is dorso-ventrally flattened; head small and without eyes and tentacles. Radulla, mantle, foot and external gills present.

2. Mantle cavity is present towards the back side.
3. Shell is in the form of 8 calcareous plates.

Order 1. Lepidopleurina

1. Shell valve are without plates.

2. Ctenidia few and posterior.

Examples: *Lepidopleurus*.

Order 2. Chitonida

1. Shell valve are with plates.

2. Gills along whole length of mantle groove.

Examples: *Chiton*, *Chaetopleura*, *Ischnochiton*.

Class 3. Scaphopoda (Gr., scapha = boat + podos = foot)

1. Exclusively marine.

2. Body bilaterally symmetrical, elongated and enclosed in a tusk-like shell open at both ends.

3. Head and eyes absent; mouth with tentacles.

4. Foot conical; radula present.

5. Kidneys are paired. Gonad is single.

6. Heart rudimentary.

7. Sexes are separate. Development includes trochophore larva.

Examples: *Dentalium*, *Pulsellum*, *Cadulus*.

Class 4. Gastropoda (Gr., gaster = belly + podos = foot)

1. Mostly marine, some freshwater, terrestrial, and few parasitic on echinoderms.

2. Includes snails and slugs.

3. Body unsegmented, asymmetrical and typically with a univalve, spirally coiled shell.

4. Head well developed and possesses eyes and tentacles.

5. Foot is large and flat.

Subclass 1. Prosobranchia

1. Mostly marine, few freshwater and terrestrial.

2. Body mass torted; head with a single pair of tentacles.

3. Shell closed by operculum.

4. Head distinct with snout bearing a pair of tentacles and a pair of eyes.

5. Foot is muscular and forms ventral part of the body.

6. Sexes are separate, gonad single, larva trochophore or veliger.

Order 1. Archaeogastropoda

1. One or two bipectinate internal gills.

2. Two kidneys and heart with two auricles.

3. Shell usually coiled.

4. Nervous system not concentrated usually with pedal cords.

5. Sexes are separate. Fertilization is external.

Examples: *Patella* (limpet), *Trochus* (top shell), *Fissurella* (key-hole limpet).

Order 2. Mesogastropoda

1. Mostly marine, some freshwater.

2. One auricle, one kidney and one mono-pectinate ctenidium.

3. Radula taenioglossate type having 7 teeth in each row.

4. Single osphradium.

5. Nervous system without pedal cords.

6. Fertilization is internal; larva is a free-swimming veliger.

Examples: *Pila* (apple snail), *Crepidula* (slipper shell), *Natica* (star shell), *Cypraea* (cowrie).

Order 3. Neogastropoda

1. Shell with more or less elongated siphonal canal.

2. Nervous system concentrated.

3. Free- swimming veliger suppressed.

Examples: *Murex*, *Magilus*, *Buccinum*, *Melongena*, *Conus*, *Oliva*.

Subclass 2. Opisthobranchia

1. Exclusively marine gastropods.

2. Shell small, without operculum or no shell.

3. Body mass torted or detorted.

4. Gills posterior to heart.

5. One auricle, one kidney and one gonad.

6. Nervous system without pleuro-visceral loop.

7. Hermaphrodite, i.e., sexes united.

Order 1. Cephalaspidea

1. Shell moderately developed.

2. Parapodial lobes present or absent.

3. Head with tentacular shield.

Examples: *Acteon*, *Hydatina*, *Bulla*.

Order 2. Anaspidea

1. Found mostly in tropical and subtropical waters.

2. Shell reduced or internal.

3. Well developed parapodial lobes.

4. Head with a pair of rhinophores.

Examples: *Aplysia* (sea-hare), *Akera*.

Order 3. Pteropoda

1. Pelagic snails with or without shell.

2. Shell reduced or internal.

3. Parapodial lobes well developed.

4. Head with a pair of rhinophores.

Examples: *Corolla*, *Clione*, *Cavolina*.

Order 4. Sacoglossa

1. Shell present or absent.

2. Pharynx suctorial.

3. Sperm duct is closed.

4. Parapodia and cerata present.

Examples: *Elysia*, *Oxynoe*.

Order 5. Acochlidiaceae

1. Minute without shell (naked snail).

2. Found in coarse sand.

3. Visceral mass separated from foot and covered with spicules.

Examples: *Acochlidium*, *Unela*.

Order 6. Notaspidea

1. Shell internal, external or reduced.

2. Mantle present but mantle cavity absent.

3. Gills bipectinate and osphradium on the right side.

Examples: *Tylodina*, *Pleurobranchus*.

Order 7. Nudibranchia

1. Shell absent.

2. Mantle or mantle cavity absent.

3. Internal gills and osphradium are absent.

4. Presence of dorsal outgrowths.

Examples: *Doris*, *Aeolis*.

Order 8. Pyramidellacea

1. Shell spirally twisted.

2. Proboscis long, operculum present but gill and radula absent.

3. Semi-parasitic forms.

Examples: *Pyramidella.*

Order 9. Philinoglossacea

1. Minute naked snails.

2. Head appendages and gills absent.

3. Visceral mass separated from foot only by a groove.

Examples: *Philinoglossa*, *Sapha*.

Order 10. Rhodopacea

1. Vermiform snails.

2. No external appendages.

3. Anus on right side of body.

Examples: *Rhodope.*

Order 11. Onchidiacea

1. Slug-like, naked or without shell opisthobranchs.

2. Pulmonary sac, anus and female gonopore located at the posterior end.

3. Male gonopore placed anteriorly.

Examples: *Onchidella*, *Onchidium*.

Order 12. Parasita

1. Endoparasitic gastropods found in the interior of holothurians.

2. Shelled embryos.

Examples: *Thyonicola*, *Entoconcha*.

Subphylum 3. Pulmonata

1. Mostly freshwater or terrestrial, a few are marine.

2. Detorted body mass.

3. Shell spiral or reduced or absent.

4. Mantle cavity or pulmonary sac with a pore on right side anteriorly.

5. Hermaphrodites.

Order 1. Basommatophora

1. Freshwater or brackish water and marine.

2. One pair of tentacles that is non-invaginable.

3. Eyes at tentacular bases.

4. Separate male and female gonopores.

Examples: *Lymnaea*, *Siphonaria*, *Planorbis*.

Order 2. Stylommatophora

1. Terrestrial pulmonates.

2. Two pairs of tentacles those are invaginable.

3. Second pair of tentacles with eyes at their tips.

4. Male and female gonopores are usually united.

Examples: *Limax*, *Partula*, *Helix* (land snail), *Retinella*.

Class 5. Pelecypoda (Gr., pelekus = batchet + podos = foot)

1. Aquatic, mostly marine, some freshwater forms.

2. Body bilaterally symmetrical and laterally compressed.

3. Head, tentacles, eyes, jaws as well as radulla absent.

4. Foot hatchet-shaped and extending between mantle lobes.

5. Gills or ctenidia are paired, one on each side.

6. Dioecious, veliger or glochidium larve in the life-history.

Order 1. Protobranchia

1. Gill filaments not folded.

2. Mouth placed at the base of proboscides.

3. Style sac is present in the stomach.

Examples: *Nuculina*, *Nucula*, *Yoldia*, *Malletia*.

Order 2. Filibranchia

1. Gill filaments incompletely fused.

2. Chitinous gastric shield in stomach developed.

3. Foot is small or poorly developed.

4. Style sac with crystalline style.

Examples: *Mytilus* (mussel), *Ostrea*, *Pecten* (scallop), *Spondylus* (edible oyster).

Order 3. Eulamellibranchia

1. Gills are firm and basket-like and help in gathering food.

2. Gill filaments fused completely to form tissue sheets.

Examples: *Unio*, *Teredo* (ship-worm), *Anodonta*, *Lamellidens*, *Enis*.

Order 4. Septibranchia

1. Marine forms.

2. Gills absent.

3. Stomach lined by chitin; style-sac reduced.

Examples: *Poromya*, *Cuspidaria*.

Class 6. Cephalopoda (Gr., kephale = head + podos = foot)

1. Exclusively marine.

2. Body dorso-ventrally elongated.

3. Shell internal, external or absent.

4. Head bears large eyes and mouth.

5. Foot modified into tentacles and siphon.

6. Dioecious; development meroblastic without metamorphosis.

Subclass 1. Nautiloidea

1. Shell external, coiled or straight.

2. Tentacles without suckers.

3. Two pair of gills and that of nephridia present.

Examples: *Nautilus*.

Subclass 2. Smmonoidea

1. Extinct.

2. Shell external and coiled.

Examples: *Pachydiscus*.

Subclass 3. Coeloidea

1. Shell internal or absent.

2. Tentacles few and with suckers.

3. One pair of gills and that of nephridia present.

Order 1. Decapoda

1. Ten arms present. Two are long and act as tentacles while rests of the arms are short.

Examples: *Sepia* (cuttle-fish), *Loligo* (squid), *Spirula* (spiral shell).

Order 2. Octopoda

1. Body globular and without fins.

2. Eight equal arms.

Examples: *Octopus*, *Argonauta*.

SOME EXAMPLES OF MOLLUSCA:-

1. *Octopus*: An *Octopus* (Commonly called devil fish) is a cephalopod mollusc of the order Octopoda. This nocturnal marine creature inhabits many diverse regions of the ocean, including coral reefs, pelagic waters and the ocean floor. It is generally found on the Pacific and Atlantic coasts. Around 300 species are recognized, which is over one-third of the total number of known cephalopod species. *Octopuses* are among the most intelligent and behaviorally flexible of all invertebrates. Humans in many cultures eat *Octopus*.

The body is unsegmented, symmetrical and soft bodied animals. Variations can be found in body parts based on species and/or geography. The head bears a pair of eyes. The mouth is surrounded by eight elongated equal arms webbed at the base and each arm bears suckers arranged in two rows. *Octopus* crawls on the ground and is able to change its color according to the background. The food is captured by the arms and is broken by radula and a pair of jaws. *Octopus* ejects ink from the ink-gland into the surrounding water, producing a smoky cloud. In males one of the arms, called hectocotylized arm, bears a spoon shaped organ at its end. The arm is used to caress the female and deposit spermatophores beneath its mantle. Sexes are separate. Development is direct. There is no larval stage. It feed upon crabs, bivalves and fishes etc (fig. 1).

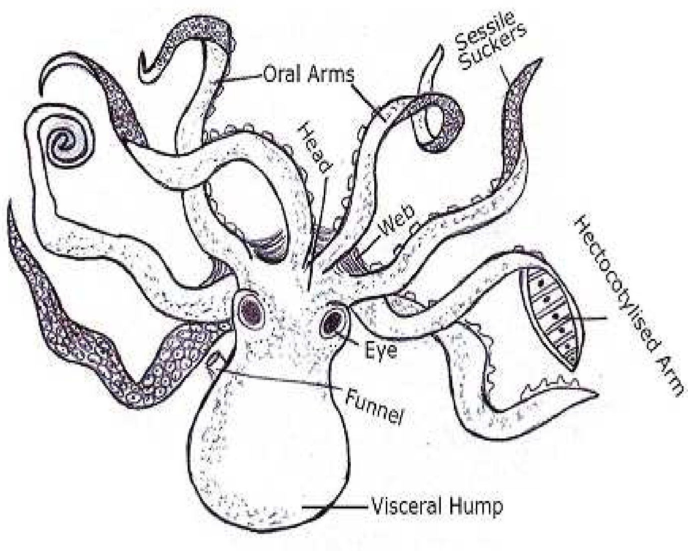


Fig 1. *Octopus*

2. *Sepia*: *Sepia* (Commony known as cuttle fish) is an invertebrate belonging to the Phylum Mollusca (fig 2). It is a marine animal that occupies shallow to mid water and is often associated with coral reefs. Body is unsegmented, bilaterally symmetrical and soft and is divisible into a large head, a small neck or collar and trunk. The head is well developed, bears a pair of eyes and 10 oral arms which are a modification of foot. Eight oral arms are smaller while two are longer and are called tentacles. The trunk extends into flaps called lateral fins on either side that help the animal in swimming. It is covered by a thick muscular mantle, enclosing a large mantle cavity, on the ventral side which contains viscera. The Sexes are separate and reproduction is sexual. It is nocturnal and carnivorous.

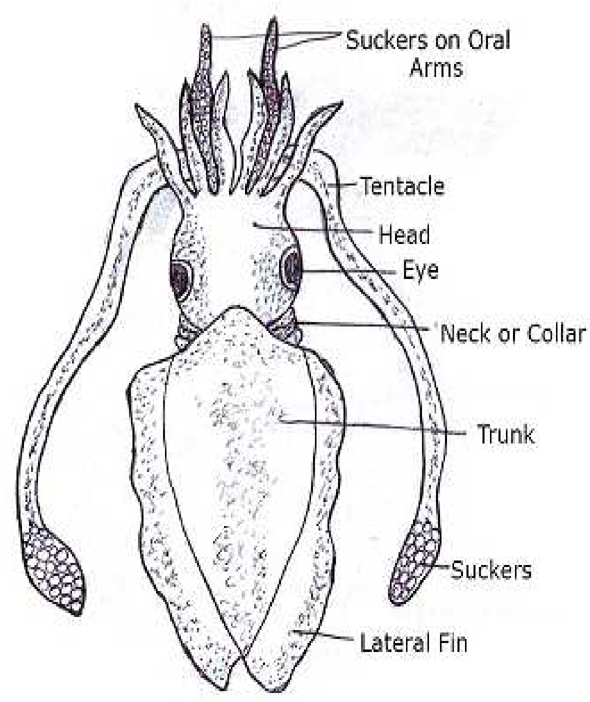
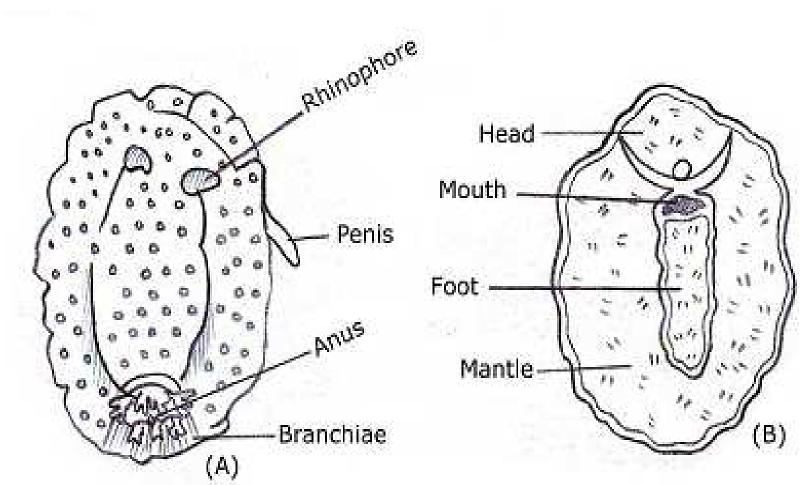


Fig. 2. Sepia

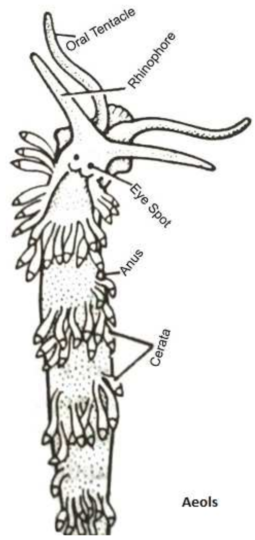
Sepia contains a large ink gland which opens in the rectum. It secretes a dark brown or black fluid stored in a reservoir. When attacked, *Sepia* confuses the predator by releasing ink through the anus and runs away. The homeopathic remedy S*epia* is prepared from the dark brownish-grey colored pigment obtained from the ink sac of the common cuttlefish and is used to cure a number of health problems, especially those related to women's reproductive organs.

3. Doris: *Doris* (Commonly known as sea-lemon) is a sluggish marine animal found under stones at low tide marks. Head bears a pair of short retractile olfactory tentacles called rhinophores. Mantle is usually pigmented and contains calcareous spicules and tubercles. Mouth is present on ventral side. Foot is ventral with a broad sole for creeping. The body is bilaterally symmetrical, unsegmented, flat, short and oval with convex dorsal surface. The animal is bisexual; the penis and the genital aperture lie asymmetrically on the right side. The anus lies mid-dorsally near the posterior end and is surrounded by a circlet of feathery, retractile secondary gills, called cerata. Development includes a free-swimming veliger larva (fig. 3).



A - Dorsal View, B - Ventral View

Fig. 3 *Doris*



4. *Chiton*: *Chitons* (formerly known as Amphineura) are marine molluscs which belong to class Amphineura and subclass Polyplacophora (fig. 4). Their size varies from small to large. About 940 extinct and 430 fossil species are recognized. *Chiton* is commonly known as sea-mice. *Chitons* are mainly found in shallow water, often under rocks and other shells, but several genera can be found in water as deep as 5,000 ft. Some are actively carnivorous, feeding on small crustaceans by smothering them with the girdle; e.g., Lepidochitona. They become active at twilight and move around very slowly in search of food. Most are grazers, and with a multi-toothed radula, they can feed on small algae and other tiny organisms.

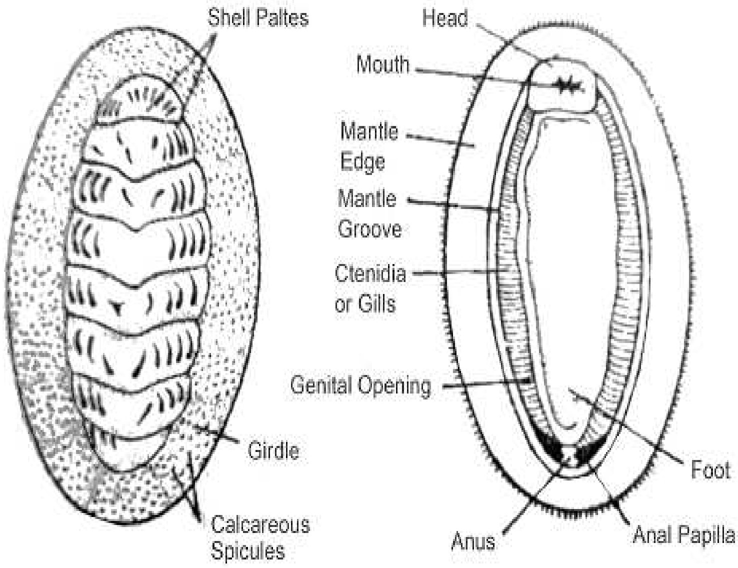


Fig.4 Chiton (A) Dorsal View (B) Ventral View

Body is unsegmented, bilaterally symmetrical and dorso-ventrally compressed. It consists of shell, foot, mantle and visceral mass. Shell is calcareous and is present on the dorsal side and is composed of 8 overlapping plates. Head is not distinct. Eyes and tentacles are absent. Foot is ventral, broad, sole-like and muscular, adapted for creeping and adhering. Mantle covers greater part of body and partly covers the edges of the shell plates. Mouth and anus are at opposite ends. Gills lie along whole length of mantle groove. Sexes are separate, gonad is single and median. Fertilization is external. Development is indirect through trochophore larva.

5. *Pecten*: *Pecten* (Commonly known as scallop) is a free-swimming marine molluscs that lives on sea bottom of 10 fathoms deep. Shell is beautifully ribbed by radiating lines. The two shell valves are unequal, the right being larger and more convex and the animal rests on this valve. Locomotion takes place in spurts; the swimming is affected by the rapid opening and closing of shell valves. Foot is very much reduced. Two large gills are present. Pectens are bisexual. It is found mainly in U.S.A. and India (fig. 5).

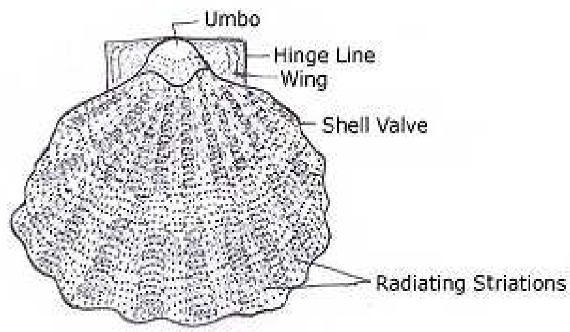


Fig 5. ***Pecten***

6. *Loligo*: *Loligo* is commonly called sea squid and is found all over the world in shallow to mid waters. Body is spindle or torpedo-shaped and divisible into head, foot and visceral hump. The head is well developed, bears a pair of eyes and ten oral arms which are a modification of foot. Eight oral arms are smaller while two are longer and are called tentacles. Shell is internal and cartilaginous. Two nephridia or kidneys are also present. Sexes are separate. An ink sac is present and serves for defence. *Loligo* is used as food by Chinese and Italians and also as bait for marine fishing (fig. 6).

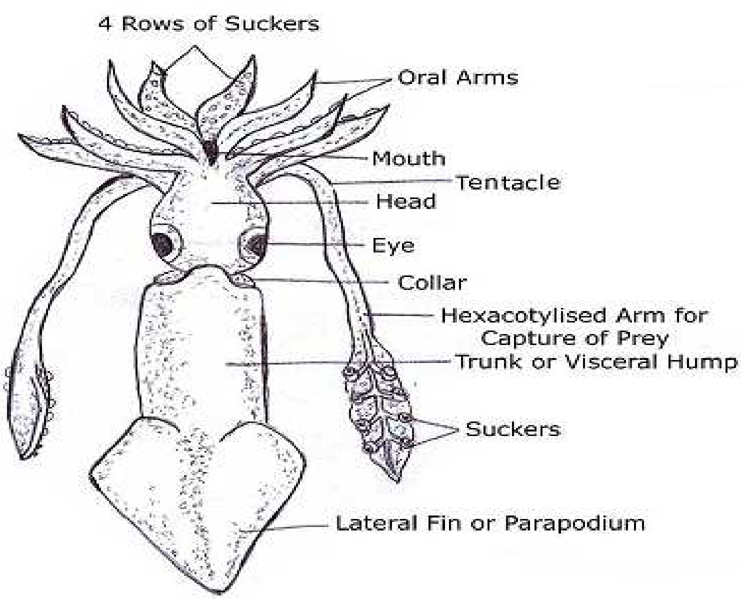


Fig. 6: *Loligo*

7. *Dentalium*: *Dentalium* (Commonly known as tusk shell) is a marine mollusc found world over in the sublittoral zone of seas. It measures 2-5 cm in length. It lies in a tubular, bilaterally symmetrical shell open at both ends. Head and foot project out from the anterior aperture of the shell. Head bears a mouth surrounded by filiform tentacles called captacula. Eyes and osphradium are absent. Mantle is entirely within the shell. The foot is long pointed, spade-like and highly extensible adapted for digging and burrowing **(Rastogi)**. Sexes are separate. Development is indirect and includes a trochophore larva. Shell of *Dentilium* is used for ornamental purposes. Its shells were once used by Red Indians of America as currency. It feeds on micorganisms like diatoms and foraminifera (fig. 7).

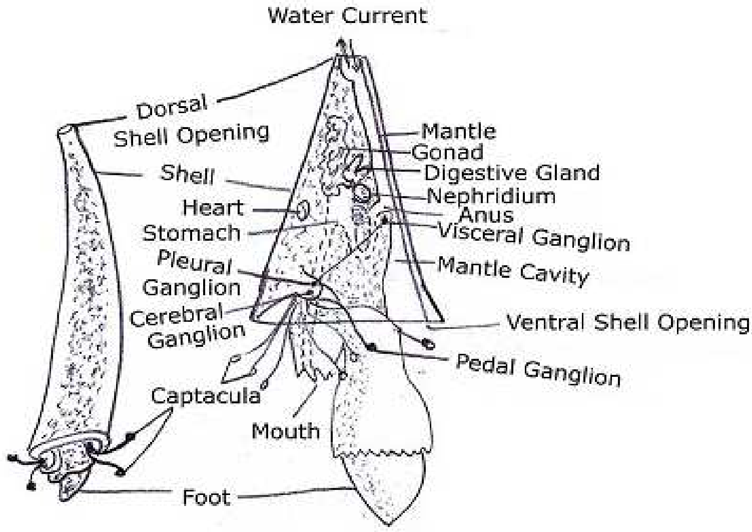


Fig. 7: *Dentalium*

7. ***Unio***: *Unio* is commonly known as freshwater mussel (fig. 8). Freshwater mussels are found in freshwater lakes, rivers and streams, inhabiting the surface layers of the muddy beds of rivers and lakes. It crawls slowly with the help of its plough-like, wedge-shaped muscular foot that leaves a deep trail all along its journey. It usually moves to shallow places by night and retires to deeper places by day. Food consists of microscopic organisms, both animals and plants, which are fed upon by filter-feeding mechanism involving both ciliary as well as mucoid movements. Animal responds to light, touch or some other stimulus by withdrawing its foot and closing the siphons, meant for incoming and outgoing water currents. Soft-bodied animal is completely enclosed within a calcareous shell which represents its exoskeleton. *Unio* is dioecious, i.e. the sexes are separate, but there is no external dimorphism.

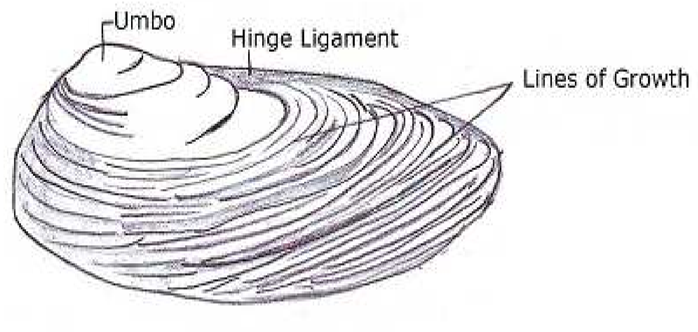


Fig. 8: ***Unio***

8. ***Aplysia***: *Aplysia* is commonly known as sea-hare. It is a marine animal found in tropical waters. It is found in India, West Indies and on the Florida Coast. It crawls over the surface of rocks and boulders. The body is soft and lumpy with a thin flexible plate-like shell covered by mantle. The head has two pairs of tentacles. The posterior pair tentacles become ear-like and are called rhinophores. The foot is broad and flat and bears a pair of lateral folds parapodia that help in swimming. Mantle possesses unicellular ink glands. These secrete purple ink used for defence. It is bisexual. It has a single gonoduct. *Aplysia* is known to form mating chains with up to 20 animals. The eggs are yellow-green, and change after 8 to 9 days into a brown color before larvae hatch. The life span is assumed to be around a year. Cooler temperature delays spawning and has been shown to extend the lifespan. Sea hare is hermaphroditic, acting as male and female simultaneously during mating. *Aplysia* is herbivorous. Its diet consists primarily of red algae like *Plocamium pacificum*, *Ceramium eatonianum* and *Laurencia pacifica* which gives the animal its typically reddish or pinkish coloration. Thus *Aplysia* resembles the food it grazes on and cannot be distinguished easily from the seaweed unless the animal is moving (fig. 9).

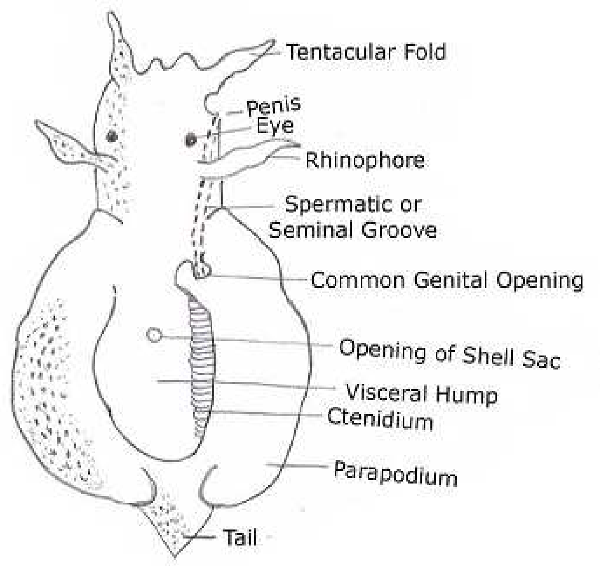


Fig. 9: ***Aplysia***

9. ***Eolis***: *Eolis* (Commonly known as sea slug) is a marine slug-like gastropod found in shallow waters crawling under surface of seaweeds. It is a small neudibranch 1 or 2 cm in length. Head bears two pair of cylindrical retractile tentacles and sessile eyes at the base of the posterior pair of tentacles.The mouth is prominent and can be most easily seen from the ventral view. Foot is muscular and ventral and serves for locomotion. Shell, mantle and true gills are absent. It is hermaphroditic and common gonad is protrandric. The animal is said to feed on hydroids which are digested and their undischarged nematocysts are collected in the cerata and discharged on irritation.

9.4- Study of Pila (Apple Snail)

Pila globosa:

Systematic position

Phylum Mollusca

Class Gastropoda

Order Mesogastropoda

Family Pilidae

Genus *Pila*

Species *globosa*

9.4.1 Habit and habitat: -

Pila globosa is one of the largest freshwater molluscs. *Pila* is amphibious. It is commonly found in ponds, lakes, tanks, pools, marshes, paddy fields, streams and rivers of Northern India. It is found in large numbers in those areas which are rich in aquatic plants like *Vallisneria* and *Pistia*. It is a voracious eater and feeds upon plant scrapings with the help of its chitinous jaws and radular teeth. It overcomes long periods of drought in a dormant condition by burying in the mud with its shell aperture tightly closed. This period of inactivity is called summer sleep or aestivation.

It creeps very slowly with the help of its ventral muscular foot, covering about 5 cm per minute. During rainy season, it leaves the ponds and makes long terrestrial excursions on land breathing directly in the air. It is commonly used as food by some people, mainly the tribals and lower economic groups in Nepal, the Sunderbans, as well as the people of West Bengal, Bihar, Uttar Pradesh and other parts of India. It is one of the most preferred gastropod species utilised by tribal people as food. This species lives in permanent and temporary stagnant water bodies and uses dry areas for breeding. Adults survive the dry season buried in soil.

9.4.2:-External morphology:

1. Shell: The shell of *Pila*, as in other Gastropoda, is univalve but coiled around a central axis in a right-handed spiral. The shell consists of 6 ½ such whorls which gradually increase in size from behind to front. The surface of the whorls is marked by faint vertical ridges, the lines of growth. A few of the latter are more prominent and are called as varices.The small rounded tip of the shell represents the apex and the whorl surrounding it is the apical whorl. The lowermost whorl is largest and is known as body whorl. The line of contact between two adjacent whorls is called as suture.

The body and penultimate whorls (except the body whorl) are called as spire. The body whorl of the shell opens to the exterior by a wide opening, the shell mouth. Its smooth continuous margin is known as peristome. It is bounded by an outer lip and an inner columnar lip. When the animal body is completely withdrawn, the shell mouth is closed by a flat, oblong plate, the operculum. The columnella of the shell is hollow and opens to the exterior through umbilicus. As such the shell is known as umbilicate (Rastogi).

Microscopic structure of shell: Like all other molluscs, *Pila's shell* is secreted by the underlying mantle. It consists of Periostracum, Ostracum and Hypostracum. The Periostracum is the thin outermost layer made of conchiolin. Ostracum is the middle layer made of calcium carbonate deposited as plates running in the direction of shell coiling. Hypostracum or nacreous layer or mother of pearl is the innermost layer. Its plates are also made of calcium carbonates that run parallel to the margin of aperture.

Operculum: Operculum is a calcarrous plate formed by cuticular secretion of the glandular cells of the animal foot. The inner surface of the opercular exhibits an elliptical area of creamy colour, the boss, which is surrounded by a shallow groove. It acts as a lid that the snail uses to close the mouth when it withdraws into the shell (fig. 10).

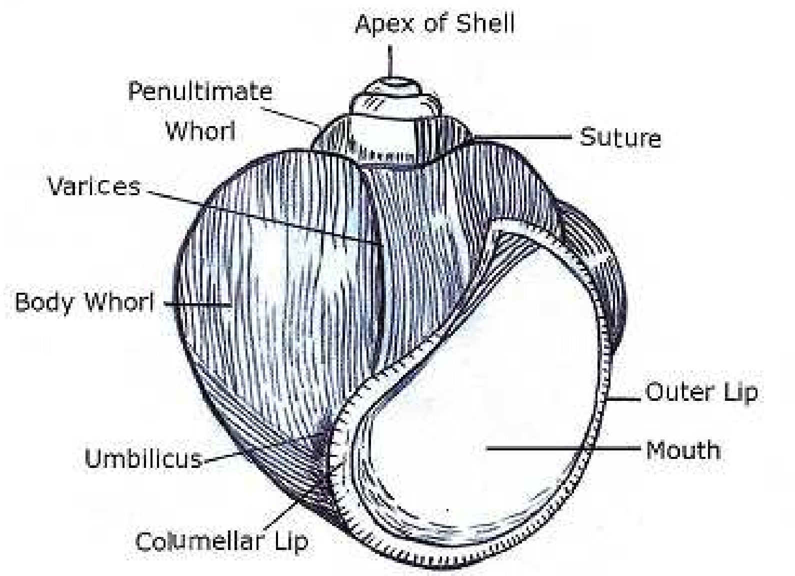


***Fig 10. Pila*:The shell with operculum**

2. Body: Body of *Pila* is divisible into four regions - head, foot, visceral mass and mantle (fig. 11).

1. Head:

Head is the anterior fleshy part of the body overhanging the foot. It bears mouth, two pairs of contractile tentacles and a pair of eyes. The tentacles arise from behind the snout from the dorsal surface of the head. The anterior pair of tentacles is called the cephalic tentacles or labial palps and is prolongations of the sides of the head. Mouth is a vertical slit-like aperture lying ventrally between the bases of the cephalic tentacles. The posterior pair of tentacles is long, fleshy and contractile and is the true tentacles.

2. Foot:

Foot is the locomotory organ of *Pila* and lies below the head. It is highly contractile and muscular with the muscle fibres arranged crosswise and lengthwise. It contains pedal glands, the secretions of which form a slime trail during locomotion. The anterior part of the foot is round and the posterior dorsal surface bears the operculum. When the foot is withdrawn, operculum completely fits into the mouth of shell and closes it. The head and foot together constitute the head-foot complex. The two are connected to the visceral mass through a slight constriction.

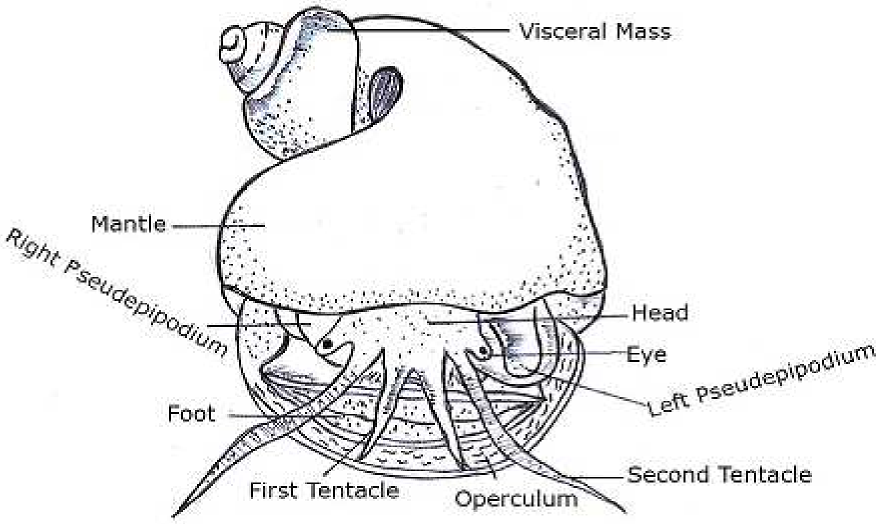


Fig11. ***Pila*****: Body after removing the shell**

3. Visceral mass: All visceral organs are contained in this lump like structure that lies above the head-foot complex. It is soft and grey to the dark brown in colour. It is spiral and coiled-like the shell in which it lies, occupying the body whorl as well as the spire. Visceral mass shows the phenomenon of torsion.

4. Mantle: Skin of the visceral mass forms a thin and delicate covering called the mantle. It is a fleshy layer or cape that secretes the shell of the mollusc. It protects the soft visceral mass and also acts as a protection cloak or hood over the head and its appendages when the animal is retracted. Anteriorly, the mantle becomes thickened and pigmented. A long, narrow supra-marginal groove runs along the thickened free edge of the mantle. It encloses a spacious cavity (mantle cavity or pallial cavity) that contains some of the important organs of the animal and together constitutes the pallial complex (Fig. 12).

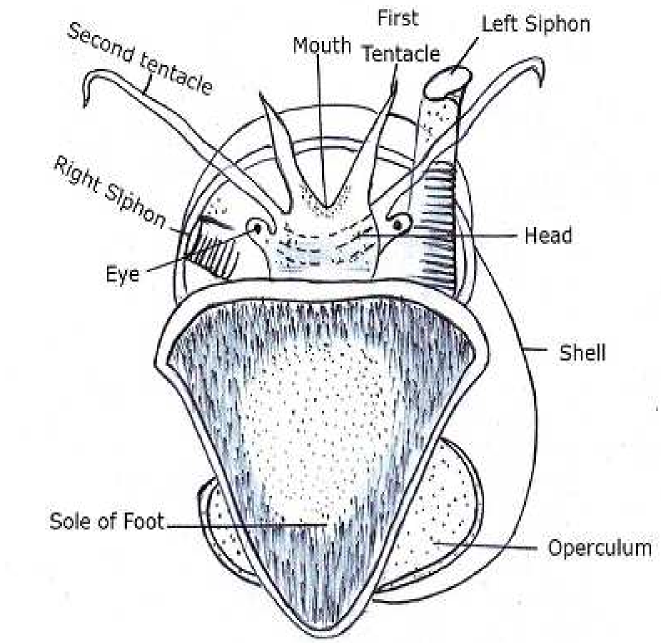


Fig.12 Ventral view to show muscular foot

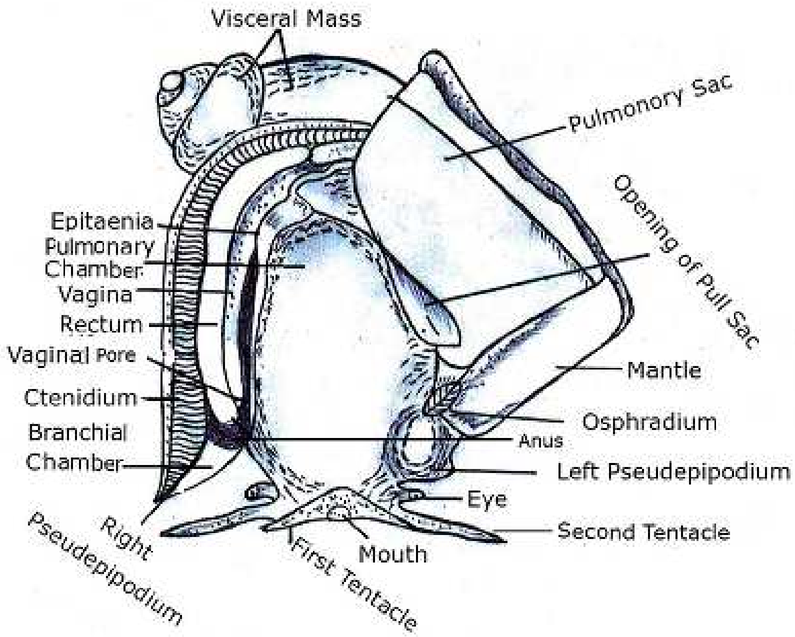


Fig.13 Pila:Mental Cavity and pallial complex

Mantle cavity is the space between the mantle and the visceral mass. A longitudinal ridge known as epitaenium imperfectly divides mantle cavity into smaller right branchial chamber and larger left pulmonary chamber. The rectum is present on the left of the ctenidium on the floor of the branchial chamber and opens to the outside by the anus which is situated just near the base of the right nuchal lobe. Anterior renal chamber projects as a reddish sac in the branchial chamber near the posterior end of the epitaenia and opens into the mantle cavity by an oblique slit. The genital duct is present on the left of the rectum and the genital aperture is present very close to the anus (Kotpal).

Nervous system:

The nervous system is well developed and comprises of two main parts – Central Nervous System and Peripheral Nervous System. Central Nervous System consists of ganglia and their commissures (connections between similar ganglia) and connectives (connections between dissimilar ganglia). The main ganglia include cerebral, buccal, pleuro-pedal, supra-intestinal and visceral. Of these supra and infra-intestinal ganglia are unpaired and rest are paired ganglions. The peripheral nervous system consists of nerves arising from CNS and innervates various parts of the body (fig. 13).

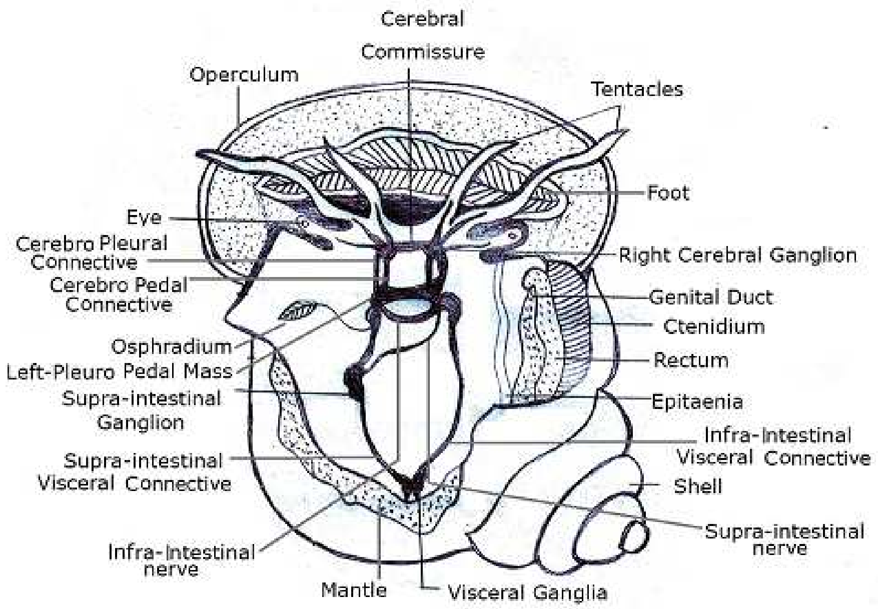


Fig. 14 : Nervous sytem of Pila

1. Ganglia: Paired ganglia, which are aggregations of nerve cells, are as follows-

(a) Cerebral ganglia: A pair of roughly triangular ganglia, situated anteriorly on the dorso-lateral sides of the buccal mass.

(b) Buccal ganglia: A pair of small, triangular ganglia, lying dorso-laterally one on either side at the junction of the buccal mass and oesophagus, partly embedded in the muscles. It sends off several nerves to the buccal mass, salivary glands, oesophageal pouch and a greater part of oesophagus.

(c) Pleuro-pedal ganglia: A pair of large, somewhat triangular, ganglionic mass present one or either ventro-lateral side of the buccal mass. Each one is formed by the fusion of an outer pleural and an inner pedal ganglion, separated by a faint notch. Right pleura-pedal ganglionic mass also consists of the infra-intestinal ganglion fused with it. It supplies nerves to the foot, parietal nuchal lobe, copulatory organ, columellar muscles, mantle, ospharidium and epitaenia.

(d) Supra-intestinal ganglion: An unpaired fusiform ganglion, lying in a sinus behind the left pleura-pedal ganglionic mass. It supplies nerves to mantle and ctenidium.

(e) Visceral ganglia: A single ganglionic mass representing two fused ganglia, situated at the lower end of the visceral mass. It provides (i) a right nerve to renal organs, reproductive organs and to the intestine (ii) a left nerve to the pericardium, stomach, liver and reproductive organs. (iii) a few snall nerves to the neighbouring nerves.

2. Commissures: Commissures are those nerves which establish connections between two similar ganglia. In *Pila* these constitute-

(a) Cerebral commissure: A thick band of nerve connecting two cerebral ganglia and lying dorsally to the buccal mass.

(b) Buccal commissure: A fine nerve which connect the two buccal ganglia and runs transversely on the ventral side of the oesophagus.

(c) Pedal commissures: Two thick nervous bands that lay one above the other underneath the buccal mass and connect the two pedal ganglia together.

3. Connectives: Connectives are those nerves which connect two different ganglia. In the nervous system of *Pila*, these are-

(a) Two cerebro-buccal connectives: These connect, on either side, the cerebral ganglion and buccal ganglion together.

(b) Two cerebro-pleural connectives: These connect, on either side, the cerebral and outer pleural ganglion of the pleuro-pedal ganglionic mass.

(c) Two cerebro-pedal connectives: These connect, on either side, the cerebral and inner pedal ganglion of the pleura-pedal ganglionic mass.

(d) Pleuro-infra intestinal connective: Also called infra-intestinal nerve, it is a nerve connection between the pleural ganglion of the left pleura-pedal mass and the infra-intestinal ganglion which is fused with the right pleura-pedal mass.

(e) Infra-intestinal visceral connective: Running below the intestine, it is a long nerve that connects the visceral ganglion with the infra-intestinal part of the right pleuro-pedal-infra-intestinal ganglionic mass.

(f) Supra-intestinal visceral connective: Running above the intestine, it is a slender nerve that connects the visceral ganglion with the supra-intestinal ganglion.

(g) Supra-intestinal-pleural connective: Also called the supra-intestinal nerve, it connects the supra-intestinal ganglion with the pleural part of the right pleuro-pedal-infra-intestinal ganglionic mass.

(h) Zygoneury: It is a nerve connection between the pleural part of the left pleuropedal ganglionic mass and supra-intestinal ganglion.

9.4.2- REPRODUCTION:-

In *Pila* the sexes are separate and sexual dimorphism is distinct. Female shell is larger and more globular than that of the male. The copulatory organs or penis is well developed in male but poorly developed in female.

Male Reroductive system:

The male reproductive system comprises of:

1. Testis
2. Vasa efferentia
3. Vas deferens
4. Copulatory organs
5. Hypobranchial gland

1. Testis: Testis is a single, flat, plate-like and triangular whitish structure, occupying the upper part of the first two or three whorls of the shell. It is separated from the shell by a thin cutaneous membrane (fig. 14).

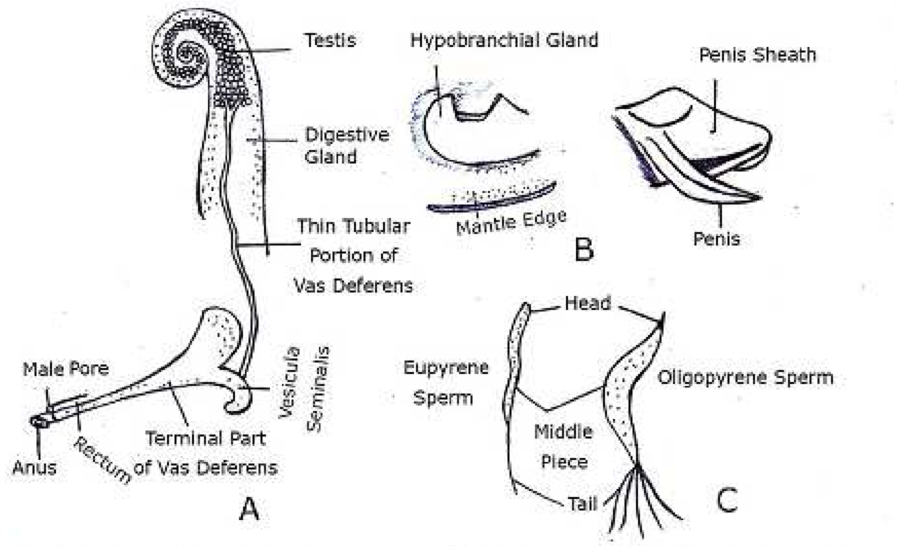


Fig. 15 *Pila:* **(A) Male reproductive organs (B) Male copulatory organs (C) Sperms**

Two types of sperms are produced in the testis are-

(1) Eupyrene sperm: These are small, thread-like, motile and capable of fertilizing ova. It measures about 25 µ long and 1.2 µ broad with a head and tail. It has twisted nucleus and a single axial filament and functional.

(2) Oligopyrene sperm: These are large, spindle-like, non-motile and incapable of fertilizing ova. It measures about 32.5 µ long and 3 µ broad with distinct head and a tail of 4 or 5 cilia. It has broad curved nucleus and with many axial filaments and are sluggish and non functional.

2. Vasa efferentia: These are fine ducts that arise from the different regions of the testis to unite to form a large common duct, the vas deferens.

3. Vas deferens: The vas deferens commences from the posterior part of the testis and differentiated into three parts:

(a) Proximal tubular part: The proximal tubular part is thin walled narrow structure and forms posterior part of testis under the skin. It runs along inner side of the digestive gland upto the posterior renal chamber and finally turns towards the left to approach the pericardium. After reaching the pericardium it opens into the ventral side of vesicula seminalis.

(b) Vesicula seminalis: Vesicula seminalis is curved, swollen and flask shaped structure with a blind rounded posterior prolongation.

(c) Terminal glandular part: It is distal thick-walled glandular part of the vas deferens which runs along the left side of the rectum into the branchial chamber and opens into it by male genital pore.

4. Copulatory organs: Copulatory organ or Penis arises separately from the mantle edge in front of the anus. It is a long, slightly curved and flagellar structure with a swollen base and a tapering free end. Penis remains enclosed in a penis sheath formed by a thick, glandular, yellow colored, flap attached to the mantle along its side, while its free left edge is rolled up to form a spout-like covering for the penis. Penis is highly extensile; being about 1.5 cm long but can attains a length of 4 cm during copulation.

5. Hypobranchial gland: The hypobranchial gland is situated at the base of penis sheath and is oval and thick with pleated surface. It consists of tall cells containing small basal nuclei. Due to absence of duct its secretions are released directly upon its surface.

Female Reproductive system:

The female reproductive system comprises of:

1. Ovary
3. Receptaculum seminis
2. Oviduct
4. Uterus
5. Vagina
6. Copulatory organ
7. Hypobranchial gland.

1. Ovary: Ovary is a branched structure of orange colour attached to the inner side of the digestive gland. Branches of the ovary or acini are single layered and flask shaped structure. The ovary occupies the first, second and sometimes also the third whorl of the shell. Their outer rounded end is closed and the inner slender tubular end unites to form a single oviduct (fig. 15).

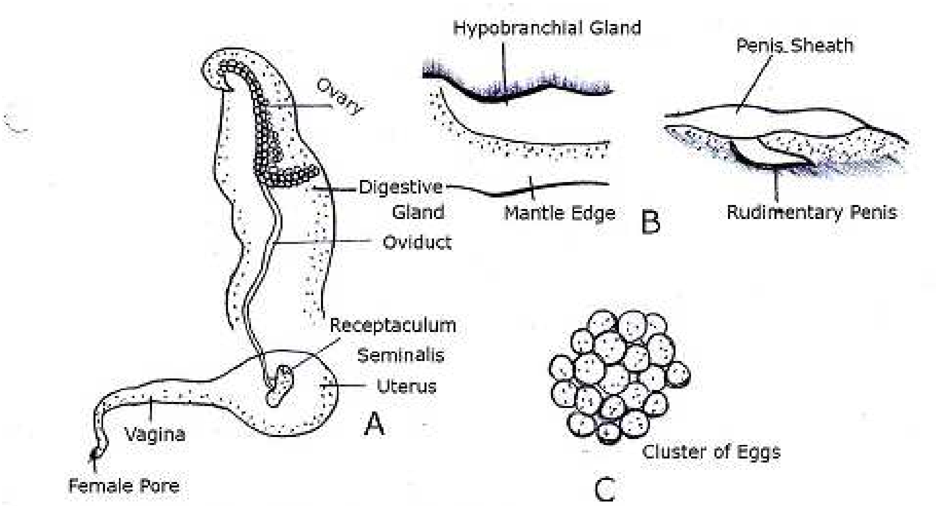


Fig. 16 ***Pila*****: Female reproductive organs (B) Rudimentary penis (C) Eggs**

2. Oviduct: The oviduct is a narrow and transparent tube arising from the ovary and passing downwards along the margin of the digestive gland. It turns downwards near the renal organ and then upwards to open into the receptaculum seminis.

3. Receptaculum seminis: Receptaculum seminis is a small bean-shaped structure and is situated at the junction of oviduct and uterus. It is enclosed in the cavity of posterior renal chamber. It is meant for storing sperms recieved from the male during copulation.

4. Uterus: The uterus is a large, yellow, pear-shaped structure. It lies below the the intestine and to the right of the renal chamber. It is differentiated into broad, vesicle-like rounded basal part and a narrow tubular apical part. The former receives the opening of receptaculum seminis and the latter opens into the vagina.

5. Vagina: The terminal narrow part of the oviduct is known as vagina. It is a white cream-coloured tubular part which runs forward on the left side of rectum to open into the branchial chamber.

6. Copulatory organ: The copulatory organ or penis in female represents the rudiment of male penis. It is a thin flagellar structure nearly 6.0mm long and pointed at the tip.

7. Hypobranchial gland: Hypobranchial gland of the female is poorly developed with rudimentary glandular thickening.

Copulation: *Pila* reproduces only during rainy season. Copulation occurs on land or on moist ground of the banks. During copulation the male and female *Pila* come together facing each other with their right nuchal lobes lying opposite to one another. Now the penis and its sheath are inserted into the mantle cavity of the female. The tip of the penis enters the female genital aperture and sperms are transferred through the vagina into the receptaculum seminis of the female.

9.4.3 FERTILISATION AND DEVELOPMENT:-

Fertilization: Fertilization is internal in *Pila*. It takes place in the uterus, where both ova and spermatozoa pass, the former from the ovary and the latter from the receptaculum seminis. Ovulation takes place two days after copulation. Female lays 200-800 eggs at a time in moist earth in a sheltered cavity near ponds and lakes. The development of embryo takes place outside the body.

Development: The eggs are round and pea sized. The eggs consist of an outer whitish shell, enclosing a double shell membrane, with a thick mass of solid white albumen. In the albumen lies a little central mass of liquid albumen containing the embryo. During development, due to torsion, the visceral mass and the shell of embryo become spirally coiled. A young snail emerges from the fertilized egg. The young ones resemble the adult in form.

9.5- SUMMARY

- Phylum mollusca (L., molluscus, soft) includes soft-bodied invertebrate animals such as Octopods, snails, slugs, mussels, clams, oysters, tusk-shells, squids etc. It is a very successful, diverse and widespread group, with about 112,000 species.

- The largest of the molluscan classes is Gastropoda, which is represented by about 35,000 living and some 15,000 fossil species.

- Molluscs can be segregated into seven classes: Aplacophora, Monoplacophora, Polyplacophora, Bivalvia, Gastropoda, Cephalopoda, and Scaphopoda. These classes are distinguished by, among other criteria, the presence and types of shells they possess.

- Class Aplacophora includes worm-like animals with no shell and a rudimentary body structure. Members of class Monoplacophora have a single shell that encloses the body.

- Members of class Polyplacophora are better known as "chitons;" these molluscs have a large foot on the ventral side and a shell composed of eight hard plates on the dorsal side.

- Class Bivalvia consists of mollusks with two shells held together by a muscle; these include oysters, clams, and mussels.

- Members of class Gastropoda have an asymmetrical body plan and usually have a shell, which can be planospiral or conispiral. Their key characteristic is the torsion around the perpendicular axis on the center of the foot that is modified for crawling.

- Class Scaphopoda consists of mollusks with a single conical shell through which the head protrudes, and a foot modified into tentacles known as captaculae that are used to catch and manipulate prey.

- Molluscan shells have always been economically important, having served as money in early days. They have been used in jewellery and buttons. The scientific study of molluscs is called malacology.

- *Pila globosa* is one of the largest freshwater molluscs that have invaded various kinds of habitats. It is commonly found in ponds, lakes, tanks, pools, marshes, paddy fields, streams and rivers of Northern India. The shell of *Pila*, as in other Gastropoda is univalve but coiled around a central axis in a right-handed spiral. It comprises of following three layers, periostracum, ostracum and hypostracum.

- Body of *Pila* is divisible into four regions head, foot, visceral mass and mantle. Head is the anterior fleshy part of the body overhanging the foot. It bears mouth, two pairs of contractile tentacles and a pair of eyes. Foot is the locomotory organ of *Pila* and lies below the head. All visceral organs are contained in this lump like structure that lies above the head-foot complex. Skin of the visceral mass forms a thin and delicate covering called the mantle.

- The nervous system is well developed and comprises of two main parts – Central Nervous System and Peripheral Nervous System. Central Nervous System consists of ganglia and their commissures (connections between similar ganglia) and connectives (connections between dissimilar ganglia). The peripheral nervous system consists of nerves arising from CNS and innervates various parts of the body.

- The sexes are separate in *Pila* and sexual dimorphism is distinct. The shell of the female is larger and more globular than that of the male. The copulatory organs or penis is well developed in male but poorly developed in female.

- The male reproductive system consists of testis, vasa efferentia, vas deferens, copulatory organs and hypobranchinal gland. The female reproductive system consists of ovary, oviduct, receptaculum seminis, uterus, vagina, copulatory organ and hypobranchial gland.

- Fertilization is internal but the development of the embryo takes place outside the body of female. Female lays 200-800 eggs at a time in moist earth in a sheltered cavity near ponds and lakes. The eggs are rounded and as big as the pea seeds.

- During development, due to torsion, the visceral mass and the shell of embryo become spirally coiled. A young snail emerges from the fertilized egg. The young ones resemble the adult in form.

9.6-Glossary:

Aerial respiration:	Inhabiting in the air.
Amphibious:	Capable of living on land as wall as in water.
Aquatic:	Found in water.
Band:	A strip of shell material differentiated by color or Construction from the shell on either side of it.
Banding:	Color marking in continuous stripes.
Barnacle:	Not a mollusk but a Crustacean.
Basal callus:	A shelly spirally-ridged thickening on the Columellar base as in olive shells.
Basal fasciole: series	A special band on the base of a shell formed by a Of more or less curved growth lines that define the Siphonal sinus (canal).
Basal fold:	A fold nears the anterior.
Basal plate:	A segment of the ribbon to which radula teeth are Attached.
Basal:	The lower part, bottom or base of the shell.

Benthic: Living on the sea bottom.

Bivalve: Possessing two shell-valves.

Byssus: A bundle of fibrous, tough conchiolin strands secreted by the foot of some bivalves, passing out of the anterior end of the shell and use to secure the animal to a substrate.

Calcareous: Composed mostly of calcium carbonate or lime.

Carnivore: Meat eating.

Copulation: A sexual act for transference of sperm from one to another of mating partners.

Freshwater: Water containing less than 0.5% salts.

Herbivore: Feeding on vegetation.

Mantle cavity: The space between the mantle and the visceral mass.

Mantle: A fleshy layer or cape that secretes the shell of the mollusc.

Marine: Found in ocean.

Omnivore: Consumes both plant and animal food.

Operculum: Calcarrous plate formed by cuticular secretion of the glandular cells of the animal foot.

Parapodia: Flesh passle-like segmented appendages of polychaete worms.

Pelagic: Inhabitation in open water, as in mid-ocean.

Terrestrial: Found in land.

Testis: A male gonad.

9.7- SELF ASSESSMENT QUESTIONS

9.7.1- Long Answer type questions:-

1. Classify *Pila* upto order?
2. Describe the morphology of the shell of *Pila*?
3. Discuss the nervous system of *Pila*?
4. Describe the reproductive organs of *Pila?*

9.7.2- Short Answer type questions:-

1.What are some representatives of the phylum Mollusca?
2. In which habitats do molluscs live?
3. What is the morphological feature of molluscs after which the phylum is named?
4. What are examples of the ecological and economic importance of molluscs?

9.7.3- Fill in the blanks: -

1. *Pila* is popularly known as……..
2. Mode of respiration of *Pila* is ………….and………..
3. The study of molluscs is generally known as…………
4. Pearl is secreted by……….
5. Respiratory pigment in mollusca is………...

Answer: 1. Apple snail

2. Aquatic and aerial

3. Malacology

4. Mantle

5. Haemocyanin

9.7.4- Multiple choice questions:-

1. The *Pila* is:

(a) Undifferentiated (b) Hermaphrodite

(c) Monocecious (d) Dioecious

2. Excretory organ of *Pila* is:

(a) Kidney (b) Keber's organ

(c) Renal organ (d) none

3. Aerial respiration in *Pila* occurs from:

(a) Ctenidium (b) Pulmonary sac

(c) Mantle (d) Branchiae

4. Torsion is shown in:

(a) *Pila* (b) *Loligo*

(c) *Unio* (d) *Mytilus*

5. Identify the larva which is characteristic of Gastropoda and Scaphopoda:

(a) Muller's larva (b) Trochophore larva

(c) Veliger larva (d) Bipinnaria larva

6. The freshwater clam or mussel is:

(a) *Mytilus* (b) *Ensis*

(c) *Anodonta* (d) *Pholas*

7. Ctenidium performs respiration is:

(a) Air (b) Water

(c) Both the place (d) Terrestrial

8. Which one is a connecting link between Annelida and Mollusca?

(a) Chaetoderma (b) Nautilus

(c) Neopilina (d) Lymnaea

9. Concology is the study of:

(a) Mollusca (b) Shell of mollusca

(c) Foot of mollusca (d) Behaviour of mollusca

10. The larva of mollusca:

(a) Glochidium (b) Veliger

(c) Both (d) None

Answer:	1. D	4. A	7. B
	2. C	5. B	8. C
	3. B	6. C	9.B
	10. C		

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UNIT 10 : PHYLUM ECHINODERMATA

Contents

10.10-Terminal Questions

10.1- OBJECTIVE

1. Understanding the general characters of echinodermata.
2. To understand its classification.
3. To explain some important echinoderms species.
4. Understanding the morphology and habitat of one of the important species of *Asterias*.
5. Understanding the digestion, reproduction and larval development of *Asterias*.

10.2-INTRODUCTION

Phylum echinodermata (Gr., echinos=spiny+derma=skin, ata=characterized by) includes exclusively marine invertebrates displaying pentamerous radial symmetry and an endoskeleton of calcareous plates and spines. Jacob Klein gave the name echinodermata. This phylum is a collection of about 7,000 living species and constitute some of the most beautiful members of sea fauna, such as starfishes or sea stars, sea urchins, sea cucumber, sea lillies and sand dollars etc. The name 'starfish' is, however, misleading as theses animals are not true fishes. A more suitable name suggested for them is 'sea star'. Common genera of sea stars are *Asterias*, *Pentaceros*, *Astropecten*, *Solaster*, *Heliaster*, *Luidia*, *Asterina* etc. Genus *Asterias* includes about 150 species of which most common is *A. Rubens*.

The echinoderms are important both biologically and geologically. Biologically, there are few other groupings so abundant in the biotic desert of the deep sea, as well as shallower oceans. Echinoderms generally have remarkable powers of regeneration of tissue, organs, limbs, and of asexual reproduction, and in some cases, complete regeneration from a single limb. Geologically, the value of echinoderms is in their ossified skeletons, which are major contributors to many limestone formations, and can provide valuable clues as to the geological environment.

Echinoderms possess a simple digestive system which varies according to diet. In many species, the large cardiac stomach can be everted and digest food outside the body. Gonads are present in each arm. In echinoderms such as sea stars, every arm bears two rows of tube feet on the oral side which help in attachment to the substratum. Echinoderms are efficient scavengers of decaying matter on the seafloor. They prey upon a variety of small organisms, thereby helping to regulate their numbers. In addition, echinoderms produce vast numbers of larvae that provide food for other planktonic organisms.

10.3.1 General characters

1. Echinoderms are exclusively marine, free living and mostly bottom-dwellers.

2. Organ system grade of body organization.

3. Body triploblastic, coelomate and symmetrical.

4. Body unsegmented with globular, star-like, spherical, discoidal or elongated with radiating arms.

5. Head absent. Body generally pentameric.

6. Body surface with five radial areas, the ambulacra, with tube feet and five inter-radial areas, the inter-ambulacra.

7. Endoskeleton is made up of spines and calcareous spicules.

8. Coelom is a large cavity lined by ciliated peristomium, coelomic fluid with coelomaocytes.

9. Water vascular system or ambulacral system present, usually with a madreporite.

10. Nervous system without brain but with a circum-oral ring and radial nerves.

11. Sense organs are poorly developed.

12. Alimentary canal straight or coiled.

13. Respiratory organs include dermal branchiae, tube feet, respiratory tree and bursae.

14. Circulatory or haemal or blood lacunar system is typically present.

15. Excretory organs absent.

16. Reproduction is usually sexual but few reproduce asexually or by regeneration.

17. Sexes are separate; fertilization is external, development indirect through free-swimming larval forms.

10.3.1 Classification

Subphylum 1. Eleutherozoa (Gr., eleutheros=free+zoios=animal)

Class 1. **Asteroidea** (Gr., eleutheros = star + eidos = form)

1. Starfishes or sea stars.

2. Body includes 5 radiating arms.

3. Tube feet with suckers.

4. Anus and madreporite are present on the aboral surface.

5. Pedicellariae present.

6. Free-living, predaceous, slow creeping and scavengerous.

Subclass 1. **Somasteroidea**

1. Fossil Palaezoic sea stars. *Platasterias latiradiata* is the only living species.

Subclass 2. **Euasteroidea**

1. Living sea stars.

Order 1. **Phanerozonia**

1. Body with marginal plates and papulae on aboral surface.

2. Pedicellariae alveolar or sessile type.

3. Tube feet without suckers.

4. Mostly live in burrows in soft bottom.

Examples: *Astropecten*, *Goniaster*, *Luidia*, *Oreaster*.

Order 2. **Spinulosa**

1. without conspicuous marginal plates but with papulae on both surfaces.

2. Pedicellariae rarely present.

3. Tube feet with suckers.

4. Aboral surface with low spines.

Examples: *Echinaster*, *Solaster*, *Asterina*, *Pteraster*.

Order 3. **Forcipulata**

1. Marginal plates inconspicuous or absent.

2. Pedicellariae pedunculate and straight or crossed.

3. Four rows of tube feet present.

Examples: *Asterias*, *Heliaster*.

Class 2. **Ophiuroidea** (Gr., ophis = snake + oura = tail + eidos = form)

1. Includes brittle stars and allies.

2. Body flattened with a pentamerous and has rounded central disc.

3. Arms usually five, rarely six or seven, and are long, slender, smooth or spiny.

4. Pedicellariae absent.

5. Madreporite on the oral surface.

6. Stomach sac like; anus absent.

7. Ambulacral grooves absent or covered by ossicles; tube feet without suckers.

Order 1. **Ophiurae**

1. Brittle and serpent stars.

2. Small and five-armed.

3. Arms move transversely.

4. Disc and arms covered with plates.

Examples: *Ophioderma*, *Ophiothrix*, *Ophiura*, *Ophiopholis*.

Order 2. **Euryalae**

1. Arms simple and branched, vertical movement.

2. Disc and arm covered by soft skin.

Examples: *Asteronyx*, *Gorgonocephalus* (basket star).

Class 3. **Echinoidea** (Gr., echinos = hedgehog + eidos = form)

1. Sea urchins and dollars.

2. Body spherical, disc-like, oval or heart-shaped.

3. Skeleton with movable spines and three-jawed pedicellariae.

4. Chewing apparatus or Aristotle's lantern with teeth.

5. Ambulacral grooves covered by ossicles.

6. Sexes separate. Gonads pentamerous.

Subclass 1. **Bothriocidaroida**

1. A single row of plates in each inter-ambulacral area.

2. Madreporite radial.

3. without typical lantern.

Examples: Single extinct Ordovician genus Bothriocidaris.

Subclass 2. **Regularia**

1. Body globular, pentamerous, with two rows of inter-ambulacral plates.

2. Aristotle's lantern well developed.

3. Mouth central.

4. Madreporite oral.

5. Anus central on aboral surface with well-developed apical plates.

Order 1. Lepidocentroida

1. Test flexible with overlapping plates.

2. Ambulacral plates extend up to mouth lip.

3. Inter-ambulacral plates in more than two rows in extinct forms.

Example: *Palaeodiscus*.

Order 2. Melonechinoida

1. Test spherical and rigid.

2. Ambulacral plates continue to mouth lip.

3. Inter-ambulacral plates in four or more rows.

4. Wholly extinct.

Example: *Melonechinus*.

Order 3. Cidaroida

1. Test globular and rigid.

2. Two rows of long narrow ambulacral plates and two rows of inter-ambulacral plates.

3. No peristomial gills.

4. Anus aboral and central.

Examples: *Histocidaris*, *Goniocidaris*.

Order 4. Diadematoida

1. Test globular usually with compound ambulacral plates.

2. Perisomial gills present.

3. Anus aboral and central.

Examples: *Echinus*, *Diadema*, *Arbacia*.

Subclass 3. Irregularia

1. Body oval or circular flattened oral-aborally.

2. Mouth central or displaced anteriorly on oral surface.

3. Anus marginal, outside the apical system of plates.

4. Tube feet generally not locomotor.

Order 1. Holectypoida

1. Test regular with simple ambulacra and centrally located peristome and apical system.

2. Lantern present.

3. Mostly extinct.

Examples: *Echinoneus*, *Holectypus*.

Order 2. Cassiduloida

1. Aboral ambulacra area petloid, forming a five-armed figure like petals of a flower.

2. Lantern absent.

3. Mostly extinct.

Examples: *Cassidulus*.

Order 3. Clypeastroida

1. Test flattened with oval or rounded shape.

2. Mouth central, anus excentric.

3. Aboral ambulacral areas petaloid.

4. Gills absent.

5. Bottom dwellers.

Examples: *Clypeaster*, *Echinocyamus*, *Echinarachinus*.

Order 4. **Spatangoida**

1. Test oval or heart-shaped with excentric mouth and anus.

2. Four aboral ambulacral areas paloid.

3. Gills absent.

4. Lantern absent.

5. Burrowing forms.

Examples: Heart urchins: *Spatangus*, *Hemipneustes*, *Echinocardium lovenia*.

Class 4. **Holothuroidea** (Gr., holothurion = sea cucumber + eidos = form)

1. Sea cucumbers.

2. Body bilaterally symmetrical, elongated on oral-aboral axis having mouth at or near one end and anus at or near the other end body wall leathery.

3. Arms and spines absent.

4. Mouth anterior, surrounded by tentacles.

5. Ambulacral grooves concealed; tube feet with suckers.

6. Respiratory tree for respiration.

Order 1. **Dendrochirota**

1. Tentacles irregularly branched.

2. Podia or tube feet numerous.

3. Respiratory tree present.

Examples: *Cucumaria*, *Thyone*.

Order 2. **Aspidochirota**

1. Tentacles peltate or leaf-like.

2. Podia or tube feet numerous.

3. Pharynx absent.

4. Respiratory tree present.

Examples: *Holothuria*, *Actinopyga*.

Order 3. **Elasipoda**

1. Tentacles leaf-like.

2. Tube feet webbed together to form fins.

3. Respiratory tree absent.

4. Deep-sea dwellers.

Examples: *Pelagothuria*.

Order 4. **Molpadonia**

1. Fifteen digitate tentacles.

2. Tube feet absent.

3. Posterior end tail-like.

4. Respiratory tree present.

Examples: *Caudina*, *Molpadia*.

Order 5. **Apoda**

1. Worm-like sea cucumbers.

2. Respiratory tree or tube feet absent.

3. Burrowing forms.

Examples: *Synapta*, *Leptosynapta*.

Subphylum II. **Pelmatazoa** (Gr., pelmatos = stalk + zooios = animal)

Stalked, sedentary echinoderms.

Class 1. **Crinoidea** (Gr., crinon = lily + eidos = form)

1. Sea lilies.

2. Body attached during part or whole life by an aboral stalk.

3. Mouth and anus on oral surface.

4. Arms with pinnules.

5. Tube feet without suckers; madreporite, spines and pedicellariae absent.

Order. **Articulata**

1. Living sea Lillies and feather stars.

2. Feather stars are sessile and free-swimming.

3. Calyx pentamerous.

Examples: *Antedon* (sea lily), *Neometra* (feather star).

A few other Echinoderms

1. *Echinus*: *Echinus* is commonly called sea-urchin (Fig 1). It is a species of marine invertebrate in the echinidae family. It is a deep sea animal found from intertidal zone to a depth of 5000 meters. In the North Sea, the species is common in all areas with hard substrates. It is found off the coasts of Portugal, Spain, France, Belgium, the Netherlands, Denmark, Norway, Sweden, the United Kingdom and Ireland. Sea urchins feed mainly on algae, but can also feed on sea cucumbers and a wide range of invertebrates, such as mussels, polychaetes, sponges, brittle stars, and crinoids.

It has a globe-shaped body enclosed within a shell or corona and having very long movable spines. The surface of corona is divided into five ambulacral regions alternating with five interambulacral regions. In each ambulacral region, there are two rows of tube feet. Mouth is present on oral surface and is surrounded by peristome. The chewing apparatus or Aristotle's lantern projects from the mouth. Anus is surrounded by a periproct and is present in the centre of the aboral surface. Water-vascular system is well developed. Development is indirect and involves free swimming echinopluteus larva. Removal of the sea urchins results in the overgrowth of seaweeds and the devastation of the coral reef habitat. When present in large numbers, sea urchins can devastate sea-grass beds in the tropics, adversely affecting the organisms dwelling within.

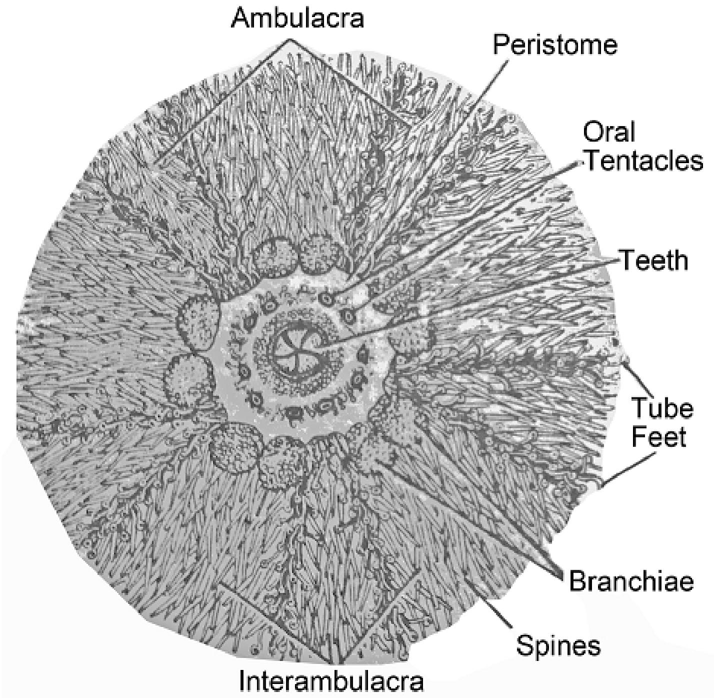

Fig.1 Echinus

2. *Ophioderma*: *Ophioderma* is also known as brittle star. It occurs from the lower shore to depths of around 150m, living on hard substrates. The common brittle star is extremely variable in colouration, ranging from violet, purple or red to yellowish or pale grey, often spotted with red. The arms are usually white or grey with pink bands. Body is made up of a roughly pentagonal central disc and five freely movable arms arising form the base of the disc. Arms are covered with calcareous plates and on either side by spines. Each arm has two grooves called bursal slits. Brittle star moves by means of its tube feet. Development is indirect through free-swimming ophiopluteus larva. The common brittle star is a scavenger, feeding on dead organisms (Fig. 2).

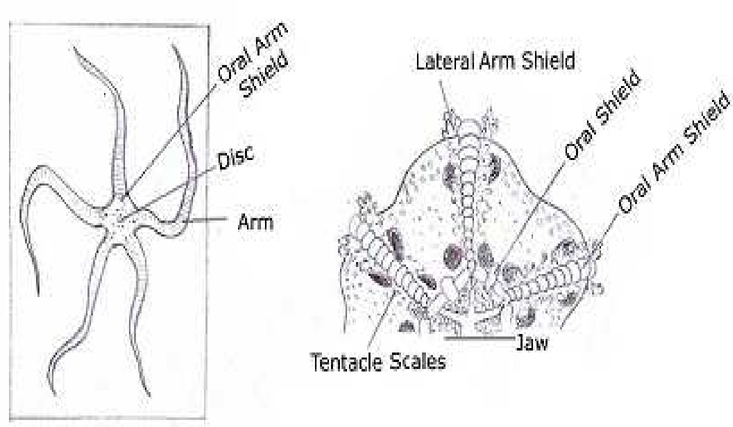

Fig. 2 *Ophioderma*

3. *Holothuria*: *Holothuria* is a genus of marine animals of the family Holothuriidae (Fig. 3). It is commonly known as sea-cucumber and is found in nearly every marine environment, but is most diverse on tropical shallow-water coral reefs. They creep slowly while engulfing micro-organisms alongwith mud. The *Holothuria*, or sea cucumbers, are an abundant and diverse group of worm-like and usually soft-bodied echinoderms. Their habitat ranges from the intertidal, where they may be exposed briefly at low tide, to the floor of the deepest oceanic trenches.

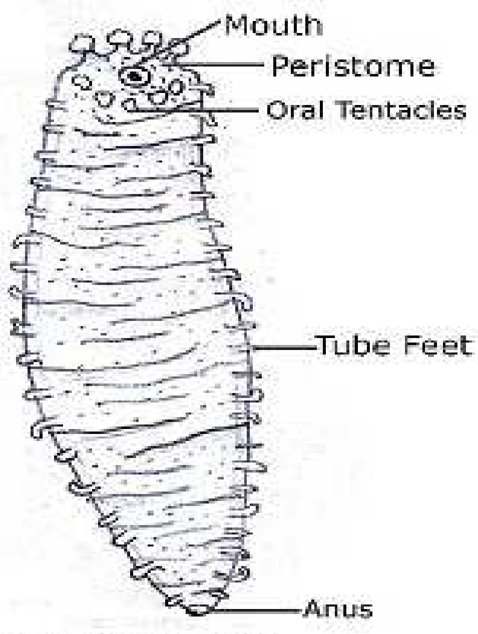

Fig. 3 *Holothuria*

The body is elongated, sausage-shaped, covered with leathery skin and having well developed respiratory tree. The mouth and anus are at the opposite ends. Body bears numerous podia or feet, locomotory on the ventral surface and papilliate on the dorsal surface. Mouth is anteriorly placed, surrounded by 1-30 peltate tentacles. Sexes are separate. Reproduction is sexual. Development is indirect. It includes two larval stages-auricularia and doliolaria respectively. Several species can swim and there are even forms that live their entire lives as plankton, floating with the ocean currents. Sea cucumbers have great economic importance. Some species produce toxins (antimicrobial, anti-inflammatory agents and anticoagulants) that are of interest to pharmaceutical firms. They also form an important part of gourmet food industry in the orient.

4. *Pentaceros*: *Pentaceros* is known as sea pentagon. Central disc is large and the five arms are short and tapering. Aboral surface is convex and bears rows of definitely arranged spines. Oral surface is concave, having a central mouth, communicating with five ambulacral groves, each bearing two double rows of tube feet. Pedicellariae are small and valvate type. *Pentaceros* is very harmful to pearl industry as it feeds on pearly oysters (Fig. 4).

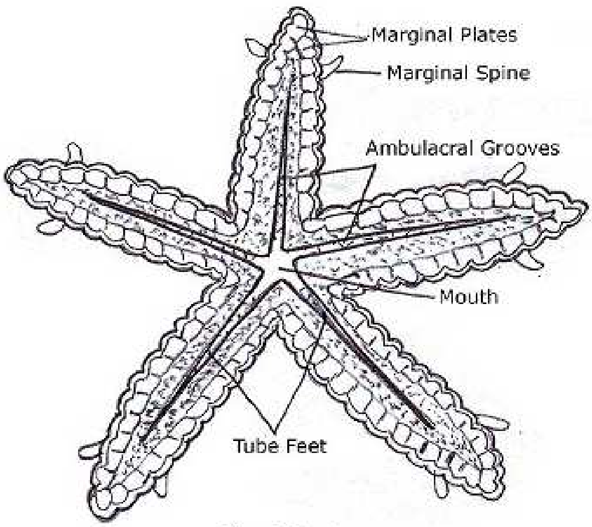

Fig. 4. *Pentaceros*

5. *Astropecten*: *Astropecten* is a common starfish, inhabiting the sandy bottom of seas. Body consists of a large central disc with 5 tapering arms and each having 2 rows of conspicuous marginal plates bearing along spines. Oral surface has a centrally positioned mouth which comes out only occasionally and communicates with 5 ambulacral grooves. Water-vascular system includes two to four polian vesicles in each interradius and the stone canal is structurally complicated. There occurs no brachiolaria larva.

5. ***Antedon***: *Antedon* is commonly known as feather star. It occurs in sea waters of the Atlantic, Western Africa, the Mediterranean and West of Tropical America. It feeds on plankton and debris and has great power of regeneration and autotomy. Body consists of a central disc and a series of ten radiating arms. The upward directed oral surface bears mouth and a projecting papilla which bears the anus while downward directed aboral surface bears several long appendages called cirri for anchoring or crawling on the substratum. Tube feet or podia without suckers present along the edges of ambulacral grooves. Sexes are separate. Reproduction is sexual. Development includes a free-swimming doliolaria larva.

10.4 *Asterias* (Star fish)

Systematic position:

Phylum Echinodermata

Subphylum Eleutherozoa

Class Asteroidea

Order Forcipulata

Genus *Asterias*

Species *Rubens*

Habits and habitat: *Asterias* are free-living marine animals that can be found at all water depths as well as crawling over rocks and shells. It can be found singly or in masses clinging to piles, piers and other clean solid objects. It exhibits slow crawling movement with the help of arms on the rocky bottom. It avoids direct sun and commonly hides itself under some shelter. Starfish possesses great power of mutility. It any pary of the body is broken due to rough treatment or it is cut to pieces, the lost part or the cut pieces are regenerated.

Asterias are mostly carnivorous and have a mouth, oesophagus, two-part pyloric stomach with a pyloric duct leading to the intestine and rectum, with the anus located in the center of the aboral body surface. These animals possess a true coelom that is modified into a unique circulatory system called a water vascular system. Sea water, instead of blood, is actually used to pump nutrients through their bodies via vascular system. They do not have gills, scales, or fins. It moves by using tiny tube feet located on the underside of its body. Adult sunflower sea stars can move at the astonishing speed of one meter per minute using 15,000 tube feet. Tube feet also help sea stars hold their prey.

Asterias feed mainly upon molluscs, especially bivalves and snails. In addition they act as scavengers on any dead animals. It relishes oysters and hence is very harmful to pearl industry. The crown-of-thorns starfish, which feeds on living polyps of reef corals, has caused extensive short-term damage to coral reefs in some parts of the Pacific and Indian oceans.

10.4.1 Structure

1. Shape and size: Most *Asterias* possess a pentamerous radial symmetry, secondarily derived from a larval bilateral symmetry. The body is flattened and flexible, with a pigmented and ciliated epidermis. Average size of *Asterias* ranges from 10 to 25 cm in diameter.

2. Color: *Asterias* is pink, orange, purple or cream in color. The upper or aboral surface is much darker than the lower or oral surface.

3. External structure: The body is distinguished into a larger central disc and five short, symmetrical rays or arms with broad bases and slightly tapering ends. The arms are not distinctly marked off from the disc. The body is marked into two surfaces: the slightly convex, upper surface which is normally directed upward is the aboral surface and the flat lower surface is oral surface.

Exoskeleton: The body is encased in a tough, hard integument, strengthened with numerous calcareous plates or ossicles.

Aboral surface: The aboral and abactinal surfaces are beset with numerous short but stout spines arranged in irregular rows parallel to the long axis of the arms (Fig. 5). All of them are supported on irregular shaped calcareous ossicles embedded in the integument. In the soft interspaces between the dermal ossicles are found small, soft, membranous sac-like outgrowths, papulae or dermal branchiae. Papulae are said to assist in respiration and excretion. The pedicellariae of star-fish are whitish jaw-like structures found on both the aboral and oral surfaces. Each pedicellaria consists of a short, fleshy, stout and movable stalk with two articulating blades, which remain movably articulated with the basilar piece. Anus is situated almost in the centre on the aboral surface. It is in the form of a flat light-coloured nearly circular plate near to the anus and between the bases of the two arms. Its surface is marked with a number of radiating narrow, straight or slightly wavy-groove. Due to the presence of madreporite the body of starfish becomes bilaterally symmetrical. The two arms between which the madreporite is situated are known as bivium, while other three as trivium.

Oral surface: The mouth is situated in the centre of the oral surface in the form of a five-rayed aperture.It is enclosed in the pentagonal depressed area, the actinostome and surrounded by thin, membranous peristome and perisomodeal membrane. Ambulacral grooves radiate out from the five corners of the actinostome and extend one to each arm along its middle upto the distal end. Each groove is borderec by two rows of calcareous ambulacral spines. Tube feet are in the form of hollow slender processes present in two rows in each ambulacral groove. These are provided with terminal suckers. These possess great power of distension and help in locomotion. At the end of each ambulacral groove, there is a bright red eye. It is formed of a number of ocelli and perceives light rays. Above each eye is found a small non-retractile sensory tentacle. It is olfactory in nature and perceives sense of smell (Fig. 5).

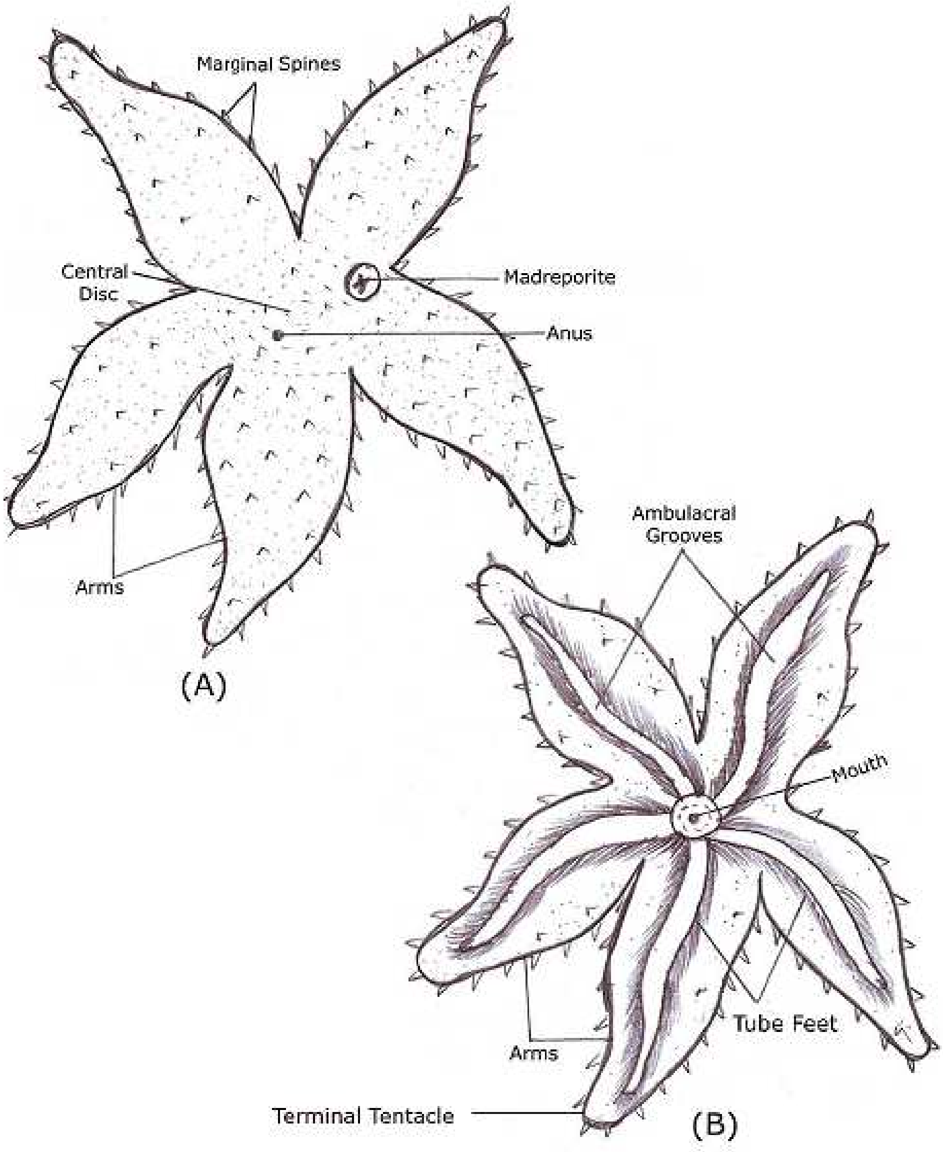

Fig.5 Asterias: External feature (A) Aboral view (B) Oral view

Pedicellariae: Pedicellariae of sea stars are minute, whitish jaw-like structures, found on both the body surfaces, in association with spines (Fig. 6). Pedicellariae may be stalked or sessile. But only stalked type occurs in *Asterias*. Each consists of a short, fleshy and a movable stalk, bearing two articulating calcareous blades or valves, resting upon and articulating with a third calcareous plate, the basal or basilar piece. Such pedicellariae (consisting of three calcareous plates) are termed forcipulate. Opposite surfaces of two valves are serrated. Valves open and close with the help of one pair of

Abductor and two pairs of adductor muscles, respectively. According to disposition of valves, two types of pedicellariae occur in Asterias: (i) Straight type- in these the valves are straight, and when closed, these meet together along their entire length. (ii) Crossed type- in these the two valves cross each other like a pair of scissors (Fig. 6).

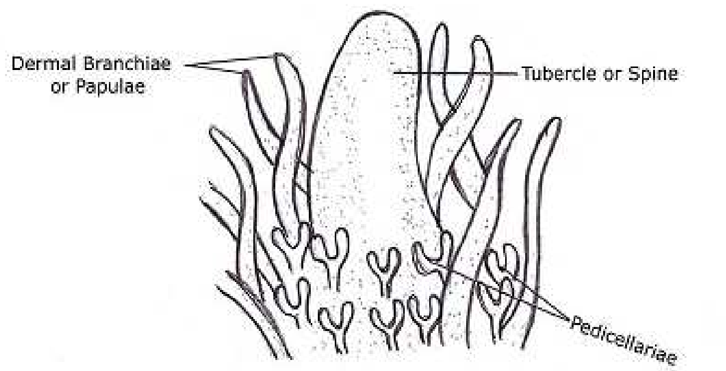

Fig. 6. ***Asterias*** **(A) A cluster of pedicellariae, papulae and tubercle**

The pedicellariae help in the capture and removal of debris and minute organisms, such as larvae, which may settle on the body surface and interfere with respiration by covering the dermal branchiae and tube feet. In some starfishes, the pedicellariae may help in capturing of small prey (Kotpal, 2005).

10.4.2 Locomotion

Locomotion is performed with the help of water-vascular system which sets up a hydraulic pressure. By the action of cilia lining the ambulacral cancals, sea water enters through madreporite and fills up all canals of the system including the tube feet. Body is moved by the steping action of tube feet which are alternately adhered to and released from the substratum. Simultaneously the ampullae of tube feet to these arms contract by the action of their circular muscles. This increases the hydraulic pressure within the tube feet, which consequently elongate, extend forward and adhere firmly to the substratum by vacuum action of their suckers. Adhesion is further strengthened by mucus secreted by the tips of the tube feet. Tube feet then shorten by contracting their longitudinal muscles and forcing some water back into their ampullae. Consequently, the suckers release their hold on the substratum.

During locomotion, one or two arms serve as leading arms, and all the tube feet extend in the same direction in a coordinated manner. However, the tube feet may nt work in unison. As a result, the sea star moves forward steadily but slowly, at a speed of about 15 cm per minute. Sea stars can also climb up the rock by the combined action of their tube feet. If a sea star is accidentally turned upside down, it can correct its posture by folding or arching its arms. In folding action, tips of one or two arms twist to bring their tube feet in contact with the substratum, thus permitting the whole body to fold over and right itself. In arching the upturned body is first raised on its arm tips and then rolled over (Kotpal, 2005).

10.4.3 Mode of Feeding and Digestive system

(I) Alimentay canal: Sea star possesses a complete digestive tract situated in the central disc. Between the mouth and anus it can be differentiated into oesophagus, stomach and intestine (Fig. 8). The alimentary canal is a short but spacious canal distinguished into the following parts:

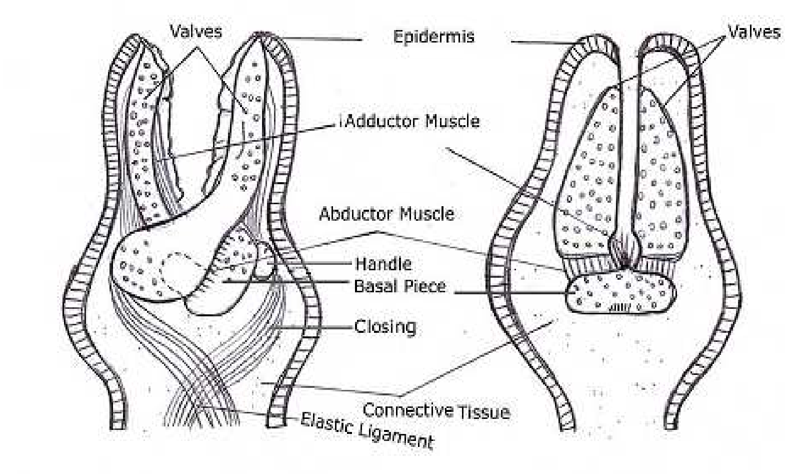

Fig. 7. ***Asterias*** **(B) Crossed type pedicellariae (C) Straight type pedicellariae**

1. Mouth: It is a pentagonal aperture surrounded by a delicate perioral membrane called peristome, situated on the oral side in the centre of central disc. The mouth is surrounded by a sphinter of muscles.

2. **Oesophagus**: Mouth opens into a short and wide oesophagus. It extends vertically to open into the stomach.

3. **Stomach**: It is a spacious sac occupying most of the interior of the central disc. It is differentiated into a larger oral part or cardiac stomach and a smaller aboral part or pyloric stomach.

(a). **Cardiac stomach**: It is a larger oval part connected with the oesophagus. Its wall is thin and greatly folded. The cardiac stomach is held in position by five pairs of mesenteries or the gastric filaments which are formed of connective tissue and muscles. The stomach is capable of everting out through mouth by the action of muscles extending from the body wall.

(b)Pyloric stomach: It is a small, flat pentagonal sac opening aborally into intestine. Angles of the pentagon lie along the radii and each receives a duct, called the pyloric duct, from the corresponding pyloric caeca.

4. Intestine: It is a short, narrow, five-sided tube extending vertically to the aboral surface to open out at the anus. It gives out two or three small, branched and brownish appendages, the intestinal or rectal caeca, at interradial positions. Intestinal caeca secreate a brownis fluid, probably excretory in nature. Part of the intestine after caeca is sometimes called the rectum.

5. Anus: The intestine opens on the aboral surface of the central disc by a small rounded aperture, the anus.

(II) Food and feeding mechanism: Star fish is carnivorous, feeding on any slow moving animal but mainly upon molluscs such as oysters, clams, mussels, snails, etc. The fish crabs and barnacles also make its food.

The food is captured with the help of tube feet and arms but the small animals are swallowed. The prey is seized by the tube feet and is folded over by the arms. The cardiac stomach is everted out and is wrapped around the prey.

To feed shelled molluscs i.e. clams, oysters and other bivalves, starfish adopts another fascinating method. It creeps over the clam, holds it with tube feet and brings free margins of the shell close to its mouth. It arches its body assuming a umbrella-like posture. It firmly attaches its tube feet to both the valves of the shell and tries to pull apart the two valves held tightly together by the powerful adductor muscles. It also attaches a few tube feet at the tips of the arms to the substratum to aid in the process. The tube feet gripping the valves of the clam's shell exert a steady pull till the adductor muscles of the clam are exhausted and give way. The muscles of clam cannot, as a rule, remain in a continuous state of contraction for a long time. As the valves gape, the starfish inserts its cardiac stomach into the mantle cavity of clam to devour it (Rastogi, 2015).

(III) Digestion, absorption and egestion: When cardiac stomach is everted over the captured prey, secretions of stomach and pyloric caeca are poured over it. Enzymes proteases, lipases and amylases, digest the proteins, fats and starches, respectively. Digestion, thus takes place outside the body. Digested materials are then carried into alimentary canal by retraction of cardiac stomach. This is brought about by contraction of gastric ligaments. Digestion of semi-digested materials, if any, is completed in stomach and pyloric caeca. Some small animals are, however, ingested as such and digested only in stomach and pyloric caeca.

Digested food is absorbed mainly by pyloric caeca and distributed to various parts of the body by coelomic fluid. Excess food is stored in the storage cells of the pyloric caeca. As the absorption of food is more or less completed in pyloric caeca, it does not require a long intestine. Hence, the intestine is very short. As animal ingests partially digested food, it has little undigested material, which is mainly eliminated through the mouth itself. Little, if any, egestion takes place through the anus.

10.4.4 Reproduction

Asterias or star-fish is unisexual, but there is no sexual dimorphism. The reproductive organs of primitive type and lack copulatory organs, accessory glands and receptacles or reservoirs for storing sperms and ova (Fig. 8).

Gonads: The testes and ovaries are morphologically similar but they show colour variation. The testes are grayish and the ovaries pinkish in colour. There are five pairs of testes or ovaries with one pair at the base of each arm lying freely between pyloric caeca and ampullae of the tube feet.

The gonads develop periodically and their size varies greatly with the proximity of spawning period. At maturity they occupy a considerable portion of the perivisceral space. Each gonad appears as an elongated feathery tuft or bunch of grapes consisting of membranous and rounded follicles. It is enclosed in a genital sinus of the perihaemal system. From the proximal end of each gonad arises a short dilated gonoduct which opens out laterally on the aboral surface by a minute gonopore. The mature sperms and ova are shed in sea water.

Fertilisation: Fertilisation is external. The eggs and sperms are shed in sea-water. The female lays about 200 million eggs in a season. The number of sperms produced is many times more.

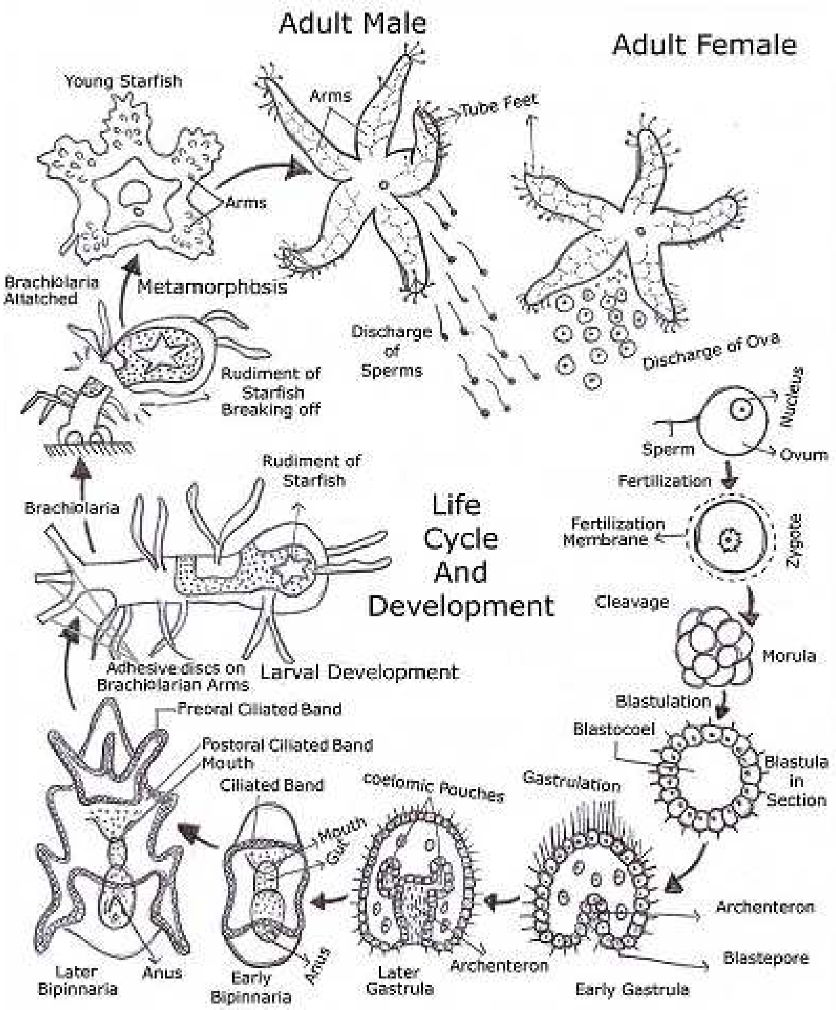

Fig. 8 *Asteiras*. **Life histroy and development**

Embryogeny: Development is indirect and includes various larval stages. The fertilized egg or zygote is spherical, 0.2-0.5 mm in diameter and contains little amount of yolk. The cleavage is rapid and holoblastic so that on the second day, a spherical, hollow, one-layered ciliated blastula or coeloblastula is formed. It swims about in water freely. Its outer layer is formed of ectoderm and inner layer of endoderm. The cavity of gastrula which is lined by endoderm is known as archenteron. It opens to the exterior by a wide aperture called blastopore. On the ventral side, a tubular ingrowth of ectoderm forms the mouth or stomodaeum.

During gastrulation, the advancing tip of archenteron buds off mesenchyme cells into the blastocoels which form the mesenchyme or mesoderm. The advancing or terminal part of archenteron also cuts off on either side a lateral pouch. The laterl pouches take their position on the right and left sides of archenteron and develop into coelomic pouches. These give rise to coelom, its mesodermal lining and water vascular system. The embryo at this stage becomes a free-swimming larva.

Larval development: The development of star-fish includes the following larval stages:

1. Dipleurula larva or early bipinnaria: This is the first larval stage and is commonly found in all the echinoderm. It is egg-shaped and bilaterally symmetrical. The uniform ciliation of the body is replaced by two ciliary wavy bands- a peri-oral band surrounding the mouth, and an aboral band lying inside the mouth. An ectodermal invagination (stomaodaeum) on the ventral side of the embryo becomes continuous with the archenteron. The opening thus developed forms the larval mouth. The archenteron gets differentiated into oesophagus, stomach and intestine. The blastopore becomes the anus. With these changes embryo develops into dipleurula larva capable of independent existence. It actively feeds on diatoms, etc. The aboral band of cilia helps in collecting the food particles. The larva swims near the surface and rotates clock-wise with the help of peri-oral bands of cilia.

2. Bipinnaria larva: The dipleurula larva soon develops on its front side a large pre-oral lobe bordered by a preoral loop of cilia. The pre-oral band now splits into apreoral loop bordering the preoral lobe and postoral loop that borders the lateral lobes. The larva thus formed is called the bipinnaria larva. It swims and feeds freely in water for a few days and enters into the next larval stage, the brachiolaria larva.

3. Brachiolaria larva: The lobes of bipinnaria larva become modified into long, slender, ciliated and contractile larval arms. From the pre-oral lobe arise three short and non-ciliated processes ending into suckers. These processes are called fixing processes. This is now known as brachiolaria larva. It swims and feeds like bipinnaria larva.

Metamorphosis: After a period of 6-7 weeks, the larva settles on some object by its fixing processes. The larval mouth, anus and ciliary bands disappear. New mouth is formed on the left side and new anus on the right of larva. The left and right sides form ultimately the oral and aboral surfaces respectively. Five arm rudiments develop around the oral-aboral axis. Skeletal elements on the arm rudiments and radial canals develop into them. The coelom of the adult develops from the right and left coelomic pouches of the larva. In each arm two pairs of outgrowths from the coelom form the first tube feet and serve for attachment. By further complex internal reorganization a bilaterally symmetrical larva transforms into a radially symmetrical adult star-fish.

10.5 Summary

- Phylum echinodermata (Gr., echinos=spiny+derma=skin, ata=characterized by) includes exclusively marine invertebrates displaying pentamerous radial symmetry and an endoskeleton of calcareous plates and spines. Jacob Klein gave the name echinodermata.

- Echinoderms are exclusively marine, free living and mostly bottom-dwellers. Organ system grade of body organization.

- *Asterias* are free-living marine animals that can be found at all water depths as well as crawling over rocks and shells.

- *Asterias* feed mainly upon molluscs, especially bivalves and snails. In addition they act as scavengers on any dead animals.
- Most *Asterias* possess a pentamerous radial symmetry, secondarily derived from a larval bilateral symmetry. The body is flattened and flexible, with a pigmented and ciliated epidermis. Average size of *Asterias* ranges from 10 to 25 cm in diameter.

- The aboral and abactinal surfaces are beset with numerous short but stout spines arranged in irregular rows parallel to the long axis of the arms.

- The mouth is situated in the centre of the oral surface in the form of a five-rayed aperture.

- Pedicellariae of sea stars are minute, whitish jaw-like structures, found on both the body surfaces, in association with spines. The pedicellariae help in the capture and removal of debris and minute organisms, such as larvae, which may settle on the body surface and interfere with respiration by covering the dermal branchiae and tube feet. In some starfishes, the pedicellariae may help in capturing of small prey.

- Sea star possesses a complete digestive tract situated in the central disc. Between the mouth and anus it can be differentiated into oesophagus, stomach and intestine.

- *Asterias* is carnivorous, feeding on any slow moving animal but mainly upon molluscs such as oysters, clams, mussels, snails, etc. The fish crabs and barnacles also make its food.

- Locomotion is performed with the help of water-vascular system which sets up a hydraulic pressure.

- *Asterias* or star-fish is unisexual, but there is no sexual dimorphism. The reproductive organs of primitive type and lack copulatory organs, accessory glands and receptacles or reservoirs for storing sperms and ova.

- There are five pairs of testes or ovaries with one pair at the base of each arm lying freely between pyloric caeca and ampullae of the tube feet.

- Fertilisation is external. The eggs and sperms are shed in sea-water. The female lays about 200 million eggs in a season.

- The development of star-fish includes the following larval stages- Dipleurula larva or early bipinnaria, Bipinnaria larva and Brachiolaria larva.

10.6 SELF ASSESSMENT QUESTIONS

10.6.1 Long Answer type questions:-

1. Describe the classification of phylum echinodermata.

2. Give an account of larval forms found in Sea star.

3. Discuss the digestive system of starfish.

4. Explain the reproduction of star fish.

10.6.2 Short Answer type questions:-

1. Write about the external morphology of star fish?

2. Draw a well labeled diagram of starfish?

3. Discuss brachiolaria larva?

4. Comments on bipinnaria larva?

5. Write short notes on *Echinus* and *Holothuria?*

10.6.3 Fill in the blanks:-

1. Respiratory trees are found in…… ……….

2. Antedon is popularly called as…………...

3. Echnidermata was coined by…………….**.**

4. Water echinodermata includes exclusively ………..**.**

5. Aristotle's lantern is found in …….**……**

Answer:

1. *Holothuria* 2. Feather star 3. Jacob Klein. 4. Marine animals. 5. Sea Urchin.

10.6.4 Multiple choice questions:-

1. *Asterias* belong to:

(a) Echinoidea (b) Asteroidea

(c) Ophiurodea (d) Holothuroidea

2. Common name of *Asterias*:

(a) Brittle star (b) Star fish

(c) Sea pentagon (d) Basket star

3. Locomotory organs of starfish:

(a) Polian vesicles (b) Podia

(c) Both (d) None

4. Characteristic feature of echinoderm:

(a) Haemal system (b) Water vascular or ambulacral system

(c) Both (d) None

5. Larval stage in life history of starfish:

(a) Dipleurula (b) Bipinnaria

(c) Brachiolaria (d) All of the above

6. The eggs of Asterias are:

(a) Macrolecithal (b) Microlecithal

(c) Megalecithal (d) Oligolecithal

7. Excretory products:

(a) Urea and creatine (b) Ammonia

(c) Urea (d) Uric acid

8. Which of the following phyla is found only in sea water?

(a) Annelida (b) Arthropoda

(c) Mollusca (d) Echinodermata

9. Most fragile arms are of:

(a) Star fish (b) Sea urchin

(c) Brittle star (d) none

10. Tube feet are locomotory in function and also perform additional:

(a) Excretory function (b) Feeding function

(c) Protective function (d) All the above

Answer: 1. B 4. C 7. A

2. B	5. D	8. D
3. B	6. B	9. C
10. B		

10.7 GLOSSARY

Aboral: In a direction away from the mouth; the part of the body opposite the mouth.

Arms: Long, flexible mobile limbs - usually containing a feeding groove.

Coelom: A body cavity (fluid filled), formed in the embryo.

Ectoderm: The outer of the three germ layers of the embryo.

Endoderm: The innermost of the three primitive germ layers of the embryo.

Endoskeleton: An Endoskeleton is an internal support structure of an animal, typically made of bone.

External fertilization: The fusion of the male and female gametes occurs outside of the animals' body Usually in a watery environment.

Fauna: All the animals that live in a particular area.

Fertilization: Union of a male gamete (sperm) with a female gamete (ovum) to give an egg, or zygote.

Gastrulation: Process by which cells of the blastoderm are translocated to new positions in the embryo, producing the three primary germ layers.

Internal fertilization: The fusion of the male and female gametes occurs within the Female's Reproductive tract.

Macrolecithal: Eggs with a large yolk.

Microlecithal: An egg containing a little amount of yolk.

Oral: In a direction toward the mouth; a part of the body on the same Surface as the Mouth.

Ovary: One of the paired female reproductive organs that produce eggs.

Pedicellariae: Small stalked or unstalked pincer-like organs on the body of Asteroids and echinoids, used for defense and grooming.

Pentameric: Five arms.

Radial: In a direction toward the central axis of an arm or ambulacrum; a part of the body near an arm or ambulacrum.

Tentacles: In holothuroids, feeding structures in the form of highly modified tube feet arranged in a ring around the mouth.

Testis: A male gonad.

Tube feet: Projections from the body wall, which are connected to the water vascular System and generally used for locomotion. They may also be modified to serve respiratory, food- catching and sensory functions.

Valve: A structure that limits or closes in opening.

Water vascular system: The water vascular system maintains communication with the surrounding Sea water through a group of pores in the madreporite.

10.8 References

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