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I SEM ZOOLOGY NOTES

V 4.0 :: 2023-24

ENGLISH MEDIUM

PS Govt. Degree College :: Penukonda :: Sri Satyasi Dist., AP

ZOOLOGY SYLLABUS - I SEMESTER
PAPER – I : ANIMAL DIVERSITY – BIOLOGY OF NONCHORDATES

UNIT I

1.1 Principles of Taxonomy – Binomial nomenclature – Rules of nomenclature
1.2 Whittaker's five kingdom concept and classification of Animal Kingdom.

Phylum Protozoa

1.3 General Characters and classification of protozoa up to classes with suitable examples
1.4 Locomotion, nutrition and reproduction in Protozoans
1.5 Elphidium (type study)

UNIT –II

Phylum Porifera

2.1 General characters and classification up to classes with suitable examples
2.2 Skelton in Sponges
2.3 Canal system in sponges

Phylum Coelenterata

2.4 General characters and classification up to classes with suitable examples
2.5 Metagenesis in Obelia
2.6 Polymorphism in coelenterates
2.7 Corals and coral reefs

Phylum Ctenophora :

2.8 General Characters and Evolutionary significance (affinities)

Unit – III

Phylum Platyhelminthes

3.1 General characters and classification up to classes with suitable examples
3.2 Life cycle and pathogenecity of Fasciola hepatica
3.3 Parasitic Adaptations in helminthes

Phylum Nemathelminthes

3.4 General characters and classification up to classes with suitable examples
3.5. Life cycle and pathogenecity of Ascaris lumbricoides

Unit – IV

Phylum Annelida

4.1 General characters and classification up to classes with suitable examples
4.2 Evolution of Coelom and Coelomoducts
4.3 Vermiculture - Scope, significance, earthworm species, processing, Vermicompost, Economic importance of vermicompost

Phylum Arthropoda

4.4 General characters and classification up to classes with suitable examples
4.5 Vision and respiration in Arthropoda
4.6 Metamorphosis in Insects
4.7 Peripatus - Structure and affinities
4.8 Social Life in Bees and Termites

Unit – V

Phylum Mollusca

5.1 General characters and classification up to classes with suitable examples
5.2 Pearl formation in Pelecypoda
5.3 Sense organs in Mollusca

Phylum Echinodermata

5.4 General characters and classification up to classes with suitable examples
5.5 Water vascular system in star fish
5.6 Larval forms of Echinodermata

Phylum Hemichordata

5.7 General characters and classification up to classes with suitable examples
5.8 Balanoglossus - Structure and affinities

RECORD WORK

1. Study of museum slides / specimens / models (Classification of animals up to orders)

Protozoa:
Amoeba, Paramoecium, Paramoecium Binary fission, Paramoecium Conjugation, Vorticella, Entamoeba histolytica, Plasmodium vivax

Porifera:
Sycon, Spongilla, Euspongia, Sycon T.S & L.S, Spicules, Gemmule

Coelenterata:
Obelia – Colony & Medusa, Aurelia, Physalia, Velella, Corallium, Gorgonia, Pennatula

Platyhelminthes:
Planaria, Fasciola hepatica, Fasciola larval forms: Miracidium, Redia, Cercaria, Echinococcus granulosus, Taeniasolium, Schistosoma haematobium

Nemathelminthes:
Ascaris (Male & Female), Drancunculus, Ancylostoma, Wuchereria

Annelida:
Nereis, Aphrodite, Chaetopteurs, Hirudinaria, Trochophore larva

Arthropoda:
Cancer, Palaemon, Scorpion, Scolopendra, Sacculina, Limulus, Peripatus, **Larvae**: Nauplius, Mysis, Zoea, **Mouth parts**: Male &female Anopheles and Culex, Mouth parts of Housefly and Mouth parts of Butterfly.

Mollusca:
Chiton, Pila, Unio, Pteredo, Murex, Sepia, Loligo, Octopus, Nautilus, Glochidium larva

Echinodermata:
Asterias, Ophiothrix, Echinus, Clypeaster, Cucumaria, Antedon, Bipinnaria larva

Hemichordata:
Balanoglossus, Tornaria larva

2. Dissections:

1. **Prawn**: Appendages, Digestive system, Nervous system, Mounting of Statocyst
2. Insect Mouth Parts
3. Laboratory Record work shall be submitted at the time of practical examination
4. An “Animal album” containing photographs, cut outs, with appropriate write up about the above mentioned taxa. Different taxa/ topics may be given to different sets of students for this purpose
5. Computer - aided techniques should be adopted or show virtual dissections

Co-curricular activities (suggested)

- Preparation of chart/model of phylogenic tree of life, 5-kingdom classification, Elphidium life cycle etc.
- Visit to Zoology museum or Coral island as part of Zoological tour
- Charts on life cycle of Obelia, polymorphism, sponge spicules
- Clay models of canal system in sponges
- Preparation of charts on life cycles of Fasciola and Ascaris
- Visit to adopted village and conducting awareness campaign on diseases, to people as part of Social Responsibility.
- Plaster-of-paris or Thermocol model of Peripatus
- Construction of a vermicompost in each college, manufacture of manure by students and donating to local farmers
- Models of compound eye, bee hive and terminarium (termitaria) by students
- Visit to apiculture centre and short-term training as part of apprenticeship programme of the govt. Of Andhra Pradesh
- Chart on pearl forming layers using clay or Thermocol
- Visit to a pearl culture rearing industry/institute
- Live model of water vascular system
- Phylogeny chart on echinoderm larvae and their evolutionary significance
- Preparation of charts depicting the feeding mechanism, 3 coeloms, tornaria larva etc., of Balanoglossus

Animal Diversity- Biology of Nonchordates

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Binominal Nomenclature

A standard and widely accepted system of naming plants and animals is the binomial nomenclature. This naming system given by Carolus Linnaeus.

Every recognized species on earth is given a two-part scientific name. This system is called "binomial nomenclature." ICZN (International code of zoological nomenclature) is the widely used code in the naming of the animal species.

First part of name indicates the genus and the second part indicates the species. Ex: *Felis leo*. The first word Genus is a simple noun while the second part - species is mostly an adjective.

All the scientific names of organisms are usually Latin; hence, they are printed in Italics. When hand written, the genus and species name have to be underlined.

The name of the genus starts with a capital letter and the name of the species starts with a small letter.

The generic as well as specific name, do not generally have less than three letters and more than thirteen letters.

Usually, the name of the author appears after the specific name at the end of the biological name and is written in an abbreviated form or in full. *Felis leo Linnaeus* or *Felis leo Linn*.or *Felis leo L*.

The year of discovery is written after the name of the person who discovered it. Ex *Felis leo Linnaeus, 1758*.

When a binomial name is changed, the name of the original author and the year kept in parenthesis. Ex. *Panthera leo (Linnaeus, 1758)*. Linnaeus originally placed the species *leo* under the genus *'Felis'* and it was shifted to the genus *'Panthera'*.

If two or more names are proposed, the correct name first proposed according to the Law of Priority is the valid name of the Genus or Species group. The first proper name is senior synonym. The next correct names are Junior Synonyms.

The extension of binominal nomenclature with subspecies is called trinomen or trinomen nomenclature. Ex. *Corvus splendens splendens*

If the genus and species name are the same and is called tautonymy. Ex. Rattus rattus, Bison bison, Catla catla (Catla), *Axix axis*, *Naja naja*

Advantages of Binomial nomenclature

These names are unique and widely accepted throughout the world. Using this system confusion created by vernacular or local language can be avoided. It indicates the phylogenetic history of that species. It helps to understand the animal's relationship with other animals.

1.3 Whittaker's Five Kingdom Classification

Five-kingdom classification proposed by RH Whittaker in 1969.

Criteria for Five Kingdom Classification

This classification was based on certain characters such as cellular structure, body organisation, source and mode of nutrition, reproduction, and interrelationship with others.

Whittaker's Five Kingdoms

The five Kingdoms are Animalia, Plantae, Fungi, Protista, and Monera.

1. Kingdom Monera:

It includes all prokaryotes like mycoplasma, bacteria, actinomycetes and cyanobacteria, or blue-green algae etc.

* These are unicellular Prokaryotes.
* Cell wall is present and made up of amino acids and polysaccharides.
* These are microscopic cells (0.1 - few microns in length).
* They do not have a well-defined nucleus.
* They contain naked DNA (No histone proteins).
* Membrane-bound cell organelles are absent.

* They use flagella for their movement.
* They are heterotrophic and autotrophic.
* They reproduced by asexually.

2. Kingdom Protista:

It includes all eukaryotes like Protozoans, Dinoflagellates, Euglenoids, Chrysophytes and Slime Moulds.

* They are simple, minute eukaryotic cells.
* Majority are unicellular but some colonial forms
* They have well-organized nucleus.
* The DNA is associated with histones
* Cellular organization is two-envelope type.
* They use flagella, cilia for their movement.
* They are either autotrophs or heterotrophs
* They opt for sexual or asexual modes of reproduction

3. Kingdom Fungi :

The molds, mushroom, and yeast**,** etc. fall under this kingdom.

* They are multicellular, multinucleate achlorophyllous eukaryotes.
* Cell wall is present and made up of chitin.
* Their body is filamentous (hyphae) and mycelial in form.
* Cellular organisation is two envelope types.
* They are non-motile.
* Most of them are heterotrophic, absorptive, saprobic.
* Reproduction by both sexual and asexual methods of spore formation
* They play the ecological role of decomposer.

4. Kingdom Plantae:

It includes Algae, Bryophytes, ferns, gymnosperms.

* They are multicellular eukaryotic organisms commonly called as Plants.
* Their body form is either thalloid (algae and some bryophytes) or differentiated into root, stem and leaves.
* They contain cellulosic cell walls.
* They have plastids.
* They are non-motile.
* They are autotrophic.
* Both sexual and asexual forms of reproduction occur in these organisms
* Spores are present in lower plants. Embryo stage is present except in algal group
* They play the ecological role of producers.
* Their food reserve is usually starch.

5. Kingdom Animalia:

It includes Sponges, Invertebrates and vertebrates.

* These are macroscopic, multicellular eukaryotes called as animals
* Eukaryotic cell is without cell wall and chlorophyll pigments.
* Body with higher degree of body organization with specialized organs
* They are highly motile.
* Their mode of nutrition is heterotrophic.
*They reproduced by both asexually and sexually.
* They play ecological role of consumer
* Their food reserve is usually Glycogen and fat.

Limitations of Five Kingdom

i. No place for Viruses and are not included in this Five Kingdom classification.

ii. Cannot differentiate between unicellular and multicellular algae.

iii. Archaebacteria differ in their structure, composition, and physiology from bacteria.

iv. Mycoplasmas are different from bacteria but placed along with prokaryotes.

v. Algae and protozoa belonged to the same kingdom.

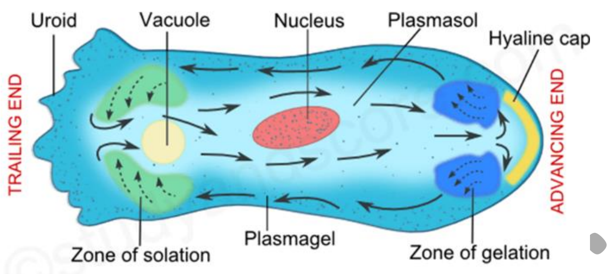
vi. No place for the symbiotic associations. For example, lichens are a symbiotic association between fungi and algae.

1.4.1 Locomotion in Protozoa

Locomotion is the movement of organisms from one place to another. There are four types of locomotion in protozoa.

1. Amoeboid (Pseudopodial) Locomotion

The pseudopodia are the temporary projections of the cytoplasm, formed on the surface of the body. Pseudopodia are the characteristic of the classes Rhizopoda and Actinopoda. Locomotion caused by pseudopodium is called amoeboid movement. The amoeboid movement brought about by the following mechanism (sol-gel theory).



SOL GEL THEORY-AMOEBOID LOCOMOTION
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First, the amoeba attaches itself to a substratum with help of plasma membrane. Ectoplasm at the point where pseudopodium is to be formed becomes thick and forms hyaline cap. Below the hyaline cap, ectoplasm undergoes liquefaction. i.e., a local change from plasmagel to plasmasol state. So, Gel at the anterior end becomes thin and weak. This causes the plasmasol to flow out this point forming a pseudopodium. Inside the growing pseudopodium the plasmasol flows forwards along the line of progression. On reaching the tip of the pseudopodium, this plasmasol is reconverted into plasmagel(gelation), at the same time the plasmagel at the rear (uroid) end is converted into plasmasol (solation) and streams forward, thus maintaining continuous movement. Thus, sol-gel conversion initiates movement in the protoplasm and thus locomotion.

2. Flagellar (swimming) Locomotion

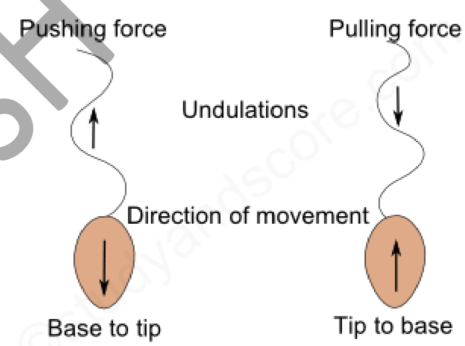
Mastigophore protozoans use flagella for locomotion. Flagella are very fine, filamentous, highly vibratile extensions of the cytoplasm. These are usually 2-4 or many in number. Flagellum shows undulations and sidewise lashing movements.

i. Undulating motion:

a. Undulation from the base to the tip causes pushing force like a propeller of boat, due to which the organism pushed backward.

b. Undulation from the tip to the base causes pulling force like a propeller of an Aeroplane, due to this the organism is pulled forward.

c. Rotatory movements are seen when the undulations are spiral.



UNDULAR MOVEMENT OF FLAGELLUM
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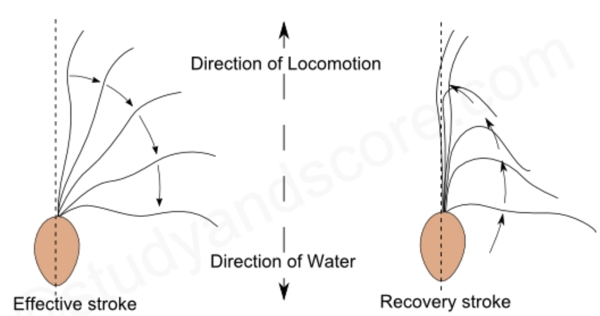
ii. Side-wise lashing movements:

It is the common movement of the flagellum, consisting of an effective down stroke followed by a relaxed recovery stroke. These strokes creates forward movements in animal.



SIDEWISE LASH MOVEMENT OF FLAGELLUM
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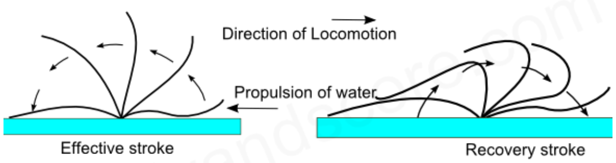
3. Ciliary (swimming) Locomotion:

Cilia are short, vibratile organelles found in large numbers on the body of ciliophoran Protozoans. Ciliary movement exhibited by the beating of the cilia.

Ciliary movement is similar to paddle movement. During swimming, an individual cilium fully extended and bends throughout its length and strikes the surrounding water. It is **effective stroke**, as a result the organism moves forwards and followed by a **recovery stroke**, in which the cilium returns to its original position.



In Paramecium, cilia in the longitudinal row show metachronous movement, while those in the transverse row show synchronous movement.

4. Gliding Locomotion:

Small metabolic movement caused by the contractions of myonemes present below the pellicle is called gliding locomotion. In flagellates, gliding locomotion is called euglenoid movement, and in sporozoans, it is called gregarine movement.

1.4.2 Nutrition in Protozoa:

Protozoa obtain nutrition in many ways. They are either autotrophic or heterotrophic or mixotrophic.

A. Autotrophic or Holophytic Nutrition

The chlorophyll bearing flagellates synthesize carbohydrates from raw materials, water and carbon dioxide in the presence of light. Ex: Euglena.

B. Heterotrophic Nutrition:

They rely on other organisms for the nutritional requirements. The modes are as follows

1. Holozoic Nutrition: Most of the Protozoa derive nutrition by ingesting other organisms. This mode of nutrition is said to be holozoic. It involves development of organelles for food capture, ingestion, digestion, assimilation and egestion of undigested food.

i. Ingestion: The mode of food ingestion in Protozoa is characteristically, referred to as phagocytosis or cell eating. It includes food capture and formation of food vacuole.

Flagellates capture food with the help of their flagella. In Euglena cytostome and cytopharynx helps in ingestion of the captured food.

In *Sarcodina*, pseudopodia help in food capturing. Ingestion of food in Amoeba occurs by circumvallation, circumfluence, import and invagination.

In *ciliates* like Paramecium, beating of the specialized cilia direct the food particles in the water current into the cytopharynx through cytostome.

Suctorians feed with the help of their tentacles. As soon as the prey attaches, the tentacles paralyze it and slowly suck its body fluids.

ii. Digestion including secretion of digestive enzymes in to the food vacuole with ingested food. Then the contents of the vacuoles digested.

iii. Assimilation: The digested food from the food vacuole diffused into the endoplasm and finally assimilated in the body.

iv. Egestion: Removal of undigested food residue through the body surface or cytopyge.

v. Storage: Surplus food is stored in form of glycogen, paramylom in the endoplasm.

* Ingestion of liquid food by invagination through surface of body is called ***pinocytosis* or *cell drinking***. Ex. Amoeba

2. Saprophytic or Saprozoic Nutrition:

It involves absorption of food by Osmosis i.e. through general body surface and no organelle is involved. This method of food getting is Osmotrophy. Food consisting in the form of solution of dead organic matter by the decomposing bacteria. This mode of nutrition found in Matigamoeba and some flagellates like Chilomonas.

3. Parasitic Nutrition:

Parasites inhabiting the intestine and blood have a distinct mouth, feed by holozoic method. The osmotrophic forms are either coelozoic or histozoic. The coelozoic forms absorb their food by their cell surface. The histozoic forms feed on the substances by osmotrophy. Parasitic saprozoic forms may also directly use the serum of their host blood.

4. Coprozoic Nutrition:

The faecal materials of other animals are swallowed as food. Ex: Copromonas.

C. Mixotrophic Nutrition:

Certain protozoans feed by more than one method at the same or at different times due to change in environment. Ex: Euglena. On the demand of the external condition (in the absence of light), they can change their mode of nutrition from holophytic to holozoic or saprophytic type.

1.4.3 Reproduction in Protozoa

Protozoans reproduce in a variety of ways and the process of reproduction is variable amongst different groups. It reproduces both asexually and sexually.

Asexual Reproduction

Asexual reproduction is a process by which young ones are produced without the fusion of gametes. Asexual reproduction is of the following types:

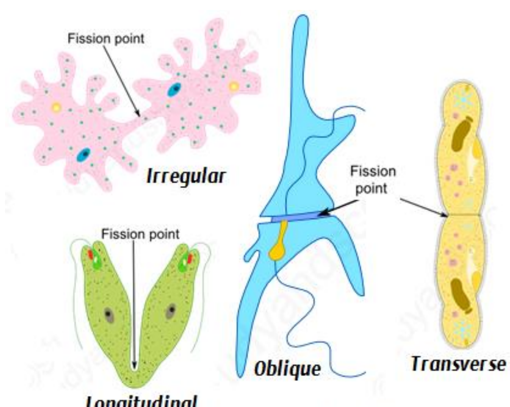
1. Binary fission: It is the most common type of reproduction in protozoans. It involves division of nucleus followed by the division of the cytoplasm, results in formation of two daughter individuals. Depending on the plane of fission, binary fission is of following types:

Transverse binary fission: The body divides transversely. Ex: *Paramecium*

Longitudinal binary fission: The animal divides longitudinally. Ex: Euglena, Vorticella

Oblique Binary fission: The plane of division is somewhat oblique to the body axis. Ex: Ceratium.

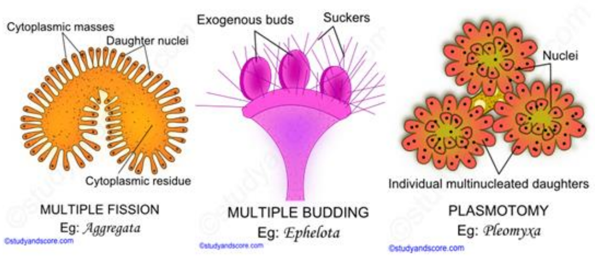
Irregular binary fission: There will be no definite plane of fission. Ex: *Amoeba*



Binary fission - Types

2. Multiple Fission: The division of the parent into numerous daughter individuals is multiple fission. The nucleus divides into many daughter nuclei. The cytoplasm then divides into many pieces. Each piece of cytoplasm encloses a single nucleus and it develops into a daughter individual.

The cell-membrane breaks and daughter individuals produced. It occurs in the sarcodines and sporozoans. Many protozoans like Amoeba, Entamoeba multiply by multiple fission in encysted stage.



3. Budding: Budding is common in Suctorian protozoans. Ex: Acinata. The bud is a smaller individual formed after nuclear division. Budding is either exogenous (Ephelota) or endogenous (Acineta). The buds may be single (vorticella) or multiples (Suctorians) formed at a time.

4. Plasmotomy: It is the division of multinucleate protozoa into two or three daughter individuals without nuclear division. Ex: Opalina, Pelomyxa etc.

5. Repeated fissions with colony formation: Colonies among protozoans are produced when nuclear division is repeated without complete separation of daughter individuals. Ex: Dinobryon.

Sexual Reproduction

Sexual reproduction is a process by which young ones produced by the fusion of gametes.

1. Syngamy

This is a complete fusion of the two sex cells resulting in the formation of the zygote. Based on structure and behaviour of the fusing gametes, syngamy is of following types:

a. Autogamy: It is the fusion of the gametes of the same parent. Ex: Actinophrys.

b. Paedogamy: The fusion of two young individuals. Ex: Actinophrys

c. Exogamy: The fusion of two gametes derived from two different individuals.

d. Hologamy: The sexual union of two mature individuals. Ex: Copromonas.

e. Isogamy: The fusion of similar gametes. Ex: Elphidium, Monocystis, Copromonas.

f. Anisogamy: The fusion of two dissimilar gametes. The large and non-motile gamete is female or macrogamete and the small motile one is male or microgamete. Ex: Plasmodium.

2. Conjugation

The conjugation is the temporary union of two mating types of individuals of the same species to facilitate exchange of nuclear materials. They retain their distinct individuality and separate out after nuclear exchange. The conjugation may be either isogamous (Paramecium) or anisogamous (Vorticella) type.

In conjugation (i) reorganization of a fresh macronucleus occurs to accelerate the metabolic activities, (ii) rejuvenation and revival of lost vigour, (iii) new nuclear combinations and new hereditary combinations arise.

Other modes of reproduction:

3. Automixis: The gametic nuclei of the same individual fuse together. Ex: P. aurelia.

4. Cytogamy: The temporary union of two individuals without any nuclear exchange. Ex: P. caudatum.

5. Plasmogamy: Two individuals may fuse by their cytoplasm to form a plasmodium and separate out unchanged with their distinct nuclei. Ex: Rhizopoda and Mycetozoa.

6. Parthenogenesis: The gametes, which fail to fertilize, start their development partheno genetically. Ex: Actinophrys

7. Regeneration: In Protozoa, any nucleated portion is capable of regeneration, while non-nucleated portions are not. Ex: Stentor.

1.5 Elphidium / Polystomella

Habit and Habitat: Elphidium is a free living, marine and creeping form, found abundantly on the bottom of the ocean.

1. Structure of Elphidium

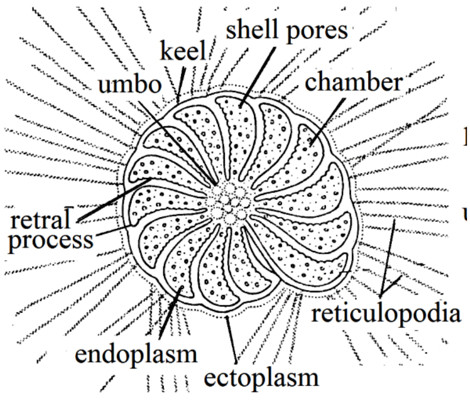
Elphidium is a unicellular animal. The body of Elphidium mainly consists of Shell, Cytoplasm, Reticulopodia etc.

a. Shell: Body of Elphidium is covered with a hard and translucent shell made up of calcium carbonate. The shell is biconvex, multilocular and perforated. The surface of the shell is chiseled. The chambers of the shell are V-shaped, and are arranged in a flat spiral in which each chamber overlaps the previous whorl. The overlapping portion is known as alar processes. The hinder margin of each chamber has a row of numerous minute backwardly directed, hollow, blind protoplasmic projections called retral processes. The central part of the shell forms the rounded umbo. The peripheral part forms a continuous rigid rim or keel.

The chambers are interconnected or communicate with each other as well as with the exterior through minute pores present in the septa. The formation of the shell begins with an initial chamber known as proloculum. As growth proceeds, additional chambers are formed around the proloculum in a spiral manner forming whorls.

b. Cytoplasm: The shell's chambers are filled with inner cytoplasm. Besides, a thin layer of cytoplasm covers the shell from outside.

c. Reticulopodia: The pseudopodia are numerous branching and anastomosing. These are the temporary extensions of the outer cytoplasm and can be withdrawn within the shell. The reticulopodia help the organism in locomotion and in nutrition.



A. Elphidium

2. Nutrition: Nutrition is holozoic. The reticulopodia will capture the prey. It forms a sort of feeding net to capture the prey. The prey is digested outside in the food vacuole and the digested food is passed into inner cytoplasm.

3. Respiration & Excretion: No specialized respiratory organs found, but the exchange of gases takes place by diffusion through the semi-permeable shell. The nitrogenous excretory products produced, excreted out by diffusion or by the process of retraction of reticulopodia.

4. Dimorphism: Elphidium exhibits dimorphism. The individual occurs in two distinct forms. 1. Megalospheric form and 2. Microspheric form. The differences between these two forms are shown below:

Characters	Microspheric form	Megalospheric form
1. Size	Small	Large
2. Shell	Thick walled	Thin walled
3. Proloculum	Small	Large
4. Nucleus	Multinucleate	Uninucleate
5. Number of forms	Less common	More common
6. Reproduction	Asexual form, Schizont (2x)	Sexual form, Gamont (x)

1.5.1 Reproduction in Elphidium (Alteration of Generations)

Elphidium occurs in two forms known as megalospheric and microspheric form. Megalsopheric form is larger and has large proloculum. It reproduces sexually. Microspheric form is smaller and has small proloculum. It reproduces asexually by Schizogony.

A. Asexual Reproduction:

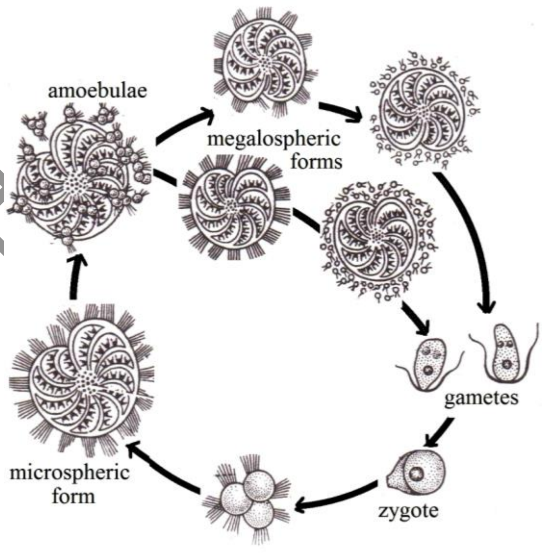
In the microspheric form the nuclei disintegrates into chromatin bodies and the cytoplasm flow out and forms a lump around the empty shell. Fresh nuclei are formed. Around each nucleus protoplasm accumulates, so that number of small amoeboid cells (amoebulae) produced. They detach from the parent shell. Each amoebula secretes now secretes a shell around itself and become the young megalospheric form, and added new chambers and it grows into a megalospheric adult.

B. Sexual Reproduction:

In the megalospheric form nucleus first undergoes repeated mitotic division. The cytoplasm also undergoes fragmentation with in the shell. Each bit of the nucleus become surrounded by cytoplasm, so that number of minute cells are produced. Each cell develop a pair of flagella and come out of the shell to swim about in the water. They are known as isogametes.

Fertilization:

The isogametes derived from the different megalospheric forms unite in pairs to form zygotes (isogamy). Each zygote secretes a shell around itself and becomes a young microspheric form. The diploid nucleus undergoes meiosis and then repeated mitosis to form several haploid nuclei. It grows by adding new chambers, so that multinucleate and multilocular microspheric adult is formed.



Elphidium life cycle

Alteration of generation:

Thus in Elphidium there is an alternation of sexual megalospheric generation with an asexual microspheric generation.

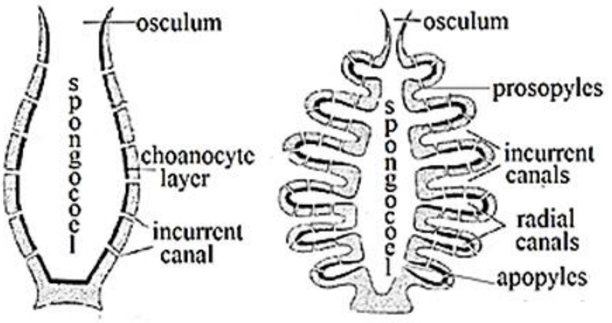
Tip: When 'm' = microspheric individual; am = amoebula; 'M' = Macrospheric individual, 'fl' = flagellula,
m → am → M → (fl + fl) → m….

2.3 Canal System in Sponges

Water circulatory system of sponges also called as canal system is the characteristic feature of the phylum Porifera. Following types of canal systems are found in sponges: 1. Ascon type 2. Sycon type 3. Leucon type

1. Ascon type:

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



Ascon type Sycon type

Outside water ---- Ostia ---- Spongocoel --- Osculum --- outside

2. Sycon type:

This type of canal system is a characteristic of syconoid sponges, e.g. *Scypha* and *Grantia*. Body wall is secondarily folded to form incurrent and radial canals paralleling and alternating with each other. Both these canals interconnected by minute pores called prosopyles. Radial canals are the flagellated chambers that open into central spongocoel by internal openings called *apopyles*. Spongocoel is a narrow, without flagellated cells but is lined by pinacocytes and opens to exterior through the osculum. The course of water current is as follows:

Outside water --- Ostia --- incurrent canal --- prosopyles --- radial canal --- apopyle --- spongocoel --- osculum --- outside.

3. Leucon type:

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

Outside water – Ostia – incurrent canals – prosopyles – radial canals – apopyles – excurrent canals – osculum – outside

There are four types of variations in Leucon system based on the varying degree of complexity of canals.

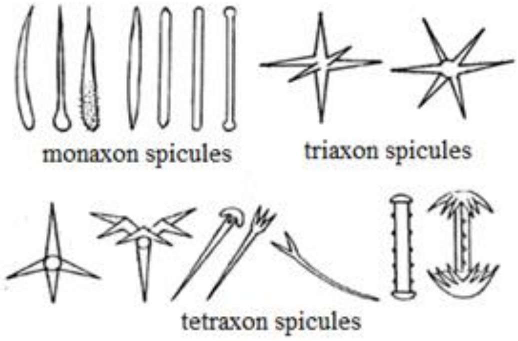
i. Euryphylous type: Broad apertures called the apopyles found. Ex: *Plakina*

ii. Aphodal type: A narrow canal, called *aphodus* is present. E.g. *Geodia.*

iii. Diplodal type: Both aphodus and prosodus are present E.g., *Spongilla* and *Oscarella.*

2.2 Skeleton in Sponges

All the sponges have a skeleton embedded in the mesenchyme. Skeleton consists of separate spicules or interlacing sponging fibers or both. Sponge spicules are made of calcium carbonate or silica. Spongin fibres are composed of a silk-like scleroprotein. Skeleton supports and protects the soft body parts of the sponges.



megasclere spicules

A. Megascleres : They are large-sized and constitute main supporting framework of sponge body. These may be of the following types:

1. Monaxon Spicules: These are formed by growth in one or both directions along a single axis. When growth occurs in one direction, the spicule is called monactinal monaxon. When the growth proceeds in both directions, the spicules are known as diactinal monaxons.

2. Triaxon Spicules: Each spicule consists of three equal axes intersecting at right angles to produce six rays.

3. Tetraxon spicules: They have typically 4 rays, radiating in different planes from common point. Ex: Amphidisc, Triaenes.

4. Polyaxon spicules: These spicules have several axes radiating from a central point.

5. Spheres: These are almost round spicules in which growth takes place around a centre.

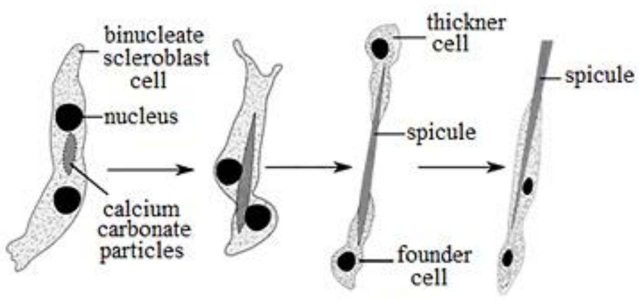
6. Desma: It is a special kind of megasclere on which silica is irregularly deposited.

B. Microscleres : These are minute spicules scattered throughout the mesenchyme and are called flesh spicules. They are two types. They may be curved in one plane or spirally twisted, C shaped and is called spires, or they may have small centers and long rays or large centers and small rays and called them as Asters.


microsclere spicules

C. Spongin Fibres: Spongin is an organic horny, elastic substance consisting of scleroprotein that is rich in sulphur and is chemically similar to collagen and sericin. They are secreted by the spongioblast cells derived from the mesenchyme. Spongin fibres form a meshwork to provide firmness to the sponge body.

Development of Spicules: The spicules are secreted by scleroblasts. Monaxon spicules are formed because of the incomplete division of scleroblast cell giving rise to binucleate scleroblast. The two nuclei begin to move away from each other and calcium carbonate begins deposit in between the space of two nuclei in the form of an axis. As the calcium carbonate needle between the two nuclei begins to lengthen, the cell divides into two, the founder cell and the thickener cell. Founder cell gives shape and length to the spicule and the thickener cell helps to thicken the spicule. When the spicule is fully formed, both the cells detach and migrate in the mesenchyme. Triradiate spicules are secreted by three scleroblast cell which come to lie in a triangular manner.



formation of monaxon spicule

2.5 Metagenesis in Obelia

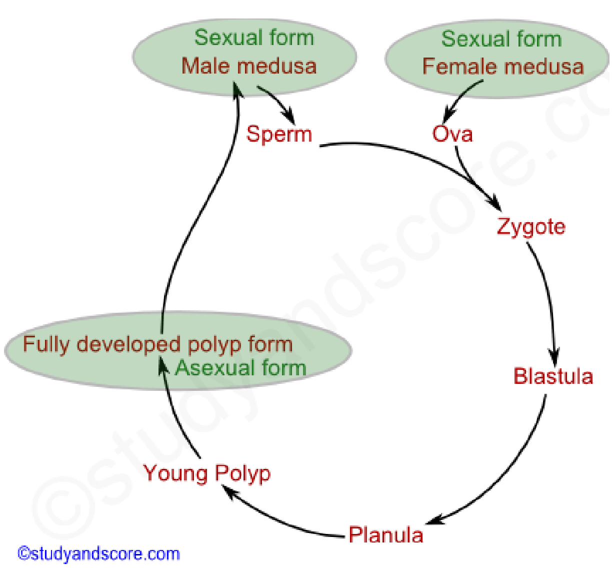
Life History of Obelia includes both asexual and sexual generations that alternate with each other to complete the life cycle. The **sedentary hydroid colony** alternates with the **pelagic medusa phase**. Hydroid colony reproduces by asexual budding to produce hydranths and blastostyles. Medusae produced from blastostyle by budding. Medusae are free-swimming sexual forms, possessing gonads. They are dioecious, i.e. testes and ovaries are borne by separate individuals. Medusae reproduce sexually by releasing either eggs or sperm into the water.

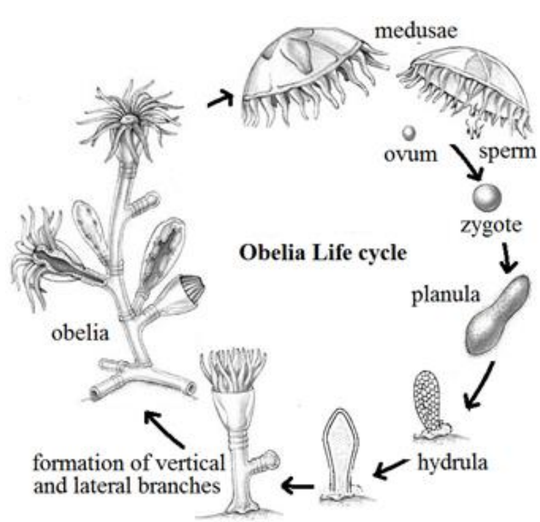
Fertilization occurs in seawater. The life history may be represented as **Gametes → Fertilization → Zygote → Blastula → Stereo gastrula → Planula larva → Hydrula → Obelia colony**. Upon fertilization, the resultant zygote develops into a ciliated free-swimming **Planula larva**. Eventually, the larva reaches the ocean floor and develops into a **hydrula**. Gradually it forms lateral buds and grows into a complex **obelia colony**.

Metagenesis

In Obelia, as evident from the above life cycle, asexual polypoid generation alternates with a sexual medusoid generation. This phenomenon is known as alternation of generations, till recently. But, in Obelia the condition is somewhat different and, therefore, objections were raised to use the term **alternation of generations** for it. Because, in Obelia, there are no true two generations to alternate each other. The medusae are modified zooids capable of free-swimming existence and they are not produced directly from a zygote but are budded off from the blastostyle. The gonads found in medusa are not formed in it but actually, they are formed in the ectoderm of blastostyle, which later on migrate into the medusa. Thus, it is rather *difficult to distinguish between sexual and asexual generations*. Hence, the term **metagenesis** is used to replace the term alternation of generations in Obelia.

Thus, in the life history of Obelia, there is a regular alternation between fixed polypoid and free-swimming medusoid phases, both of them being diploid. Such an alternation of generations between two diploid phases, known as **metagenesis**.





2.6 Polymorphism of Coelenterata

Polymorphism is an important feature of phylum Coelenterata. It is the process of possessing two or more than two morphologically different types of individuals in the colony or body of same species. The different individuals are called zooids. There are two kinds of basic zooids, polyp and medusa.

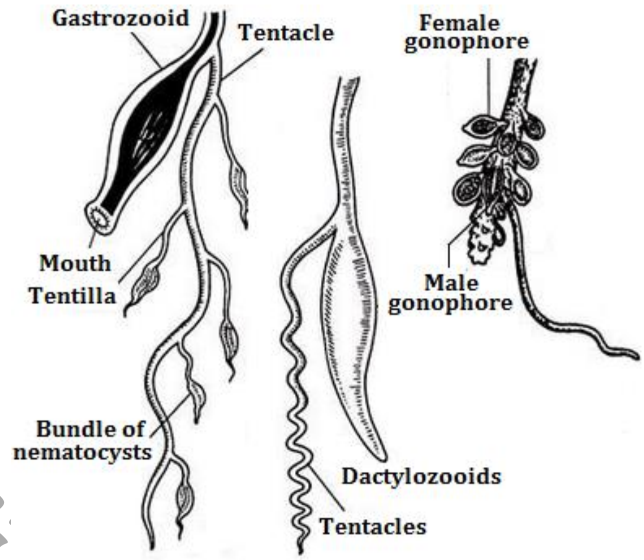
i. Polyp are concerned with feeding, protection and asexual reproduction. **ii. Medusa** concerned with sexual reproduction. All other types of zooids are modifications of these two types of zooids.

1. Modifications of Polyp

*i. **Gastrozooids*** or feeding zooids are typical polyps with a mouth and surrounding tentacles. The long tentacles bear's lateral branches called tentilla. Each tentilla ends in a coil of nematocysts.

*ii. **Dactylozooids***, which are used for defence, are polyps without mouth and usually with a long basal tentacle. The tentacles is unbranched.

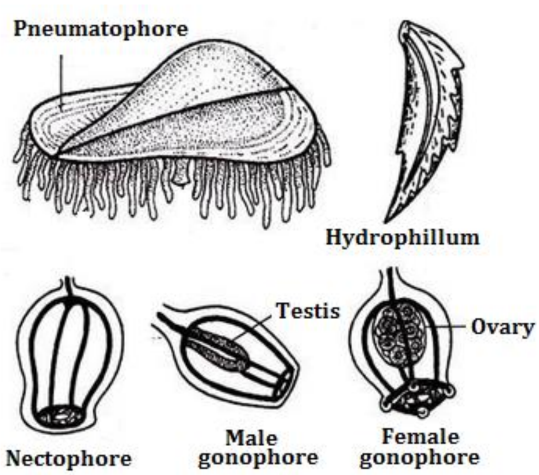
*iii. **Gonozooids*** or blastostyles are reproductive zooids derived from polyp, which produce sexual medusae or gonophores by budding.



2. Modifications of Medusa

*i. **Nectophore**, or **nectocalyx*** or swimming bell is a medusa modified for locomotion of the colony. The mouth and tentacles are absent. The musculature is well developed.

*ii. **Pneumatophore** or **float*** is a bladder-like modified medusa filled with mixture of gases and helping the colony to float on the surface. It is situated at the apex of the colony.



*iii. **Phyllozooid** or **bract*** is leaf-like zooid, studded with nematocysts and serving to protect the colony.

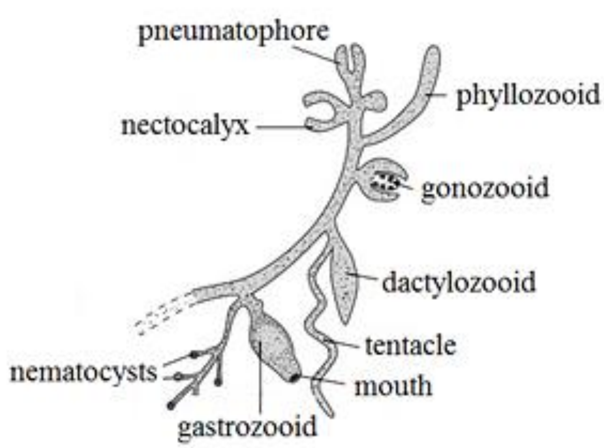
*iv. **Gonophores*** bears gonads, dioecious and produce germ cells for reproduction. The male gonophore contain the testes and the female gonophore contains the ovaries.

3. Pattern of Polymorphism: Degree of polymorphism varies greatly in different group of Hydrozoa**.**

i. Dimorphic: It is simplest and commonest pattern of polymorphism. They have only two types of zooids. Gastrozoids are concerned with feeding, while gonozoids with asexual budding forming sexual medusae. Ex: *Obelia, Tubularia.*

ii. Trimorphic: Besides Gastrozooids and gonozooids, they also possess a third type of individuals, the defensive dactylozooids. Hence, they are Trimorphic. Ex: *Plumularia.*

iii. Polymorphic: This colony contains more than three types of zooids. Members of the order **Siphonophora**, free-floating colonial hydrozoans, display an even greater degree of polymorphism. These include gas-filled floats called **pneumatophores**, pulsating, locomotory structures called **nectophores**, and flattened, protective individuals called bracts or **phyllozooids** in the upper part of the colony followed by a long train of **cormidia.** Each cormidium bear **gastrozooids**, small and large **dactylozooids** with long and short tentacles and branched **gonozooid** with gonophores. The whole colony looks like a single individual.



Generalized siphanophora polymaorphism

4. Significance of Polymorphism: Polymorphism is concerned with the division of labour. This improves the chances of survival.

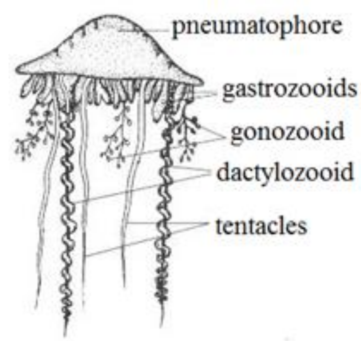
5. Origin of Polymorphism: There are two theories to explain the origin of polymorphism in coelenterates.

Poly-organ theory: According to this theory, individuals of a colony are actually the organs of a single medusoid individual.

Poly-person Theory: According to this theory, the various zooids of a colony are only the modified polyps which have the power to produce the medusa.

2.6.1 Polymorphism in Physalia

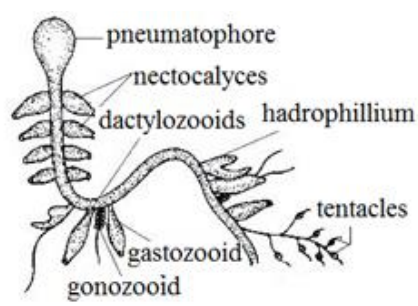
Physalia is a polymorphic, pelagic coelenterate, also called as *Portuguese-Man-of war*. It floats above the surface of water with help of a large gas filled **pneumatophore** found on aboral side. Below the pneumatophore hangs a colony of several non-linear cormidia. Each cormidium bear three types of zooids. i. **Gastrozooid** with a long tentacle helps in feeding. ii. Small and large **dactylozooids** are tubular, mouthless individual with a long tentacle helps in capturing the food organisms. iii. **Gonozooids** are branching blastostyles having leaf-like gonophores and are unisexual.



Physalia Polymorphism

2.6.2 Polymorphism in Halistemma

Halistemma possesses a long, slender, floating axial tube or stem. The upper end of the stem is expanded to form small **pneumatophore,** filled with gas. Proximal part of the stem bears closely set bell-shaped swimming bells, **nectocalyces** or **nectophores.** They lack mouth, tentacles and sense organs. They are modified medusae, muscular and propel the colony forward.

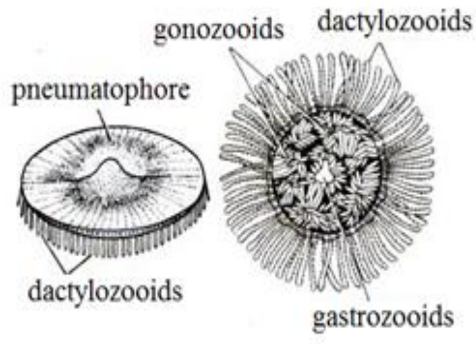


Halistemma polymorphism

Distal part of the stem carries repeated groups of closely set polyps, called cormidia. Each cormidium consists of four types of zooids. i. **Bract**: It is the protective zooid, also called hydrophyllium. It is in the form of a flat scale or leaf-like bract. ii. **Gastrozooid**: It is the nutritive zooid, bears mouth and long branched basal tentacles. iii. **Dactylozooid**: It protective zooid with a single unbranched basal tentacle and without mouth. iv. **Gonozooid**: It is a reproductive zooid. It has either male or female gonophores.

2.6.3 Polymorphism in Porpita

Porpita is found in the seas. It is pelagic, floats on or near the surface. It is regarded as an inverted polyp; its body is discoid and contains a flattened disc-like chitinous shell. The shell contains many air-filled chambers and functions as a **float or pneumatophore**. At the center of the float (on the ventral side), there is a single large **gastrozooid** (nutritive). It encloses stomach and bears mouth. The rim of the disc bears numerous **dactylozooids** with nematocysts. Many **gonozooids** (reproductive) hang in between the gastrozooid (or hydranth) and dactylozooids.



Porpita polymorphism

2.7 Corals & Coral Reefs

2.7.1 Corals

Corals are deposits of lime or $CaCO_3$ formed by coelenterates. These are solitary or colonial polypoid forms and live in an exoskeleton of calcium carbonate secreted by themselves. Some of them grow into huge mounds, while others are large and branched colonies. Most of the corals belong to the class Anthozoa and few others to the class Hydrozoa.

i. Hydrozoan corals

The hydrozoan corals belong to order Milleporina and order Stylasterina. These are colonial forms and secrete massive exoskeletons. The calicoblast layer of these animals secretes the calcareous exoskeleton. Hydrozoan corals are the major contributors of calcium carbonate skeletons on coral reefs. Ex: Millepora, Stylaster

2. Anthozoan corals: The anthozoan corals belong to subclasses Octocorallia and Hexacorallia.

i. Octocorallia Corals

a. Horny corals: The horny, or fan corals are members of the Order Gorgonacea. Majority of horny corals resembles plants with a short main trunk and lateral branching stems, which may be in the same plane. The colony secretes a horny proteinaceous material, gorgonin along with calcareous spicules around the polyps.

b. Soft corals: They are all members of the Order Alcyonacea. They are composed mostly of living tissue i.e. Mesoglea. Spiny skeletal elements embedded within the tissue. Ex. Alcyonium

c. Stony corals: These belong to order Stolonifera. The skeleton consists of calcareous spicules, and stained red with iron salts. The skeleton consists of vertical parallel tubes connected together by lateral platforms, e.g., Tubipora (organ-pipe coral).

d. Blue coral: A unique species, blue coral (Heliopora coerulea) is the sole member of the order Helioporacea. In its colony of polyps, the calcareous spicules form a massive skeleton. The larger cavities on the surface of skeleton contain polyps.

ii. Hexacorallian corals

a. True corals: Among Hexacorallia, Antipatharia includes black corals like Antipathes. In it, the colony is tree-like and its skeleton consists of branched chitinoid axis. The Madreporaria includes stony corals or true corals like mushroom coral (Fungia), star coral (Astrea) and brain coral (Meandrina or Meandrina). Among these, some are solitary, while most of them are colonial forms and the principle builders of the coral reefs.

i. Solitary corals having disc or cup or mushroom shaped corallites. The corallites are often without a theca, lie loose on the bottom, and remain attached by a stalk. They may reproduce by longitudinal fission or by budding from any part of the body surface. Ex: Fungia, Flabellum, etc. **ii. Colonial corals** usually form low flat plates, spherical masses, cups, or vases. They may be branched also. The colonies are formed by asexual methods from a single sexually produced polyp. Ex: Madrepora, Meandrina, Tubipora, etc.

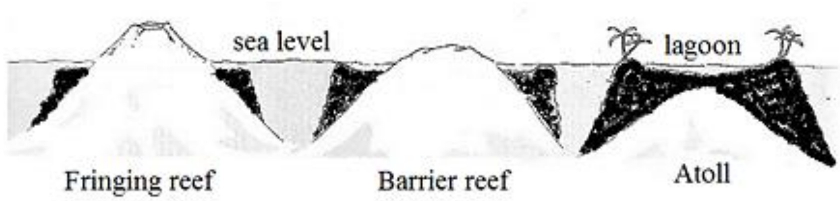
Based on its structural organisation, the corals can be divided into three types: 1. **Imperforate** or **Aporose**: They have compact thecae and sclerosepta. Ex: Flabellum, Astrea. 2. **Perforate:** The corallum is loosely constructed ad extremely porous. Ex: Porites, Madrepora. 3. **Fungid**: They may be either perforate or imperforate Ex: Fungia

2.7.2 Coral Reefs

Coral polyps build coral reefs. Most of the coral reefs are built from stony corals, whose polyps cluster in groups. Corals secrete hard $CaCO_3$ exoskeletons that support and protect the coral. This turns into a hard, rock-like structure upon which other coral larvae can settle. Over time, as the calcium carbonate builds up and corals reproduce, the size of a coral reef grows. Most reefs flourish nicely in shallow, warm ocean waters with temperature ranges between 23°–29°C. They are, commonly found in tropical and subtropical waters of western Atlantic and Indo-Pacific oceans, generally within 30°N and 30°S latitudes. More than 100 countries have a coral reef within their borders, and over half of the world's coral reefs are found within six countries: Australia, Indonesia, Philippines, Papua New Guinea, Fiji, and the Maldives.

Types of Coral Reefs: Coral reefs are of three kinds. 1. Fringing reefs 2. Barrier reefs 3. Atolls

1. Fringing reef: Fringing reefs grow near the coastline around islands and continents. They are separated from the shore by narrow, shallow lagoons. Fringing reefs are the most common type of reef.



Coral reefs

2. Barrier reef: Barrier reefs also parallel to the coastline but extend to a great distance from the shore. They are separated from land by deeper, wider lagoons. At their shallowest points, they can reach the water's surface forming a barrier to navigation. The famous barrier reef is the Great Barrier Reef off the northeast coast of Australia extending over 1200 miles long and in some places 90 miles from the shore.

3. Atoll: Atolls are rings of coral that enclosing lagoons and are usually located in the middle of the sea. Atolls usually form when islands surrounded by fringing reefs sink into the sea or the sea level rises around them. The rim of the reef is broken into channels. These channels connect the sea to the lagoon. Ex: Bikini atoll.

2.8 Characteristic Features & Affinities of Phylum Ctenophora

A. Characteristic Features of the Phylum Ctenophora

1. They are free-swimming, marine, solitary, pelagic animals. Commonly called sea-walnuts, comb-jellies or sea-gooseberries
2. The body is transparent, gelatinous, pear-shaped, cylindrical, or flat or ribbon-shaped.
3. They have a bi-radially symmetrical body along an oral-aboral axis.
4. They are diploblastic. Mesoglea is present between the ectoderm and endoderm.
5. They lack nematocysts.
6. They have eight meridional rows of comb-like ciliary plates on the surface for locomotion. Hence, name as comb jellies.
7. They have special adhesive and sensory cells i.e. colloblasts or lasso cells present in tentacles, which helps in food captures.
8. Digestive system is complete. Stomach is branched with gastro-vascular canals.
9. Their nervous system is diffused types and the aboral end bears a sensory organ, called statocyst.
10. They do not have skeletal, circulatory, respiratory and excretory organs.
11. The animals are hermaphroditic or bisexual.
12. Development is mosaic, determinate, indirect type with Cydippid Larva.
13. All the Ctenophores exhibit bioluminescence.
14. All are predators and feed on other small planktonic animals.

<u>B. Affinities of Ctenophora:</u>

i. Resemblance with Coelenterata:

a. similarities with coelenterata.

1. Radial symmetry.
2. Tissue grade of organization
3. Absence of Coelom.
4. Diploblastic body wall
5. Presence of Mesoglea
6. Presence of Gastrovascular Cavity
7. Diffused Nervous system
8. Presence of statocysts

b. dissimilarities with coelenterata.

1. Absence of nematocysts
2. Presence of aboral sense organs
3. Presence of two tentacles
4. Presence of colloblats
5. Presence of comb plates
6. Presence of Anal pores
7. Presence of muscular cells in mesoglea
8. Mosaic type of development

Thus, it seems that ctenophores are more specialized and advanced than coelenterata

jj. Resemblance with Platyhelminthes:

a. similarities with Platyhelminthes

1. Flat compressed body
2. Creeping mode of locomotion
3. General Ciliation of the body.
4. Branched Gastrovascular cavity.
5. Gelatinous mesenchyme with muscle fibres and cells.
6. Determinate type of development

Recent view:

According to De-beer the ctenophores were evolved from polyclad turbellarians is because the Muller's larva of Polycladida has been retained as the Ctenophore. The following are the resemblances between the Ctenophora and Muller's larva

* Stomodeum occupies in lower side while main nervous system occupies in the upper pole of the embryo.
* Origin of mesoderm is similar
* Locomotary organs are 8 ciliated bands, the cilia forms comb in Muller's larva
* Paired tentacles in both

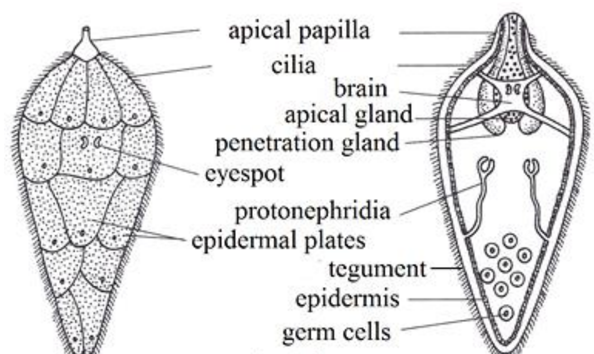
On the above grounds, De-beer concluded the evolution of the ctenophore from Polyclad flatworms seems to be conclusive and satisfactory.

3.2 Life Cycle of Fasciola

Fasciola is a digenetic parasite. Its life cycle completed in two hosts, namely sheep and a snail (Lymnea).

1. Copulation: Copulation occurs within the body of the host. Fertilization occurs in the ootype.
2. Capsule formation: The fertilized egg is surrounded by yolk cells and are further surrounded by chitinous shell. The capsule has an opening with operculum.
3. Cleavage, Development: Fertilized egg starts its development within the uterus. It undergoes cleavage with in the capsule. Capsules then released into the bile duct through gonophore. Then they reach the intestine and are pass out through the faeces of the host. Development further proceeds and within 9-20 days forms a ciliated larva called miracidium, which comes out through the opening of capsule in water.

i. Miracidium Larva

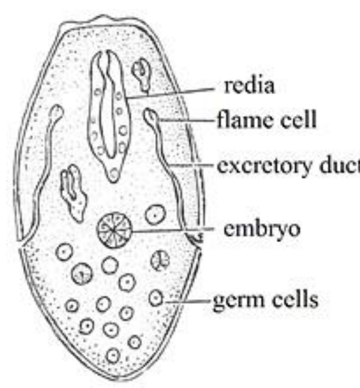


Miracidium

Miracidium is a minute, oval, non-feeding and free-swimming larva. It is covered with 21 flat ciliated epidermal cells lying in five rows. Anteriorly it has a conical apical papilla, through which the apical glands opens out. On each side of the apical gland is a bag-like penetration gland. There are two X-shaped nervous system with eyespots, germ cells and a pair of laterally opened protonephridia are present in the larval body.

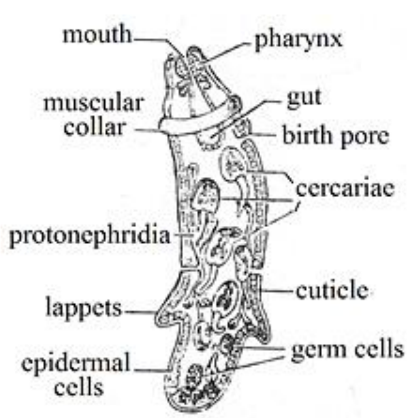
Within 6-24 hours, after getting a suitable host, miracidium with help of its apical papilla and penetration glands enters and finally reaches to snail's digestive gland. In the tissues, the miracidium lost its cilia and sense organs and becomes a sporocyst.

ii. Sporocyst Larva



Sporocyst

The sporocyst is an elongated sac-like and covered with a thin cuticle, below which are mesenchyme cells and some muscles. The glands, nerve tissue, apical papilla and eyespots of miracidium disappear. The hollow interior of sporocyst has a pair of protonephridia, germ cells and germ balls. The sporocyst moves about in the host tissues and its germ cells develop into a third type of larva called redia larva. A sporocyst forms 5 to 8 rediae. The rediae larvae pass out of the sporocyst by rupture of its body wall into the snail tissues with the aid of the muscular collar and ventral processes, then the rediae migrate to the liver of the snail.



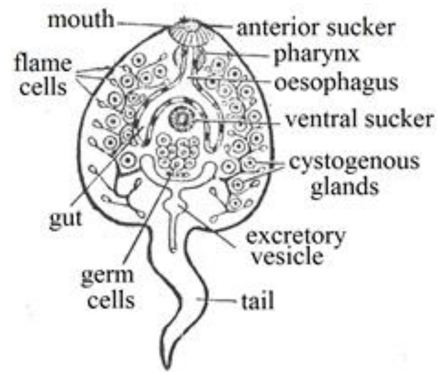
Redia

iii. Redia Larva

It is cylindrical in shape and is covered by a thin cuticle. It has anterior mouth leads into a pharynx that ends in small intestine. Little behind the pharynx is the muscular collar. Behind the collar, birth pore is located. At the posterior end, a pair of projections called lappets found and above each lies the excretory pores. It contains groups of germ cells, which by division form a second generation of daughter rediae during summer months, but in winter, they produce 14-20 Cercaria larvae. They come out through birth pore into the snail tissues.

iv. Cercaria Larva

The cercaria has an oval body and a simple long tail. Its body covered by cuticle, below it are muscles and cystogenous glands. It has two suckers (oral and ventral) and an alimentary canal consisting of mouth, pharynx and a bifid intestine. There is an excretory bladder with a pair of protonephridial canals (excretory tubules) with a number of flame cells. An excretory duct originates from the bladder, travels through the tail and bifurcates to open out through a pair of nephridiopores. The cercariae escape from the birth pore of the redia, and then migrate from the digestive gland of the snail into the pulmonary sac from where they pass out into surrounding water.

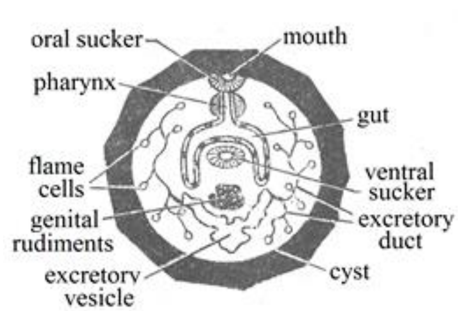


Cercaria

v. Metacercaria

The cercariae swim about in water for 2 to 3 days, and then they lose their tails and get enclosed in a cyst secreted by cystogenous glands. The encysted cercaria is called a metacercaria. It is round and protected by cyst wall. The mouth is at the centre of the oral sucker. Pharynx and bifid intestine are present. The flame cells increase in number. If the metacercariae are formed in water they can live for a year, but if they are formed on grass or vegetation then they survives only for a few weeks, they can withstand short periods of drying.

Finally, the metacercaria along with aquatic leaves reach the intestine of the host, when it feeds upon aquatic plants. Here the cyst is dissolved and the young fluke reaches the liver through hepatic portal system and continue the life cycle after maturation and egg lying.



Metacercaria

5.1.11 Pathogenesis

Fasciola hepatica affects the liver but it also causes hepatitis and inflammation in the bile ducts. The bile ducts thicken, calcify, and eventually form gall stones as a result. During heavy infection, the liver flukes seriously affect the liver and its functions and cause a disease called liver rot.

The sheep becomes dull and sluggish which is followed by swelling and pain in abdomen, weight is lost, eye-sockets become pale, liver is greatly enlarged, Lactation and breeding are greatly reduced and finally the sheep dies. Thus, the infection of Fasciola causes heavy mortality in sheep population.

Man also gets infection by taking contaminated food, water and improperly cooked meat of infected sheep. Liver rot also occurs in man. Other symptoms includes eosinophilia, fever etc. If the number of parasites increased in man, death occurs.

3.3 Parasitic Adaptations in Helminthes

Several species of the group helminthes are parasites, they develops certain adaptations for survival and race continuation in the body of their hosts. Endo-parasites show highest degree of adaptation. These adaptations may be morphological, physiological or reproductive.

I. Morphological adaptations:

Morphological adaptations, occurred either in the form of attainment or degeneration of new organs.

A. Degeneration of organs:

In order to lead a parasitic life complete or partial degeneration or loss of organs has taken place in the body of parasites. Important organs in which degeneration have occurred are

i. Organs of locomotion: They lost Locomotary organelles completely.

ii. Tropic organs: They get fully or partially digested food from the host. Hence, the alimentary canal has either totally disappeared (Taenia solium) or exhibit fair degree of degeneration (Fasciola, Ascaris).

iii. Nervous system and sense organs: The nervous system poorly developed and sense organs completely lost.

B. Attainment of new organs:

The parasites have attained certain special structures, which help them adjust well within the body of their host. They are

i. Shape of the body: The have round or dorso-ventrally flattened or ribbon like body, enable them to hangs or fit in the space of host's body where they reside.

ii. Protective covering: Body wall with multi-layered thick cuticle protects the body from digestive juice of the host.

iii. Organs of attachment: They have developed certain organs of attachment to keep the parasite in their respective position. The different forms of adhesive organs are

a. Acetabulum: In flatworms, acetabulum act as anchoring structure e.g. Fasciola.

b. Suckers: They are strong organs of attachment. Ex. Fasciola hepatica, Taenia solium.

c. Hooks: Anterior end of the body bear hooks and spines as organ of attachment.

d. Jaws: In Ascaris, chitinous jaws are present, helps to anchor with the wall of gut.

e. Glands: The secretary glands present near the mouth, help them to dissolve tissues by secreting histolytic juices.

II. Physiological adaptations:

Some of the physiological adaptations exhibited by parasites are as below

1. Secretion of antienzymes and mucous: They developed strong impermeable cuticle, lime cells, and antienzymes to neutralize the effect of gastric juice and digestive enzymes of the host. They stimulate the gut of the host for secretion of mucous, which provides protective covering around it.

2. Anaerobic respiration: As there is low oxygen content inside the body the host, they modified to respire anaerobically. They get energy from glycogen breakdown.

3. Osmotic adaptability: The parasites maintain almost same osmotic pressure with the host environment. This prevents unnecessary water loss and facilitates the nourishment absorption.

4. Elaboration of reproductive organs: In helminth parasites, reproductive system has become very well developed and complicated. The important adaptations are:

a. Hermaphroditism: They have attained hermaphroditism and capable of self as well as cross-fertilization.

b. Development of cyst wall: The eggs and larvae with resistant wall or membranes. These prevents desiccation and the action of digestive juices of the host.

c. Fecundity: The parasites possess enormous fecundity; producing large number of eggs and embryos ensures continuity of their life.

d. Complexity of life cycle: Most of the endoparasite has complex life cycle involving two or more hosts. The presence of intermediate hosts ensures its dispersal, which is essential for its existence.

3.5 Ascaris (Round worm)

Ascaris lumbricoides is the endoparasite of human intestine. It occurs more frequently in children than of adults.

1. Life cycle

Ascaris is monogenetic parasite. Man is the only known definitive host.

i. Copulation and fertilization

Copulation occurs in the small intestine of host (man) and fertilization occurs in the oviduct of female Ascaris.

ii. Eggs in faeces and egg structure

The eggs are laid (roughly about 200000 eggs daily) in the intestine of host come out with faecal matter in un-embryonated form.

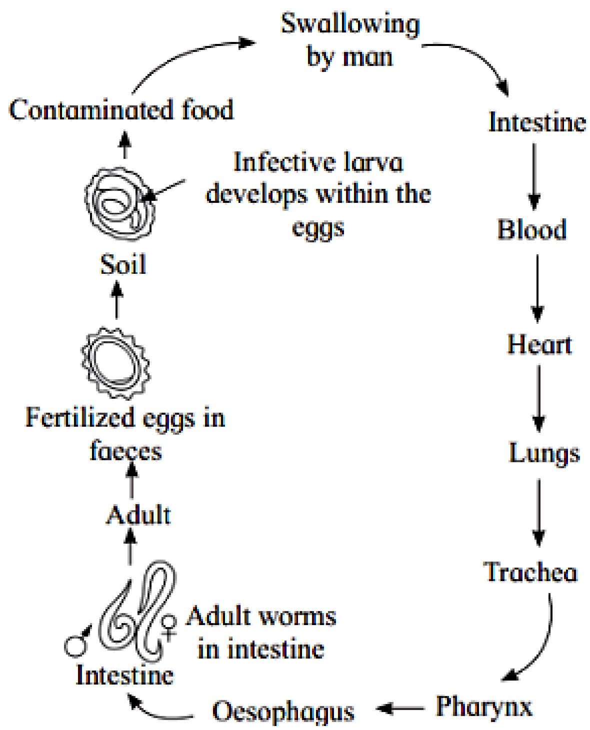
The fertilized eggs are round or oval. They usually measure about 60µ by 45µ. The zygote has a thick, clear inner chitinous shell covered over by an irregular albuminous coat. The egg contains a very large conspicuous, unsegmented ovum (the nucleus is concealed by a large amount of coarse yolk granules).

iii. Early development in Soil

Embryonation occurs in soil as optimum temperature of 20-25^{0}C with sufficient moisture and O_2. Cleavage of fertilized egg is of spiral and determinate type. The first stage non-infective larvae formed within 10-14 days from the onset of cleavage and called as Rhabditiform larva. After a week it moults once (first moult) within the egg and becomes the second stage of Rhabditiform larva, which is capable of infecting the host.

iv. Human Infection (new host)

Human get infection with ingestion of embryonated egg contaminated food and water. A second stage larva is stimulated to hatch out by the action of host's digestive juice in the small intestine.



v. Migration of Larva (Extra intestinal)

Within six hours of post-infection hatched out larvae penetrates the intestinal wall and carried to liver through portal circulation. They remain in the liver for a few days and develop to the early third stage larva. It then travels via blood to heart and to lungs by pulmonary circulation within 4-7 days of infection. The larva in lungs moults twice (5-6 days 2^{nd} moult; 10 days 3^{rd} moult), enlarges and breaks into alveoli.

vi. Re-entry into the small intestine

From alveoli, the larvae then pass up through bronchi and into trachea. When the cough swallowed, the larva passes down the oesophagus to the stomach and reached into small intestine once again. Within intestine parasite moults once (4^{th} moult) and becomes adult worm.

vii. Sexual maturity

Sexual maturation occurs within 6-10 weeks and begins its life cycle again.

2. Pathogenesis

Infection of *A. lumbricoides* in man is known as Ascariasis. There are two phase in ascariasis.

Phase I - migrating larvae (Pulmonary Ascariasis): The migrating larvae cause pathological lesions. The severity of lesions depends upon the sensitivity and nutritional status of the host, and number of migrating larvae.

During migration and moulting through lungs, larvae may causes pneumonia with low-grade fever, Bronchospasm, Dyspnea, wheezing, and Non-productive cough, chest pain and other allergic symptoms like eosinophilia may occur.

Phase II - Adult worm (Intestinal Ascariasis): Few worm in intestine produce no major symptoms and but some time give abdominal pain especially in children. Large number of adult worms affects the nutritional status of host by robbing the nutrition leading to malnutrition and growth retardation in children.

Clinical manifestations includes Nausea, Vomiting, Colicky abdominal pain, Abdominal distention, Weight loss and diarrhea, Malabsorption of nutrition, Growth retardation. Heavy worm in children leads to acute intestinal obstruction (intussusceptions), common bile duct obstruction (Jaundice), obstruction of appendix (appendicitis) and hepatomegaly.

The metabolites of living or dead worm are toxic and immunogenic. Ascaris also produces various allergic toxins, which manifests fever, conjunctivitis and irritation.

4.2 Coelom and Coelomoducts in Annelida

4.2.1 Coelom in Annelida

A space inside the body is called as body cavity or coelom, lies between the outer body wall and inner digestive tube. It is the true body cavity, which is large, and fluid filled. It contains most of the visceral organs.

i. Coelom formation in Annelida

In Annelida, the coelom is called a Schozocoelom. It is the secondary body cavity formed by the splitting of mesoderm during embryonic development. Externally, the coelom is lined by parietal epithelium, and internally, by visceral or splanchnic epithelium. The peritoneum surrounds all the internal organs, including the alimentary canal. Therefore, the coelom is also called the perivisceral cavity.

Coelom is divided into fluid filled compartments by transverse partition called septa, which extend from the annuli of the body wall to the alimentary canal. There may or may not be a perforation in the septum. If perforated, the coelomic fluid communicates from one compartment to another. The coelom also communicates with the exterior by two sets of ducts namely nephridia and coelomoduct.

ii. Coelom modifications in Annelida

- Polychaeta coeloms are divided by transverse septa. These septa can be complete or incomplete. In Arenicola, the coelom is nearly uninterrupted due to the existence of only the first three septa and a small number at the posterior end of the coelom. Aphrodite has a large coelom surrounded by cilia.
- Oligochaeta (Pheretima) has a first septum between segments 4 and 5. The next eight septa have no apertures, and from the fourteenth segment to the end, there are many apertures with sphincter muscles.
- Hirudinea has a very reduced coelom and is restricted to longitudinal haemocoelomic channels, the gonads, and the vasa deferentia. Acanthocadella has a perivisceral coelom with septa only in the anterior region.
- The archiannelid has a large coelom, divided into chambers by transverse septa.

iii. Significance of Coelom

The coelom plays a great role in the life of animals. The coelomic fluid serves several functions:
1. It acts as a hydroskeleton
2. It allows free movement and growth of internal organs
3. It serves for transport of gases, nutrients and waste products around the body
4. It allows storage of sperm and eggs during maturation
5. It acts as a reservoir for waste.

4.2.2 Coelomoducts

In annelids, the body is divided into a number of segments. Each segment will show segmental structures. Coelom ducts and Nephridia arranged segmentally in these organisms.

1. Coelomoducts

These are generally wide tubes of mesodermal origin. They formed as invaginations of coelomic epithelium. They open out on the body through genital pores. They open into the coelom through ciliated funnels called coelomostomes. Coelomoducts serve primarily as gonoducts. As a result, these will be restricted to segments with reproductive structures. In some forms, they serve as excretory ducts.

2. Nephridia

These are coiled tubes, formed by the invagination of ectoderm. They are arranged repeatedly in all segments. Each nephridia communicates with outside by nephridiopore. If the nephridium opens out into the coelom through nephrostome, it is described as open. If it is absent, it is closed. Different types of nephridia are present.

i. Protonephridia: These are primitive nephridia. They end blindly in the coelom. They have solenocytes, which look like flame cells. Polychaetes like Vanadis, Tomopteris, etc., have protonephridia.

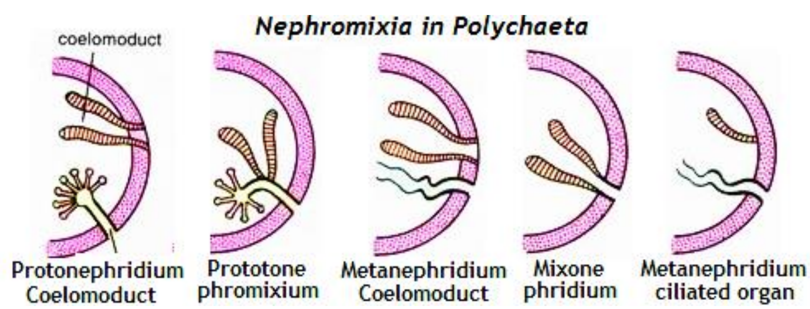
ii. Metanephridia: The metanephridia are the advanced type. It opens into the coelom by a ciliated funnel or nephrostome. The other end of it opens to the exterior through the nephridiopore. They are found in the majority of polychaetes, all the oligochaetes and leeches.

iii. Micro and Meganephridia: Depending on their size, nephridia are classified as micronephridia or meganephridia. Generally, micronephridia will be more in segments, and meganephridia will be one pair per segment.

iv. Exo and Entero nephridia: An exonephric nephridium communicates directly with the outside through the nephridiophore, whose primary function is excretory, whereas an endonephric nephridium is one whose terminal ducts eventually open into the alimentary canal, which is osmoregulatory in nature.

3. Nephromixia

It has been observed that in some Polycheates and archiannelids, nephroidia and coelomoducts unite to form nephromixia. It serves as both an excretory organ and a genital duct. They are of following types:



a. Protonephromixium: Protonephridia and coelomoducts are united. Ex. Phyllodoce.

b. Metanephromixium: Metanephridia and coelomoducts are united. Ex. Hesione.

c. Mixonephrium or Nephromixium: Coelomoduct and nephridium will unite as a single duct, the funnel being coelomoduct and the duct is nephridial. Ex. Arenicola.

d. Ciliated organ: The coelomostome of the coelomoduct separates from the metanephromixium and attaches to the dorso-lateral muscles as a dorsal ciliated organ. It keeps the coelomic fluid in circulation. Ex. Nereis.

4.3.1 Scope of Vermiculture

1. It provides **vermicompost**

2. It provides **vermi wash**

3. It supplies organic **fertilizer**

4. Vermitechnology supplies **worm casts**

5. The worm casts are used as **manure** for crops and gardens

6. The earthworms can be converted into **vermi protein.** This protein utilized for **poultry and fish feed**

7. It provides **employment** opportunities

8. The **vermi wash** can be used as **foliar spray** on crops

9. By converting organic wastes and garbage into **compost**, pollution can be controlled

10. It has tremendous prospects in converting agro-wastes and city garbage into **valuable** agricultural input

11. Small and marginal formers produces **vermi compost** on their own for their crops

12. Vermicompost is an excellent **manure** for home gardens, kitchen gardens and commercial plant nurseries in urban arears.

13. The enterprise offers remarkable scope in rural areas

14. **Less skill** is required

15. Vermicomposting helps to convert rural and urban bio-wastes into **nutrient rich organic manures**

4.3.2 Significance of the vermiculture

1. Vermiculture is an efficient method for stabilization of organic solid and sewage sludge wastes.

2. It helps to ecover organic material and return to the soil.

3. It provides bio compost

4. Bio-compost is free from heavy metals and toxic compounds. Hence, it guarantees for soil fertility

5. The earthworms have the capacity to absorb heavy metals like Fe, Cd, Cr and Pb into their body tissue, making for soil user friendly

6. Vermicompost is an eco-friendly natural fertilizer prepared from biodegradable organic wastes and it is free from chemical inputs.

7. Vermicoposting has no adverse effects on soil, plants and environment

8. It promotes better root growth and nutrient absorption

9. It improves both macro and micro nutrient status of the soil

10. Vermicompost improves the physical, chemical and biological properties of the soil.

11. Vermicompost improves soil aeration, texture and tilth thereby reducing soil compaction

12. Is also controls soil as well as environmental pollution

13. It maintains the soil health and improves water retention capacity of soil because of its high organic matter content.

14. Earthworms effectively harness the beneficial soil microflora and destroy soil pathogens.

15. Earthworms convert organic wastes into vitamins, enzymes, antibiotics, protein rich products and other organic components

16. Earthworms take part in the process of bioconversion of organic sludge into bio fertilizer.

4.3.3 Earthworm species used in Vermi culture

Earthworms are classified as detrivores and geophages based on their feeding habits.

a. Detrivores:
They feed on plant litter or dead roots, and other plant debris or on mammalian dung on or near the soil surface. These worms are humus formers and comprise the epigeic and anecic forms.

Epigeics are surface dwellers who feed on the surface of the soil with organic matter. Ex. *Perionyx excavatus*, *Eisenia fetida*, *Eudrilus euginae*, *Lumbricus rubellus*.

Anecics live in deep soil in vertical and permanent burrows. Ex. *Lampito mauritii*, *Lumbricus terrestris*, *Polypheretima elongata*.

b. Geophagous:
These worms, feed below the surface and intake greater quantities of organically rich soil. It comprise the endogeic earthworms. These earthworms spend much of their time mainly in the mineral layer of the soil and burrow. Ex. *Metaphire posthuma*, *Octochaetona thurstoni.*

Epigeics and anecics were harnessed for vermicomposting. *Eisenia fetida* is one of the most widely used worldwide. *Lumbricus rubellus*, *Eudrilus eugeniae* and *Perionyx excavates* are other suitable species.

Redworm species in both *Eisenia fetida* and *Lumbricus rubellus* are composters, living naturally in soils that contain a lot of organic matter. For this reason, they are often used together in vermicomposting systems.

4.3.4 Vermiculture Process

The vermiculture involves the following steps

1. **Site Selection**: Select a cool, shady place away from direct sunlight, rains, direct heat

2. **Vermibed Preparation**: The vermibed is prepared in a pit or on open ground or in containers. The containers like earthen pot, cement tanks, wooden boxes, buckets also used. When culture is done in a pit, a rectangular pit with dimensions of 2x2x2 feet is dug. The pit is lined with a polyethylene sheet to prevent earthworms from escaping.

The pit is filled with bed materials and food materials with a total height of one feet.

* First layer – broken bricks at the bottom
* Second layer – coarse soil
* Third layer – Loamy soil
* Fourth layer – coconut/ paddy husk, sawdust,
* Fifth layer – Hay straw (cut gross)
* Dampen the bed by sprinkling water

All the above layer forms a basal layer and it should be 4 inches in height. It filters and drains excess water. Provide shelter to worms

Above the basal layer, bed materials are loaded to a height 4 inches. The bed material includes shredded cardboard box or shredded paper or grass clippings or coir waste or saw dust or coconut husk. Above this layer, hay or straw is spread and is covered with coconut leaves or gunny bags. Above each layer, water is sprinkled. Microorganisms ferment the bed materials. As a result heat rises. After two weeks, the heat decreases. By the 2nd to 3rd week's production of heat inside the pit will ceases and will come to 25-30^{0}C. Incase no warmth is felt by hands; understand that the predigested vermibed is ready for inoculation of earthworms.

3. Selection of earthworms: For use in the vermicomposting process, the Epigeics and Anecics were harnessed. *Eisenia fetida* is one of the most widely used worldwide. *Lumbricus* *rubellus*, *Eudrilus eugeniae* and *Perionyx excavates* are other suitable species.

4. Earthworm feed preparation: Earthworm is a detrivore and omnivore. The feed of the earthworm includes cow dung, Green foliage, vegetable ramnants, and discarded parts of fruits, droppings of horses, pigs, sheep, and biogas slurry. These materials mixed, heaped, and allowed to decompose for 15 days in a cool shady place. The microorganisms ferment the materials.

5. Inoculation of Earthworms: Release epigeic, anecic, or both types of earthworms 50 per 10 kg of the bed on the top of the vermibed. Earthworms will penetrate into the bottom. There are two types of

6. Feeding of earthworms: The earthworms are fed-with pre-decomposed feedstock. The feed is loaded on the top of the vermibed with a thickness of 8 inches. Cover the surface with jute bags and keep them wet by sprinkling water daily or alternative days. Vermibed turned upside down once in 15 days. Worms breed and multiply in the bed.

7. Harvesting: In about 2 months, the Vermicompost is ready (may vary depending on organic waste used as substrate). It will be black, granular, lightweight and humus-rich. Vermicompost harvesting requires manual isolation of worms from the castings. Watering is stopped for two to three days before emptying the beds to make it easier to remove the worms from the compost. The worms will be pushed to the bottom of the bed by this. For new culture beds, the worms are collected. To retrieve the cocoons, young worms, and unconsumed organic waste, the gathered Vermicompost is dried and passed through a 3 mm sieve. For seeding the new culture beds, cocoons and young worms are used.

4.3.5 Economic Importance: Vermicompost

The process of converting organic wastes into compost by earthworm is called vermicomposting
- Vermicompost is the black gold
- It improves soil fertility
- It prevents soil degradation as wastes are made into wealth
- Garbage is converted into black gold
- Black gold makes green gold (Crops)

1. Advantages over Chemical fertilizers

The continuous use of chemical fertilizers causes these problems: Soil fertility degradation, depletion of fossil fuels and oxygen, and reduction of soil microorganisms. Microorganisms and earthworms degrade organic wastes into rich inorganic castings, improving soil fertility and plant growth. Composting agrees with nature.

2. Friend of farmer

Earthworms considered as the farmer's friend because of their influence in **increasing the fertility of the soil**. The activity of the worm **loosens the soil**. It permits the **entry of air and water** into the soil. Further the soil is passed through the intestine, **the nitrogenous waste is added** to it and making the compost in a valuable manure. Earthworms are small and simple but green creatures in the green revolution.

Earthworms directly or indirectly helpful to us in many ways, instead of putting the wastes into garbage bags they can be dumped into compost pits, which **lessen the garbage** in homes.

Adding compost to the soil brings a number of environmental benefits. The following are the most important benefits

3. Compost enriches the soil

The composting process encourages the production of **beneficial microorganisms**, which in turn break down organic matter to **create humus**. Humus is a rich nutrient, which increases the **nutrient content** in soil and helps soil to retain **moisture**.

Compost helps to **suppress** the plant **diseases and pests**. It promotes **higher yield** in agriculture crops and thus reduce or eliminate the need for chemical fertilizers and pesticides.

4. Compost: Prevents Pollution and soil erosion

* Composting organic materials avoid the production of methane and leachate formulation in the landfills.

* Compost has the ability to prevent pollution

* It also prevents erosion and silting on embankment parallel to the creeks, lakes, rivers and turf loss on roadsides, hillsides and playing fields.

5. It serves as a markable commodity

It is a low-cost alternative to landfill covers and soil amendments. In addition to converting pathogenic and harmful municipal organic wastes into useful compost, vermicomposting prevents pollution. The use of vermicomposting is a cost-effective method of removing contaminants.

Plant growth depends upon soil health. Vermicompost builds soil health. It increases both organic matter and soil microbes, both of which are essential for soil health. Soil is revitalized with quality compost.

In addition to promoting healthier plants, it reduces or eliminates the need for chemical fertilizers and toxic pesticides while reducing the cost.

6. Vermicompost: Remedial measures

Compost has the ability to regenerate poor soil. Composting is a great way to absorb odours, semi-volatile organic compounds, and volatile organic compounds, including heating fuels, polyaromatic hydrocarbons, and explosives.

It prevents heavy metals from migrating to water resources or being absorbed by plants.

Compost degrades wood preservatives, pesticides, and chlorinated and non-chlorinated hydrocarbons in contaminated soils.

7. Vermiwash

It is the excreta and mucus secretion of the earthworms. This can be collected when water is passed through the medium of the earthworm.

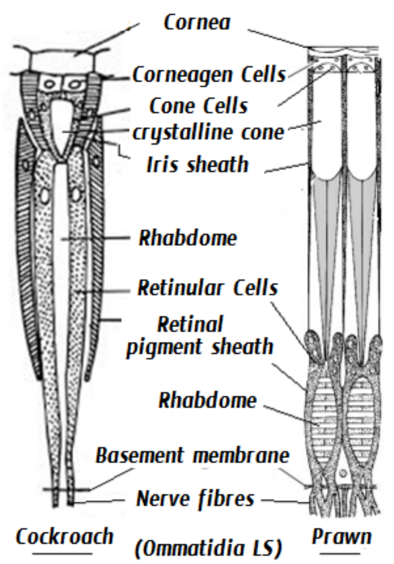
It is a pale yellowish liquid containing micronutrients from the organic matter in the medium. It also contains enzymes and secretions of earthworms, which aid in the growth of the plant.

4.5.1 VISION IN ARTHROPODA

Phylum Arthropoda has two types of eyes for the purpose of vision- simple eye and compound eye

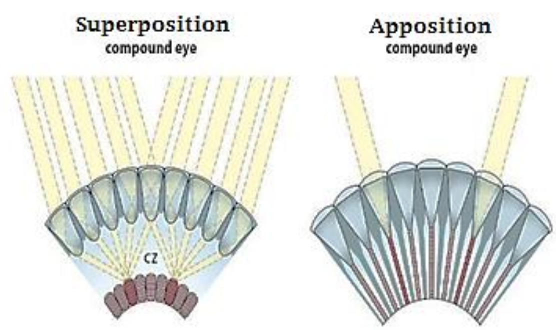
1. Compound eyes

In the phylum Arthropod (insects and crustaceans), compound eyes have evolved to be one of the distinguishing features. Compound eyes are made up of several smaller repeating units called ommatidia. These are the structural and functional units of compound eyes. In each ommatidium, there is a Cornea, Corneagen cells, a transparent crystalline cone, cone cells, and a pigmented iris sheath. These parts constitute diaptrical or light focusing region. Rhabdomes, retinular cells, retinal sheaths, and basement membranes make up the receptor region under cone cells. It perceives the light and sends the impulse to brain.



Compound eyes can't provide distant or sharp vision but can pick up motion and provide 360° views. In each Ommatidia, a small portion of the object seen can be seen independently and not the entire object. These small images are combined in the brain to form a complete image of the object that is made up of small dots, hence mosaic vision. Compound eyes are excellent at detecting motion. Ommatidia turn on and off as an object moves across the visual field. Insects respond better to moving objects than stationary ones due to the flicker effect.

a) Superposition image: During dim light, in nocturnal arthropods, the pigment sheath shrinks and ommatidia no longer remain optically isolated. Even oblique light rays can strike one or more ommatidia and create overlapping images. This is a superposition image and it's unclear.



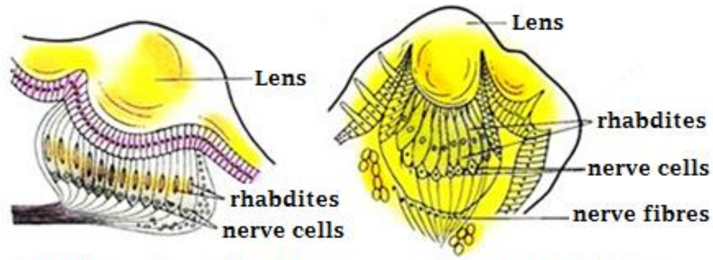
b) Apposition Image: During bright light exposure, the pigment sheath extends and separates the ommatidia. Light cannot pass from one ommatidium to another. Ommatidiums form tiny images of objects, and these tiny images are arranged side by side to form a mosaic image. As a result, an apposition image is formed.

2. Simple Eyes

i. The Insect Ocelli: An ocellus is a simple eye that provides distant vision to the eye. The ocelli also provide nocturnal vision to night flying insects, which locate their way by aligning their eyes at an angle with the moon or stars.

Scorpion belongs to the **class Arachnida** has a pair of large median indirect eyes and five pairs lateral direct eyes. Lateral eyes are small in size, 3-5 pairs and located on the lateral sides of prosoma.

ii. The Median Indirect eyes: Median eyes are large, convex and covered with a thick cuticle, which forms the cornea. The hypodermis forms a thick vitreous body. The rhabdome with many sensory retinal cells, point backwards, towards the tapetum. In the dark, scorpions use their median eyes to see because the dim light goes into the eye and is reflected by the tapetum to strike the rhabdome again.



Scorpion: VS of Median Eye VS of Lateral Eye

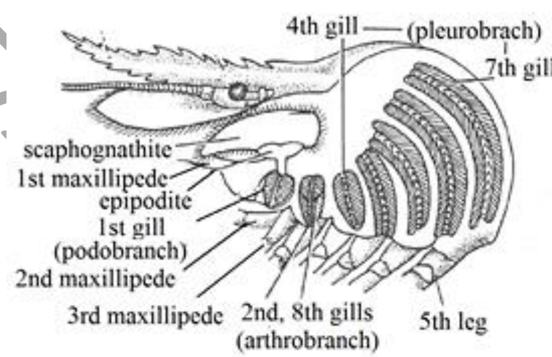
iii. The Lateral direct eyes: Lateral eyes are small. Externally, this eye is covered by a biconvex lens formed from a transparent cuticle. Under the lens, the epidermis forms a thin vitreous body. As these eyes lack a tapetum, several rhabdomes point directly towards the source of light. The lateral eyes provide vision in daytime or in bright light.

4.5.2 RESPIRATION IN ARTHROPODA

Arthropods inhabit a variety of habitats. They breathe in air as well as water and in some both. Their respiratory organs vary according to their habitats.

1. Gills

In majority of crustaceans, gills are the chief respiratory organs. In Prawn, gills are enclosed in a gill chamber on each side of the cephalothorax and are covered by a carapace. Along with gills, **branchiostigite** and 3 pairs of leaf like **epipodites** also carry out respiratory function.



Prawn: Gills

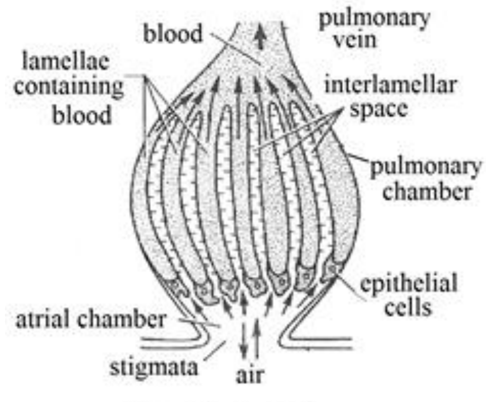
There are three types of gills in prawn. A pair of **Podobranchs** attached on the coxa of the second maxillipedes. Two pairs of **Arthrobranchs** attached to the arthrodial membrane of the third maxillipedes. **Pleurobranchs** are 5 pairs of arched gills attached in the gill chamber on the outer margin of cephalothorax, just dorsal to the walking legs. The gill lamellae are flat, plate-like arranged parallel to each other like the pages of a book.

In the gill chamber, water flow is maintained by the action of the Scaphognathite and exopodites. During the flow, the inner vascular surface of the branchiostegites, gills and epipodite of maxillipeds come in continuous contact with water. The gaseous exchange takes place through the respiratory surface by the process of diffusion.

2. Book Lungs

Book lungs are the respiratory organ found in certain air-breathing arachnid arthropods like scorpions and some spiders. There are four pairs in scorpions and up to two in spiders.

Each book lung consists of two regions i.e. anterior atrial chamber and posterior pulmonary chamber. **Atrial chamber** opens to the exterior by a slit-like spiracle or **stigmata** that opens on the ventro-lateral side of the sternum. **Pulmonary chamber** consists of nearly 150 vertical, delicate folds or **lamellae** arranged like leaves of a book. Each lamella is a hollow structure, made of two thin layers of respiratory epithelium with rich supply of blood.



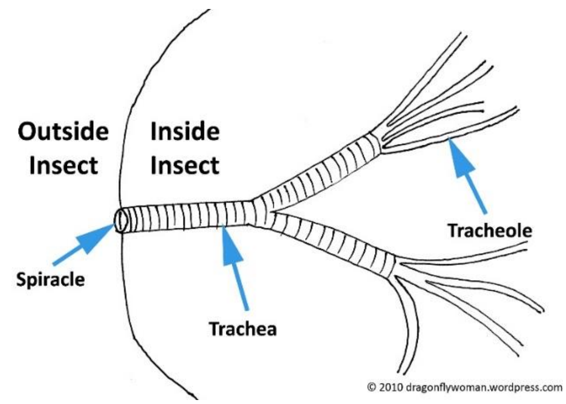
Scorpion book lung

Dorso-ventral and **atrial muscles** regulates the in and out flow of the air in the book lung. When the book lungs are *relaxed*, air rushes inside through stigmata to the atrial chamber and inter-lamellar spaces. The diffusion of gases occurs in the inter-lamellar spaces between the air and venous blood.

When the muscles *contract*, the air present in inter lamellar spaces pushed out into the atrial chamber. From the atrial chamber, air forced outside through the stigmata.

3. Trachea

The Tracheal System is the most efficient gas exchange system in insects. Through the trachea, oxygen gets directly to the cells.



Tracheal tubes consist of epithelial cells and spiral ridges called taenidia, which prevent them from collapsing. Tracheae opened externally by small openings called spiracles through which air enters. There are 10 pairs of spiracles in most insects, two in the thorax and eight in the abdomen.

The tracheae further divided into tracheoles, which are finer and profusely branched air capillaries. They penetrate in all parts of the body. Normally, these tubes are lined with a protein named trachein, and they are filled with a fluid that dissolves oxygen and diffuses it to the tissues. Insect respiration is influenced by paired tergosternal muscles. By contracting, they expel air from the abdominal cavity. When these muscles relax, the abdominal cavity returns to its original shape and draws air into the trachea.

4. Tracheal gills

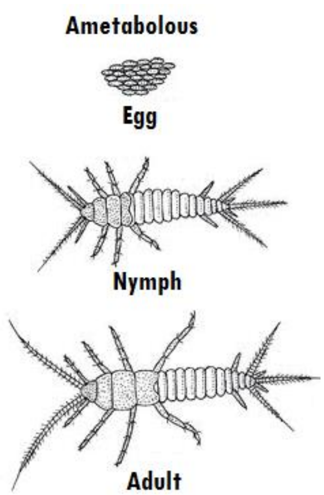
Tracheal gills are leaf-like extensions on the terminal abdominal segments that carry respiratory epithelium. Ex: Larvae of aquatic insects such as mayfly and dragon fly.

4.6 Arthropoda: Metamorphosis in Insects

Metamorphosis is the process of transformation of an immature larval individual into sexually mature reproducing adult. The transformed adult is completely different from larvae in form, structure and habit. It is the way insects grow and mature. Their lives are divided into separate stages for resting, growing and reproducing.There are four types of metamorphosis in insects.

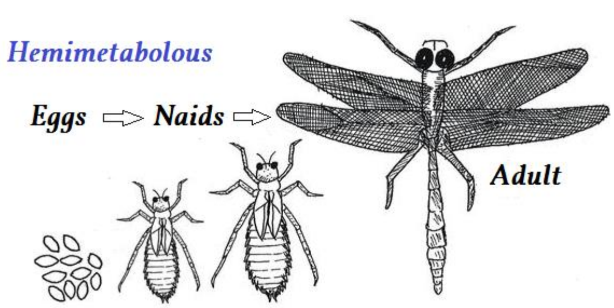
No Metamorphosis:

This type of metamorphosis is also known as ametabolous development. In this type, the newly hatched pro-nymphs resembles the adult characters and grow directly as an adult without an intermediate stage. Ex: Lepisma



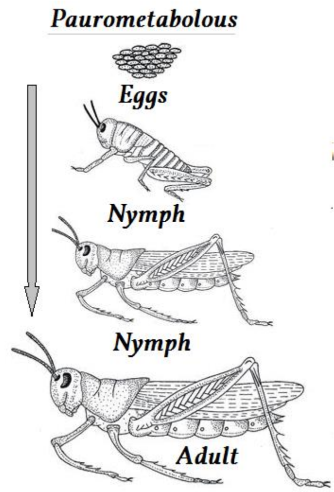
Incomplete Metamorphosis:

This type of metamorphosis is also known as **hemimetabolous** development. In this type, the immatures are called nymphs or, if aquatic, naiads. These immature stages are aquatic and they respire with the help of tracheal gills. On the other hand, the adults are terrestrial and respire with the help of tracheae. Ex: Dragon fly



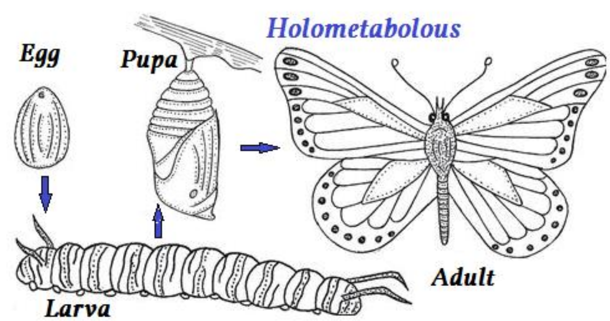
Gradual Metamorphosis:

This type of metamorphosis also known as **paurometabolous** development. In this type, the newly hatched young ones resemble the adult in general body form but lacks wings and external genital appendages. The young nymphs undergo several nymphal stages through successive moulting to transform into adult. Ex: Grosshopper.



Complete Metamorphosis:

This type of metamorphosis is also known as **holometabolous** development. In this type, four metamorphic stages are included namely egg, larva, pupa and adult. After hatching larva moults several times to become fully grown one. It later becomes a pupa within a secreted case called as puparium. Inside the puparium, the pupa differentiates into adult and then breaks open the case to emerge out. Ex: Butterflies, Wasps, Moths



4.7 Peripatus Structure, Affinities

4.7.1 Peripatus Structure

It lives under stones; bark of trees and in shady places. It is nocturnal in habit. During day time it remains in the dark place and in night time it comes out in search of food. It feeds on small insects, worms and termites.

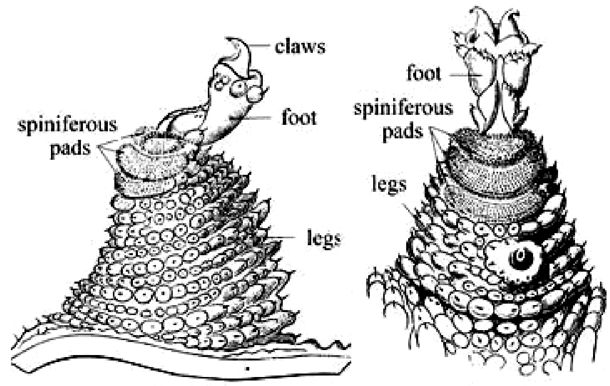
Peripatus is seen in West Indies, America, Congo, Australia, Tasmania, Newzealand, Malaya etc. It exhibits discontinuous distribution.

a. External structure

It is a soft bodied, worm like animal. It grows up to 1 to 2" in length. The soft body shows deep black colour on the dorsal side and light red colour on the ventral side.The integument exhibits large number of wrinkles or ring like constructions which are superficial. The skin is soft and bears many minute papillae and bristles along the mid-dorsal line of the body. It produces slimy secretion which is protective and helps in capturing the food organisms. The body is divisible into two parts. 1. Head and 2. Long trunk

1. Head: Head is composed of three segments. They are fused. It has a pair of many segmented antennae. On the ventral side of the head mouth is seen. The mouth is surrounded by a lip which has ridges. A pair of jaws with teeth surrounds the mouth. A tongue is also seen in the mouth. A pair of oral papillae will be present. Each oral papilla contains the openings of slime glands. On the dorsal side of the head a pair of simple eyes will be seen.

2. Trunk: It contains 14-42 segments arragned serially. All the segments are alike. Each segment shows a pair of appendages. The anus is terminal and it is present at the posterior end of the body. On the ventral side below the anus the genital pore is present.



a. Lateral view **Peripatus : Leg** b. Ventral view

Appendages: Each segment contains a pair of appendages. Each appendage shows two parts. 1) A conical proximal leg. 2) A short distal foot with a pair of horny claws.

The leg shows two spiniferous pads at its distal end. The leg bears rigns of papillae with bristles. The foot is attached to the distal end of the leg. All the appendages are hollow.

4.7.2 Affinities of Peripatus

Peripatus is a unique organism. It forms a connecting link between Annelids are Arthropods. It exhibits several important Annelidan characters and some Arthropodan characters. In addition to these, peripatus exhibits some peculiar characters not shown by either Annelids or Arthropods.

a. Annelidan Affinities

Peripatus resembles the annelids in the following features

1. Vermiform body with bilateral symmetry.
2. True head is absent.
3. Presence of thin flexible cuticle
4. Presence of dermomuscular body wall with circular and longitudinal muscles.
5. Appendages are hollow and unjointed.
6. Paired segmentally arranged nephridia.
7. Presence of a pair of simple eyes on the dorsal side of head.
8. Presence of cilia in the reproductive ducts.

b. Arthropodan Affinities

Peripatus resembles the arthropods in the following characteristic features:

1. Presence of a chitinous cuticle.
2. Presence of jointed appendages arranged one pair in each segment.
3. Presence of jaws in the mouth which are modified appendages.
4. Presence of haemocoel.
5. Presence of colourless blood.
6. Presence of long, tubular and dorsal heart enclosed by pericardium.
7. Presence of tracheal system with stigmata.
8. Presence of tubular gonads around the gut.

c. Onychophoran Characteristics

The following characteristic features are peculiar to Onychophora in which they differ from other phyla

1. Presence of superficial segmentation of the body.
2. Presence of velvety skin.
3. Segments behind head are simple and identical.
4. Presence of one pair of jaws in the mouth cavity.
5. Presence of trachea which open out with diffused stigmata.
6. Presence of a ladder like nervous system.
7. Genital organs are arranged in a manner which is not seen in any other animals.

In fact, onychophorans are neither annelids nor arthropods but possess distinct characteristics of their own. Hence at present, Onychophora is considered as a separate phylum. This is supported by the discovery of a mid Cambrian fossil, Aysheaia which closely resembles the modern Onychophora.

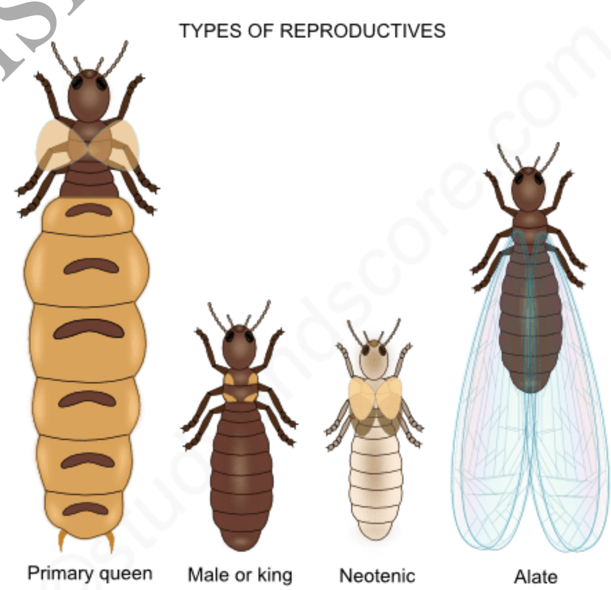
4.8.1 Social Organization in Termites

Termites were the first animals, which started living in colonies and developed a well-organised social system about 300 million years ago, much earlier than honeybees and ants. Colony comprises two major castes, the fertile castes and sterile castes.

i. Fertile Caste: The fertile caste is of the following two forms.

1. **Long winged or Colonizing Adults, Macropterous, or Primary Reproductives**:

The winged adults are produced in good number in rainy season (**Alates**). Male and female individuals go on nuptial flight and copulate in the sky. After mating, a pair settles down at a suitable site and castoff their wings (**De-Alates**) and turn into queen and kings to establish a new colony.



King: Usually there is a single king in a colony living with the queen in the royal chamber. It is smaller than queen. Its function is to mate intermittently and provide sperm to the queen. Life of the king is shorter, so a new one replaces the king.

Queen: The queen is also a single in a colony and is largest measuring 60- 80 mm in length. The sole function of the queen is egg laying. After mating, she can lay more than 1000 eggs per day. The life span of a queen is recorded to be 5 to 10 years. The queen lives in royal chamber of the nest and feeds royal jelly. The queen is well served by the workers.

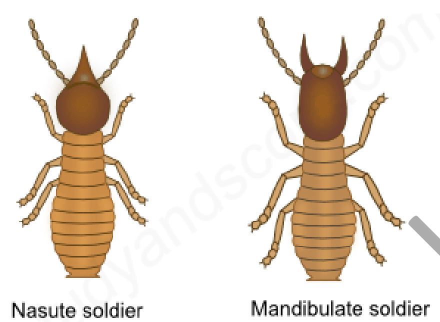
2. **Neotenics**:

When the primary or original king or queen dies or gets old, or when they got separated from the colony, its place is taken by the Neotenics in nymph form or ergates (workers) with or without moults. They are of two types

Short-winged adults (Brachypterous): These are supplementary or substitute or neotenic king and queen. They have short pad-like wings, ocelli, rudimentary compound eyes, and small reproductive organs. They attain maturity by special feeding without further moulting and become the substitute queen.

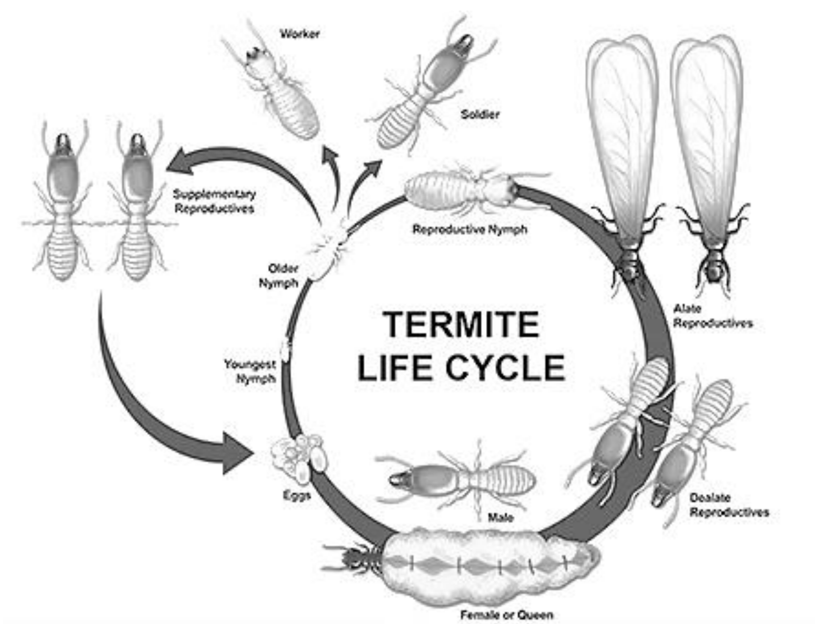
Wingless form (Apterous): There are worker-like substitute kings and queens, which occurs, in the more primitive species. The nymphs or ergates (workers) are without wings and possess less developed eyes, and reproductive organs become a functional reproductive in the colony with one or two moults.

ii. Sterile caste (Non- Reproductives): It includes workers and Soldiers. They are blind, sterile and wingless forms of both sexes.



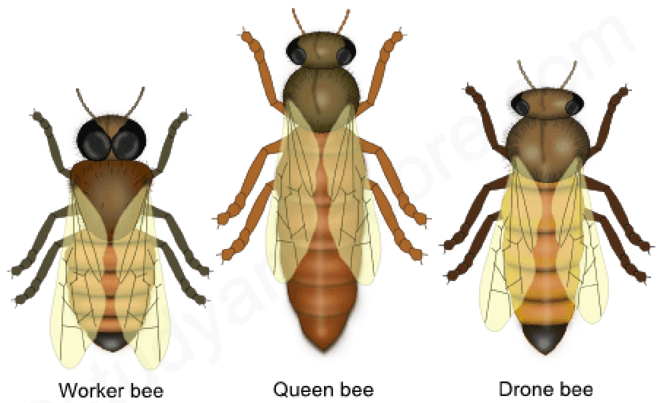
3. Workers: They constitute major numbers in a colony (80% - 90%).Workers perform all the duties for the colony except reproduction. They take care of the eggs and young, undertake the labours of food gathering, food storage and feed the nymphs, king and queens, and nest maintenance. They can metamorphose into winged reproductive castes and act as potential supplementary reproductive castes. Their life span is about one to two years.

4. Soldiers: They are larger than the workers, and constitute 5-8% in number in a colony. Soldiers defend their colony from intruders by the use of powerful jaws or by ejecting a white sticky repellent from an opening on their head. Soldiers for food rely on workers. Soldiers can be mandibulate or nasutes depending on the species. Their life span is about one to two years.



4.8.2 SOCIAL ORGANIZATION OF APIS

Honeybee is a social insect. They have well developed caste system and division of labour. Each honeybee colony has three types of individuals. They are the Queen, worker and drone.



POLYMORPHISM (CASTE SYSTEM) IN HONEY BEES

1. Queen: It is a diploid, fertile female. The size of the body of queen is much larger than other castes of bees of the colony. Each colony will have only one queen. She is fed with special diet, called royal jelly. Her work in the colony is to copulate with the Drones and is responsible for laying eggs for a colony. She lays about 1000 to 1500 eggs every day and lives for about two to three years. She lays both fertilized eggs (from which females develop) and unfertilized eggs (from which males develop).

2. Drones: They are fertile and haploid males. The drones are born out of unfertilized eggs in the brood chamber. The males are larger than workers and are quite noisy. They have large wings, robust body and reduced mouthparts. They can't feed themselves but they have to be fed by workers. They are stingless and their sole function is to copulate with the queen and to fertilize the eggs. The number of drones in a colony varies from 200-300. Drones live only for a short period.

3. Workers: They are sterile and diploid females. They are the smallest among all the other castes but they constitute majority population of the bees in a colony. Numerous adaptations have occurred in the worker bees for performing various functions. Workers are female but are incapable of producing eggs. The life span of a worker bee is about 4 to 5 months.

Worker bees are again of different types depending on the type of work they do.

Laying worker: These worker bees lay unfertilized eggs in the absence of the queen bee. Drones develop from these unfertilized eggs.

Nurse workers: These worker bees are 1-10 days old. They serve the queen with royal jelly. They also serve the larvae and drones with honey and beebread. They also help in cleaning the beehive.

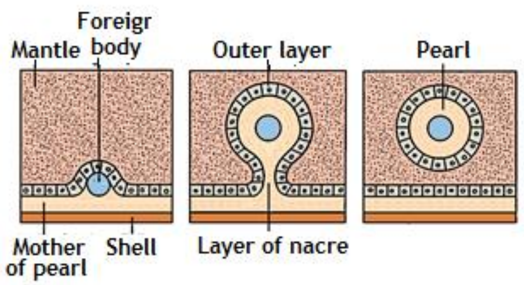
House workers: These workers are 10-20 days old. They perform house cleaning, comb building, accepting nectar and pollen for foragers and finally guard the hive. The wax glands secrete bee wax. These workers also transfer the eggs with larva to make new queen.

Field workers: These workers are 20 days plus older. They travel to distant places to collect the nectar, pollen grains and resin from the flowers and deposited into the storage chambers. They convert the nectar into honey. They also make Propolis, which is special bee glue, used to seal the cracks in the comb. Worker bees use a series of movements known as the "waggle dance" to help each other find nearby food sources, water, and other points of interest.

5.2 Formation of Pearl in Molluscs

Pearl is secreted by the mantle as a means of protection against a small external particle. When an external particle or body, such as a grain of sand or a small parasite invades in between the mantle and the shell it becomes enclosed in a sac of mantle epithelium, which produces irritation. The irritation stimulates the mantle epithelium to secrete thin concentric layers of mother of pearl around the foreign body. The amount of deposition is in direct proportion to the degree of irritation. After several years, a pearl will be formed, usually, it requires 3 to 4 years to produce a pearl of considerable size but a large pearl requires about 7 years. The foreign particles in the pearl are called nucleus whereas the thin nacre layers are concentric and called the mother of pearl.

Various clams and oysters form pearls, but those produced by the marine pearl oysters, ***Meleagrina*** of Eastern Asia are the most valuable.



5.3 The Sense Organs of Molluscans

Molluscans have sensory organs such as Tentacles, Eyes, Osphradia, and Statocysts.

1. Tentacles

The gastropods bear one or two distinct pairs of head tentacles depending on the species. In Pila, anterior tentacles are conical and short, located along the anterolateral side of the snout. They are also known as oral tentacles or labial tentacles. The posterior pair of tentacles are long, filamentous, and situated a little posterior to labial tentacles. At the tip of the posterior tentacles contains eyes. The posterior tentacles are also called rhinophores or eyestalks. Anterior tentacles are specialized for contact chemoreception (tasting), while the posterior tentacles are specialized for distance chemoreception (smelling) as well as air or water current detection.

2. Eyes

The eye is a sensory organ that detects light. Molluscs have the most diverse eye shapes and functions. There are 7-12 different kinds of eyes, ranging from pit-like gastropod eyes to pinhole-like Nautilus eyes to lens-like cephalopod eyes. Cephalopods such as octopus, squid, and cuttlefish have eyes as complex as those of vertebrates, while scallops have up to 100 simple eyes. Gastropods and cephalopods have paired eyes on their heads. Chitons' shells contain a dispersed network of tiny eyes that can function as compound eyes. Many gastropods have stalked eyes that can be retracted into the stalk in the event of danger.

3. Statocysts

Statocysts are small, paired globular structures lying close to pedal ganglion (Pila, Unio) or Pedo-visceral ganglia (Sepia). The center of the globular structure contains fluid, in which floats many minute or a mass of $CaCO_3$ called statoconia or statolith. The central cavity is surrounded by a leathery capsule (Pila) or a layer of sensory epithelial cells (Unio). Statocysts receive nerves either from the cerebral ganglion (Pila and Unio), or from the statocyst nerve (Loligo). Statocysts maintains the equilibrium (balancing organ) of the body.

4. Osphradia

Osphradia are specialized chemical sense organs. Limpets (Patellidae) have two osphradia, but advanced gastropods have a reduced left osphradium due to torsion.

In Unio, there are two osphradia above the visceral ganglion, and in Pila, there is only one on the left side of its pulmonary chamber. Some cephalopods, gastropods, and scaphopods have lost this organ. Pila's osphradium is oval, elongated, broad in the middle and pointed at the ends. It has a central axis with 22-28 thick fleshy and triangular leaflets arranged on either side. The epithelium of each leaflet consists of sensory, ciliated and glandular cells. Epithelium encloses a space filled up with nerve mass, connective tissue and blood space.

Tasks of Osphradium:

* To examine the water quality (Physical and chemical nature) or to taste the purity of water entering the mantle cavity. Eg. Unio, Pila

* To find partners. Eg. Mud Snails (Viviparous)

* To find prey in carnivorous snails. Eg. Common Whelk (Buccinumundatum)

5.5 Water vascular system or Ambulacral system in Starfish

The water-vascular system is a characteristic feature of echinoderms. It is a modified part of coelom and consists of a system of sea water-filled canals having certain corpuscles. This system consists of

i. Madreporite: The madreporite is a rounded calcareous plate-like structure present on the aboral side. Grooves or furrows are present on the surface of madreporite. Each furrow contains many minute pores. Each pore leads through pore canal. They unite to form collecting canals that opens into an ampulla that connects the stone canal.

ii. Stone canal: It is a short, 'S' shaped canal, extends down wards and opens into the ring canal at the oral end. The stone canals are supported by a series of calcareous rings, and their lumen has a prominent ridge with two spirally coiled lamellae.

iii. Ring canal: It is wide pentagonal ring-like vessel lying around the mouth. The angles of this pentagonal ring lie in the radial position.

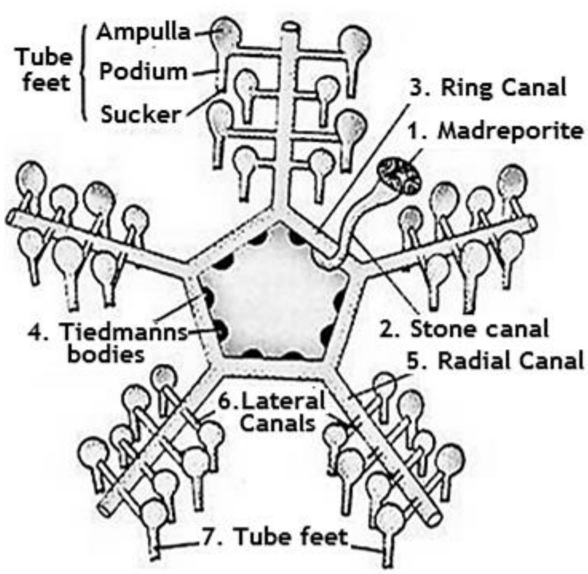
iv. Tiedemann's bodies: The ring canal gives out inter radially nine small, yellowish, glandular, sac like structures called Tiedemann's bodies from its inner margins. They produce phagocytes.

v. Polian vesicles: A ring canal gives off five elongated, pear-shaped muscular sacs with long necks known as polian vesicles. These sacs are thought to regulate pressure and manufacture amoeboid cells within the ambulacral system.

vi. Radial canal: From its outer surface, the ring canal gives off a radial water canal into each arm that runs throughout the length of the arm and terminates as the lumen of terminal tentacle.

vii. Lateral canals: Each radial canal throughout its length gives off two rows of alternately long and short narrow lateral canals. Each lateral canal ends with tube feet.

viii. Tube Feet: A tube feet is a hollow, elastic, thin walled, cylindrical sac like structure having an upper sac like ampulla, a middle tubular podium and a lower disc like sucker.

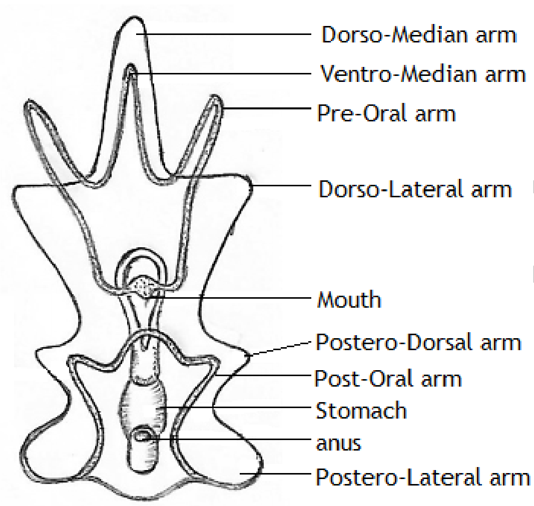


Functions: The water vascular system is a complex hydraulic system used for functions like locomotion, respiration, catching prey and removal of waste products.

5.6 Larval forms of Echinodermata

1. Bipinnaria Larva

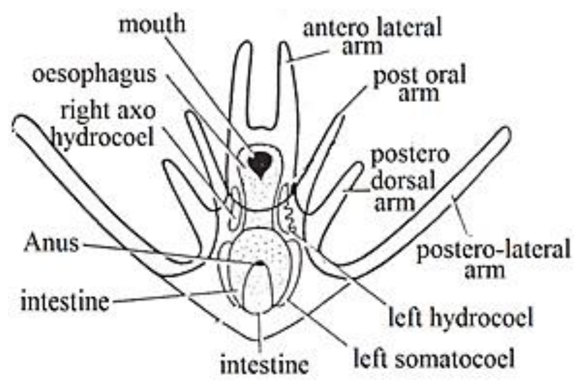
It is the larval form seen in the life history of starfish. It is a free-swimming pelagic larva with bilateral symmetry. It has elongated preoral region and broader postoral region. It has an anterior pre-oral lobe, where the cilia forms preoral and postoral bands. These two bands of cilia are drawn into many arms. They are ventro-median arm, a pair of pre-oral arm, Median dorsal arm, a pair of antero-dorsal arm, a pair of postero-dorsal arm, a pair of postero-lateral arm, a pair of post oral arm. The digestive system is developed with mouth and anus. This larva resembles Tornaria larva of Balanoglossus. Slowly, this larva grows into Brachiolaria larva.



Bipinnaria Larva

2. Ophiopluteus larva

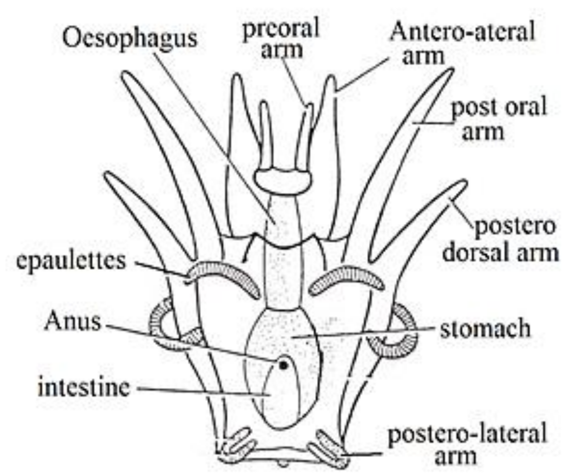
This is the larval form of class Ophiuroidea. It is a small pelagic, transparent, bilaterally symmetrical larva that swims freely. The preoral lobe is small and has long arms, supported by calcareous rods. The margin of these arms lined with undivided ciliated band. It has two antero-lateral, two post-oral, two posterior-dorsal and two posterior-lateral arms. Pre-oral and antero-dorsal arms absent. It has very long posterio-lateral arms directed forwards hence the larva resembles the letter V. The digestive system is developed with the mouth and the anus. The locomotion is normally mediated by ciliated bands, which may thicken to form epaulettis in some cases. This larva swims for some time before undergoing a metamorphosis.



Ophiopluteus larva

3. Echinopluteus larva

It is the larva of Echinoidea. It is microscopic, transparent, bilaterally symmetrical and free-swimming.

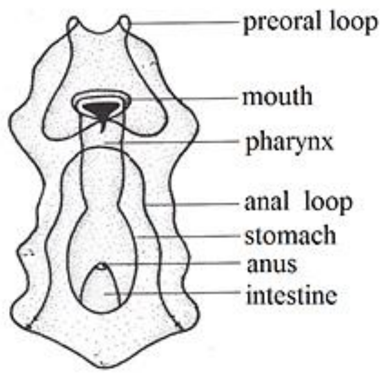


Echinopluteus larva

The larva has an oval body with ciliated bands that develop into arms. It has six arms supported by calcareous rods when fully developed. These include pre-oral, antero-dorsal, antero-lateral, post-oral, post-dorsal, and postero-lateral arms (in pairs). In certain forms, the postero-lateral arm is very short, directed backwards or even absent. In some forms, the antero-dorsal arms do not exist. Locomotion is by ciliated bands, thickened in some cases and called epaulettes. The mouth, anus and gut are well developed. This larva undergoes rapid metamorphosis and develops into an adult. It shows regeneration.

4. Auricularia Larva

It is the larval form of Holothuroidea. This larva is transparent, pelagic, and externally bilaterally symmetrical. It has a single longitudinal ciliated band, which forms a preoral loop around the mouth and an anal loop around the anus. The pre-oral lobe is very well developed. There are no calcareous rods, which are replaced by spheroids or star-shaped or wheel-like bodies. It swims by means of the ciliated band. Internally the larva contains a curved gut with sacciform stomach, a hydrocoel, and a right and left somatocoel. The auricularia larva soon transforms into another larval form, the doliolaria larva.

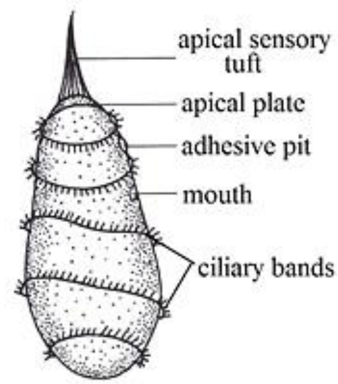


Auricularia larva

5. Doliolaria Larva

The auricularia larva is transforms into a Doliolaria larva in the Holothurians. It is a free-swimming larva. The body is barrel shaped and bilaterally symmetrical and is surrounded by 3-5 ciliated loops. Mouth is present between 2 and 3 ciliary bands on the ventral side. The inconspicuous preoral lobe develops ectodermal thickenings and forms an apical plate. The apical plate bears a tuft of cilia, which helps to maintain balance while swimming. Doliolaria transforms into adult, but the stage may be absent in some holothurians.

In crinoids, doliolaria is similar to holothuroidea. However, above the first ciliary band, just below the apical plate, in the mid ventral line, there is an adhesive pit, which contains secretory glands. Between the 2 and 3 ciliary bands there is a wide shallow depression, the vestibule which does not communicate with the mouth. Inside of the larva formed by Coelom and digestive system and the remaining area filled with mesenchyme. In this stage, mouth is absent. The larva attached to the substratum with help of Adhesive pit. This end is aboral end and the opposite end is called oral end. Gradually larva changes in to pentacrinoid larva and develops into adult.



Doliolaria larva

5.6 External Morphology of Balanglossus

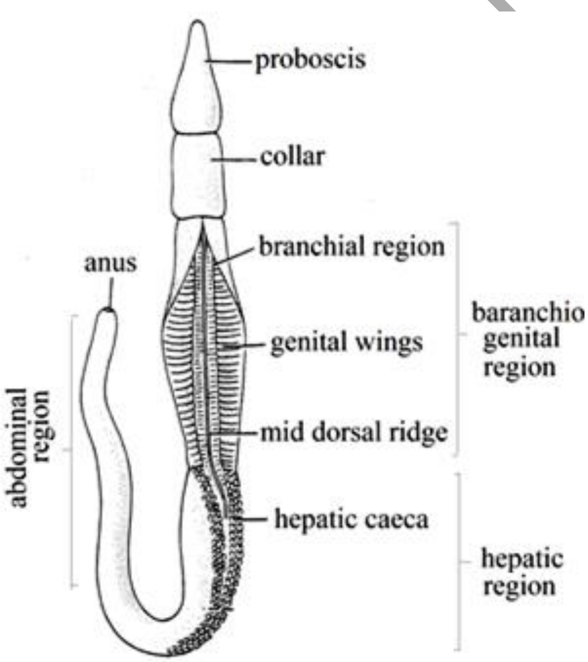
It lives in U-shaped burrows excavated in the sandy bottom of intertidal zones. The body is soft, elongated, cylindrical, and bilaterally symmetrical. The body is unsegmented, it can be divisible into three distinct regions: proboscis, collar and trunk.

1. Proboscis: It is the anterior part of the body and is either rounded or conical in shape. The posterior end of the proboscis has a narrow neck, connects with collar. The mouth is located on the ventral side and its lips are the ventral edges of the collar region.

2. Collar: The collar is the middle, short and cylindrical part. Its flap-like or funnel-like anterior margin termed collarette, completely surrounds and conceals the proboscis stalk and the posterior part of proboscis. Ventrally, below the proboscis stalk, the collarette encloses a permanently open wide aperture, the mouth. The posterior end of collar is demarcated from the trunk by a circular constriction.

3. Trunk: The trunk is the elongated posterior part of the body. It is somewhat flat and annulated on the surface. It has a mid-dorsal and a mid-ventral longitudinal ridge. The trunk is divisible into three parts, an anterior branchio-genital region, a middle hepatic region, and a posterior abdominal or post hepatic region.

i. Branchio-genital region: The branchiogenital region of trunk is marked by a pair of lateral, thin, flat and longitudinal flaps, the genital wings containing the gonads. The anterior half of branchiogenital region bears two longitudinal rows of small branchial apertures or gill pores. One row



Balanoglossus

of gill pores is mounted on a prominent longitudinal ridge on each side of the mid-dorsal ridge. The two genital wings can be curved to meet mid-dorsally so as to conceal the gill pores. In some species, a posterior prolongation of the collar, called the operculum, may cover the anterior most gill pores.

ii. Hepatic region: The middle or hepatic region of trunk is somewhat smaller than the genital region. It is greenish in colour and its dorsal surface is marked by the presence of numerous irregular intestinal sacculations of hepatic caeca.

iii. Abdominal Region: This is posterior part of the body. It tapers gradually and has a terminal anus.

5.7 Affinities of Balanoglossus

Different affinities and systematic position of Balanoglossus are, as shown below

I. Affinities with Annelida

a) Similarities

1. Worm like body.
2. Burrowing or tubicolous habitat.
3. Spiral coils of faeces like the castings of earthworms near burrows.
4. Similar blood vascular system in both groups.
5. Tornaria resembles trochophore larva

b) Differences

1. Presence of dorsal nerve cord
2. Presence of gills in the pharynx.
3. Development differs
4. Pre-oral coelom of tornaria is absent in trochophore.
5. Trochophore larva bears a pair of nephridia which are absent in Tornaria larva.
6. Blastopore becomes mouth in Annelida and anus in Tornaria

These differences suggests no definite relationship with Annelida.

II. Affinities with chordates

a) Similarities

1. Presence of notochord (stomochord).

2. Presence of dorsal tubular nerve cord.

3. Presence of pharyngeal gills.

b) Differences

1. Chordates do not have the body and coelomic regions corresponding to those of hemichordates.

2. There is no post-anal tail, cephalic importance, paired appendages in hemichordates.

3. Metamerically segmentation of certain systems as observed in chordates is totally absent in hemichordates.

4. Gills are present towards dorsal side in Balanoglossus.

5. The stomochord is not comparable with the notochord. It is present only in the proboscis.

6. Dorsal nerve cord is hollow and present only in the collar region of Balanoglossus.

The inclusion of Balanoglossus under phylum chordata is not universally accepted. The nature of the notochord is questionable. Recent researchers do not accept the notochordal nature of the buccal diverticulum. The nervous system in general is typically of the non-chordate type except for the presence of a lumen in the nerve cord of the collar. The only important chordate feature is the gill slits.

III. Affinities with Echinodermata

a) Similarities

1. Nervous systems is poorly developed and form epidermal nerve plexus

2. Origin and development of coelom

3. Ciliated bands twisted in Tornaria, Auricularia and Bipinnaria.

4. The gut is similar in same shape and divisions

5. Blastopore becomes anus

6. Cleavage and gastrulation is similar

7. Great power of regeneration

b) Differences

1. Apical plate, telotroch of the Tornaria are absent in Echinoderms

2. Eye spots of Tornaria larva wanting in echinoderm larvae.

The two are closely related groups and may have evolved from a common ancestor. Some DNA-based studies such as 18rDNA sequence analyses of enteropneusta suggest that hemichordates are closer to the echinoderms than chordates. This view is supported by the fact that the larvae of at least some hemichordates closely resembles those of some echinoderms.

NS1-321

BSc DEGREE EXAMINATIONS -March, 2023
First Year - I Semester
ZOOLOGY
Paper I : ANIMAL DIVERSITY :: BIOLOGY OF NON CHORDATES
Regular / Supplementary

Time : 3 Hours ***Max. Marks : 75***

SECTION - A
(Short answer questions)

Answer any FIVE of the folowing (5 x 5 = 25 marks)

1. Binomial Nomenclature
2. Metagenesis
3. Extra intestinal Migration
4. Nephromyxia
5. Pearl formation
6. Bipinnaria Larva
7. Social Life in Bees
8. Binary fission

SECTION - B
(Essay questions)

Answer ALL the questions (5 x10= 50 marks)

9. Whittakers Five kingdom classification (OR) Elphidium Alternation of generations
10. Polymorphism in Coelenterata (OR) Canal System in Sponges
11. Fasciola Life cycle (OR) Nematyhelminthes characters & Classification
12. Vermicomposting Process (OR) Peripatus Structure & Affinities
13. Water Vascular System in Starfish (OR) Sense organs in Mollusca

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SECTION - A
(Short answer questions)

Answer any FIVE of the folowing (5 x 5 = 25 marks)

1. Ciliary motion
2. Coral Reefs
3. Sporocyst
4. Woring of Commpound Eye
5. Osphradium
6. Vermicompost significance
7. Turbellaria Class
8. Trachea

SECTION - B
(Essay questions)

Answer ALL the questions (5 x10 = 50 marks)

9. Asexual reproduction in Protozoa OR Five Kingdom classification
10. Skeletal system in Sponges OR Ctenophora characters & Affinities
11. Ascaris Life cycle OR Parasitic adoptations in Helminthes
12. Metamorphosis in Insects OR Coelomoducts in Annelida
13. Larval forms of Echinodermata OR Balanoglossus Affinities

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SECTION - A
(Short answer questions)

Answer any FIVE of the folowing (5 x 5 = 25 marks)

1. Conjugation
2. Ctenophora characters
3. Parasitic Adaptations
4. Social Life in Termites
5. Statocyst
6. Complete metamorphosis
7. Elphidium Shell
8. Simple eyes

SECTION - B
(Essay questions)

Answer ALL the questions (5 x10 = 50 marks)

9. Process of nutrition in Protozoa OR Five Kingdom classification
10. Obelia Metagenesis OR Porifera characters and classification
11. Ascaris life cycle OR Fasciola life cycle
12. Respiration in Arthropoda OR Vermicomposting process, Economic importance
13. Water vascular system in Starfish OR Hemichordate characters & Classification