



BILINGUAL
TEXTBOOK



Sem - I

First Year B.Sc. **ZOOLOGY**

Animal Diversity-I
Biology of Nonchordates



ANDHRA PRADESH STATE COUNCIL OF HIGHER EDUCATION

(A Statutory Body of the Government of A.P)



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TEXTBOOK

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First Year B.Sc.
ZOOLOGY
Animal Diversity-I
Nonchordates

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**ANDHRA PRADESH
STATE COUNCIL OF HIGHER EDUCATION**

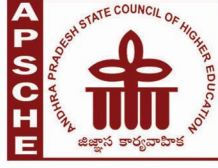
(A Statutory Body of the Government of A.P)

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Foreword

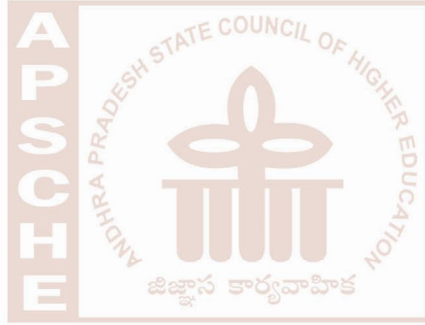


The Andhra Pradesh State Council of Higher Education, in line with the directions of the Hon'ble Chief Minister of Andhra Pradesh, introduced English Medium in all Degree programmes from this academic year 2021-22. As part of empowering the students joining Degree programmes from vernacular medium, the AP State Council of Higher Education is bringing out *podcasts*, *video casts* and notably the *bilingual text books*. These bilingual books are written in English, with the gist of the content in Telugu to enable the students to comprehend the content in their mother tongue. The bilingual text book is envisioned on the core concept of Outcome Based Education, highlighting the learning outcomes for every chapter. These are better called as bilingual resources rather than textbooks, as the APSCH has developed a template for the bilingual textbooks designing them with concepts and frameworks going beyond the usual reading material.

Furthering the detailed description of the topics, as per the common syllabus of the Redesigned Curricular Framework for Choice Based Credit System, the bilingual text book contains Glossary, where certain important terms which the student might be unfamiliar with are identified and explained in one or two sentences, which is not a mere dictionary meaning. Links to online videos or audios which will be useful for further reading and understanding of the topics are given under the Interactive links. To foster further reading, information on online resources, articles or another text book pertaining to the content are provided. To make the text book more of a resourceful book, Curricular Activities, wherein suggested activities that could be taken up in realization of the outcomes are provided for the benefit of students. To help the students to assess understanding of the content, Self Assessment instruments are provided. For Advanced Learners, caters to the needs of advanced learners providing them with additional material about the topics. Finally, for every chapter References are provided.

I sincerely appreciate the Authors and the Editors for taking pains in bringing out this bilingual text book in a record time, replete with knowledge which fosters the academic progression of students. I earnestly thank my Academic Officers, Dr. B. S. Selina, Sri. Srirangam Mathew, Dr. P. Anil Kumar for their coordinating activities and Prof. K. Rama Mohana Rao, the Vice-Chairman of APSCHE under whose guidance the publication is brought out.

K. Hemachandra Reddy
Chairman, APSCHE



PREFACE

The contentions of the Government of Andhra Pradesh to develop the student skills into a good resourceful information, a project was envisaged. In the process of implementation of the project, it was decided English as the medium of instruction, as the student can be competent at all levels. The task was entrusted to the nodal agency for higher education in our state, the APSCHE. In consultation with the academicians and educationalists, APSCHE has designed the presentation of the subject content as bilingual text books. This is for the advanced benefit of the students in general and with Telugu Medium background in particular.

We have been in teaching over the period were entrusted with the preparation of the Zoology subject content for the first semester. As per the curriculum prescribed for Zoology we planned and executed the preparation of this present book. The presentation is in a nutshell in holistic way was the need, and was written in student centric concept. In this unified approach correct concept in a lucid manner was done for the enhanced betterment of students skills.

Thus, we have maintained our emphasis on the fundamentals that are essential for the foundation in Zoology at UG level. In teaching Zoology most of the colleges and the stake holders always envisage for a detailed advanced study material for which we have prioritized and feel have really contributed the best. The illustrations and the diagrammatic presentations are self explanatory, hence the student will be happy to read, learn and enhance skills for the betterment to face the challenges.

In spite of our best efforts, with a belief in improving the volume, we welcome the constructive criticism from the academic fraternity. All criticism will be reviewed and the suggestions will be considered in future editions.

We express our gratitude to the Chairman and all the officials of APSCHE for their continuous, unstinted, cordial support and co-operation all along the preparation of the book.

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UNIT - I

PRINCIPLES OF CLASSIFICATION & PROTOZOA

LEARNING OUTCOMES :

By completion of this unit, the student should be able....

- * to know the need for classification.
- * to learn the principles of Taxonomy.
- * to know the binominal nomenclature.
- * to learn the five kingdom classification.
- * to know the outline classification of the kingdom Animalia.
- * to study the general characters of Protozoa.
- * to classify the Protozoa upto classes with examples.
- * to study the morphology, life processes and reproduction of *Elphidium*.
- * to know types of locomotory organelles and types of locomotion in protozoans.
- * to learn types of nutrition in protozoans.
- * to know types of reproduction in protozoans.

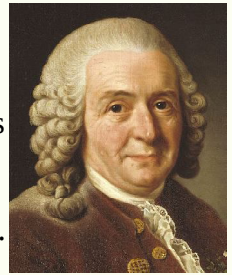
INTRODUCTION

Life processes like growth, metabolism, response to stimuli and reproduction are exhibited by the living organisms. They include microbes, plants and animals. About 1.7 to 1.8 million organisms are described so far. It is impossible to study all living organisms. It is necessary to understand specific means to make this possible.

Protozoa includes unicellular consumers. Protozoa (proto = first, zoon= animal) means first animals. About 92,000 species of protozoans are described so far.

Carl von Linnaeus was born on May 23, 1707 in Sweden.

Linnaeus had been impressed by what he read about the stamens and pistils of flower as sexual organs. His publication



Systema Nature (1735) established him as a Taxonomist.

He was called father of Taxonomy for his system of classification of plants and animals. He explained binomial system of nomenclature in the 10th edition of *systema naturae*.



Libbie Henrietta Hyman (1888 - 1969) of USA performed research on lower invertebrates like Hydra and planarian. She wrote the widely used **Laboratory Manual for Elementary Zoology** and **A Laboratory Manual for Comparative Vertebrate Anatomy**. She preferred working with invertebrates, and became authority on invertebrate taxonomy. She wrote comprehensive reference series **The Invertebrates** (6 Volumes :1940-1968).

యూనిట్ - 1

వర్గీకరణలోని ముఖ్య సూత్రాలు & ప్రోటోజోవా

అధ్యాయం - 1

వర్గీకరణలోని ముఖ్య సూత్రాలు

జీవులను వాటి గుర్తింపు లక్షణాల ఆధారంగా అనుకూలమైన సమూహాలుగా విభజించే పద్ధతిని వర్గీకరణ అంటారు. జీవులను వర్గీకరించే పద్ధతినే టాక్సనమీ అంటారు. విస్తృత జీవవైవిధ్యాన్ని గురించి తెలిపే శాస్త్రాన్ని సిస్టమేటిక్స్ అంటారు. ఇది వివిధ జీవ సమూహాల మధ్య ఉన్న పరిమాణాత్మక సంబంధాలను, పరిణామ సరళిని గురించి తెలుపుతుంది. సిస్టమాటిక్స్ లోని కీలక భాగమే టాక్సనమీ. వర్గీకరణలో ఏడు అవికల్పక అంతస్తులు ఉంటాయి. అవి - రాజ్యం, వర్గం, విభాగం, క్రమం, కుటుంబం, ప్రజాతి, జాతి.

జంతువులకు నిర్దిష్టమైన శాస్త్రీయమైన పేరును పెట్టే పద్ధతిని నామెన్క్లేచర్ అంటారు. కరోలస్ లిన్నేయస్ ద్వినామ నామకరణను ప్రవేశపెట్టాడు. దీని ప్రకారం ప్రతీ జీవికీ రెండు పదాలు కలిగిన శాస్త్రీయ నామం ఉంటుంది. మొదటి పదం ప్రజాతి/జీనస్, రెండోది జాతి/స్పీ/సీస్ ను సూచిస్తాయి. ఈ శాస్త్రీయ నామాన్ని ఇటాలిక్స్ లో ముద్రించాలి. ప్రజాతి పేరు కాపిటల్ అక్షరంతోను, జాతిపేరు చిన్న అక్షరంతోను ప్రారంభం అవుతాయి.

ఆర్. హెచ్. విట్టకర్ ఐదు రాజ్యాల వర్గీకరణను ప్రవేశపెట్టాడు. అవి మొసీరా, ప్రోటిస్టా, ఫంగై, ప్లాంటే, ఏనిమేలియా. వర్గీకరణలో పిండ దశలోని మూడు ప్రాథమిక జనన స్థలాలు - ఎక్టోడర్మ్, ఎండోడర్మ్, మీసోడర్మ్ : జీవుల స్థాయి - కణాలస్థాయి, కణజాలస్థాయి, అవయవ మరియు వ్యవస్థల స్థాయి : దేహకుహరాలు - ఏసీలోం, మిథ్యాసీలోం, సీలోం సౌష్ఠవం - వలయ, ద్విపార్శ్వ : బీజరంధ్ర రూపాంతరం - ప్రోటోస్టోంలు, ద్యుటిరోస్టోంలు : రక్తప్రసరణ - వివృత, సంవృత వంటి లక్షణాలను పరిగణనలోకి తీసుకొంటారు.

ఏనిమేలియా రాజ్యాన్ని పారాజోవా, యూమెటాజోవా అనే రెండు ఉప రాజ్యాలుగా విభజించారు. యూమెటాజోవాలో రేడియేటా, బైలరీరియా అనే గ్రేడులు ఉంటాయి. బైలరీరియాలో ప్రోటోస్టోమియా (ఏసీలోమేటా, మిథ్యాసీలోమేటా, పైజోసీలోమేటా), ద్యుటిరోస్టోమియా మరియు ఎంటిరోసీలోమేటా అనే డివిజన్లు ఉంటాయి.

PRINCIPLES OF CLASSIFICATION

The process by which any thing is grouped into convenient categories based on some easily observable characters is known as **Classification**. The scientific term used for these categories is **Taxa** (taxon : singular). The taxa can indicate categories at very different levels. Animals, mammals, rabbits are all taxa - but one must know that rabbit is a mammal and mammals are animals. Hence animals, mammals, rabbits represent taxa at different levels.

The theory and practice of identifying, naming and classification of organisms is known as **Taxonomy**. The word of Taxonomy was proposed by A.P. de Candolle. The branch of science that deals with the vast diversity of life is the **Systematics**. Systematics is a key part of Taxonomy. Systematics also reveal the trends and evolutionary relationships of different groups of organisms. These relationships establish the phylogeny of organisms.

Taxonomic hierarchy includes seven obligate categories namely kingdom, phylum, class, order, family, genus and species. There are other intermediate categories like sub kingdom, grade, division, sub division, subphylum, super class, sub class, super order, sub order, super family, sub family and sub species. Adding the suffix *idea* to the type generic name forms the name of the family. The name of sub family can be coined by adding the suffix *inae* to the type generic name. The name of super family by adding the suffix *oidea*.

1.1.1. Binomial nomenclature and Rules of Nomenclature

The process of naming of animals with distinctive scientific name is called **nomenclature**. The widely used system of nomenclature is the **Binominal Nomenclature**. Carolus Linnaeus popularised the Binomial Nomenclature and described it in the 10th edition of his book **Systema Naturae**. The Binomial nomenclature of Linnaeus is now referred to as **Binominal Nomenclature**.

In Binominal Nomenclature, each organism is provided with an appropriate scientific name consisting of two words, the **binomen**. The first word refers to the **genus**. Genus is a noun and the word is the **species** and is mostly an adjective. The generic name begins with a capital letter and the specific name with a small letter. Names must be latin or latinised form and are usually printed in Italic font.

The name of the taxonomist follows the scientific name either in full form or in an abbreviated form. e.g., *Felis leo* Linnaeus. The year of discovery is written after the name of the person who discovered it. e.g., *Felis leo* Linnaeus 1758.

International Congress of Zoology (ICZ) (1895) in its third meeting appointed a committee to draw the International Rules of Zoological Nomenclature. These rules were adopted by the fifth International Congress of Zoology (1901), as International Code of Zoological Nomenclature (ICZN). The code established a permanent International Commission on Zoological Nomenclature (ICZN). It has power to interpret, amend or suspend provisions of the code.

The code states that if two or more names are published for the same organism, the **senior synonym** is the correct name and the later names are **junior synonyms**. The earliest published of the two or more identical but independently proposed names for different organisms of the same or different taxa is the **senior homonym**, whereas the other names are **junior homonyms**.

Statement of principle of priority states that the valid name of a taxon is the oldest available name applicable to it, unless that name has been invalidated or other name is given procedure by any provision of the code or by any ruling of the commission. When the name of the genus is not the one under which original author placed a species, or if its generic name is changed subsequently, the name and the year of the original author are written in parenthesis e.g., *Panther leo* (Linnaeus, 1758). It is written so because Linnaeus originally placed the species name *leo* under the generic name *Felis* and it was shifted to the generic name *Panthera*.

1.1.2 Concept of Whittaker five Kingdom Classification

R.H. Whittaker (1969) proposed the Five Kingdom classification based on cell structure, thallus organisation, mode of nutrition, reproduction and phylogenetic relationships. These kingdoms are Monera, Protista, Fungi, Plantae and Animalia. Characteristic features of these five kingdoms are described in the table.

S. No.	Characteristics	Kingdoms				
		Monera	Protista	Fungi	Plantae	Animalia
1	Type of cells	Prokaryotic	Eukaryotic	Eukaryotic	Eukaryotic	Eukaryotic
2	Cell wall	Polysaccharides and amino acids (non cellulose)	Present in some forms	Present but cellulose is absent	Present (formed by cellulose)	Absent
3	Nuclear membrane	Absent	Present	Present	Present	Present
4	Body organisation	Cellular	Cellular	Loose tissue (multicellular)	Tissue and organ	Tissue, organ and organ system
5	Mode of nutrition	Autotrophic (Chemo and photosynthetic) and heterotrophic (saprophytic or parasitic)	Autotrophic (photosynthesis) and heterotrophic	Heterotrophic (saprophytic or parasitic)	Autotrophic (Photosynthesis)	Heterotrophic (holozoic or saprozoic)

Earlier systems of classification included bacteria, blue green algae, fungi, mosses, ferns, gymnosperms and angiosperms under **plants**. The common character to keep them in plants is the presence of **cell wall** in their cells. But they differ widely in other characteristics. The same classification include prokaryotes and eukaryotes and unicellular and multicellular organisms together. This classification did not differentiate between heterotrophic and autotrophic organisms (e.g. green plants). Their cell wall composition is also different (Fungi have chitin and green plants have cellulose). Hence, fungi were placed in a separate kingdom (**Fungi**). All prokaryotes were placed in kingdom **Protista**. *Chlamydomonas* and *Chlorella* (have cell wall) were placed in Protista along with *Paramoecium* and *Amoeba* (lack cell wall). This happened because the criteria for classification changed. These types of changes will take place in future also depending on the improvement or in understanding of characteristics and evolutionary relationships over time, an attempt has been made to evolve a classification system which reflects the morphological reproductive and phylogenetic similarities. Components of five kingdom classification are summarised here under:

Kingdom I - Monera

- Archaeobacteria
- Eubacteria

Kingdom II - Protista

- Crysophytes
- e.g. Diatoms
- Dinoflagellates
- e.g. *Gonyaulax*
- Euglenoids
- e.g. *Euglena*
- Slime moulds
- e.g. Saprophytic protists
- Protozoans
- e.g. *Amoeba*, *Paramecium*, *Plasmodium*

Kingdom III - Fungi

- Phycomycetes
- e.g., *Rhizopus*
- Ascomycetes
- e.g., *Penicillium*
- Basidiomycetes
- e.g., *Agaricus*
- Deuteromycetes
- e.g., *Trichoderma*

Kingdom IV - Plantae

- Algae
- e.g., *Spirogyra*
- Bryophyta
- e.g., *Marchantia*
- Pteridophyta
- e.g., *Selaginella*
- Gymnosperms
- e.g., *Cycas*
- Angiosperms
- e.g., *Hibiscus*

Kingdom V - Animalia

- Porifera
- e.g., *Sycon*
- Cnidaria
- e.g., *Obelia*
- Acnidaria
- e.g., *Pleurobrachia*
- Platyhelminthes
- e.g., *Fasciola*
- Nematoda
- e.g., *Ascaris*
- Annelida
- e.g., *Pheretima*
- Arthropoda
- e.g., *Palaemon*
- Mollusca
- e.g. *Pila*
- Echinodermata
- e.g, *Asterias*
- Hemichordata
- e.g., *Balanoglossus*
- Chordata
- e.g., *Oryctolagus*

1.1.3 Classification of Animal Kingdom

1.1.3.1. Basic body plans (bauplans) of animals

I. Number of primary germ layers in embryo

1. During development from a single called zygote, animals form layers of cells to form an adult.
2. The embryos of diploblastic animals have two cell layers, namely , an outer ectoderm and an inner endoderm.
3. The emryos of triploblastic animals have three cell layers, namely, an outer ectoderm, middle mesoderm and an inner endoderm.
4. The existance of three layers distinguishes them into protostomes and deuterostomes.

II. Division of Labour

- | | |
|--|--|
| 1. Cellular grade of organisation | - The specific body functions are performed by cells. |
| 2. Tissue grade organisation | - The specific body functions are performed by tissues. |
| 3. Organ and organ system grade organisation organ | - The specific body functions in the body are performed by organ or systems. |

III. Body cavities

1. Based on the type of body cavity, animals can be divided into three major groups namely acoelomates, pseudocoelomates and coelomates.
2. Acoelomates lack body cavity e.g., Platyhelminthes.
3. Pseudocoelomates have a fluid filled cavity called pseudocoelom e.g, Nematoda.
4. Coelomates have coelom that is lined by mesoderm e.g., Annelida to Chordata.

IV. Symmetry :

1. Radial Symmetry - Primitive than bilateral symmetry
2. Bilateral symmetry - Advanced and is often associated with cephalisation.

V. Fate of blastopore

1. Protostomes - Embryonic blastopore develops into mouth.
2. Deuterostomes - Embryonic blastopore becomes anus and mouth is formed later at its opposite end.

VI. Gut

1. Intracellular digestion and extracellular digestion.
2. A sac like gut with only one opening called mouth.
3. A complete gut has two openings namely mouth and anus.

VII. Circulation of blood

1. Blood is circulating in open cavities called sinuses (**open type** of circulation)
2. Blood is circulating only in the blood vessels (**closed type** of circulation).

1.1.3.2 Kingdom Animalia

Kingdom Animalia is divided into two subkingdoms based on the body organisation.

Sub kingdom 1. Parazoa : These are multicellular animals without the formation of well defined tissues
e.g., Phylum - Porifera.

Sub kingdom 2. Eumetazoa : These are multicellular animals with well defined tissues in the body.
Eumetazoa includes two grades.

Grade A. Radiata or Diploblastica : These are eumetazoas with primary radial symmetry and diploblastic body
.
e.g., Phylum Cnidaria and Phylum Ctenophora.

Grade B. Bilateria or Triploblastica:	These are eumetazoans with bilateral symmetry with triploblastic body. Bilateria includes two divisions, namely Protostomia and Deuterostomia.
Division a. Protostomia :	These are metazoans in which blastopore develops into mouth . Protostomia is divided into three sub divisions, viz., Acoelomata, Pseudocoelomata and Schizocoelomata.
Sub division i. Acoelomata :	These are eumetazoans without body cavity. e.g., Phylum Platyhelminthes
Sub division ii :Pseudocoelomata :	These are eumetazoans with a body cavity. But it is not true coelom as it is not lined by peitoneal layers. e.g., Phylum Nematoda.
Subdivision iii .Schizocoelomata:	These are eumetazoans with a true coelom, which is formed by splitting of mesoderm. e.g., Phylum Annalida, Arthropoda and Mollusca..
Division b. Deuterostomia :	These are eumetazoans in which anus is formed from the blastopore of the embryo. Later mouth is formed at the opposite end. This division includes one sub division viz, Enterocoelomata.
Subdivision : Enterocoelomata :	These are eumetazoans with true coelom which is formed from the archenteron. e.g., Phylum Echinodermata, Hemichordata and Chordata.

* Schizocoelomates and eunterocoelomates are together called **eucoelomates**.

PHYLUM : PROTOZOA

Protozoa included the unicellular consumers. It was a phylum under Animal Kingdom as per two kingdom classification. Protozoans are placed in the Kingdom Protista as per five kingdom classification. Protozoa means first animals. Anton van Leeuwenhock was the first to observe a protozoan (*Vorticella convellaria*) under microscope. He called them are **animalcules**. The term Protozoa (protos - first, zoo - animal) was coined by Goldfuss. Hyman called the protozoas as acellular animals.

1.2.1. General Characters of Protozoa

1. Protozoans are **unicellular animals**. They are often called **acellular animals**, because a single cell performs all life activities.
2. They may be solitary (e.g, *Amoeba*) or coloneal (e.g, *Cladospongia*). They may be free living or symbiotic.
3. Body symmetry is spherical (e.g., *Actinophyrs*), radial (e.g., sessile forms), bilateral (e.g, *Giardia*) or asymmetrical (e.g., *Amoeba*).
4. Body is naked, or bound by pellicle. Some forms are provided with shells.
5. Locomotory organelles are pseudopodia, flagellae or cilia. In some myonemes help in locomotion.
6. Nutrition is holozoic, holophytic or osmotrophic (saprophytic or parasitic). Digestion is intracellular.
7. Exchange of respiratory gases takes place through general body surface by diffusion. In parasitic forms, respiration is anaerobic.
8. Excretion occurs through general body surface by diffusion or by contractile vacuoles. Contractile vacuoles are mainly osmoregulatory organelles and are common in fresh water forms.

9. Protozoans reproduce asexually and sexually. Binary fission, multiple fission, plasmotomy, budding etc. are asexual methods of reproduction. Syngamy, conjugation etc., are sexual methods of reproduction.
10. Most of the protozoans undergo encystment to overcome unfavourable conditions.
11. Protozoans are said to be **immortal** (exempt from natural death) because somatoplasm and germ plasm are not different..

e.g., *Amoeba*, *Plasmodium*, *Paramoecium*

1. 2. 2. Classification of Protozoa

Protozoa is a large, varied group and hence, it is difficult to classify. Many people proposed the classification in various ways. The classification proposed by B. M. Honigberg et. al. was adopted here. They classified the Protozoa into four sub phyla, viz., Sarcomastigophora, Sporozoa, Cnidospora and Ciliophora.

Sub Phylum I. Sarcomastigophora

1. Locomotory organelles in these protozoans are pseudopodia and flagellae.
2. Sarcomastigophora includes three super classes, viz., Mastigophora, Opalinata and Sarcodina

Super class 1. Mastigophora

1. Body of these protozoans is covered by pellicle
2. Locomotory organelles are flagellae.
3. They reproduce asexually by longitudinal binary fission.
4. Mastigophora includes two classes, viz., phytomastigophorea and Zoomastigophorea

Class A : Phytomastigophorea

1. These are free living protozoans.

ప్రోటోజోవా

సాధారణ లక్షణాలు, వర్గీకరణ :

ప్రోటోజోవాలోని జీవులను ఏకకణ జీవులు లేక అకణజీవులుగా వ్యవహరిస్తారు. ఇవి సూడోపోడియా, ఫ్లాజెల్లే, సీలియా వంటి నిర్మాణాలతో చలిస్తాయి. శ్వాసక్రియ, విసర్జన క్రియ పరస్పర వ్యాపనం ద్వారా జరుగుతాయి. అలైంగిక, లైంగిక పద్ధతుల ద్వారా ప్రత్యుత్పత్తి జరుపుకొంటాయి. ప్రోటోజోవన్ను నాలుగు ఉపవర్గాలుగా విభజించారు. అవి సార్కోమాస్టిగోఫోరా, స్పోరోజోవా, నిడోస్పొరా, సీలియోఫోరా. ఈ ఉపవర్గాలను ఫైటోమాస్టిగోఫోరియా, జూమాస్టిగోఫోరియా, ఒపాలినేటా, రైజోపోడా, పైరోప్లాస్మియా, ఏక్టినోపోడియా, టీలోస్పొరియా, టాక్సోప్లాస్మియా, హప్టోస్పొరియా, మిక్సోస్పొరిడియా, మైక్రోస్పొరిడియా, సీలియేటా అనే విభాగాలుగా విభజించారు.

ఎల్ఫీడియం :

ఎల్ఫీడియం సముద్రజలాల్లో స్వేచ్ఛగా ఈదుతూ నివశించే ద్విరూపక, ఏకాంతజీవి. ఎల్ఫీడియం అనేక గదులతో కూడిన కర్పరాన్ని కలిగి ఉంటుంది. మొదటి గదిని ప్రోలాక్యులం అంటారు. గదులన్నీ జీవపదార్థంతో నిండి ఉంటాయి. కర్పరపు సూక్ష్మరంధ్రాల ద్వారా జీవ పదార్థం బయటకు ప్రవహించి, సూడోపోడియాను ఏర్పరుస్తుంది. ఇవి చలనానికి, ఆహారసేకరకు తోడ్పడతాయి.

మైక్రోస్పెరిక్ రూపం చిన్న ప్రోలాక్యులం, అనేక కేంద్రకాలను కలిగి ఉండి అలైంగిక ప్రత్యుత్పత్తి ద్వారా మెగాలో స్పెరిక్ రూపాలను ఏర్పరుస్తుంది. మెగాలోస్పెరిక్ రూపానికి పెద్ద ప్రోలాక్యులం, ఒక్క కేంద్రకం మాత్రమే ఉంటాయి. ఇది లైంగిక ప్రత్యుత్పత్తి ద్వారా మైకోస్పెరిక్ రూపాలను ఏర్పరుస్తుంది. అంటే ఎల్ఫీడియం జీవిత చరిత్రలో ఏకాంతర జీవిత దశలు వ్యక్తం అవుతాయన్నమాట.

ప్రోటోజోవన్నలో చలనం :

ప్రోటోజోవన్ను సూడోపోడియా, ఫ్లాజెల్లే, సీలియా ద్వారా చలిస్తాయి. కొన్నింటిలో మయోనీంల ద్వారా కూడా చలనం జరుగుతుంది. సూడోపోడియా ద్వారా జరిగే చలనాన్ని అమీబాయిడ్ గమనం అంటారు. ఈ చలనంలో వెలుపలి చిక్కని ప్లాస్మజెల్, లోపలి, పలుచని ప్లాస్మాసాల్ గాను: ప్లాస్మాసాల్ నుండి ప్లాస్మజెల్ గాను జీవపదార్థం రూపాంతరం చెందుతుంది. ఈ చలనాన్ని సాల్ జెల్ సిద్ధాంతం వివరిస్తుంది.

2. Euglenoids and some dinoflagellates have chlorophyll bearing chromatophores.
3. Nutrition is autotrophic or heterotrophic

e.g., *Euglena*, *Noctiluca* .

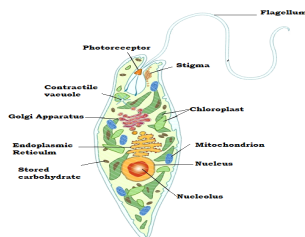


Fig. 1. 2. 1 .*Euglena*

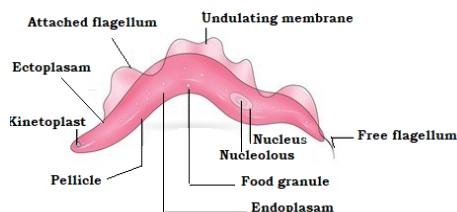


Fig. 1. 2.2 . *Trypanosoma*

Class B : Zoomastigophorea

1. These protozoans are mainly parasitic.
2. Chloroplasts are absent
3. Nutrition is holozoic, saprobic or parasitic.

e.g., *Trichonympha*, *Trypanosoma*.

Super class 2 Opalinata

1. These protozoans are commensals or parasites in the gut of frogs and toads.
2. Body is covered by cilia, which are arranged in oblique rows, but lack infra ciliary system.
3. Some are binucleate and others are multinucleate, but all are homokaryotic.
4. Longitudinal binary fission and plasmotomy are the asexual methods of reproduction. Sexual reproduction occurs by anisogamy.

e.g., *Opalina*, *Zelleriella*

ప్లాజెల్లే ద్వారా జరిగే చలనం ప్లాజెల్లార్ గమనం. దీనిలో ప్లాజెల్లే యొక్క అందుబాటులో గమనం, కశభ పార్శ్వతోపుడు చలనం, గ్రేషన్ గమనం వల్ల జరుగుతుంది.

సీలియా ద్వారా జరిగే చలనంలో సీలియా ఏకకాలిక పద్ధతి, బహుకాలిక పద్ధతిలో ఎఫెక్టివ్, రికవరీ స్ట్రోక్ల ద్వారా గమించడం వల్ల జీవి వేగంగా చలిస్తుంది. మయోసీమ్ల ద్వారా గైడింగ్, మెటబోలి అనే చలనం జరుగుతుంది.

ప్రోటోజోవన్లలో పోషణ :

ఆహారాన్ని లోనికి తీసుకోవడం, దానిని జీర్ణం చేసుకొని పెరుగుదల, జీవక్రియలు, దెబ్బతిన్న కణజాలాల పునరుద్ధరణలకు వినియోగించడం వంటి ప్రక్రియలన్నింటినీ కలిపి పోషణ అంటారు. జాంతవ పోషణలో ఘనరూప ఆహారపదార్థాలను సూడోపోడియా సహాయంతో, లేక అభివృద్ధి చెందిన ఓరల్ ఏపరేటస్ ద్వారా లోనికి గ్రహించడాన్ని ఇంజెషన్ అంటారు. ప్రోటోజోవన్లలో కణాంతర్గత జీర్ణక్రియ జరుగుతుంది. లోనికి చేరిన ఆహారం ఆహార రిక్తకలుగా ఏర్పడతాయి. లైసోసోంలు స్రవించిన ఎంజైములు వీటిలోని ఆహారాన్ని జీర్ణం చేస్తాయి. జీర్ణమైన ఆహారం జీరపదార్థంలోకి చేరుతుంది. మిగిలినది దేహ ఉపరితం ద్వారా లేక కణపాయువు ద్వారా విసర్జితం అవుతుంది. పాదపీయ భక్షణ (స్వయం పోషణ) పత్రహరితం కల ప్రోటోజోవన్లలో జరుగుతుంది. CO_2 H_2O సహాయంతో ఈ పత్ర హరితం సూర్యరశ్మితో ఆహారాన్ని తయారుచేస్తుంది. శాప్రోజోయిక్ పోషణలో జీవులు దేహ ఉపరితం ద్వారా కర్బన పదార్థాలను శోషణం చేసుకొంటాయి. పరాన్నజీవ పోషణలో కొన్ని ప్రోటోజోవన్లు ఇతర జీవులలో నివశిస్తూ వాటి నుండి పోషణను గ్రహించి ఆతిథేయికి నష్టాన్ని కల్గిస్తాయి.

Super class 3 : Sarcodina

1. These protozoans move with pseudopodia.
2. Sarcodina includes three classes, namely, Rhizopodia, Piroplasma and Actinopoda.

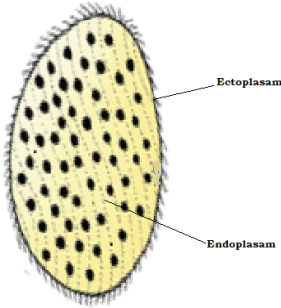


Fig. 1. 2. 3. *Opalina*

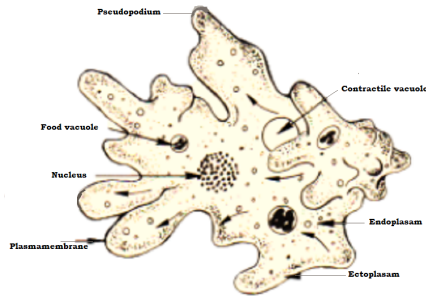


Fig. 1. 2. 4. *Amoeba*

Class A : Rhizopodea

1. These protozoans are amoebas, foraminiferans and mycetozoans (slime moulds).
2. Body is naked (e.g., *Amoeba*) or covered by a test (e.g., *Arcella*). Foraminiferans have a calcareous porous shell.
3. Locomotory organelles are pseudopodia.
e.g., *Amoeba*, *Entamoeba*, *Elphidium*.

Class B : Piroplasma

1. These are parasitic protozoans.
2. Locomotory organelles are absent.
3. spores are absent.
e.g., *Babesia*.

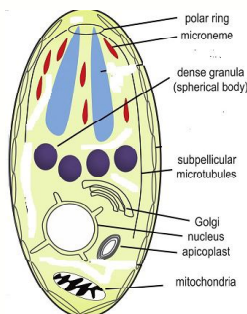


Fig. 1. 2. 5. *Babesia*

ప్రోటోజోవన్నలో ప్రత్యుత్పత్తి :

తనలాంటి సంతానాన్ని జనింపచేసుకొనే జీవప్రక్రియను ప్రత్యుత్పత్తి అంటారు. ప్రోటోజోవన్న ఏకకణ జీవులు కాబట్టి బీజకోశాలు ఉండవు. అవి అలైంగిక, లైంగిక ప్రత్యుత్పత్తి ద్వారా ప్రత్యుత్పత్తి జరుపుకొంటాయి.

ద్విధా విచ్ఛిత్తి, బహుధా విచ్ఛిత్తి, మొగ్గ తొడగటం, ప్లాస్మాటోమీ మైదలైనవి అలైంగిక విధానాలు. ద్విధావిచ్ఛిత్తి అనుకూల పరిస్థితులలో జరుగుతుంది. దీనిలో కేంద్రక విభజనను కారియోకైనేసిస్ అనీ, జీవపదార్థ విభజనను సైటోకైనేసిస్ అనీ అంటారు. ద్విధావిచ్ఛిత్తి నిలుపుగా (యూగ్లీనా), అడ్డంగా (పేరమీషియం) లేక క్రమరహితంగా (అమీబా) జరుగుతుంది.

బహుధావిచ్ఛిత్తి ప్రతికూల పరిస్థితులలో జరుగుతుంది. ఒక జీవి విభజన చెంది అనేక జీవులు ఏర్పడతాయి. స్పొరోజోవన్నలో దీనిని పైజోగనీ అనీ, స్పొరోగనీ అనీ పేర్కొంటారు. అమీబాలో బహుధావిచ్ఛిత్తిని స్పార్యలేషన్ అంటారు. బడ్డింగ్ అనేది స్థానబద్ధజీవులైన ఎసినేటా వంటి జీవుల్లో జరుగుతుంది. ఒపాలినాలో ప్లాస్మాటోమీ జరుగుతుంది. ఈ ప్రక్రియలో బహుకేంద్రక జీవి, కేంద్రక విభజన జరపకుండా పిల్ల జీవులుగా విభజన చెందుతుంది.

లైంగిక ప్రత్యుత్పత్తిలో బీజకణాలు ఏర్పడి, అవి కలసి, సంయుక్త బీజం ఏర్పడి, అది ప్రాథజీవిగా ఎదుగుతుంది. సింగమీలో రెండు బీజకణాలు కలసి సంయుక్త బీజం ఏర్పడుతుంది. బీజకణాలు కలసి సంయుక్తబీజం ఏర్పడుతుంది. బీజకణాల ప్రాక్టోండ్రకాల కలయికను ఆంఘీమిక్సిస్ అంటారు. ఐసోగమీ, ఎనైసోగమీ, ఆటోగమీ, హోలోగమీలు సింగమీలోని రకాలు.

సంయుగ్మంలో చైతన్యం కోల్పోయిన రెండు సీవియేట్లు తాత్కాలికంగా కలసి, కేంద్రక పదార్థాన్ని పునర్ వ్యవస్థీకరించుకొని, కోల్పోయిన చైతన్యాన్ని తిరిగి పొందుతాయి.

Class C : Actinopodea :

1. Heliozoans, radiolarians and acanthareans are included in this group.
2. Locomotory organelles are axopodia (a type of pseudopodia).
3. These protozoans have skeleton in the form of silicious shell, strontium sulphate spines or silicious scales and spines.
4. Shells of dead radiolarians accumulate on the ocean floor and form radiolarian ooze.

e.g., *Collozoum*, *Actinophrys*, *Acanthometra*.

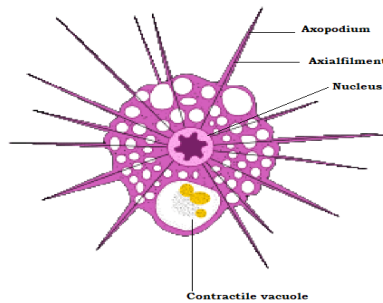


Fig. 1. 2. 6. *Actinophrys*

Sub Phylum II : Sporozoa or Apicomplexa

1. These are parasitic protozoans.
2. Locomotory organelles are absent (Pseudopodia, if present, are useful in ingestion)
3. Sporozoites have apical complex that helps to penetrate into host cells.
4. Sporozoa includes three classes, namely, Telosporea, Taxoplasmea and Haplosporea.

Class 1 : Telosporea

1. Sporozoites of telosporeans are long
2. Reproduce asexually and sexually. Sexual reproduction by isogamy or anisogamy.

e.g., *Plasmodium*, *Monocystis*.

Class 2 : Toxoplasmea

1. Spores are absent in toxoplasmeans.
2. These animals reproduce only by asexual method called **endodyogeny** (Internal budding wherein two daughters are produced within a mother cell and the mother cell is destroyed in the process).

e.g., *Toxoplasma*.

Class 3 : Haplosporea

1. Spores are amoeboid
2. Reproduction is only asexual (by multiple fission).

e.g., *Haplosporidium*

Sub Phylum III : Cnidospora

1. These are parasitic protozoans
2. Special locomotory organelles are absent.
3. Spores are provided with one or more polar filaments.
4. Cnidospora includes two classes, namely, Myxosporidea and Microsporidea.

Class 1 . Myxosporidea

1. These protozoans are extracellular parasites.
2. Spores are typically with two polar filaments.

e.g., *Myxobolus*.

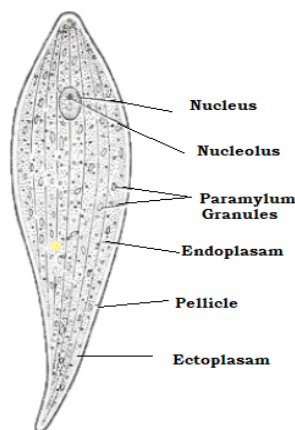


Fig. 1. 2. 7. *Monocystis*

Class 2 . Microsporidea

1. These protozoans are intracellular parasites.
2. Spores are typically with single polar filament
e.g., *Nosema*.

Sub phylum IV. Ciliophora

These are complex protozoans and this sub phylum contains a single class, namely, Ciliata.

Class : Ciliata

1. These protozoans have cilia which are useful in locomotion and food capture. Suctorians are sessile forms and have cilia in young stages only.

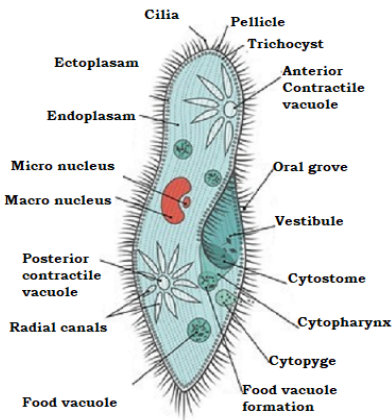


Fig. 1. 2. 8. *Paramoecium*

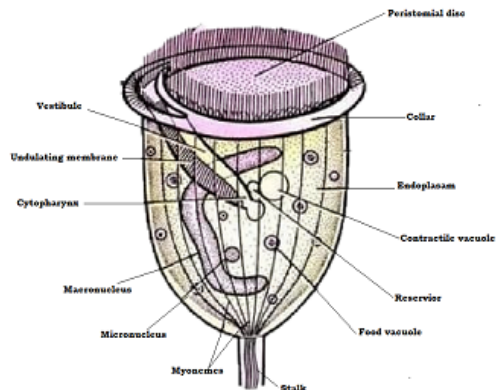


Fig. 1. 2. 9. *Vorticella*

2. They have infra ciliary system.
3. They exhibit **nuclear dimorphism** - macronucleus is vegetative and polyploid and micronucleus is reproductive and diploid.
4. Asexual reproduction is by binary fission or budding.
5. Sexual reproduction is by conjugation which brings about nuclear reorganisation.

e.g. *Paramoecium*, *Vorticella*

1.2.4. Locomotion in Protozoa

Movement of organisms from one place to the other is known as locomotion. It is performed in search of food, shelter, mate and to escape from the predators. Locomotion is influenced by external and internal factors.

Protozoans move with the help of locomotory organelles like **flagellae**, **cilia**, cellular extensions such as **pseudopodia** and **myonemes**. Pseudopodia help in amoeboid movement (e.g., *Amoeba*), cilia and flagellae help in swimming in *Paramecium* and *Euglena* respectively. Myonemes help in gliding movement in *Euglena* and sporozoans.

Locomotory Organelles

- | | | | |
|------------------|--|---|----------------------------|
| 1. Pseudopodia - | Lobopodia | : | e.g., <i>Amoeba</i> |
| | Filopodia | : | e.g., <i>Euglypha</i> |
| | Reticulopodia or | : | e.g., <i>Elphidium</i> |
| | Myxopodia | | |
| | Axopodia or | : | e.g., <i>Actinophrys</i> |
| | Actinopodia | | |
| 2. Flagellae- | Stichonematic | : | e.g., <i>Euglena</i> |
| | Pantonematic | : | e.g., <i>Paramecium</i> |
| | Acronematic | : | e.g., <i>Chlamydomonas</i> |
| | Pantracronematic | : | e.g., <i>Urceolus</i> |
| | Anematic | : | e.g., <i>Chilomonas</i> |
| 3. Cilia* | | | e.g., <i>Paramecium</i> |
| 4. Myonemes - | Contractile fibrils present below the pellicle in ectoplasm e.g., <i>Euglena</i> | | |

* A group of cilia that form a bundle is known as **cirrus**

* A row of adhering cilia forming a long sheet is known as **undulating membrane**

* Smaller rows of adhering cilia form the **membranelles**.

1. Amoeboid Movement

Locomotion effected by pseudopodia is known as amoeboid movement. It is common in rhizopodeans like *Amoeba*, *Entamoeba* etc. Besides these protozoans, amoeboid movement is exhibited by amoeboid cells, macrophages and phagocytic leucocytes like neutrophils, monocytes etc., of metazoans.

Many theories were proposed to explain the amoeboid movement. Out of them **sol-gel theory** or **change of viscosity theory** proposed by **Hyman** was widely accepted and was confirmed and explained by **Pantlin** and **Mast**. According to this theory, the outer cytoplasm of *Amoeba* (i.e., ectoplasm) is called **plasmagel** (viscous, thin, non granular, transparent and contractile) and the inner cytoplasm (i.e., endoplasm) is called **plasmasol** (less viscous, fluid like, more granular and opaque). Plasmagel and plasmasol are interconvertible. Formation and disappearance of pseudopodium are due to interconvertibility of plasmagel and plasmasol, which is **physico chemical change**. Gel becomes sol by absorbing water and sol becomes gel by losing water. During Amoeboid movement :

- i. *Amoeba* attaches to the substratum by plasmalemma at the temporary advancing end.
- ii. The hyaline layer of plasmagel (ectoplasm) at the advancing end forms a **hyaline cap**. Behind this cap, a point of weakness in the elasticity of plasmagel is formed. Hence the inner plasmasol (endoplasm) flows forward, forming a **pseudopodium** and plasmasol that flows outward behind the hyaline cap changes the colloidal state from sol to gel and joins the plasmagel.
- iii. The outer region of the plasmasol, which is flowing forward undergoes gelation and produces a rigid **plasmagel tube**. The gelation of plasmasol extends the plasmagel tube forward.
- iv. At this stage two ends appear in *Amoeba*. The advancing end is smooth and round, and the trailing end (called uroid) has wrinkled surface.

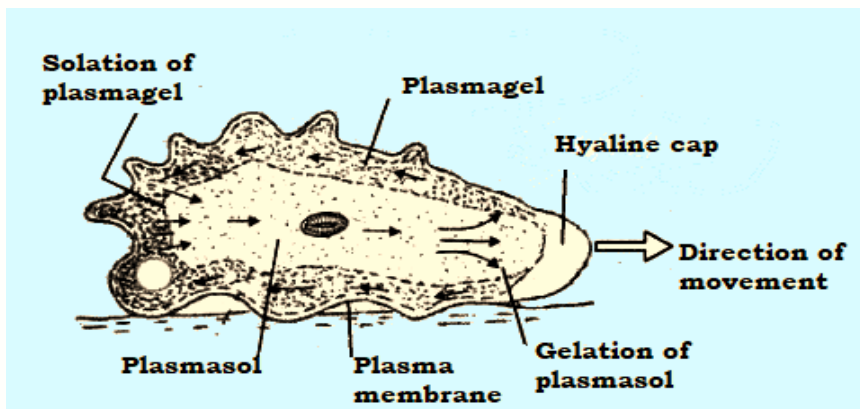


Fig. 1. 2. 10. Amoeboid movement

- v. Around the region of hyaline cap, an annular region of sol to gel transformation is formed. It is called **zone of gelation**. Uroid is the **zone of solation** where gel becomes sol.
- vi. Plasmagel at uroid changes into sol and flows forward continuously through the gel tube. As the plasmasol flows forwards, the pseudopodium elongates further and the body of *Amoeba* moves in that direction.
- vii. The gelation at advancing end and solation at uroid occur simultaneously at the same rate. Due to this *Amoeba* moves forward continuously

Explanation of sol-gel theory on molecular basis

- I. Goldacre and Lorch explained the gelation and solation on the basis of folding and unfolding of two contractile proteins present in the cytoplasm, viz., **actin** and **myosin**.
- II. They explained that when these molecules unfold, the cytoplasm gels and when they fold, the cytoplasm solates.
- III. The proteins in plasmasol are in folded state. They unfold at the place of gelation by losing water at the advancing end. These unfolded proteins at the uroid fold due to absorption of water.
- IV. These events lead to the formation of a pseudopodium which leads to amoeboid movement.
- V. The energy required for this process is available from the ATP.

Allen proposed that plasmosol flows forward due to the pulling force caused by the sliding action of the actin molecules over the myosin at the advancing end. This is referred to as **Fountain Zone theory**

2. Swimming

The locomotion in protozoans brought about by the flagellae and cilia is known as swimming locomotion. Hyman called the flagellae and cilia as **undulopodia**, because they cause progression by beating. They are useful in bringing about

locomotion in water (In case of parasitic forms, they cause locomotion in body fluids of the host).

A. Flagellar movement

Locomotion brought about by flagellum is called flagellar movement. Flagellum shows undulation movements, sidewise lashing movements and spiral gyration.

i Undulation movement

Undulation from base to tip causes a **pushing force** (like propeller of a boat) and the organism is pushed forwards. Undulation from the tip to base causes a **pulling force** (like propeller of an aeroplane) and the organism is pulled forwards. If flagellum bends to one side and shows a wave like movement from the

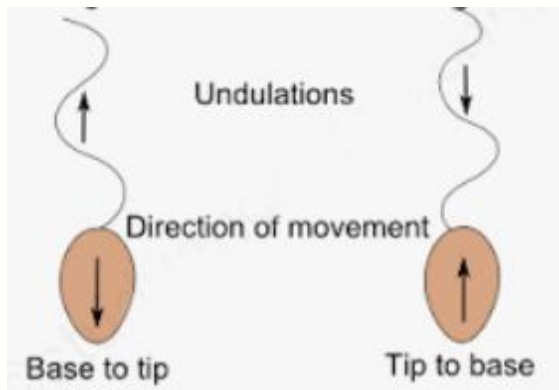


Fig. 1. 2. 11. Undular movements of flagellum

base to the tip, the organism moves laterally in opposite direction. When the undulations are spiral, they cause rotation of the organism in the opposite direction, which is called **gyration**.

ii. Sidewise lashing movements

The flagellar movement of many flagellates is a sidewise lash or paddle beat, consisting of two strokes, viz., the **effective stroke** and **recovery stroke**. Energy required for these movements is obtained from ATP.

Effective stroke : Flagellum becomes rigid and starts bending the one side beating fastly against the water. This beating is at right angles to the longitudinal axis of the body and the organism moves forward.

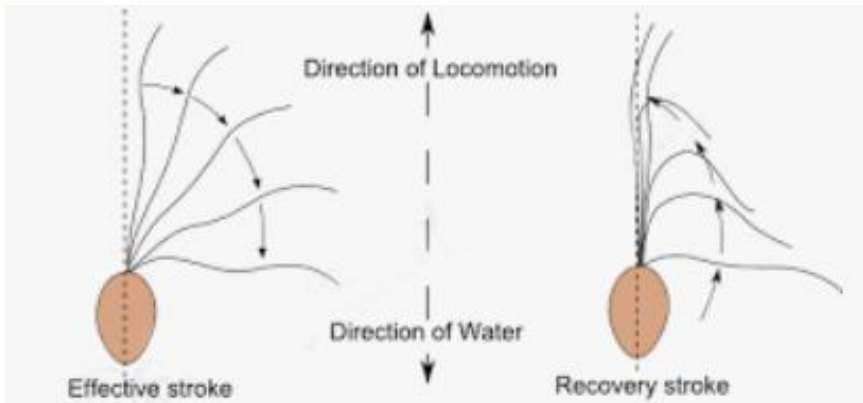


Fig. 1. 2. 12. Sidewise lashing movements of flagellum

Recovery stroke : Flagellum becomes comparatively soft, so as to offer least resistance to water and moves backwards to its original position. It is called recovery stroke.

iii. Simple conical gyration movement

In simple conical gyration, the flagellum turns like a screw. This exerts the propelling action that pulls the organism forward through water with a spirallal roation around the axis of movement and gyration on its own axis.

B. Ciliary movement :

Locomotion brought about by cilia is called ciliary movement and is observed in ciliates. Cilium shows pendular movements - swing back and forth. These are called **effective stroke** and **recovery stroke** respectively. Cilurm moves the water parallel to the surface of its attachment similar to paddle stroke movemenet.

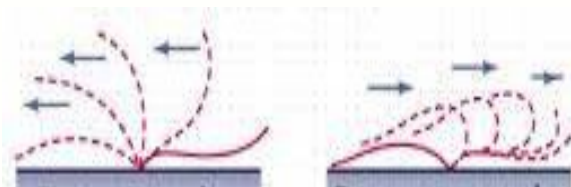


Fig. 1. 2. 13 Ciliary movements

i. Effective stroke

Cilium bends and beats against the water. It is called effective stroke. Body moves forwards in this stroke as the cilium pushes the water backwards.

ii. Recovery stroke

After the effective stroke, cilium comes to its original position by its backward movement without any resistance.

In *Paramecium*, cilia are arranged in longitudinal rows as well as transverse rows. The direction of effective stroke of cilia is oblique to the long axis of the body. Hence *Paramecium* swims in a spiral way rotating on its own axis. Cilia show two types of coordinated rhythms, viz., **synchronous rhythm** and **metachronous rhythm**. In synchronous rhythm the cilia in transverse rows beat simultaneously. In metachronous rhythm, cilia in longitudinal rows beat one after the other. Hence a metachronal wave passes from anterior end to the posterior end. When *Paramecium* comes in contact with undesirable object, the beating of cilia is reversed and the organism moves backward for a short distance. The ciliary movement is coordinated by **infraciliary system** through a neuromotor centre called **metorium** present near the cytopharynx. The infraciliary system together with metorium forms the **neuromotor system** that coordinates the beating of cilia. Hence, ciliary movement is the fastest locomotion in protozoans.

3. Gliding

Certain protozoans have contractile filaments present below the pellicle in ectoplasm. They are called **myonemes**. The small zig zag movement in protozoans caused by the contraction and relaxation of myonemes is called **gliding movement**. It is exhibited by flagellates, sporozoans, cnidosporans and some ciliates.

4. Metaboly

Pellicle of protozoans contains proteinaceous strips supported by dorsal and ventral microtubules. In many protozoans the strips can slide past one another, causing wriggling locomotion called **metaboly**. In this process, temporary change in shape of the body occurs.

1.2.5. Nutrition in Protozoa

The process of taking in food and using it for growth, metabolism and repair of damaged tissues in the body is called **nutrition**. Some of the protozoans can synthesise their food by photosynthesis and others obtain nourishment in many ways. The following are the various types of nutrition in protozoans.

1. Holozoic nutrition : Nutrition in majority of protozoans is holozoic type. Like animals, they ingest solid food. The food of protozoans include bacteria, diatoms, algae, rotifers, other protozoans, crustacean larvae etc. Holozoic nutrition involves the processes like ingestion, digestion, absorption, egestion etc.

A. Ingestion : Intake of food is described as ingestion. The mode of ingestion in most of the protozoans is by phagocytosis. Colourless flagellates capture their food with the help of their flagellae. Rhizopods ingest their food with the help of pseudopodia. Ciliates ingest the food through a well developed oral apparatus.

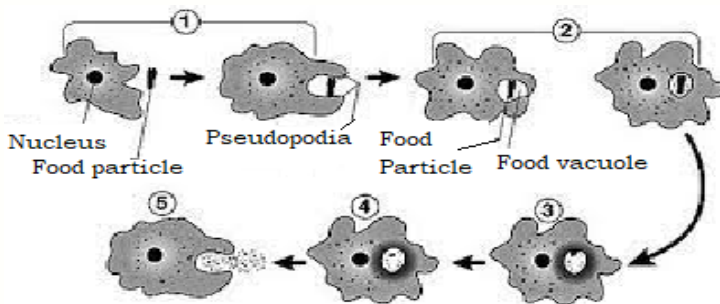


Fig. 1. 2. 14. Nutrition in *Amoeba*

Suctorians feed with the help of tentacles. The free end of each tentacle has a knob, and the tentacle has a tube in the centre. Whenever the prey comes in contact with the knob of the tentacle, it is paralysed by some toxin. Then prey is sucked through the tube of the tentacle.

B. Digestion : Digestion in protozoans is intracellular and it takes place in food vacuoles. The contents of food vacuole are acidic in the beginning and thus the prey dies. Then the contents in food vacuole become alkaline. Lysosomes filled with enzymes are fused with the food vacuoles. Proteolytic enzymes digest proteins into amino acids and carbohydrate splitting enzymes digest them into simple sugars. Some protozoans can digest fats.

C. Absorption and assimilation : Digested food diffuses into the endoplasm where it is utilised for metabolic activities. Excess food is stored in the endoplasm in the form of glycogen, fat droplets, paramylum, chromatoid bodies etc.

D. Egestion : Elimination of undigested matter is called egestion. Ciliates egest the undigested matter through cytopyge. In other protozoans undigested matter is egested through the body surface.

Ingestion of liquid food through the body surface may occur in certain protozoans by the process called **pinocytosis** or cell drinking. Pinocytic channels are formed on body surface to enclose the liquid food from the surroundings. Lower ends of these channels are pinched off as **pinosomes** which later become food vacuoles.

2. Holophytic Nutrition (Autotrophic Nutrition)

Protozoans having chlorophyll or some allied pigment can prepare complex molecules of organic food by photosynthesis using inorganic substances like water, CO₂ in presence of sunlight. (like green plants) e.g., *Euglena*.

Some protozoans harbour chlorophyll bearing algae like *Zoochlorellae* which manufacture organic food for themselves as well as for the host by photosynthesis. e.g., *Paramoecium bursaria*

3. Saprozoic Nutrition

Some protozoans absorb complex organic substances in solution through the body surface from the surrounding medium by **osmosis**. The method of getting food by this process is called **osmotrophy**. Protozoans that adopt this method of nutrition are called **saprozoic forms**. Some protozoans adopt holozoic nutrition, but absorb certain organic compounds through body surface. e.g., *Balantidium coli*. Colourless flagellates (e.g., *Polytoma*) also absorb organic fluids through body surface.

4. Parasitic Nutrition

- i. Some of the parasitic protozoans feed upon the undigested or digested food of their hosts. They are called food robbers. In this process, they may adopt holozoic or saprozoic methods to get nourishment

e.g., *Balantidium*, *Nictotherus*

- ii. Some parasitic forms feed on the living tissues of their hosts causing harm to them. They absorb the food through body surface or ingest by phagocytosis

e.g., *Trypanosoma*, *Plasmodium*

5. Coprozoic Nutrition

The type of nutrition in which the protozoan feeds on the faecal matter of other organisms is known as coprozoic nutrition.

e.g., *Dimastigamoeba*, *Clamydophrys*

6. Mixotrophic Nutrition

Some protozoans adopt more than one method of nutrition to nourish themselves. This is called mixotrophic nutrition.

e.g., *Euglena* (autotrophic and saprozoic)

1.2.6. Reproduction in protozoans

One of the important life processes is producing young ones of same kind, the reproduction. As the protozoans are unicellular organisms, gonads are lacking. Protozoans mainly reproduce asexually. In some forms, sexual reproduction also takes place. In some, asexual method is the only type of reproduction.

2.6.1. Asexual reproduction in protozoans

Reproduction without the fusion of pronuclei is called asexual reproduction. Genetic recombination does not occur in it. The young one shows uniparental inheritance, without any genetic variations. Generally protozoans reproduce asexually during favourable conditions. The asexual methods include binary fission, multiple fission, budding (gemmation) and plasmotomy.

1. Binary fission

Binary fission is the most common method of asexual reproduction in protozoans. In this process the parent is divided into two daughter individuals. It involves division of nucleus (called **karyokinesis**), followed by the division of cytoplasm (called **cytokinesis**). The plane of binary fission may be irregular (e.g., *Amoeba*), longitudinal (e.g., *Euglena*) or tranverse (e.g., *Paramecium*). In ciliates exhibiting nuclear dimorphism, the macronucleus divides amitotically and the micronucleus mitotically.

The daughter individuals formed by binary fission carry all the organelles of parent organism. Some organelles like mitochondria divide at the time of division. Certain organelles like oral apparatus, flagellae, contractile vacuoles etc, are received by one daughter individual and are formed afresh in the other daughter individual.

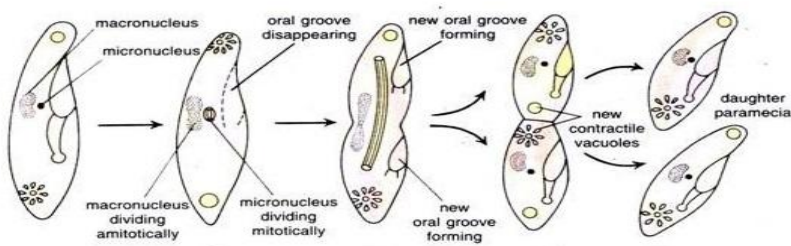


Fig. 1. 2. 15. Binary fission in *Paramecium*

2. Multiple fission

Division of parent protozoan into many daughter individuals is known as multiple fission. In free living forms multiple fission takes place during unfavourable conditions. In multiple fission, nucleus divides into many daughter nuclei followed by the cytoplasmic division and thus many daughter individuals are formed. It is common in rhizopods and sporozoans.

- Asexual multiplication in sporozoans is often described as **schizogony**. The resultant daughter individuals grow into trophozoites.
- Gamogony and sporogony are multiple fissions in protozoans related to sexual reproduction.
 - Gamogony** is the multiple fission by which gametes are formed
 - Sporogony** is the multiple fission by which spores or sporozoites are formed.
- Sporulation** is the multiplication of *Amoeba proteus* without encystment.

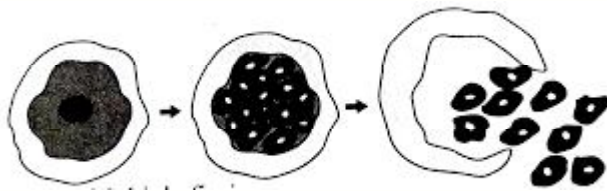


Fig. 1. 2. 16. Multiple fission in *Amoeba*

3. Budding or Gemmation

Budding is a common method of asexual reproduction in suctorians (e.g., *Acineta*). Bud is a smaller individual formed after nuclear division. **Monotonic** budding is seen in ciliates like *Vorticella*, in which only one bud is formed at a time. Multiple buds are formed in suctorians. Budding may be **exogenous** (e.g., *Ephelota*) (in which buds are formed on the surface of the parent) or **endogenous** (e.g., *Acineta*) (in which buds are formed inside the body of the parent).

4. Plasmotomy :

Division of a multinucleate protozoan into multinucleate daughter individuals by cytoplasmic division (but without nuclear division) is called **plasmotomy**. The nuclei of the parent are distributed among the daughter individuals. e.g., *Opalina*



Fig. 1. 2. 17. Plasmotomy

2.6.2. Sexual reproduction in protozoans

Sexual reproduction takes place by the fusion of pronuclei with the formation of gametes, or without the formation of gametes. Genetic recombination occurs in sexual reproduction during the formation and during fusion of gametes. Sexual reproduction in protozoans occurs by syngamy, conjugation etc.

1. Syngamy :

Complete fusion of two gametes, resulting in the formation of zygote is known as **syngamy**. Fusion of gametic pronuclei is called **amphimixis** and the resultant nucleus is called zygote

nucleus or **syngaryon**. Syngamy in protozoans can be divided into the following types :

- a. Isogamy :** the fusion of pronuclei of similar gametes is known as isogamy. Isogamy is common in foraminiferans, gregarinians, phytomonads etc.
e.g., *Elphidium*, *Monocystis*, *Chlamydomonas*
- b. Anisogamy:** The fusion of pronuclei of dissimilar gametes is known as anisogamy. Generally, the smaller and motile gametes are called microgametes or male gametes. The larger and nonmotile gametes are called macrogametes or female gametes. Anisogamy is common in sporozoans and phytomonads.
e.g., *Plasmodium*, *Volvox*
- c. Autogamy :** Fusion of gametes or pronuclei derived from the same parent individual is called **autogamy**. it is seen in certain ciliates and heliozoans
e.g., *Paramecium aurelia*, *Actinophrys*.
- d. Hologamy :** In this process, gametes are not formed. Two mature organisms which act as gametes are fused to form a zygote.
e.g., *Trichonympha*, *Copromonas*

2. Conjugation : Temporary union of two senile ciliates of two different mating types for the exchange of nuclear material and its reorganisation is known as **conjugation**. It restores the vigour and vitality which are lost due to chromosomal imbalance in their macronuclei due to repeated amitotic divisions during binary fission. Unfavourable conditions also induce conjugation.

e.g., *Paramecium caudatum*, *Vorticella*

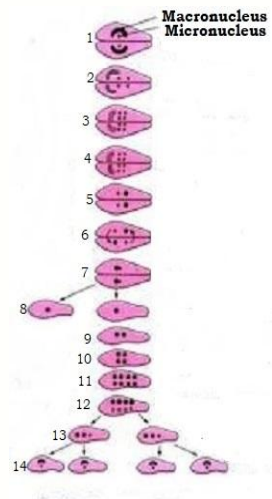


Fig. 1. 2. 18. Conjugation in *Paramecium*

1.5

Elphidium

Systematic position

Phylum	:	Protozoa
Sub phylum	:	Sarcomastigophora
super class	:	Sarcodina
Class	:	Rhizopodea
Order	:	Foraminiferida
Genus	:	<i>Elphidium</i>
Species	:	<i>crispa.</i>

1.5.1. Habit and habitat

Elphidium is a marine, free living protozoan found creeping about on sea weeds. It is a dimorphic solitary and free swimming organism.

1.5.2 Morphology

Elphidium has a pale yellow, translucent spherical or oval shell, formed mainly by calcium carbonate. Shell measures about 1 mm is diameter. Shell has many chambers (muitilocular or polythalamus) and are arranged in a planospiral way. Each chamber is convex anteriorly and concave posterorly. The concave surface possess retral processess (filled with cytoplasm). Minute

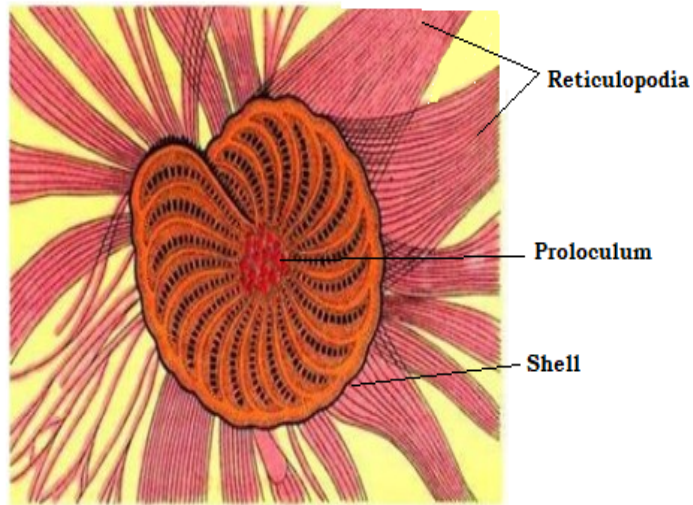


Fig. 1. 5. 1 *Elphidium*

pores are present among the retral processes, through which cytoplasm extends out as pseudopodia of reticulopodia type. They help in locomotion and food collection. Central part of the shell is round and convex and is called **umbo**. Peripheral part of the shell consists of a rim called **keel**. Shell is formed as a single chamber called **proloculum**. As the animal grows, successive chambers are formed in a spiral manner. Each chamber is larger than the preceding one. Posterior edges of the chambers overlap the preceding chambers and these overlapping portions are called **alar processes**.

Elphidium is a **dimorphic form** - the two forms are **megalospheric form** and **microspheric form**. Their morphology is similar but differ from each other in the following features.

Megalospheric form

1. Size is comparatively large
2. Proloculum is larger
3. Uninucleate form
4. Reproduces sexually and produce

microspheric forms produce megalospheric forms

Microspheric form

1. Size is comparatively small
2. Proloculum is smaller
3. Multinucleate form
4. Reproduces asexually and

In megalospheric form, one of the chambers contain a single nucleus. Whereas the microspheric form contains many nuclei, which are irregularly distributed in all chambers. Each nucleus contains many nucleoli.

1.5.3 Nutrition

Nutrition in *Elphidium* is holozoic. It feeds on minute organisms such as diatoms, crustacean larvae and other protozoans. Reticulopodia form a net and secrete mucous layer to trap the prey organisms. Substances in mucous layer paralyse the prey and the enzymes initiate digestion. Then the prey is enclosed in a food vacuole and is drawn into endoplasm. Generally digestion is completed outside the shell and the digested food diffuses into the endoplasm.

1.5.4 Reproduction

Elphidium is a dimorphic animal and the two forms are megalospheric form and microspheric form. Megalospheric forms sexually reproduce and produce the microspheric forms. Microspheric forms asexually reproduce and produce megalospheric forms. Hence, the life cycle of *Elphidium* exhibits a definite **alternation of generations**.

1. Gamogony or sexual phase

The megalospheric form of *Elphidium* is larger, uninucleate and is with a large proloculum. Megalospheric form (or gamont) produce numerous gametes. All gametes are similar (**isogametes**) and each is provided with a pair of flagellae. The nucleus of megalospheric form undergo many divisions

and each nucleus is surrounded by some cytoplasm, and organises into a biflagellate isogamete.

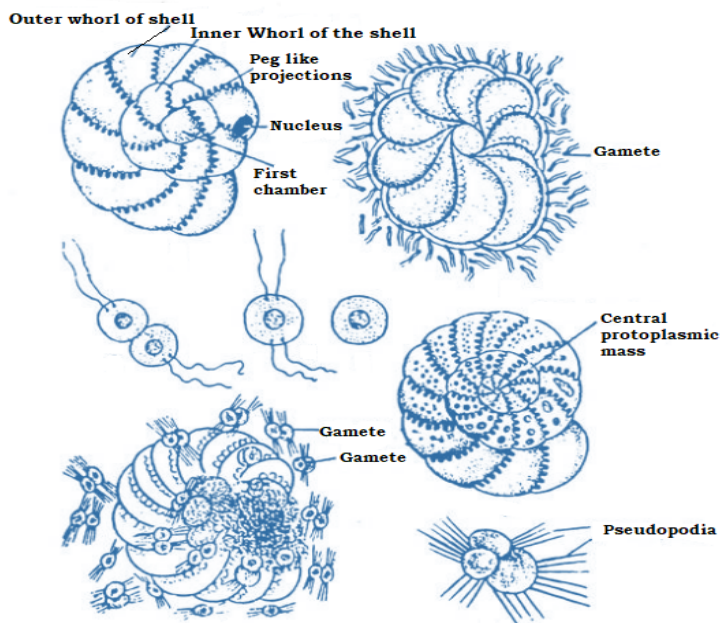


Fig. 1. 5. 2. *Elphidium* - Life history

These isogametes reach the surrounding sea water through the pores of the shell. In sea water, the isogametes of different parents (i.e., gamonts) unite and fuse in pairs (as the two gametes are similar, the syngamy is described as **isogamy**) forming **zygotes**.

2. Agamogony or asexual phase

The zygote formed at the end of sexual phase secretes the shell around the small proloculum and becomes a young microspheric form. Its nucleus first divides by meiosis and then by many mitotic divisions. As the individual grows, new chambers are added and thus a multinulate and mulilocular adult agomote, schizont or microspheric form is formed.

Microspheric form reproduces asexually and the asexual phase is called **schizogony**. During this process entire cytoplasm along with nuclei creeps out of the shell as a lump. This lump is organised into a large number of amoeba like uninucleate cells called agametes or amoebulae.

The amoebulae are detached from the parent body. Each amoebula secretes a large proloculum with shell chambers and becomes a megalospheric form or garmont. Gradually it grows in size, secretes additional chambers and becomes an adult.

GLOSSARY

Actin and myosin	: Contractile proteins in the cytoplasm of <i>Amoeba</i>
Amphimixis	: Fusion of pronuclei of gametes
Classification	: The process by which any thing is grouped into convenient categories based on some easily observable characteristics.
Coelom	: Body cavity lined by mesodermal peritoneum.
Deuterostomes	: Animals in which embryonic blastopore becomes anus

INTERACTIVE LINKS

- * <https://www.biologydiscussion.com/invertebrate-zoology/protozoa/nutrition-and-protozoa-with-diagram/28389>
- * <https://micorbiologynote.com/reproduction-in-protozoa/>
- * <https://www.slideshare.net/Hemantkrdu/reproduction-in-protozoa>

CURRICULAR ACTIVITIES

I. Class room seminars :

1. Principles of classification
2. Binominal nomenclature
3. Five kingdom classification
4. *Elphidium* - structure and life history

II. Group discussion

1. Principles of classification and nomenclature
2. Locomotion and nutrition in protozoans
3. Reproduction in protozoans.

III. Field work

1. Observation of various categories of organisms on the college campus and nearby agricultural farm
2. Collection of sample of water from nearby pond and observe locomotion in various protozoans.

IV. Self Assessment

A. Choose the correct answer :

1. First act in Taxonomy is
 1. Identification
 2. Nomenclature
 3. Classification
 4. Ordering the taxa
2. Echinoderms and chordates are
 1. Radially symmetrical
 2. Schizocoelomates
 3. Protostomes
 4. Deuterostomes
3. Assertion (A) : Linnaeus system of classification is essentially an artificial system.. Yet, it has become a natural system.
Reason (R) : Similarities forming the basis of his classification are indicative of genetic relationships
 1. Both A and R are true. R is correct explanation for A
 2. Both A and R are true. R is not correct explanation for A
 3. A is true. But R is false
 4. A is false. But R is true.
4. Non cellulose cell wall is present in
 1. Protista
 2. Plantae
 3. Animalia
 4. Monera
5. Study the following statements and pick up the correct ones :
 - I. Multicellular animals without tissues are included in Platyhelminthes
 - II. Annelids are protostomes and schizocoelomates
 - III. Deuterostomes with pentaradial symmetry in adults are included in Mollusca.
 - IV. Chordates exhibit bilateral symmetry and are deuterostomes.
 1. I, II
 2. II, IV
 3. III, IV
 4. I, IV

6. Flagellae are locomotory organelles in
1. Sarcodina
 2. Mastigophora
 3. Ciliata
 4. Sporozoa
7. Statement I : In *Elphidium*, megalospheric form produces the isogametes
Statement II : In *Elphidium*, microspheric form reproduces sexually and produce megalospheric forms.
1. Both statements I and II are correct
 2. Statements I and II are false
 3. Statement I is correct, but II is false
 4. Statement I is false, but I is correct
8. In metachronal rhythm, cilia moves
1. At a time in a transeverse row
 2. One after the other in an oblique row
 3. Alternately in any row
 4. In an undular pattern
9. Nutriton in colourless flagellates like *Polytoma*
1. Holozoic
 2. Saprozoic
 3. Holoplytic
 4. Parasitic
10. Match the following :
- | | List - 1 | List - 2 |
|--------------|--------------------------|----------|
| A. Isogamy | I. <i>Plasmodium</i> | |
| B. Anisogamy | II. <i>Actinophrys</i> | |
| C. Autogamy | III. <i>Monocystis</i> | |
| D. Hologamy | IV. <i>Trichonympha</i> | |
| | V. <i>Amoeba proteus</i> | |
- | | A | B | C | D |
|----|-----|-----|----|-----|
| 1. | III | I | II | IV |
| 2. | III | V | II | IV |
| 3. | IV | II | I | III |
| 4. | IV | III | II | V |

B. Fill in the blanks

1. The branch of science that deals with the vast diversity of life is the _____
2. Binomial nomenclature was described in the 10th edition of _____
3. Mode of nutrition in *Plantae* is _____
4. Undulation movement is effected by _____
5. Syngamy in *Plasmodium* is _____

C. Short answer type questions

1. Define Taxonomy.
2. What is the full form of ICZN ?
3. Name the five kingdom in Whittakar's classification
4. What are protostomes and deuterostomes ?
5. What are the two forms of *Elphidium* ?
6. What is metagenesis ?
7. What are plasmagel and plasmasol ?

FOR IGNITED MINDS CHAPTER 1

1. A group of closely related organisms which are capable of interbreeding and produce fertile offspring is known as a **species**.
2. There are two types of classification - artificial and natural
 - i. **Artificial classification** is based on one or a few easily observed characteristics and is usually designed for a practical purpose with an emphasis on convenience and simplicity.
 - ii. **Natural classification** tries to use natural relationships among organisms. It consider more evidence than artificial classification, including internal as well as external

3. In binominal nomenclature, each organism is named by using two words - genus and species. **Trinominal nomenclature** is the extension of binominal nomenclature. This system permits the designation of sub species. Hence the scientific name consists of three words - **trinomen**. The word indicating sub species also begins with a small letter and it is a latinised word

e.g., *Corvus splendens insolens*, *Corvus splendens protegatus*

4. The practice of naming animals, in which the generic name and the species name are the same is known as **tautonymy**.
e.g., *Axix axis*- Spotted deer ; *Naja naja*- Indian cobra

FOR IGNITED MINDS

CHAPTER 2

1. Protozoans are unicellular organisms and some of them are parasitic and cause various diseases in human beings. Some of them are -

S.No.	Name	Livel in ... of man	Intermediate Host	Disease caused
1.	<i>Entamoeba histolytica</i>	Intestine	-	Amoebiasis
2.	<i>Trypanosoma gambiense</i>	Blood	Tse tse fly	African sleeping sickness
3.	<i>Leishmania donovani</i>	Reticuloendothelial cells	Sand fly	Kala azar
4.	<i>Plasmodium vivax</i>	Hepatocytes and erythrocytes	Man	Malaria

2. *Noctiluca*, *Certium* are bioluminescent protozoans
3. *Trichonympha* is a symbiont in alimentary canal of termites. *Trichonympha* secretes cellulose digesting enzyme glucosidase, in turn termites nourish *Trichonympha*. (Mutualism)
4. Protozoans help indirectly in purification of water of water bodies by feeding on putrifying bacteria. Planktonic protozoans provide directly or indirectly the source of food supplies to man, fish and other animals. The microscopic skeletons of dead pelagic Foraminiferida, Radiolaria, Heliozoa sink to the bottom forming **oozes** on the ocean floors

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- * Invertebrate Zoology by E.L. Jordon & P.S.Verma, S. Chand & Co.
- * Text Book of Invertebrates by Marshall, Parker & Haswell
E.L.B.S. and Mac millan, England
- * Biological Science by Taylor D.J, N.P.O. Green & Stort G.W
Cambridge University Press.



UNIT-II

Learning outcomes

On completion of this unit will be able to

- Classify the representatives of phylum Porifera up to classes
- Assess the importance of skeleton in sponges
- Perceive the functioning of the canal system in sponges

PHYLUM : PORIFERA

Learning outcomes

On completion of this chapter will be able to

- Contrast the characters of phylum porifera from other phyla
- Understand Canal system of sponges
- Learn Skeleton in sponges and its importance

Introduction:

Sponges are sessile (sedentary) aquatic organisms. They comprise a highly successful and variable group, inhabiting both marine and freshwater habitats. R. E. Grant (1830) grouped sponges into phylum Porifera, (L. pore bearing animals). Due to unique Cellular organisation in these animals, Huxely (1875), Sollas (1894) thought of ungrouping them from Metazoa. Tuzet (1963) mentioned that though sponges bear most primitive characters they were considered as the diverse animals formed during the evolution of Metazoans and considered them as Parazoa. Sponges have endo skeleton made of spicules composed of either calcium carbonate or silica, which are present in many species. Spicules come in an array of forms, their type, shape, combination and arrangement help in the identification of a specimen.

Sponges are of great ecological, commercial and evolutionary importance. Sponges may act as bioeroders and environmental quality indicators. In the past, sponges were used as household items, for personal hygiene, for the relief of pain, for treating disease, and in art. More recently, interest in sponges is largely due to their production of novel bioactive compounds, which may have potential biomedical and anti-fouling applications. In addition, their skeletal structures have instigated further interest due to their unique optical and mechanical properties, which may enable future manufacturing of advanced materials.

General Characters

Sponges are the first multicellular organisms with cellular level body/level organization. Specific tissues or organs are absent.

1. All are aquatic, mostly marine, a few freshwaters (family Spongillidae),
2. Solitary or colonial, all lead a sessile mode of life.
3. Body shape may be vase-like, cylindrical, tubular, cushion-shaped, many-branched, etc.
4. Exhibit radial symmetry or asymmetrical.

Body wall with outer pinacoderm (dermal epithelium), inner choanoderm (gastral epithelium) and gelatinous non-cellular matrix (mesohyl) in between.

5. Mesohyl consists of **skeletal** components and free **amoeboid cells**.

యూనిట్ - 2 - వర్గం పోరిఫెరా

జంతురాజ్యంలో మొదటగా ఏర్పడిన బహుకణ జీవులు పోరిఫెరా వర్గపు జీవులు. వీటిలో కణాల సంఖ్య అధికంగా ఉంటుంది. కానీ కణజాల వ్యవస్థ ఏర్పడలేదు. ఈ కణాలే అన్ని జీవక్రియలను నిర్వహిస్తాయి. స్పంజికల దేహవ్యవస్థలో కణ విచ్ఛేదనం, కణాల మధ్య క్రియాత్మకమైన శ్రమ విభజన కనిపిస్తుంది. ఒక కణానికి, ఇంకొక కణానికి దాదాపుగా సంబంధం ఉండదు. వీటిలో అవయవాలు లేవు. ఇవి ఏకాంత సహనివేశ జీవులు, స్థానబద్ధ జీవులు, ద్విస్తరిత శరీరకుడ్యం ఉంటుంది. దేహం వెలుపల పినాకోడర్మ్, లోపల కోయనోడర్మ్, మధ్యస్థంగా కణరహిత జిగురు వంటి మిసోహైల్ కణజాలం ఉంటాయి.

దేహ ఉపరితలంలో అనేక చిన్న చిన్న ఆస్టియా కొన్ని పెద్ద నిశ్వాస ఆసుక్యులం అనేవి నీటిని లోపలికి, వెలుపలికి పంపించడంలో తోడ్పడతాయి.

స్పంజికల శరీర కుడ్యంలో అనేక కాలువలుంటాయి. ఈ కాలువలన్నీ దేహాంతర్భాగంలో గల పరిజరరకుహరం లేదా జరరాభ కుహరిక లోకి తెరుచుకొంటాయి. ఈ పెద్ద కుహరం ఆస్కులం ద్వారా వెలుపలికి తెరుచుకొంటుంది.

ఆస్థిపంజరం కాలేరియన్ లేదా సిలీషియన్ కంటకాలు లేదా స్పంజికా తంతువులు లేదా రెండింటిని కలిగి ఉంటుంది. కొన్నింటిలో ఆస్థిపంజరం ఉండదు. దీన్ని అమీబోసైట్ కణాలు స్రవిస్తాయి. అభివృద్ధిలో స్వేచ్ఛగా ఈదే ఆంఫిబ్లాస్టులా లేదా పేరంక్రైములా అనే శైలికామయ డింభకాలు ఏర్పడతాయి.

స్పంజికలలో స్కెలిటిన్ ఆధారంగా చేసుకొని ఈ వర్గాన్ని మొత్తం మూడు విభాగాలుగా విభజించారు. అవి : కాలేరియా, హెగ్జాక్టీనిల్లిడా, డెమోస్పాంజియా పోరిఫెరా వర్గంలో స్కెలిటిన్ స్పిక్యుల్ లేదా స్పాంజిన్ ఫైబర్తో ఏర్పడుతుంది.

స్పిక్యుల్స్ అనేవి మైక్రోస్కోపిక్ క్రిస్టలైన్ నిర్మాణాలు, ఇది స్పాంజీలకు వాటి దృఢత్వం మరియు రూపాన్ని ఇస్తుంది. స్పిక్యుల్స్ ను స్కిరోబ్లాస్ట్ కణాలు అని పిలువబడే ప్రత్యేక మెసెంక్రైమల్ అమీబోసైట్ల స్రవిస్తాయి.

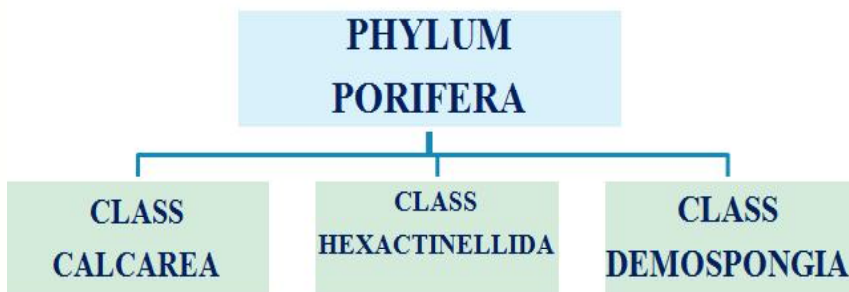
కెనాల్ సిస్టమ్ ప్రత్యేకంగా ఏర్పడినది. ఇది స్పాంజిలలో మాత్రమే కనిపిస్తుంది. దీని ద్వారా సముద్రనీరు శరీరం లోని గదులలో ప్రవహిస్తుంది. కెనాల్ సిస్టమ్ ఆహారం తీసుకోవడం, వ్యర్థపదార్థాలను బయటకు పంపడం, ప్రత్యుత్పత్తి కణాలను బయటకు పంపడంలో ఉపయోగపడుతుంది. కెనాల్ సిస్టమ్ లో ఉండు ప్రధాన భాగాలు ఆస్టియ, ఇన్ కరెంట్ కెనాల్, ప్రొసోపైల్, రేడియల్ కెనాల్, అపోపైల్, ఆసుక్యులం.

కెనాల్ సిస్టమ్ మూడు రకాలు అవి. 1. సైకాన్ రకం లేదా సైకనాయిడ్ రకం 2. ఆస్కాన్ రకం లేదా ఆస్కానాయిడ్ రకం, 3. ల్యూకాన్ రకం లేదా ల్యూకనాయిడ్ రకం

6. Body Cells loosely arranged and do not form definite layers, hence regarded not truly diploblastic.
7. Body with many incurrent pores (ostia) through which seawater enters into the body cavity.
8. Body cavity divided into canals and chambers (Canal system) that serve for the flow of seawater.
9. Through one or more excurrent pores (osculum) seawater exits from the body cavity (Canal system).
10. Choanocytes or flagellated collar cells usually line chambers of the canal system.
11. Skeleton is in the form of calcareous or siliceous spicules or in the form of protein - spongin fibres, or both, or absent.
12. Digestion intracellular.
13. Specific Respiratory and Excretory organs absent, canal system performs the function of respiration and excretion.
14. Primitive nervous system is present with poorly developed neurons.
15. All sponges are hermaphrodite, but exhibit cross fertilization.
16. Asexual reproduction by buds or gemmules. Sexual reproduction is by formation of ova and sperms.
17. Exhibits well-developed regeneration power.
18. Cleavage holoblastic.
19. Development includes a free-swimming ciliated larva amphiblastula or parenchymula.

Classification :

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



CLASS 1: CALCAREA

- These are small sized calcareous sponges (10cm in height).
- Solitary or colonial.
- Body cylindrical or vase like in shape.

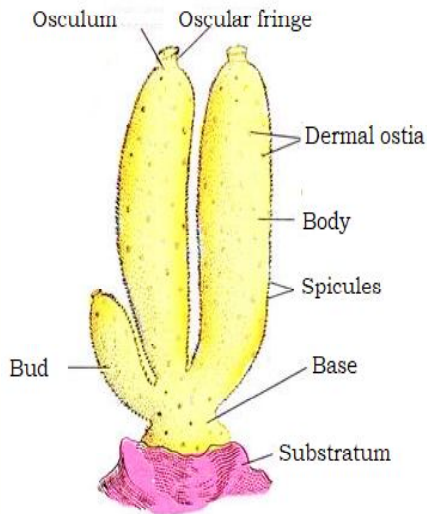


Fig. 2.1.1 Sycon Image Source: Wikimedia Commons

- Skeleton formed of calcareous spicules which may be one, three, or four rayed.
- All are marine animals.
- Body organisation may be Asconoid, Syconoid or leuconid type.
e.g. Leucosolenia, Scypha, Granita, Scycon

CLASS 2: HEXACTINELLIDA

- Generally found in medium size but some time few sponges reached one meter in length.
- They are commonly known as glass sponges.
Body shape cylindrical, funnel shaped or cup shaped.
- The canal system is very typical and body organization Syconoid type.
- These are found in deep marine water.

e.g. Euplectella (Venus flower basket), Hyalonema (Glass- rope sponge)



Fig. 2.1.2 Specimen of *Euplectella*, collected by HMS Challenger, preserved at Natural History Museum, London
(Image Source: wiki media commons)



Fig. 2.1.3 Specimen of *Euplectella*
Source: Wiki Media commons

CLASS-3: DEMOSPONGIAE

- Solitary or colonial.
- Body is cup or vase shaped.
- Demospongiae showed both small and large size.
- Spicules are seen monaxon or tetraxon.
- The canal system is leuconoid type.
- All are marine poriferans except freshwater sponges of family Spongillidae.

e.g. Chalina, Microciona, Haliscara



Fig. 2.1.3 Chalina (Image source Wiki Media Commons)

2.2. Skeletal system in sponges

Sponges possess endoskeleton that gives their bodies shape and structure. All the sponges have a skeleton embedded in the mesenchyme. Skeleton consists of separate spicules or interlacing spongin fibers or both. Skeleton supports and protects the soft body parts of the sponges. Skeleton also serves as the basis of classification of the sponges into various classes like Calcarea, Hexactanellida and Desmospongia.

Spongin

Spongin is an organic, horny, elastic substance which resembles silk in chemical composition. It is a scleroprotein containing sulphur and chemically related to collagen.

In the class Desmospongia, spongin fibers occur in various forms. It may occur as a cement connecting together siliceous spicules. It may be found in the form of branching fiber in which siliceous spicules are embedded. In Keratosa, spicules are completely absent and spongin alone is formed.

Development of spongin

Spongin fibers are secreted by flask-shaped mesenchyme cells called as spongioblast cells. During the development the spongioblast cells are arranged in rows and the spongin rods secreted by them are fused with the neighbouring cells to form a long fiber. Later the spongioblasts vacuolated and finally get degenerated after secreting certain amount of spongin.

Spicules

Structure and types

Spicules are microscopic crystalline structures which gives the sponges their rigidity and form. Spicule consists of spines or rays that radiate from a point. These are secreted by special mesenchymal amoebocytes called scleroblast cells.

The following are various types of spicules:

On basis of type of deposit on core organic matter: All kinds of spicules have a core of organic material around which either calcium carbonate or colloidal silica is deposited. Accordingly, spicules are of two types:

Calcareous spicules: The organic material in this type of spicules is calcium carbonate or calcite. This is the characteristic of the sponges of class Calcarea.

Siliceous spicules: The organic material in this type of spicules is Colloidal silica or Silicon. These types of spicules are the characteristic of the sponges of class Hexactanellida.

On the basis of size and function: Spicules can be of large size or small size. Accordingly, spicules can be of two types:

Megascleres: These are larger spicules constituting main skeleton of sponge body.
Microscleres: These are the small spicules occurring interstitially.

On the basis of number of axes and rays: Spicules may occur in several forms like the simple rod form or in the form of forks, anchors, shovels, stars, plumes etc. The spicule forms depend on the presence of number of axes and rays. Accordingly, they can be divided into the following forms:

Monaxon: These kinds of spicules are formed by the growth along one axis. They may be straight needle-like or rod like or may be curved. Their ends may be pointed or hooked or knobbed. Monaxons can be both calcareous and siliceous types

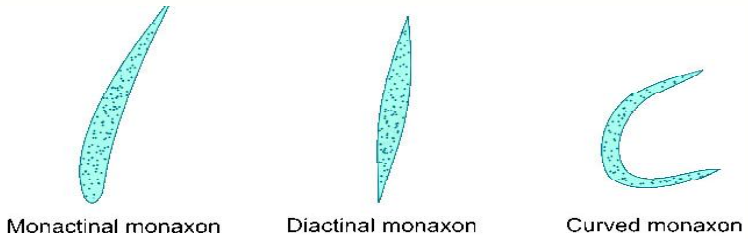


Fig.2.2.1 Monaxon spicules

Triaxon: These spicules have three axes that cross one another at right angles to produce six rays. Thus, it is also called hexactinal spicule. These triaxon spicules are characteristic of glass sponges of the class Hexactanellida

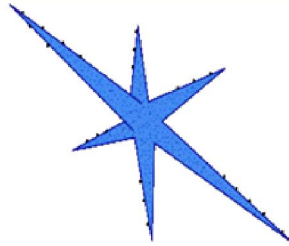


Fig. 2.2.3 Triaxon spicule

Polyaxon: These are the spicules with several equal rays radiating from a central point. They may be grouped to give star-like appearance. Polyaxon spicules are found along with microscleres.

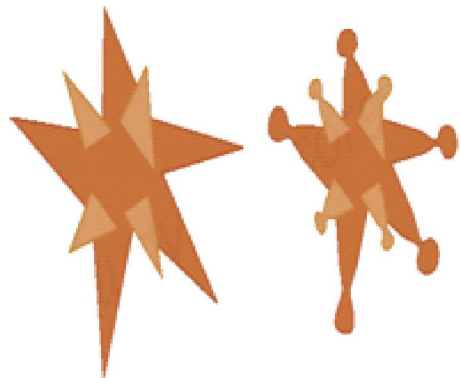


Fig. 2.2.4 Polyaxon spicules

Development of spicules

The calcareous spicules are secreted by special type of cells called as sclerocytes. These sclerocytes are derived from binucleated mesenchymal scleroblasts. A monaxon spicule or each ray of the triradiate spicule is secreted by a group of two sclerocytes.

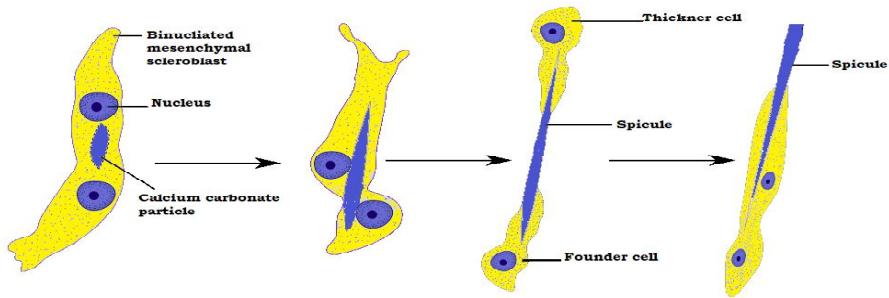


Fig. 2.2.5. Secretion of Monaxon Spicule

Among these two sclerocytes one acts as **thickener cell** and the other acts as the **founder cell**.

The initiation of the formation of the spicule starts with the deposition of a particle of calcium carbonate between the two nuclei of the binucleated mesenchymal cells. This particle grows drawing apart the two nuclei and then two sclerocytes are formed. Now the thickener cell lays down additional layer of calcium carbonate adding to the thickness of the spicule. When the spicule is fully formed, both the cells i.e., thickener cell and the founder cell wander into the mesenchyme. The scleroblast secreting a calcareous spicule is called as **calcoblast**, while the scleroblast secreting a siliceous spicule is called **silicoblast**.

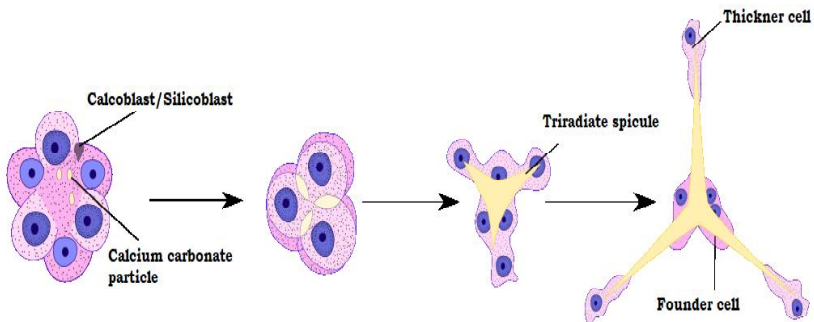


Fig.2.2.6. Secretion of Triaxon Spicule

2.3. Canal system in sponges

Introduction

Water circulatory system of sponges also called as canal system is the characteristic feature of the phylum Porifera. Canal system is also known as auriferous system. The canal system of sponges helps in food acquisition, respiratory gas exchange and also in excretion.

Numerous perforations on the body surface of the sponges are for ingression and egression of water current are the main constituents of the canal system. Inside the body, the water current flows through a certain system of spaces where by the food is captured from the incoming water and the excretory material is sent out into the outgoing water.

Various components of canal system are as follows:

1. **Ostia or dermal pores:** The external grooves of body surface is covered by a thin pore membrane. It bears two or more openings, the ostia or the dermal pores. These pores are surrounded by contractile myocytes. These can reduce the diameter of dermal pores and thus regulate the amount of incoming water. These open into the incurrent canals.
2. **Incurrent canals:** These are narrow space placed radially between adjacent radial canals and resemble them in shape and size. These are lined with pinacocytes. These open to the outside through ostia but are blind at their inner ends.
3. **Prosopyles:** Incurrent canals communicate with radial canals through prosopyles. Each prosopyle is a perforation in a single tubular cell, the porocyte.
4. **Radial or flagellated canals:** These chambers are lined by flagellated choanocytes and are called flagellated chambers or radial canals. The radial canals and the incurrent canals lie parallel and alternate to each other being separated by the mesenchyme. They are arranged in such a way that in vertical section of the body wall, each radial canal appears to be surrounded by four incurrent canals and likewise each incurrent canal is surrounded by four canals. Radial canals end blindly at their outer ends but open into spongocoel at their inner ends.
5. **Apopyles:** The openings of radial canals into spongocoel are called apopyles or gastric ostia. These are surrounded by contractile myocytes which regulate the diameter of the apopyles.

6. **Spongocoel:** It is the large central cavity into which the radial canals open through their apopyles. It is the central space all along the length of the body.
7. **Osculum:** The spongocoel opens to the outside through a terminal opening, the osculum. The osculum is surrounded by special contractile myocytes. These form a sphincter which regulates the rate of flow of water from the body. Water current plays the most vital role in the physiology of the sponges. The water current is caused by beating of flagella of the collar cells.

All exchanges between sponge body and external medium are maintained by means of this current. Food and oxygen are brought into body through this water current. Also, the excreta are taken out of the body with the help of this water current. The reproductive cells are carried out and into the body of the sponges by the water current.

Types of canal systems

Different sponges have different arrangement and grades of complexity of internal channels and accordingly the canal system is been divided into the following three types:

Ascon type of Canal system

This canal system is the simple of all the three. It is found in asconoid type of sponges like *Leucosolenia* and also in some of the developmental stages of all the syconoid sponges.

The body surface of the asconoid type of sponges is pierced by a large number of minute openings called as incurrent pores or ostia. These pores are intracellular spaces within the tube-like cells called porocytes. These pores extend radially into mesenchyme and open directly into the spongocoel.

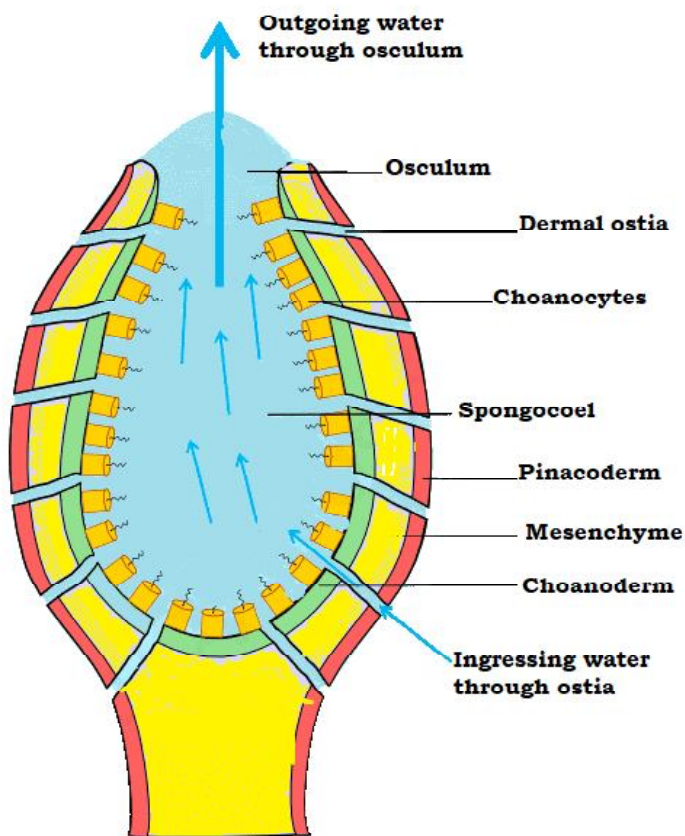


Fig.2.3.1 Ascon type of Canal system

The spongocoel is the single largest spacious cavity in the body of the sponge. The spongocoel is lined by the flattened collar cells or choanocytes. Spongocoel opens outside through a narrow circular opening called as osculum located at the distal end and it is fringed with large monaxon spicules.

The surrounding sea water enters the canal system through the ostia. The flow of the water is maintained by the beating of the flagella of the collar cells. The rate of water flow is slow as the large spongocoel contains much water which cannot be pumped out through a single osculum.

Course of water current in Asconoid type canal system

Seawater water → Ostia → Spongocoel → Osculum → outside

Sycon type of canal system

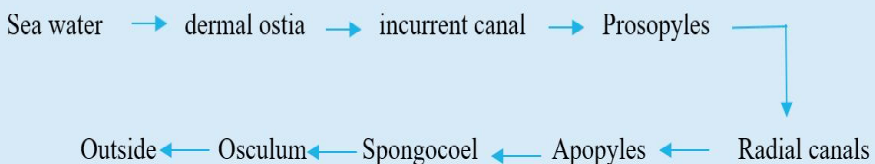
Sycon type of canal system is more complex compared to the ascon type. This type of canal system is the characteristic of syconoid sponges like *Scypha*. Theoretically this canal system can be derived from asconoid type by horizontal folding of its walls. Also, embryonic development of *Scypha* clearly shows the asconoid pattern being converted into syconoid pattern.

Body walls of syconoid sponges include two types of canals, the radial canals and the incurrent canals paralleling and alternating with each other. Both these canals blindly end into the body wall but are interconnected by minute pores. Incurrent pores also known as dermal ostia are found on the outer surface of the body. These incurrent pores open into incurrent canals.

The incurrent canals are non-flagellated as they are lined by pinacocytes and not choanocytes. The incurrent canals lead into adjacent radial canals through the minute openings called prosopyles. On the other hand, radial canals are flagellated as they are lined by choanocytes. These canals open into the central spongocoel by internal ostia or apopyles.

In sycon type of canal system, spongocoel is a narrow, non-flagellated cavity lined by pinacocytes. It opens to the exterior through an excurrent opening called osculum which is similar to that of the ascon type of canal system.

Course of water current in Syconoid type canal system



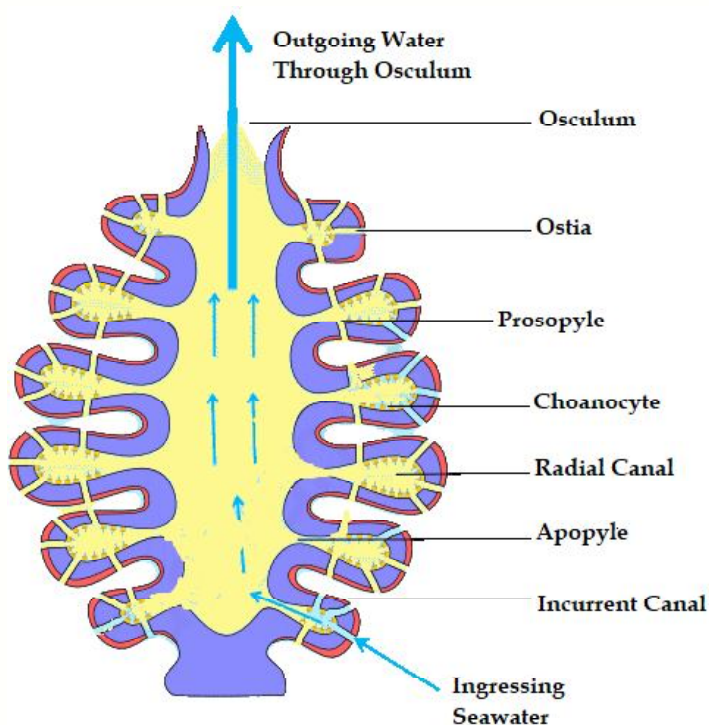


Fig. 2.3.2 Sycon type of canal system

Sycon canal system takes a more complex form in few species like *Grantia*, where the incurrent canals are irregular and branching forming large sub-dermal spaces. This is due to the development of cortex, involving pinacoderm and mesenchyme spreading over the entire outer surface of sponge.

Leucon type of canal system

This type of canal system results due to further folding of body wall of the sycon type of canal system. This canal system is the characteristic of the leuconoid type of sponges like *Spongilla*. In this type the radial symmetry is lost due to the complexity of the canal system and this result in an irregular symmetry.

The flagellated chambers are small compared to that of the asconoid and syconoid type. These chambers are lined by choanocytes and are spherical in shape. All other spaces are lined by pinacocytes. The incurrent canals open into flagellated chambers through prosopyles. These flagellated chambers in turn communicate with the excurrent canals through apopyles. The excurrent canals develop as a result of shrinkage and division of spongocoel.

The large and spacious spongocoel which is present in the asconoid and syconoid type of canal systems is absent. The spongocoel is much reduced. This excurrent canal finally communicates with the outside through the osculum.

Course of water current in Leuconoid type canal system

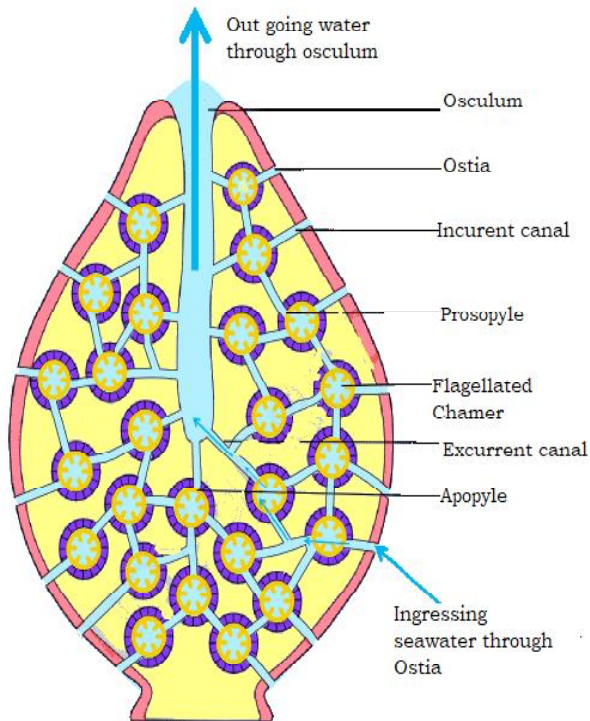
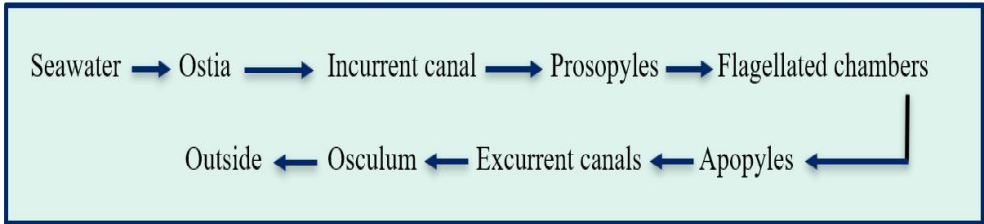


Fig. 2.3.3 Leucon type of canal system

Leucon type of canal system has the following three successive grades in its evolutionary pattern:

Eurypylous type: This is the simplest and the most primitive type of leuconoid canal system. In this type the flagellated chambers directly communicate with the excurrent canal through broad apertures called the apopyles.

Ex: Plakina

Aphodal type: In this type of canal system the apopyles are drawn out as a narrow canal called aphodas. This connects the flagellated chambers with the excurrent canals.

Ex: Geodia

Diplodal type: in some of the sponges, along with aphodas another narrow tube called prosodus is present between incurrent canal and flagellated chamber. This arrangement gives rise to diplodal type of canal system.

Ex: Spongilla

Sponges are the highly peculiar and diversified animals of the animal kingdom. Since their origin they were surviving with very minute modifications in the body structure. Their body structure with the endoskeleton frame of spicules is drawing the attention of structural engineering models. Poros nature of sponge body is another area of research poroelasticity peculiar biological phenomenon.

GLOSSARY

Acellular	Without cellular organisation.
Amphiblastula	Blastula-like sponge larva.
Asconoid	Type of sponge structure in which canals pass directly from the ostia to the Spongocoel, which is lined with collar cells.
Apopyle	Pore leading from the chamber into the central cavity in sponge.
Choanocyte	Flagellated collar cells found in sponges. Cleavage-Series of early division of an egg into cell.

Endoskeleton	A supporting framework on the inside of an animal, whether it be cartilaginous, bony.
Exoskeleton	A supporting structure on the outside of an animal body. The skeleton of an invertebrate is usually an exoskeleton.
Leuconoid	Type of Canal system in sponges
Osculum	Relatively large external opening of the central cavity through which water leaves a sponge.
Ostium	An opening to a passage or to a canal system in sponges.
Porocyte	Water intake cell of certain sponges, characterised by canal passing through it.
Syconoid	Type of canal system in sponges

SELF ASSESSMENT

- First formed multicellular animals of the animal kingdom are
 - 1) Protozoa
 - 2) Porifera
 - 3) Annelida
 - 4) Mollusca
- Outer layer of the porifera body
 1. Endoderm
 2. Protoderm
 3. Pinacoderm
 4. Choanoderm
- Inner layer of the porifera body
 1. Endoderm
 2. Protoderm
 3. Pinacoderm
 4. Choanoderm
- Special system seen only in the phylum porifera
 1. Reproductive system
 2. Respiratory system
 2. Canal System
 4. Endocrine system
- Skeleton system in sponges is mainly supported by
 1. Spines
 2. Spicules
 3. Spongin fiber
 4. Both 2 & 3
- Ostia of canal system helps in
 1. Ingress of seawater in to the canal system
 2. Expulsion of seawater from the canal system
 3. Exchange of respiratory gases
 4. All the above

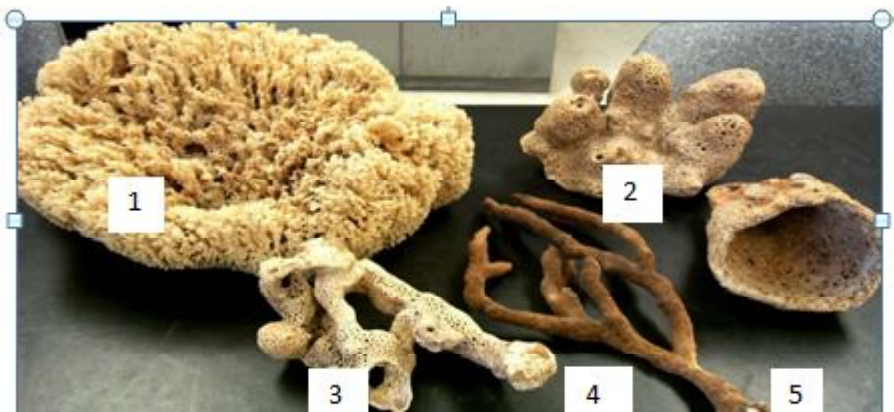
7. Calcareous spicules are characteristic of the class.....
8. Siliceous Spicules are characteristic of the class.....
9. Incurrent canal and radial canal are connected by
10. Secrete Spicules
11. Porocyte is
12. Apopyle is.....

Key

1-2, 2-3, 3-4, 4-2, 5-4, 6-1, 7- Calcarea, 8 - Hexactinellida 9 -Prosopyles, 10 - Sclerocytes, 11- Water intake cell 12- Pore leading to the central cavity.

INTERACTIVE LINKS

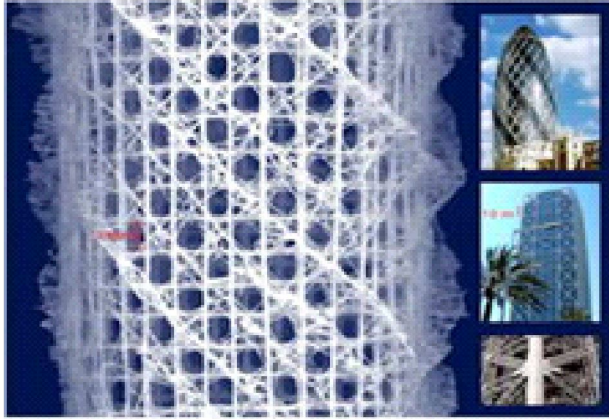
1. <https://www.notesonzoology.com/protozoa/phylum-porifera-classification-and-features-protozoa/1429>
2. <https://animaldiversity.org/site/accounts/information/Porifera.html>
3. <https://www.youtube.com/watch?v=IWITK0-jWOQ>



Sponges' museum specimens (Source: P R Government College (Autonomous), Kakinada- Zoology Museum)

Legend: 1. Grantia 2. Scycon 3. Leucosolenia 4. Chalina 5. Poterion

FOR IGNITED MINDS



1. Arrangement of Spicules in the sponge body is considered for the structural designing. <https://science.sciencemag.org/>
2. [https://manoa.hawaii.edu/exploringourfluidearth/biological/invertebrates/ phylum-porifera/](https://manoa.hawaii.edu/exploringourfluidearth/biological/invertebrates/phylum-porifera/) for research and additional information on the evolutionary significance and areas of current research on porifera visit the site.

2.4. Phylum Cnidaria General Characters and classification

Learning Outcomes

- To Identify the structural organization of Phylum Cnidaria
- To understand the taxonomic position of Cnidaria
- To understand the evolution of digestion process in animal kingdom.
- To Describe the progressive development of tissues.
- To Identify two general body forms found in the Cnidaria.
- To Understand the identifying features of the Cnidarian classes.

Introduction :

Cnidarians are aquatic, mostly marine (except Hydra is a Freshwater Cnidarian), Solitary or Colonial, **Radially Symmetrical** (Sea anemones exhibits bi-radially symmetry) **Diploblastic** animals. Previously cnidaria and Ctenophora phyla are included in the phylum coelenterata, due the presence of **coelenteron**. At present these two groups are separated into two individual phyla according to the presence or absence of **cnidoblasts or cnidocytes**. Cnidarians are a group of individuals, possessing cnidoblasts for anchorage, defense and capture of prey. Cnidarians are the first metazoans to reach tissue level organization and attains primitive type nerve net like nervous system.

Phylum cnidaria includes diverse animals like hydra, jellyfish, sea anemones and corals. Lions mane jellyfish (*Cyanea capillata*) or Arctic red jellyfish is the largest non-colonial cnidarian. whereas *Psammohydrananna* (Hydra) is the smallest cnidarian. Phylum cnidaria now contains nearly 11000 species. The name cnidaria comes from the greek word “Cnidos” means stinging as all these individuals contain Cnidoblasts or stinging Cells.

The unique nature of cnidarians has they have two basic body forms i.e., sessile cylindrical polyp (Ex Hydra, Sea Anemone) and Free swimming

umbrella-shaped, medusa (Ex : Aurelia) many Cnidarians forming colonies that are single individuals composed of both medusa and polyp forms (Ex.Obelia)

General Characters :

1. These are mostly marine. A few like Hydra live in freshwater.
2. Many are colonial (e.g.*Hydractinia*, *Pennaria*,*Campanularia*) and some are Solitary.
3. Few are sessile or sedentary (e.g.*Obelia*, *Sea Anemone*) and Some others are free Swimming (e.g. *Aurelia*).
4. Cnidarians are the first organisms to exhibit tissue level of organization.
5. Most of the Cnidarians are Radially Symmetrical, Sea anemones show biradial symmetry.
6. Cnidarians exhibit two basic body forms i.e., polyp and medusa

Polyp : It is cylindrical, sessile (Rarely free), solitary or colonial.

Manubrium and tentacles are face upward.

Tentacles usually 24.

Reproduces asexually by budding.

Medusa : It is umbrella or bell-shaped free swimming and solitary.

Manubrium and tentacles are downward. 16 tentacles in young medusa numerous in adult. Reproduces sexually by gametes.

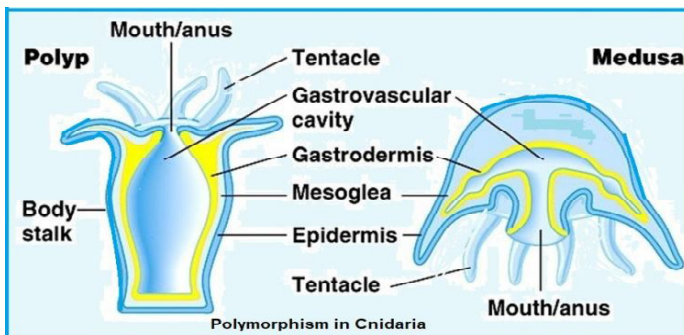


Fig.2.4.1 Morphological differences between Polyp and Medusa

వర్గం : నిడేరియా

2.4. సామాన్య లక్షణాలు - వర్గీకరణ

సరిచయం : నిడేరియా వర్గానికి చెందిన జీవులు జలచరజీవులు. అత్యధికంగా సముద్ర ఆవాసాలలో నివశించును (హైడ్రా మంచినీటి నిడేరియా జీవి). ఇవి ఏకాంత లేదా సహనివేశ, వలయసౌష్ఠవం కలిగిన (సీఆనిమోన్లు మాత్రం ద్వివలయ సౌష్ఠవం ను ప్రదర్శించును) ద్విస్తరిత శరీరకుడ్య జీవులు. ఇంతకు ముందు నిడేరియా, టీనోఫారా వర్గాలను వాటిలో ఉండే జరరప్రసరణ కుహరం ఆధారంగా సీలెంటిరేటా వర్గంలో చేర్చారు. కాని ప్రస్తుతం ఈ జీవులలో దంశకణాలు ఉండడం లేదా లేకపోవడం ఆధారంగా సీలెంటిరేటాను రెండు వర్గాలుగా వేరు చేశారు. నిడోబ్లాస్ట్లను కలిగిన జీవులను నిడేరియాలో చేర్చారు. ఈ నిడోబ్లాస్ట్లు అతుక్కోవడానికి, ఆత్మరక్షణకు, భోజ్యజీవిని వట్టుకోవడానికి ఉపయోగపడతాయి. నిడేరియా జీవులు కణజాల స్థాయికి చేరిన మొట్ట మొదటి మెటాజోవన్లు మరియు ప్రాథమికమైన వల వంటి నాడీవ్యవస్థను మొదటిసారిగా ఏర్పరుచుకొన్న జీవులు.

నిడేరియన్లలో ప్రత్యేకంగా రెండు రకాల జీవకాలు కనిపిస్తాయి. అవి స్థానబద్ధ, స్థూపాకార పాలిప్ (ఉదా : హైడ్రా, సీఆనిమోన్) మరియు స్వేచ్ఛగా ఈడే ఛత్రాకార మెడూసా (ఉదా : అరేలియా). అనేక నిడేరియన్లు సహనివేశాలను ఏర్పరుచును. ఆ సహనివేశాలు ఒక జీవికి సంబంధించిన మెడూసా, పాలిప్ రూపాలుగా ఉంటాయి. (ఉదా : ఒబీలియా)

సాధారణ లక్షణాలు :

- ❖ 1. ఇవి అధికంగా సముద్ర జీవులు. హైడ్రా వంటి జీవులు మంచినీటిలో నివశించును.
- ❖ 2. అనేక జీవులు సహనివేశ జీవులు. (ఉదా : హైడ్రాక్వీనియా పెన్నేరియా, కంపాన్యులేరియా) కొన్ని ఏకాంతజీవులు (హైడ్రా).
- ❖ 3. నిడేరియన్లలో కొన్ని స్థానబద్ధజీవులు (ఒబీలియా, సీఆనిమోన్) మరియు కొన్ని స్వేచ్ఛ జీవులు (జెల్లీ చేప).
- ❖ 4. నిడేరియన్లు మొట్టమొదట కణజాల స్థాయికి చేరిన జీవులు.
- ❖ 5. అనేక జీవులు వలయసౌష్ఠవం కలిగి ఉండును. కాని సీఆనిమోన్లలో ద్వివలయసౌష్ఠవం ఉండును.

Even though polyp and medusa forms show differences, but they are strictly homologous or fundamentally similar structures.

Similarities between polyp and medusa :

Both are radially symmetrical.

Both are diploblastic derived from germ layers, ectoderm and endoderm.

Mouth is homologous in both.

Anus is absent in both.

Both are carnivorous.

Gastro vascular cavity lined by gastrodermis in both.

In colony forming Cnidarians, (e.g. *Physalia*, *Velella*, *Porpita*) these Polyp and Medusa are slightly modified into some other forms to perform different functions. This phenomenon is called **Polymorphism**.

7. Some Cnidarians (e.g. *Alcyonium*, *Tubipora*, *Fungia*, *Madrepora*) have an exoskeleton composed of calcium Carbonate. These calcareous horny exoskeletons are called **coral**. Most of the Anthozoa organisms form corals. **Exo skeleton** is almost absent in Hydrozoa, Scyphozoa classes (*Millepora*, *Stylaster* are the hydrozoan organisms exceptionally forms corals)

8. Body wall of all cnidarians composed of an outer **epidermis** and inner **gastroderms**. In between these two layers a gelatinous **mesoglea** is present. Mesoglea is acellular (Hydrozoa class) or cellular (Scyphozoa, Anthozoa classes)

9. The body wall contains **stinging cells or cnidoblast or cnidocytes** (hence the name Cnidaria) is the unique characteristic feature of Cnidarians. Each Cnidocyte contains a fluid filled membranous capsule called **nematocyst**. Cnidocytes helps in defence, adhesion and capturing the prey.

Structure of Cnidoblast :

A cnidoblast is an oval or rounded cell. Single prominent nucleus present on the basal region. The interior of cnidoblast contains one giant secretory organelle called **cnidocyst or nematocyst** that can deliver sting to other animals. Some Nematocysts are filled

- ❖ 6. నిడేరియన్లు రెండు రకాల జీవకాలను కలిగి ఉంటాయి అవి పాలిప్, మెడూసా.

నిమటోసిస్ట్ - రకాలు: నిడేరియన్లలో దాదాపు 30 రకాల నిమటోసిస్ట్లు కనిపిస్తాయి.

వీటిలో కొన్ని ముఖ్యమైన నిమటోసిస్ట్లు పెనిట్రెంట్స్, వాల్యెంట్స్, స్టీరియోలైన్ గ్లటినెంట్స్ (ఎట్రైకస్ ఐసోరైజా) స్ట్రెప్టోలిన్ గ్లటినెంట్స్ (హోలోట్రైకస్ ఐసోరైజా) హైడ్రాలో కనిపించును. ఒబీలియాలో పెనిట్రెంట్స్ మాత్రమే ఉంటాయి. అరీలియాలో స్టీరియోలైన్ గ్లటినెంట్స్, స్ట్రెప్టోలైన్ గ్లటినెంట్స్ మరియు హెటిరో ట్రైకస్ నిడోబ్లాస్టిక్ యూరిటెల్స్ ఉండును.

- ❖ అభివృద్ధి అప్రత్యక్షంగా ఉండి స్వేచ్ఛగా ఈదే శైలికామయ ప్లానులా లార్వాను కలిగి ఉండును.
- ❖ ఒబీలియా జీవిత చరిత్రలో పాలిప్, మెడూసా రూపాలు రెండూ ఉండి తరాల ఏకాంతరత లేదా మెటాజెనిసిస్ను ప్రదర్శించును. పాలిప్ రూపం అలైంగిక పద్ధతిలో మెడూసాలను ఏర్పరిస్తే, మెడూసా రూపం లైంగిక ప్రత్యుత్పత్తి ద్వారా పాలిప్లను ఏర్పరుచును.
- ❖ పూర్ణభంజిత, సమాన విదళను జరుగును.

వర్గము నిడేరియా - వర్గీకరణ

నిడేరియా వర్గాన్ని మూడు విభాగాలుగా విభజించారు. అవి

1. హైడ్రోజోవా
2. హైఫోజోవా
3. ఆంథోజోవా

2.5. ఒబీలియా జీవక్మలేటా

ఒబీలియా స్థానబద్ధ, సముద్ర, హైడ్రాయిడ్ సహనివేశం. ఇది అట్లాంటిక్, పసిఫిక్ తీరాల్లో అధికంగా ఉండును. ఈ జీవి అలైంగిక, లైంగిక రూపాలలో కనిపిస్తుంది. అలైంగిక రూపంను శాఖాయుత హైడ్రాయిడ్ కోలని అంటారు. ఇది రాళ్ళకు, కర్పరాలకు, కర్ర దుంగలకు అతికి ఉండును. ఒబీలియా చాలా సున్నితంగా, తెల్లగా లేదా లేత గోధుమ వర్ణంతో ఒక ఫర్ వలె పెరుగును. దీని లైంగిక రూపం అస్పష్టమైన గంటాకృతి లేదా గొడుగు ఆకృతిలో స్వేచ్ఛగా ఈదుతూ మెడూసాగా పిలవబడుతుంది.

with a toxic fluid **hypnotoxin**, which is chemically a mixture of proteins and phenols. The narrowed outer end of nematocyst contains long, hollow filament called thread tube.

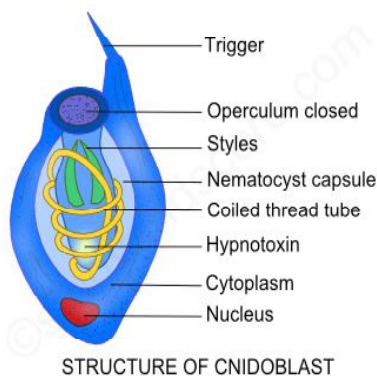


Fig. 2.4.2 Structure of Cnidoblast

The base of the thread tube is swollen to form butt. **Butt** contains three large spines called barbs or stylets and three spiral rows of minute spines called barbules or spines. The butt is covered externally by little lid like structure the operculum. The outer end of the cnidoblast projects a tiny, pointed hair like process called **cnidocil**(The trigger of Cnidoblast).

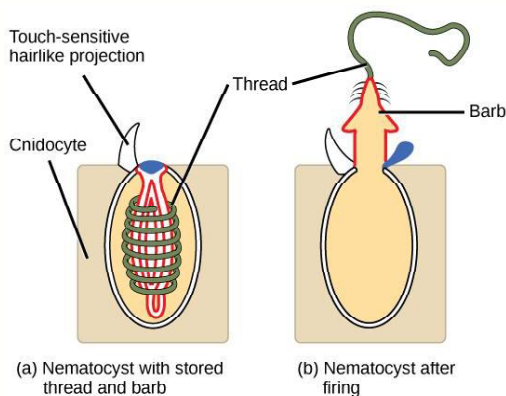


Fig. 2.4.3 Difference between closing and opening of nematocyst

Cnidoblasts are occurred in all cnidarians. They are especially abundant in the oral region and on tentacles. Cnidoblasts located on epidermis (e.g. Hydrozoa) or on both epidermis and gastrodermis (Ex : Scyphozoa, Anthozoa).

Types of Nematocysts: About 30 different kinds of nematocysts are found among the different Cnidarians. Penetrant, Volvent, Stereolineglutinant (Atrichous Isorhizas) Streptolineglutinant (Holotrichous Isorhizas) – Found in Hydra. Penetrants occur in

హైడ్రాయిడ్ సహనివేశంలో అనుఘటకాలు

హైడ్రాయిడ్ సహనివేశంలో హైడ్రోజెజా, హైడ్రోకాలస్ మరియు జీవకాలు సాధారణంగా లోపలి సీనోసార్క్, వెలుపలి పెరిసార్క్ స్తరాలను కలిగి ఉండును.

ఒబీలియాలో మెటాజెనిసిస్ :

ఏకాంతర తరాలు అంటే ఒక జీవి జీవితచరిత్రలో ద్వయస్థితిక అలైంగిక రూపం, ఏకస్థితిక లైంగిక రూపం క్రమంగా ఒకదాని తరువాత ఒకటి సంభవిస్తాయి. ఈ రకమైన ఏకాంతర తరాలు సామాన్యంగా మాస్ మొక్కలు, ఫెర్న్ మొక్కల జీవిత చరిత్రలో అలైంగిక ద్వయస్థితిక రూపం (స్పోరోఫైట్), లైంగిక ఏకస్థితిక రూపం (గామిటోఫైట్) ఒకదాని తరువాత ఒకటి ఏకాంతరంగా ఏర్పడును.

ఒబీలియా జీవితచక్రంలో ద్వయస్థితిక హైడ్రాయిడ్ సహనివేశం పార్వకోరకీభవనం ద్వారా అలైంగిక ప్రత్యుత్పత్తి జరుపుకొని మెడూసాలను ఉత్పత్తి చేయును. ఈ ద్వయస్థితిక మెడూసాలు లైంగిక ప్రత్యుత్పత్తి జరుపుకొని హైడ్రాయిడ్ సహనివేశాన్ని ఉత్పత్తి చేయును. దీనిని బట్టి స్పష్టంగా జీవిత చరిత్రలో తరాల ఏకాంతకత అనే ఆలోచన కలుగుతుంది. అయితే ఒబీలియా జీవిత చరిత్రలో అలైంగిక, లైంగిక రూపాలు రెండూ ద్వయస్థితి స్థితిలో ఉంటాయి కనుక తరాల ఏకాంతరత అనేది ఒబీలియాకు వర్తించదు. ఇది స్థిరమైన అలైంగిక హైడ్రాయిడ్ సమూహం మరియు స్వేచ్ఛగా ఈదే లైంగిక మెడూసాయిడ్ రూపాల మధ్య క్రమం తప్పకుండా రెండు ద్వయస్థితిక రూపాల మధ్య జరిగే ఏకాంతరత. దీనినే కొంతమంది మెటాజెనిసిస్ గా పిలుస్తారు.

నిడేరియన్లలో పాలిమార్ఫిజం

ఒకే జాతికి చెందిన జీవిలో ఒకటి కంటే ఎక్కువ రూపాలు ఉండి అవి రూపం, పనితీరులో విభిన్నంగా ఉండటాన్ని పాలిమార్ఫిజం అంటారు. ఈ జీవకాలు మధ్య సమర్థవంతమైన శ్రమ విభజన ఉండును. నిడేరియన్లలో విభిన్నమైన రూపాలు కలిసి ఒక సమూహాన్ని ఏర్పరుచును. ఒక బహురూపక సహనివేశంలో అనేక రూపాలు ఉంటాయి. ఈ రూపాలను జువాయిడ్స్ అంటారు. సాధారణంగా జువాయిడ్స్ రెండు ప్రాథమిక రూపాలయిన పాలిప్ మరియు మెడూసా నుండి ఏర్పడును.

Obelia. Stereolineglutinants, strepolineglutines and micro-basic euryteles are found in Aurelia.

Penetrants (Stenotele):

- Largest and most complex nematocyst.
- Thread tube contains stylets and spines.
- Thread tube is open at the far end.
- Hypnotoxin is present that paralyzes the prey.

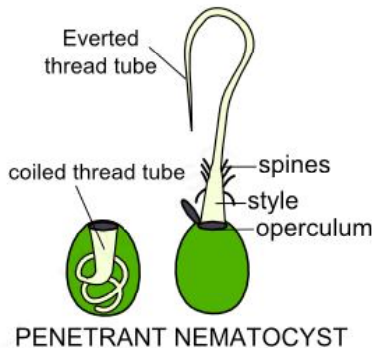


Fig. 2.4.4 Penetrant Nematocyst

Volvent (Desmoneme)

- Smaller than penetrant.
- Butt, stylets and spines are absent.
- Thread tube closed at far end.
- Coils the prey. Hypnotoxin is absent.

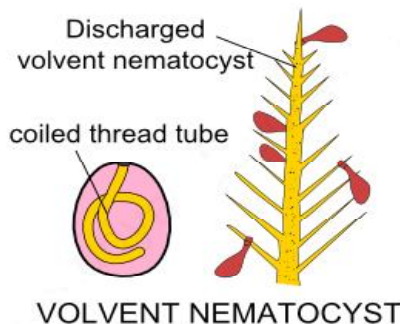


Fig. 2.4.5 Structure of Volvent

బహురూపకత యొక్క ప్రాముఖ్యత

బహురూపకత అనేది ఒక శ్రమ విభజన దృగ్విషయం. వివిధ జీవక్రియలను నిర్వహించడానికి వివిధ అవయవాలకు బదులు భిన్నమైన జువాయిడ్స్ ఉంటాయి. పాలిప్ రూపాలు, ఆహార సేకరణ, రక్షణ మరియు అలైంగిక ప్రత్యుత్పత్తిలో తోడ్పడితే, మెడూసా రూపాలు లైంగిక ప్రత్యుత్పత్తిలో తోడ్పడును.

పాలిప్ రూపాలు : 1. గాస్ట్రోజువాయిడ్ 2. డాక్టైలోజువాయిడ్స్ 3. గోనోజువాయిడ్స్

మెడూసారూపాలు : 1. న్యుమటోఫోర్స్ 2. బ్రాక్ట్ 3. నెక్టోఫోర్ లేదా నెక్టోకేలిక్స్ లేదా ఈదే గంటలు, 4. గోనోఫోర్

బహురూపకత యొక్క ప్రాముఖ్యత :

పాలిమార్ఫిజం అనే దృగ్విషయం శ్రమ విభజన కొరకు అవశ్యకం. దీనిలో వివిధ జువాయిడ్స్ నిర్దిష్ట విధులు నిర్వహించును. పాలిప్లు మార్పు చెంది ఆహారసేకరణ, రక్షణ మరియు అలైంగిక ప్రత్యుత్పత్తి కొరకు ఏర్పడితే మెడూసాలు మార్పు చెంది లైంగిక ప్రత్యుత్పత్తిలో తోడ్పడును.

కోరల్స్ మరియు కోరల్ రీఫ్స్ కోరల్స్ అనేవి సీలెంటిరేటా జీవులు ప్రవించిన కాల్షియం కార్బోనేట్ నిర్మాణాలు.

ప్రవాళ అస్థిపంజరం - నిర్మాణం :

ఒక ఏకాంత పాలిప్ ఏర్పరిచే కోరల్ ను కొరల్లెట్ అంటారు. సహనివేశపాలిప్లు ఏర్పరిచే కోరల్ ను కొరల్లమ్ అంటారు.

వివిధ సమూహాలలో ప్రవాళాలు - రకాలు

1. హైడ్రోజోవన్ కోరల్స్

2. ఆక్టోకోరల్స్ ప్రవాళాలు

3. హెక్టాకోరాలియన్ ప్రవాళాలు

కోరల్ రీఫ్స్ :

కోరల్ కోలనీలు పాలిప్ల బడ్డింగ్ ద్వారా నిరంతరం పెరిగి కోరల్ రీఫ్స్ ను ఏర్పరుస్తాయి. ఇవి సాధారణంగా CaCO_3 తో నిర్మితమై కోరల్ పాలిప్లతో ప్రవించబడతాయి.

Stereolineglutinant : (Atrichous isorhiza)

Small and oval nematocysts.

Butt, stylets and spines are absent.

Thread tube opened and secretes sticky substance to capture the prey.

Hypnotoxin is absent.

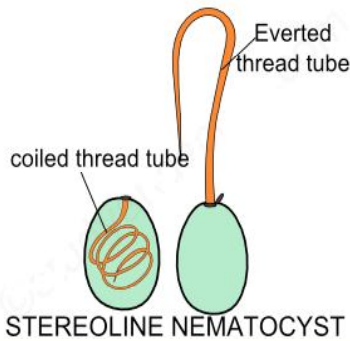


Fig. 2.4.6 Structure of Stereolineglutinant

Streptolineglutinents : (Holotrichous Isortiza)

Large oval nematocysts.

Butt is absent.

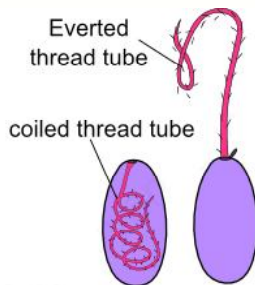


Fig. 2.4.7 Structure of Stereolineglutinant

Thread tube bears spiral rows of spines.

Micro-basic eurytele :-

Nematocyst is small.

Thread tube opens at the tip.

Butt bears unequal spines.

పాలిప్ రూపాలు : 1. గాస్ట్రోజువాయిడ్ 2. డాక్టైలోజువాయిడ్స్ 3. గోనోజువాయిడ్స్

మెడూసారూపాలు : 1. న్యుమటోఫోర్స్ 2. బ్రాక్ట్ 3. నెక్టోఫోర్ లేదా నెక్టోకెలిక్స్ లేదా ఈదే గంటలు, 4. గోనోఫోర్

❖ బహురూపకత యొక్క నమూనాలు

హైడ్రోజోవన్లలో సమూహంలోని జువాయిడ్స్ సంఖ్య అధారంగా బహురూపకత స్థాయి వివిధ రకాలుగా ఉంటుంది. కనుక నిడేరియన్లను ద్విరూపక, త్రిరూపక, బహురూపక జీవులుగా పిలుస్తారు.

1. ద్విరూపకం - రెండు జువాయిడ్స్ను కలిగి ఉండును
2. త్రిరూపకం - మూడు జువాయిడ్స్ను కలిగి ఉండును
3. బహురూపకం - అనేక జువాయిడ్స్ను కలిగి ఉండును.

బహురూపకత యొక్క ప్రాముఖ్యత :

పాలిమార్ఫిజం అనే దృగ్విషయం శ్రమ విభజన కొరకు అవశ్యకం. దీనిలో వివిధ జువాయిడ్స్ నిర్దిష్ట విధులు నిర్వర్తించును. పాలిప్లు మార్పు చెంది ఆహారసేకరణ, రక్షణ మరియు అలైంగిక ప్రత్యుత్పత్తి కొరకు ఏర్పడితే మెడూసాలు మార్పు చెంది లైంగిక ప్రత్యుత్పత్తిలో తోడ్పడును.

కోరల్స్ మరియు కోరల్ రిఫ్స్ కోరల్స్ అనేవి సీలెంటిరేటా జీవులు స్రవించిన కాల్షియం కార్బోనేట్ నిర్మాణాలు.

ప్రవాళ అస్థిపంజరం - నిర్మాణం :

ఒక ఏకాంత పాలిప్ ఏర్పరిచే కోరల్ను కొరల్లైట్ అంటారు. సహనివేశపాలిప్లు ఏర్పరిచే కోరల్ను కొరల్లమ్ అంటారు.

వివిధ సమూహాలలో ప్రవాళాలు - రకాలు

1. హైడ్రోజోవన్ కోరల్స్ :

2. ఆక్టోకోరల్లైన్ ప్రవాళాలు :

3. హెక్టాకోరాలియన్ ప్రవాళాలు :

కోరల్ రిఫ్స్ :

కోరల్ కోలనీలు పాలిప్ల బడ్డింగ్ ద్వారా నిరంతరం పెరిగి కోరల్ రిఫ్స్ను ఏర్పరుస్తాయి. ఇవి సాధారణంగా CaCO_3 తో నిర్మితమై కోరల్ పాలిప్లతో స్రవించబడతాయి.

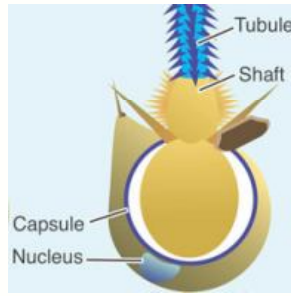


Fig. 2.4.8 Structure of Micro-basic eurytele

10. The cavity present in the cnidarians is called **Coelenteron or gastrovascular cavity**. It opens out through the mouth surrounded by tentacles. Mouth serves for ingestion as well as for egestion.
11. Digestion is both **extracellular and intracellular**. Extracellular digestion takes place in coelenteron whereas intracellular digestion takes place in the **nutritive muscle cells** of gastrodermis.
12. Respiration and excretion are simple through the process called **diffusion**.
13. Neurons are interconnected to form primitive **net like nervous system**. (Nervous system first appeared in Cnidaria)
14. In *Obelia* sense organs are **statocysts** for equilibrium. In Aurelia tentaculocyst or **rhopalium** are the sense organs for equilibrium, photoreception and chemoreception.
15. Asexual Reproduction takes place by **budding** (e.g. :*Hydra*, *Sea Anemone*), **Fragmentation** (e.g. *Sea Anemone*) and **strobilation** (Ex : Aurelia Scyphistoma larva).
16. Cnidarians are generally **unisexual or dioecious** (Ex : Aurelia, Sea Anemone) but some are bisexual or **hermaphrodite or monoecious** (Ex : Hydra)
17. Fertilization is mostly external but in Aurelia it is external (takes place in oral arms) or internal (takes place in stomach).
18. Development is indirect and includes a free-swimming ciliated larva called **planula**.
19. In obelia which exists in both polyp and medusa forms exhibit **alternation of generations (Metagenesis)** i.e., polypoid forms produce medusa asexually and medusa produce the polypoid forms sexually.
20. Cleavage is **holoblastic** and equal.

Classification of the phylum Cnidaria :-

Phylum Cnidaria is classified into three classes. Namely 1. Hydrozoa 2. Scyphozoa 3. Anthozoa.

కోరల్ రిఫ్ట్ - రకాలు : కోరల్ రిఫ్ట్ ఏర్పడే విధానాన్ని ఆధారంగా చేసుకొని వీటిని మూడు రకాలుగా వర్గీకరించారు. అవి :

1. ఫ్రింజింగ్ రిఫ్ట్లు

2. బారియర్ రిఫ్ట్లు

3. అటాల్స్

కోరల్ రిఫ్ట్ ఏర్పడే విధానం-సిద్ధాంతాలు :

1. సబ్జిడెన్స్ సిద్ధాంతం

2. గ్లెసియేషన్ కంట్రోల్ సిద్ధాంతం

వర్గం-టీనోఫారా

టీనోఫారా సముద్ర జీవులతో కూడిన ఒక చిన్న వర్గం. వీటిని సామాన్యంగా కూంబ్జెల్లిలు, సీగూస్ బెల్రీస్ లేదా సీవాల్ నట్స్ గా పిలుస్తారు. ఇవి స్వేచ్ఛగా ఉండే, పారదర్శక జెల్లి వంటి మృదువైన శరీరాన్ని కలిగి ఉండి బైరేడియల్ సిమ్మెటిని ప్రదర్శించే సముద్ర జీవులు. చలనం కొరకు ఎనిమిది దువ్వెన వంటి ఫ్లైటిన్ ఫలకాలు, భోజ్యజీవిని బంధించడానికి తోడ్పడే లాసోకణాలు లేదా కాలోబ్లాస్ట్లు కలిగి ఉండుట టీనోఫారా జీవుల ప్రత్యేకత.

ఇంతకు పూర్వం వర్గీకరణలో టీనోఫారా, నిడేరియా ఉపవర్గాలను కలిపి సీలెంటిరేటా అనే వర్గంలో చేర్చారు. అయితే ప్రస్తుతం టీనోఫారా జీవులను వాటి ప్రత్యేక లక్షణాల ఆధారంగా ఒక వర్గంగా పరిగణిస్తున్నారు. హాట్స్ చెక్ ఈ జీవులను టీనోఫారా అనే నిర్దిష్ట వర్గంలో చేర్చెను. టీనోఫారా వర్గంలో వంద కంటే తక్కువ జాతులు కలవు.

టీనోఫారా వర్గీకరణ : టీనోఫారా వర్గమును స్పర్శకాలు ఉండడం, లేకపోవడం బట్టి రెండు విభాగాలుగా వర్గీకరించారు. 1. టెంటాక్యులేటా 2. నూడా

వర్గం టీనోఫారా-సంబంధ భాందవ్యాలు :

వివిధ శాస్త్రవేత్తలు టీనోఫారా జీవుల ఆవిర్భావం మరియు సంబంధాలపై భిన్నమైన అభిప్రాయాలను కలిగి ఉన్నారు. వీటి సున్నితమైన శరీరం వలన ఎటువంటి శిలాజ సమాచారం లభ్యం కాలేదు. శిలాజాలు లోపించటం వలన టీనోఫారా జీవుల ఆవిర్భావం అనిశ్చితంగా ఉన్నది.

Class-1: Hydrozoa

These are mostly colonial. (Ex : *Physalia*, *Halistemma*, *Stephalia*) and some are Solitary (Ex : *Hydra*).

Many hydrozoans are marine but *Hydra* lives in freshwater.

Common forms in this class are Hydras and sea furs.

Both Polyp and medusa forms are present in the life cycle of hydrozoans.

Coelenteron is undivided.

Mesoglea is simple and acellular.

Cnidoblasts are located on epidermis only.

Exhibits a high level of **Polymorphism**.

Some hydrozoans forms **corals** (Ex: *Millepora*, *Stylaster*).

Gonads are derived from epidermis.

Indirect development which includes free swimming **planula larva** and sedentary **Hydrula larva**. (Ex : *Obelia*), **Actinula larva** (Tubularia)

Examples : *Hydra* (Freshwater Polyp), *Obelia* (Sea fur), *Physalia* (Portuguese man of war), *Hydractinia* (Hedgehog hydroid), *Millepora* (Fire coral or stinging coral), *Velella* (little sail), *Porpita* (Blue button), *Halistemma*, *Campanularia*, *Plumularia*, Tubularia

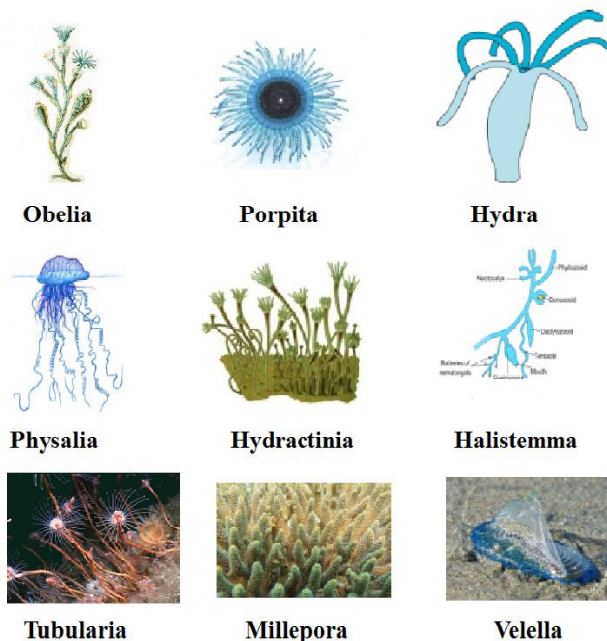


Fig. 2.4.9 Different Hydrozoan Cnidarians.

Class-2 :Scyphozoa

All of the scyphozoans are Solitary.

Exclusively marine organisms.

This class includes **jelly fishes** and **moon jellies**.

Predominantly in the medusoid stage. Polyp stage is reduced and restricted to larval stage only (**Scyphistoma**, **Ephyra larva** in Aurelia).

Coelenteron is divided into four chambers (gastric pouches) and some Canals.

Mesoglea contains amoebocytes.

Cnidoblasts occurs both in ectoderm and endoderm.

Polymorphism is absent.

Coral forming animals are absent.

Gonads are derived from endodermis or gastrodermis.

Indirect development which includes **planula larva**, **Scyphistoma larva** and **Ephyra larva**.

Examples: *Aurelia* (Jellyfish or moonjelly), *Rhizostoma*, *Cyanea*, *Catostylus* (Blue jelly blubber).

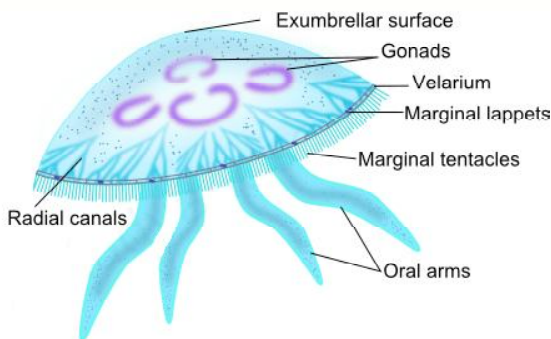


Fig. 2.4.10 Structure of Aurelia

Class 3 : Anthozoa : These are solitary (Ex: Sea Anemone) or colonial (*Tubipora*, *Alcyonium*, *Heliophora*).

Exclusively Marine. This class includes **Sea Anemones** and **Coral animals**.

All are Polyps, no medusa form is found in anthozoans.

Coelenteron is divided into eight or more septa or mesenteries.

Mesoglea contains connective tissue.

Cnidoblasts occur both in ectoderm and endoderm.

Gonads are derived from endoderm.

Development is indirect which contains **planula larva**.

Examples: *Metridium*, *Adamsia* (Sea anemones), *Edwardsia*, *Actinia*, *Utricina*, *Corallium rubrum* (Red stone coral), *Gorgonia* (Sea fan), *Pennatula* (Sea Pen),

Alcyonium (Dead man finger), *Heliophora* (blue coral), *Renilla* (Sea pansy), *Antipathes dichotoma* (Black Coral), *Fungia* (Mushroom Coral), *Astraea* (Star Coral), *Madrepora* (Staghorn Coral), *Meandrina* (Brain Coral).



Actinia



Metridium



Madrepora



Gorgonia



Heliopora



Corallium



Pennatula



Fungia



Alcyonium



Antipathes



Renilla



Meandrina

Fig. 2.4.11 Different Anthozoans

INTERESTING FACTS ABOUT CNIDARIANS

Cnidarians can have a life span of about a few months to more than 4,000 years, while some are even immortal. Most cnidarians that include jellyfish are short-lived, like for example, the Moon Jellyfish (*Aurelia*) live approximately for 8 to 12 months only. Immortal jellyfish (*Turritopsis dohrnii*) is the one species of Jellyfish that is almost immortal. Sea anemones are known to live more than Jellyfishes. They can live for as long as 60 to 80 years of age because they are able to clone themselves and as such, they don't get old so easily. Other cnidarian species like *Hydra* are known to reach maturity in about 5 to 10 days, with having a lifespan of at least 4 to 6 years. Phylogenetic studies and Molecular Clock analysis show that Cnidarians have evolved on earth around 740 million years ago.

2.5. Metagenesis in *Obelia geniculata*

Learning Outcomes:

To Understand the alternation of generations.

To Identify the differences between asexual and sexual forms of obelia.

To Understand the structural organization in Cnidarians.

To Identify different zooids in Obelia.

Systematic Position :

Phylum	: Cnidaria
Class	: Hydrozoa
Order	: Hydroida
Sub order	: Leptomedusae
Genus	: <i>Obelia</i>
Species	: <i>geniculata</i>

Obelia is commonly called as Sea fur. *Obelia* is a typical hydrozoan because it is colonial, strictly marine and having both Polyp and medusa stages in its life cycle.

Habits and Habitat : *Obelia* is a sedentary, marine, hydroid colony. It is abundant in both Atlantic and pacific coastal waters and found upto the depth of 80 meters. It occurs both in asexual and sexual forms. The asexual form is predominant, branched hydroid colony found attached to the rocks, stones, shells of animals, wooden piling. It looks like a delicate, whitish or light brown almost fur-like growth. The sexual form is an inconspicuous bell or an umbrella shaped free-swimming stage called medusa.

Hydroid colony : It is delicate, semitransparent and whitish or light brown in colour. It consists of horizontal root like stolon or hydrorhiza and vertical branching stem like

hydrocauli(Singular, hydrocaulus). Hydrocaulus rises upto 2-3cm from hydrorhiza. Each vertical stem or hydrocaulus produces branches in an alternate manner. Each branch ends with Polyp or hydronth. In the axis of older Polyp, reproductive Zooids, called **blastostyles** or **gonozooids** are produced. At this stage the obelia colony contains two types of zooids hence it is called as **dimorphic form**. When blastostyles develop medusa, the colony becomes **trimorphic**.

Components of Hydroid colony :

The Hydrorhiza, hydrocaulus and the zooids basically consists of an inner coenosarc and outer perisarc.

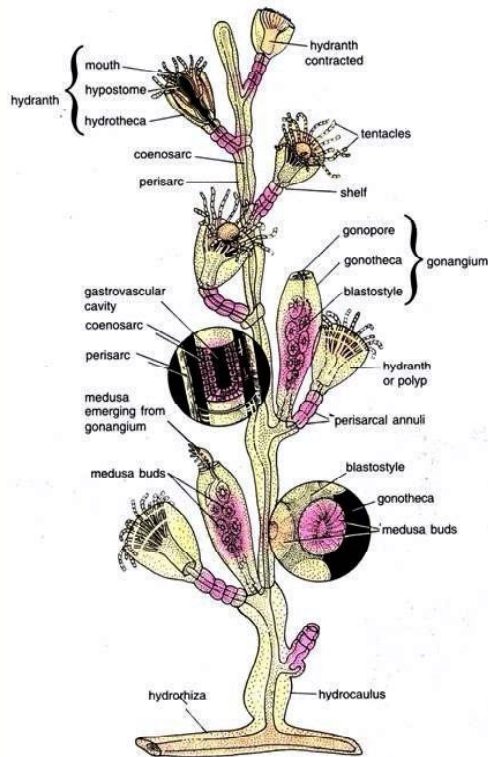


Fig.2.5.1 Obelia Colony

Coenosarc : Branches and zooids of the colony consist of an inner tubular living **Coenosarc**. It consists of an outer epidermis and inner gastrodermis.

In between these two layers gelatinous mesoglea is present. Coenosarc contains a cavity called the gastrovascular cavity.

Perisarc : Coenosarc is surrounded by an outer yellowish or brown, tough, transparent and non-living chitinous layer called **perisarc**. It is secreted by epidermis of Coenosarc. Perisarc protects the colony and acts as a supporting exoskeleton. At the base of each zooid, perisarc bears annular constrictions called **perisarc annuli**. The annuli permit limited swaying movements under the influence of water currents.

Zooids : The term zooid is used for an individual form of Coelenterate colony. Hydroid colony of obelia exhibiting two types of zooids.

1. Polyp (or) Hydranth : It is the nutritive zooid of the colony. Nutritive Zooid is also called **gastrozooid or trophozooid**. It is yellowish in colour and radially symmetrical, cylindrical structure. The proximal end of the polyp is narrow and continuous with coenosarc of hydrocaulus. The distal end of the polyp is produced into a conical elevation, the **manubrium or hypostome**. The terminal end of the hypostome bears mouth. Rising from the base of Hypostome, Thirty filiform tentacles are present. The perisarc which surrounds the hydranth is called **hydrotheca**.

2. Blastostyle : When the **hydrocaulus** has reached its full development, it produces special club-shaped bodies called **blastostyles, or blastozooids, or gonozooids**. A blastostyle has the form of a narrow elongated tube without mouth and tentacles. The perisarc, covering blastostyle, forms a loose, transparent, vase-like capsule called **gonotheca**. The distal end of gonotheca contains an aperture called gonopore. The blastostyle undergoes **lateral asexual budding** to produces sexual individuals called **medusae or gonophores**. Fully formed medusae detach from blastostyle to escape into surrounding water through gonopore. Gonotheca together with blastostyle and medusae is referred to as the **gonangium** (Gr., gonos: Seed + angeion: vessel). Now the hydroid colony with medusa becomes **trimorphic**.

3. Medusa : Medusa are modified zooids meant for sexual reproduction. A full grown medusa of obelia is a tiny umbrella, or bell shaped structure measuring 1 or 2 mm in diameter. The outer convex surface is called **ex-umbrellar surface** and the inner concave surface is called sub-umbrellar surface. From the centre of the concave sub-umbrellar surface hangs down a short, hollow, handle-shaped process, the manubrium bearing mouth at its free distal end.

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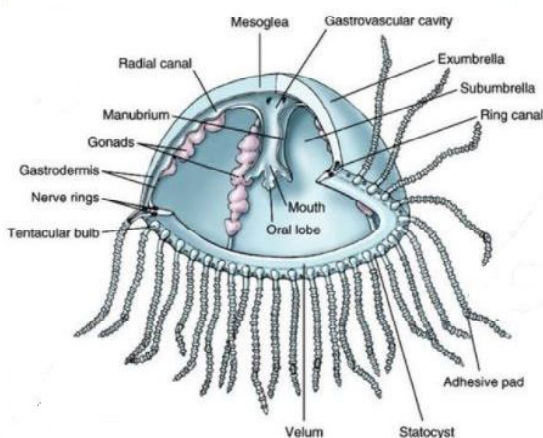


Fig. 2.5.2 Obelia Medusa

Circular edge of the umbrella is produced inwards into a very narrow, rudimentary fold called **velum**. A fleshy budded medusa bears only sixteen (16) tentacles. The number of tentacles gradually increases with age. The rectangular mouth leads into a narrow passage running through the **manubrium** called **gullet**. It is followed by dilated stomach. Four **radial canals** extend from the stomach and open into a **circular canal or ring canal**, running close to the free margin of the umbrella. Medusa has eight marginal receptor organs or statocysts, these are situated at the bases of eight adradial tentacles on subumbrellar surface, inside the bell margin. **Statocysts** are considered to be the organs of equilibrium and muscular coordination.

Medusa are **dioecious** i.e., testes and ovaries are in separate individuals. Each medusa bears only four gonads situated on the subumbrellar surface, one in the middle of each radial canal. Outer wall of mature gonads ruptures to release the gametes in the water.

Life History of obelia :

Life-history of obelia includes both asexual (hydroid colony) and sexual (Medusa) generations. These are regularly alternate with each other to complete the life cycle, hence the life cycle is called **alternation of generations** or **metagenesis**.

Fertilization: The male and female gametes of obelia released into water and fertilization takes place in water, hence fertilization is external.

Development: Fertilized egg or zygote undergoes equal and complete or **holoblastic cleavage** that produces a solid ball of cells called **morula**. This morula undergoes further cleavages to produce **blastula** and **gastrula**. Finally the gastrula elongates, to produce ciliated free swimming larva known as **planula**.

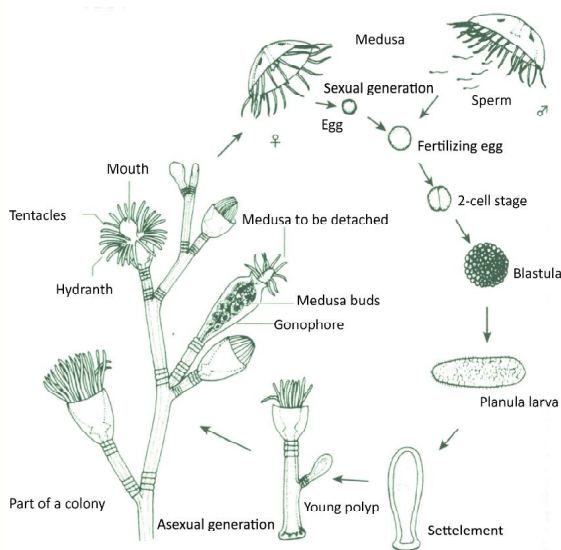


Fig. 2.5.3 Obelia Life Cycle

Planula larva : The anterior end of planula is broader than its posterior end. The cavity present inside the larva is called **enteron**.

Hydrula larva : After a brief and active free-swimming existence, the planula larva settles down. The larva attaches itself by its anterior end to stone, weed, wood or some other solid objects in the sea and becomes a Hydrula larva. The larva now closely resembles a simple Polyp or hydra with manubrium and tentacles. By repeating asexual budding, hydrula gradually changes into a new complex of branching obelia colony similar to parent.

A Metagenesis in obelia :

Alternation of generations may be defined as a phenomenon where by in the life history of an organism a diploid asexual phase and a haploid sexual phase regularly alternates with each other. This type of alternation of generations is common among plants like mosses and ferns where an asexual diploid (Sporophytic) and a sexual haploid (gametophytic) generation alternate regularly in their life cycle .

In obelia life cycle, diploid asexual hydroid colony undergoes **lateral budding** to produce medusa. The diploid sexual medusoid form undergoes sexual reproduction to give rise to hydroid colony. This fact apparently seems to have given rise to the idea of **alternation of generations**. In fact, both asexual and sexual forms in the life cycle of obelia are diploid so the exact alternation of generations are not applicable to obelia. It is a regular alternation between fixed asexual hydroid and free swimming sexual medusoid phases, both of which are diploid. However, few workers termed the life cycle of Obelia as **metagenesis**.

2.6. Polymorphism in cnidarians

Learning Outcomes:

- To Identify the basic forms polyp and medusa in Cnidarians.
- To Understand the origin of other zooids from basic forms.
- To Understand the essentiality of division of labor among the individual zooids.
- To Identify the functions of different zooids in Cnidaria.
- To Understand about the formation of colonial individuals.

The occurrence of more than one type of individuals within the same species, which differ in form and function is known as **polymorphism** (Gr, Polys; many + morpheia; form). This ensures an efficient **division of labor** between the several individuals. In cnidarians the different zooids often get united in the form of a colony. A polymorphic colony contains many individuals called zooids, they are derived from two basic forms i.e., polyp and medusa.

Polyp: A polyp has a cylindrical body with a mouth surrounded by tentacles.

Medusa: A medusa has an umbrella shaped body with marginal tentacles and mouth is located at the end of manubrium.

Importance of Polymorphism: Polymorphism is essentially a phenomenon of division of labor. Different functions are assigned to different individuals, rather than to the parts or organs of one individual. Thus, polyps are meant for feeding, protection and asexual reproduction while medusa are concerned with sexual reproduction.

Generally Polypoid forms are gastrozooids, dactylozooids, gonozooids whereas medusoid forms are pneumatophores, bracts, nectopore (or) nectocalyx (or) swimming bells and gonophores.

(I) Polypoid forms:

1. Gastrozooids:

The nutritive Polyps are called gastrozooids.

They alone take up **nutrition** in the colony.

Mouth is present.

A single, long and contractile tentacle consists of batteries of nematocysts.

Lateral branches of tentacles are called **tentilla**.

2. Dactylozooids :

These are called **palpons, feelers or tasters**.

Mouth is absent.

Unbranched basal tentacle is present, equipped with batteries of nematocysts.

These zooids are **protective** in function.

3. Gonozooids :

These are reproductive Polyps.

Produces sexual medusa or gonophores.

(II). Medusoid forms :

1. Pneumatophore :

It is a bladder like medusa filled with secreted gas.

Performs floating function.

2. Nectophore (or) Nectocalyx or swimming zooid :

It is a muscular bell without manubrium or tentacles.

Helps in locomotion of the colony by swimming.

3. Phyllozoid or Bract :

These are also known as hydrophyllia.

Contains leaf-like structure.

Protects other zooids of the colony.

4. Gonophores :

These are bearing gonads.

Producing gametes.

Pattern of Polymorphism:

The degree of Polymorphism varies greatly in different groups of hydrozoans according to the number of zooids that occur in the colony. When the colony contains two zooids it is dimorphic, three zooids it is trimorphic and many zooids it is polymorphic.

1.Dimorphic: Simple and common pattern of Polymorphism is exhibited by many hydrozoan colonies like *Obelia*, *Tubularia*, *Campanularia*. They have only two types of Zooids i.e., Gastrozooids or hydrants for nutrition and Gonozooids (or) blastostyles for asexual reproduction. Such colonies, bearing only two types of zooids, are called dimorphic.

Note : In obelia once the gastrozoid produces medusa then it is called trimorphic form.

Trimorphic : Some forms like *Plumularia* are trimorphic, besides gastrozooids and gonozooids they also possess a third type of zooids called dactylozooids for protection.

Polymorphic : The Cnidarian individuals having more than three zooids in their colony are called Polymorphic. **Siphonophora** order organisms exhibits high level of Polymorphism.

Examples: *Hydractinia*, *Halistemma*, *Physalia*, *Velella*, *Porpita*.

Hydractinia : In *Hydractinia* a greater degree of Polymorphism is found with five types of zooids, all are derived from Polyp. Each zooid performs a specialized function as shown in the following.

1. Gastrozooids – Feeding

2. Dactylozooids – Protection
3. Tentaculozooids – Sensory cells
4. Skeletozooids – Spiny projections of chitin
5. Gonozooids - Production of gametes

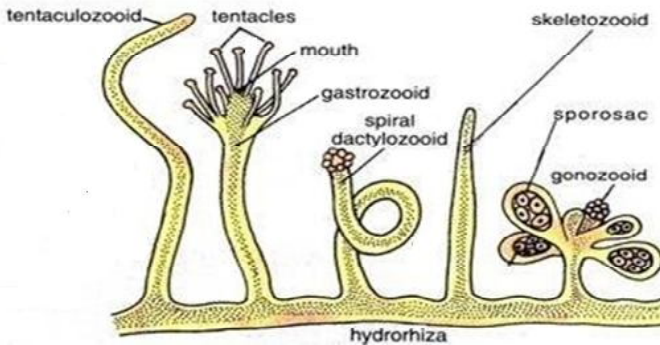


Fig. 2.6.1 Hydractinia Colony

Halistemma : This is a floating form having six types of zooids. Out of these six types of zooids, three are derived from Polyp and remaining three are derived from medusa.

Polypoid forms : Gastrozoid, Dactylozoid, Gonozooids

Medusoid forms : Pneumatophore, Nectocalyses(or) swimming bells, Bract (or) hydrophilia.

A small **Pneumatophore** or float represents the first part of the stem for floating.

Pneumatophore is followed by several pairs of closely-set transparent medusa like, known as **swimming bells** or nectocalyses for swimming.

Below nectocalyx, the axial stem gives at regular intervals closely set zooids called **cormidia**.

Each cormodium has been protected by **bract or hydrophyllia**, consisting of gastrozooids, gonozooids and dactylozooids.

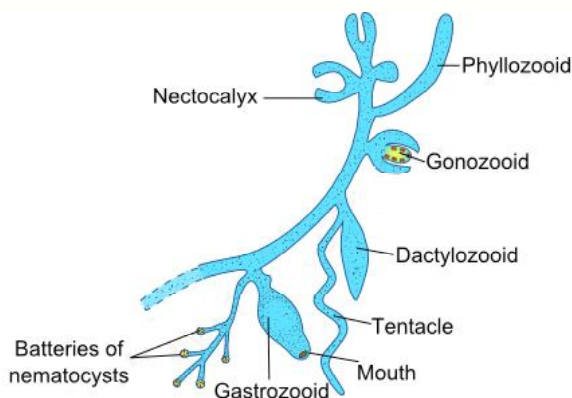


Fig. 2.6.2 Halistemma Colony

Physalia : It is commonly called **Portuguese man of war**.

This is a free floating, pelagic, colonial form.

Four types of zooids occur in the colony of physalia.

1. Pneumatophore : Medusa is modified into a large sac-like structure called Pneumatophore.

It is filled with 90% Nitrogen 1.5% Argon and with other gasses.

Performs floating function.

2. Gastrozooids : These are modified Polyps meant for nutrition.

3. Dactylozoid:These are modified Polyps for protection.

4. Gonozooids :These are modified Polyps for Reproduction.

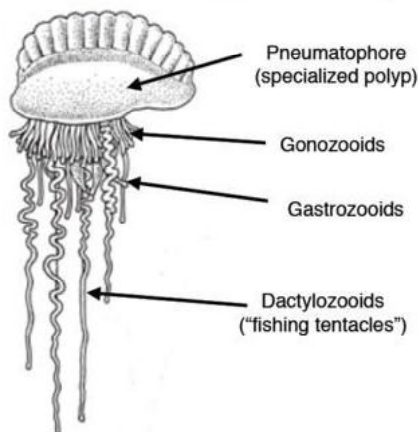


Fig.2.6.3 Physalia Colony

Porpita : It has a medusoid disc like large pneumatophore and chitinous shell with many concentric gas chambers.

On the ventro central region is a single large gastrozoid which is surrounded by clusters of small gonozooids.

and the edge of the disc tentacle like dactylozooids armed with nematocysts.

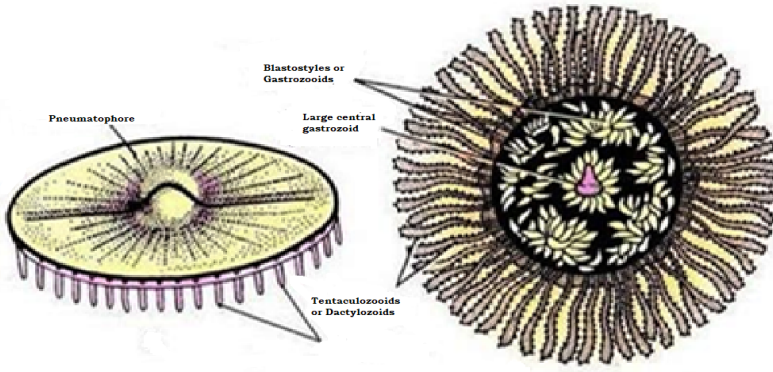


Fig. 2.6.4 Porpita Colony

Velella :

It is a close relative of physalia.

Pneumatophore is flat, chambered with a chitinous disc.

Colony has a clear, transparent and vertical ridge passing obliquely across the dorsal surface of pneumatophore called as **sail**.

Single gastrozoid is present at the centre for nutrition.

Gonozooids surround the gastrozoid.

Dactylozooids located at the margin for protection.

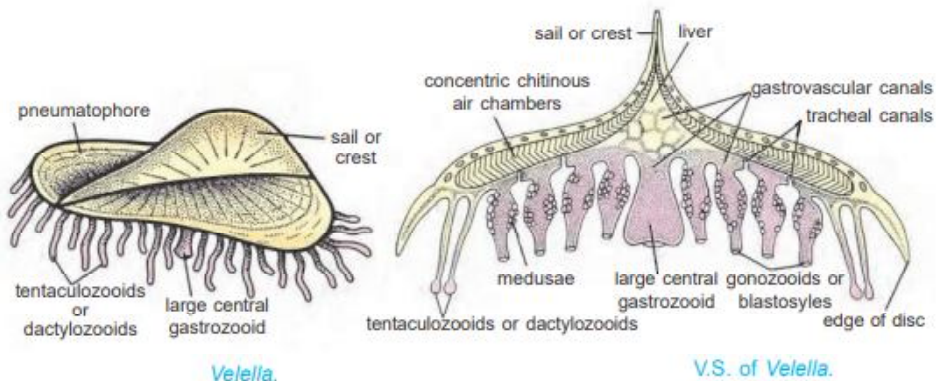


Fig.2.6.5*Veella* Colony

Origin of Polymorphism :

Polymorphism is one of the unique characteristics of cnidaria. The origin of polymorphism has been explained by many theories as shown below.

Poly-organ theory : This theory was proposed by Huxley (1859), Eschscholtz (1829), E.Metchnikoff (1874) and Muller (1871).

According to this theory, a polymorphic colony is supposed to be a single medusoid zooid. Its various components are regarded to be the modified organs of this medusoid zooid. The various parts of the zooid i.e., manubrium, tentacles, umbrella etc., multiply independently from one another and they have assumed different forms to perform different functions.

Poly-Person theory : This theory was first proposed by Leuckart (1851), Vogt (1848), Gegenbaur (1854), Kolliker (1853), Clans (1863) and later strongly supported by E. Halckel (1888), Balfour (1885) and sedgewick (1888).

This theory explained that a colony is not a single individual but various parts of the colony are modified individuals which have changed their structure due to division of labour. They are all modified from the primitive zooid which was Polyp.

Medusa theory : This theory proposed by Haeckel (1888) as a compromise between the above theories. This theory says that the siphonophores formed from gastrula was a medusoid individual, from which zooids or persons appeared by budding from the subumbrella.

Significance of Polymorphism :

The phenomenon of Polymorphism is essentially one of division of labor in which specific functions are assigned to different individuals. Thus Polyps are modified for feeding, protection and asexual reproduction, while medusa are concerned with sexual reproduction. This distribution of functions among diversified individuals and their subsequent modifications in cnidarians may have resulted from their initial simple organization and lack of organ specialization. Polymorphism gave the colonies a competitive edge in protection, food gathering and eventual survival.

INTERESTING FACTS ABOUT JELLY FISHES

*The dangerous **Carukia barnesi**, one of the known species of box jellyfish which can cause Irukandji syndrome. Jellyfish stings killed about 1,500 people in the 20th century and cubozoans are particularly dangerous. The “sea wasp” **Chironex fleckeri** has been described as the world’s most venomous jellyfish. On the other hand, some large jellyfish species of the **Rhizostomae** order are commonly consumed in Japan, Korea and Southeast Asia. Jellyfish is very low in cholesterol and sugars, but cheap preparation can introduce undesirable amounts of heavy metals. A number of the parasitic **Myxozoans** are commercially important pathogens in salmonid aquaculture.*

2.7. Corals and Coral reefs

Learning Outcomes:

- To understand the formation of corals and coral reefs.
- To understand the composition of corals.
- To Identify the role of corals in wild life protection.
- To Identify differences between hard and soft corals.
- To Differentiate between fringing reefs, barrier reefs and atolls.

Corals are calcareous exoskeletal structures of Cnidarians. Coral forming animals are marine, mostly colonial, polypoid cnidarians. Most of them belong to the class Anthozoa and few to the class Hydrozoa.

Structure of coral Polyp: A typical coral polyp forms a colony measuring about 10 mm. long and 1 to 3 mm in diameter. Solitary coral polyps are measures up to 25cm indiameter. In all coral polyps basal disc is absent because the basal region of polyps is surrounded by a calcareous exoskeleton.

Oral disc bears numerous tentacles in several rows around an elongated oral or circular mouth. Pharynx is short without **siphonoglyphs**. Mesenteries are restricted to the upper part of coelenteron. Living Polyps are found only on surface layers of coral masses. They feed at night both by **raptorial and suspension feeding**. Most of the corals symbiotic with **zooxanthellae**.

Structure of coral skeleton:

A coral formed by solitary Polyp is called **corallite**. A group of colonial Polyps to form a skeletal mass called **corallum**. The basal part of each corallite is called, basal plate. Theca surrounds the aboral portion of Polyp. Cavity of the cup contains vertical radiating ridges called **sclerosepta**. The inner ends of sclerosepta fused at the center to form **columella**.

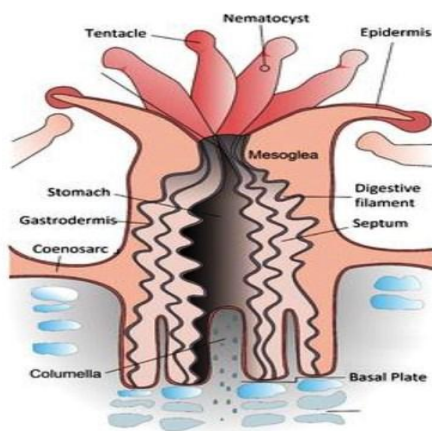


Fig. 2.7.1 Coral polyp

Formation of coral skeleton:

The coral polyp begins to secrete a basal plate at the base region. Following it, radial folds develop which secrete sclerosepta. At the same time, a rim is built up as thecal wall around the coral polyp. Coral colony grows in size continuously by budding of new Polyps, particularly along the surface layers of coral masses.

Types of corals in different groups:

1. Hydrozoancorals: Some of the hydrozoan animals secrete corals called hydroid corals. Skeleton is secreted by modified epidermal cells called calicoblasts. All hydroid corals are colonial and branched.

Examples :*Millepora*, *stylaster*

2. Octocoralliacorals : The order Alcyonacea includes colonial, soft corals. Secrete soft, internal skeleton of protein (collagen) with calcareous spicules.

Examples :*Alcyonium* (Dead man's finger), *Tubipora* (organ pipe coral), *Heliopora* (Blue cord), *Gorgonia* (Sec fan), *Corallium* (Red coral), *Eunicea* (Sea Rods), *Pennatula* (Sea pens).

3.Hexacorallia Corals : Order madrepora includes stone corals or true corals. Polyps secrete, heavy, calcareous external skeleton. These are either solitary or colonial.

Examples for Colonial corals :Madrepora (stone coral or stag horn coral), Favia, Oculina, Acropora, Meandrina (Brain coral).

Solitary corals :Fungia (Mushroom coral), Flabellum, Caryophylla.

Coral Reefs :

Coral colonies grow continuously in size by budding of new Polyps and form coral reefs. Coral reefs are basically made up of CaCO_3 secreted by coral polyps. Most coral reefs are built from stone corals. Other contributors of coral reefs are hydrocorallines and alcyonarians.

Most coral reefs are found in shallow tropical and semitropical waters. The optimum temperature for the growth of corals is in between 22°C - 28°C and at depths corals ranging from 50-200 ft. Coral reefs are also called **rainforests of the sea** as they provide a shelter for at least 25% of all marine animals. Coral reefs first appeared 485 million years ago in the early Ordovician period. Coral reefs are now under threat due to **Eutrophication**, high temperatures, ocean acidification, overfishing and El Nino effect.

Types of coral reefs : Depending upon their formation, coral reefs are classified into three types.

1.Fringing reefs : A fringing reef grows directly from shore line. It may extend out to a distance of $\frac{1}{4}$ th mile from shore. The **reef flat** (reef back) is the shoreward, flat broadest area of the reef. It is exposed during low tide. The reef slope found at the outer edge of the reef closest to the open ocean.

Corals grow much more abundantly on this slope. The upper portion of this slope is called the **reef crest**. A shallow water channel, 50-100 meters broad, lies between the reefedge and shore is called **lagoon**. The largest fringing reef in the world is the **Ningaloo reef** stretching to around 260 km along the coastline of Western Australia.

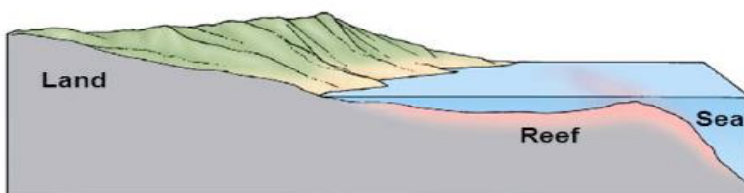


Fig.2.7.2Fringing reef

2. Barrier reef : Barrier reefs are like fringing reefs but they are located half mile to 10 miles away from the shore. Lagoons 30-70m deep and are best suited for navigation.

Ex :- Great Barrier reef of Australia about 2000 km long.

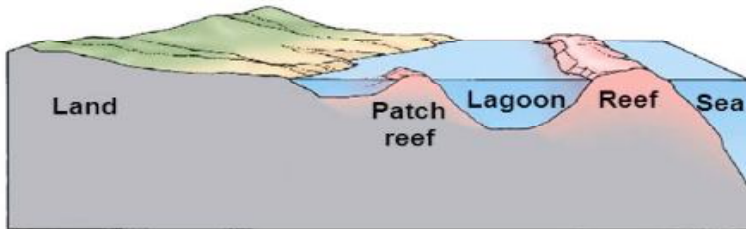


Fig. 2.7.3 Barrier reef

3. Atolls : These atolls are also known as **coral islands** or lagoon islands. They are ring-like or horse-shoe shaped reefs which encircle a lagoon but not an Island. The atoll of Bikine lies in the Pacific Ocean is famous.

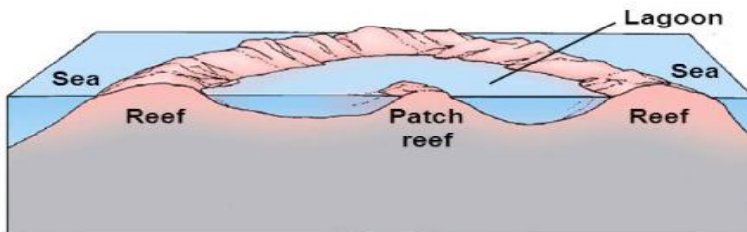


Fig. 2.7.4 Atoll

Importance of coral reefs :

Coral reefs are highly favorable sites for the accumulation of Petroleum deposits.

Coral reefs form rich biodiversity in oceans.

Corals also have decorative value.

Coral reef organisms are used to treat cancer, arthritis and Alzheimer's disease.

Coral skeletons also serve as raw material for preparation of lime, mortar and cement.

Ecologically coral skeletons act as natural barriers against waves, hurricanes, sea erosion and cyclonic storms.

Coral reefs serve as good nursery grounds for commercial fishes.

Destruction of Coral reefs :

As global temperatures increase, corals are in danger of extinction. Coral reefs are unseen back bones of the earth's ecosystem. The following are the main causes of destruction of coral reefs.

1.Reef bleaching : Increase in water temperature leads to expelling of zooxanthellae symbiotic algae by corals leads to destruction of coral reefs.

2.Poison fishing :It is unfortunately common practice to use the cyanide to capture the aquarium fishes by stunning them for domestic saltwater aquariums.This causes destruction of coral reefs.

3. Water Pollution : Water pollution is perhaps the most obvious cause of coral reef destruction. Reefs are harmed and destroyed when oil, fertilizer are dumped in the coral area.

Formation of coral reefs : Many theories have been advanced to explain the formation of coral reefs. But only a few of them are satisfactory. The following are the theories which satisfactorily explain the formation of coral reefs.

1. Subsidence theory : This theory was proposed by **Darwin**. According to this theory, all known coral reefs are found in the regions where subsidence of land has taken place. He explains that initially the corals grow as fringing reefs on the shores of islands in a shallow tropical sea. Subsidence of the islands commenced so that the fringing reef became a barrier reef, separated by, wide, deep-water channel called lagoon. While further sinking of the island leads to disappearance of the island to form an atoll.

2. Glaciation control theory : This theory was proposed by **Albrecht Penck and Reginald Daly**. They advocated that during the glacial period formation of ice-caps lowered the level of the ocean by 60-70m. At that time extreme cold temperatures prevailed. Subsequently ice melted and the temperature rose. The corals began to grow on the flat platform of the ocean bottom and kept pace with raising levels of the ocean forming gigantic reefs.

GLOSSARY

Alternation of generation: Alternate succession of sexual (haploid) and asexual (diploid) generation in the life cycle of an organism.

Atoll: Horse shoe or ring like island consisting of a belt of coral reef surrounding a central lagoon.

Barrier reef: Reef separated from shore by wide deep channel.

Basal disc: Flattened foot of some coelentrates which attaches to substratum by secreting some sticky substance.

Budding: A form of asexual reproduction in which a new individual develops from some generative anatomical point of the parent organism.

Calcareous: Containing lime or calcium.

Cnidaria or Coelentrata: Phylum including animals possessing cnidoblast structures.

Cnidoblast: Type of cell in which nematocyst is found.

Dactylozoid: Sensory polyp of Hydrozoa.

Dioecious: Having male and female reproductive organs in separate individuals.

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

Ephyra: Free swimming larva of scyphozoan coelenterates.

Fringing reef: Coral ridge build up from ocean bottom.

Gastrovascular: Serving the function of both digestion and circulation.

Hydranth: Expanded end of a branch of hydroid colony specialized for vegetative function.

Hydrocaulus: Main stalk like stem of a hydroid colony.

Hydrorhiza: Basal root like portion of a hydroid colony used for attachment with the substratum

Hydrotheca: Transparent membrane that extends from the perisarc and surrounds the main part of the hydranth.

Hypostome: Structure surrounding mouth in coelentrates.

Lappet: Flap like projection.

Manubrium: A structure projecting from the middle of sub-umbrellar surface of medusa. It bears mouth at its freeend.

Mesogloea: Non cellular jelly like substance present between ectoderm and endoderm in coelentrates.

Metagenesis: Alternation of sexual with asexual generation in the life cycle of coelentrates.

Metazoa: Multicellular animals.

Monoecius: Organism having both male and female reproductive organs.

Nematocyst: A stinging capsule found in coelentrates it is produced by a cell called cnidoblast.

Pelagic: Inhabiting in open water away from shore.

Regeneration: Replacement by growth of lost part of the body.

Strobilation: Budding in the segments of sessile scyphozoan coelentrates larvae

Tentaculocyst: Sense organs of some coelentrates.

Zoid: A single animal form that is a part of polymorphic colony

SELF ASSESSMENT

1. Identify fresh water Cnidarian from the following.
1. Hydra 2. Obelia 3. Physalia 4. Aurelia
2. Diploblastic body wall and Radial symmetry are present in
1. Protozoa 2. Cnidaria
3. Echinodermata 4. Annelida
3. Dactylozooids of cnidarians like physalia are useful for
1. Protection 2. Reproduction 3. Nutrition 4. Floating
4. Polymorphism is exhibited by
1. Hydra 2. Sea anemone 3. Physalia 4. All the above
5. Highest degree of polymorphism is exhibited by
1. Hydra 2. Physalia 3. Obelia 4. Halistemma
6. The most important character of the phylum cnidaria is
1. presence of tentacles around the mouth
2. presence of large quantities of mesoglea
3. exhibition of polymorphism
4. presence of cnidoblasts
7. In cnidarians extracellular digestion occurs in
1. Nutritive muscular cells of the endoderm
2. Coelenteron 3. Choanocytes
4. Musculo epithelial cells of the ectoderm
8. Polymorphism is seen in
1. Porifera 2. Cnidaria
3. Platyhelminthes 4. Nematoda
9. The stinging cells present in cnidarians are
1. Interstitial cells 2. Cnidoblasts
3. Archeocytes 4. Neoblasts
10. Nerve cells and sensory cells 1st appear in the phylum
1. Porifera 2. Cnidaria
3. Platyhelminthes 4. Nematoda

-
11. The characteristic larva present in Cnidarians is
1. Amphiblastula
 2. Ephyra
 3. Planula
 4. Muller
12. Only free-floating forms are included in this class of the phylum cnidaria
1. Hydrozoa
 2. Scyphozoa
 3. Anthozoa
 4. All the above
13. Exclusively sedentary forms are included in this class of the phylum cnidaria
1. Hydrozoa
 2. Scyphozoa
 3. Anthozoa
 4. All the above
14. Noncellular mesoglea is present in
1. Hydrozoa
 2. Scyphozoa
 3. Anthozoa
 4. All the above
15. Cnidoblasts occur in the ectoderm only in
1. Hydrozoa
 2. Scyphozoa
 3. Anthozoa
 4. All the above
16. Germ cells are derived from ectoderm in
1. Anthozoa
 2. Scyphozoa
 3. Hydrozoa
 4. All the above
17. Metagenesis is exhibited by
1. Hydra
 2. Obelia
 3. Adamsia
 4. Pennatula
18. Portuguese man of war is
1. Obelia
 2. Aurelia
 3. Gorgonia
 4. Physalia
19. Identify a set of Hydrozoans from the following
1. Adamsia and pennatula
 2. Aurelia and Rhizostoma
 3. Physalia and Halistemma
 4. Hydra and Adamsia
20. Jelly fishes belong to the class
1. Hydrozoa
 2. Scyphozoa
 3. Anthozoa
 4. All the above

STATEMENTS

21. The following are the statements regarding Hydrozoans.

- I. Mesoglea is cellular
- II. Cnidocytes are present both in ectoderm and endoderm
- III. Germ cells are ectodermal
- IV. Life history includes polyp and medusa

The correct combination is

1. I and II 2. III and IV 3. II and III 4. I and IV

22. The following are the statements regarding Anthozoans.

- I. Life history includes both polyp and medusa stages
- II. Mouth leads into stomodaeum and mouth bears ciliated grooves called siphonoglyphs
- III. Gastrovascular cavity is divided into many compartments by mesenteries
- IV. Germ cells are Ectodermal in origin.

The correct combination is

1. I and IV 2. I and III 3. II and IV 4. II and III

23. Study the following 3 columns matching.

Class	Character	Example
I. Hydrozoa	Non-cellular mesoglea	Hydra
II. Scyphozoa	Large quantities of mesoglea with amoebocytes	Rhizostoma
III. Anthozoa	Cellular mesoglea with connective tissues	Gorgonia

Which of the above are correct?

1. All 2. All except I 3. All except II 4. All except-III

SEQUENCES

24. Arrange the cnidarians in a sequence belong to the classes Scyphozoa, Hydrozoa and Anthozoa respectively.

- A) Gorgonia B) Halistemma C) Rhizostoma

1. C-B-A 2. A-B-C 3. B-A-C 4. C-A-B

ASSERTION AND REASON

25. (A) : The phylum coelenterate now renamed as phylum cnidaria.

(R) : The coelenterates with cnidoblasts or stinging cells are called cnidarians

- 1. Both A & R are true. R correctly explains 'A'
- 2. Both A & R are true. But 'R' cannot explain 'A'
- 3. 'A' is only true. But 'R' is not true
- 4. Both A & R are not true

2.8 Phylum Ctenophora

Learning Outcomes:

- To Understand the evolutionary pattern of animal kingdom.
- To Identify unique structures in Ctenophora.
- To Know about the comb jelly.
- To Explore the structures and adaptations of Ctenophores.
- To Describe the function of lasso cells.

Ctenophora is a small Phylum of marine animals. Which are commonly known as **comb jellies** (Greek Cten, “comb”; phere, “to bear”), **Sea gooseberries** or **sea walnuts**. They are free swimming, transparent, jelly like, soft bodied, exclusively marine animals having **biradial symmetry**. Unique characteristic features of Ctenophores are that they contain 8 comb like ciliary plates, for locomotion, the **lasso cells** or **colloblasts** for catching small prey.

In previous classifications, ctenophores have been placed in subphylum **Acnidaria** under the phylum **Coelenterata**. But the present tendency is to consider them as separate Phylum due to their unique characteristic features. Hatschek placed them under a distinct phylum Ctenophora. Phylum Ctenophora includes less than 100 species only.

General Characters :

1. All are **exclusively marine**.
2. All are solitary and free-swimming animals.
3. Exhibit tissue level organization.
4. Most of the body structures are radially arranged but tentacles are paired hence, they exhibit **biradial symmetry**.

5. Eight longitudinal rows of transverse plates, bearing fused cilia, called **comb plates** help in locomotion. (Absent in Ctenoplane and Coeloplane) Ctenophores are the largest non colonial animals that use cilia as the main method of locomotion.

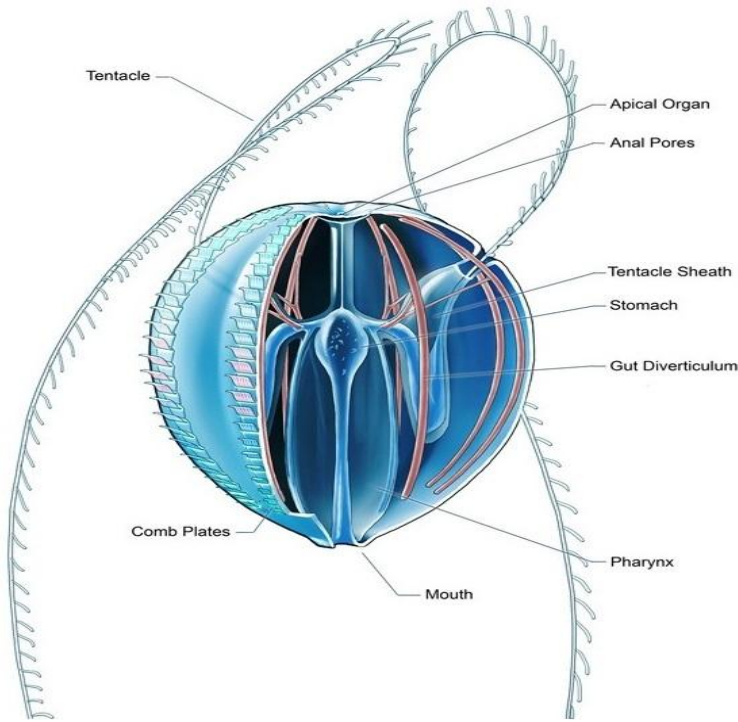


Fig. 2. 8.1 Pluerobrachia

6. A pair of long, solid, retractile tentacles are present at the aboral region. The surface of the tentacles bears specialized **glue cells** called **colloblasts or lasso cells** which secrete a sticky substance that facilitates catching small prey.

7. The body is **diploblastic** having ectoderm and endoderm. The body has outer epidermis and inner endodermis, middle jelly like mesoglea with scattered cells, and muscle fibers. So, Ctenophores may also be considered as triploblastic.

8. **Gastrovascular cavity** consists of a pharynx. Stomach and a system of gastrovascular canals and two aboral and pores.

9. Digestion is both extracellular and intracellular.

10. **Nematocysts** are completely absent.

11. Respiratory circulatory, skeletal and excretory systems are completely absent.

12. The Nervous system is diffused type and the aboral end bears a sensory organ called **statocyst**.
13. Asexual reproduction and alternation of generations are absent.
14. Only sexual reproduction occurs.
15. All are monoecious (Hermaphrodite).
16. Gonads originate from endoderm.
17. Fertilization is external.
18. Development is determinate and indirect with characteristic **cydippid** larvae.
19. **Regeneration** and **bioluminescence** are common.

Classification :

Phylum Ctenophora is classified into two classes according to the presence or absence of **tentacles**.

Class -1 :Tentaculata

Adults possess two long aboral tentacles.

Some organisms possess two large oral lobes and four slender flap like auricles around the mouth.

Examples :*Pleurobrachia*(Sea gooseberry),*Hormiphora*, *Mnemiopsis* (Sea Walnut), *Cestum* (Venus girdle),*Velamen*, *Ctenoplana*, *Caenoplana*



Mnemiopsis



Cestum



Ctenoplana

Fig. 2.8.2 Tentaculata organisms

Class-2 : Nuda

Tentacles are absent both in larval stage and adult stage.

Example :*Beroe* (Comb Jelly)



Fig. 2.8.3 Beroe

Affinities:

Different workers have dissimilar views regarding the origin and relationship of Ctenophores. No fossil record is available due to their soft bodies. In the absence of fossils, the Ctenophore's origin remains uncertain.

Affinities with Cnidaria:

Resemblances with Cnidaria

- Biradial symmetry.
- Body parts arranged through oral - aboral axis.
- Presence of gelatinous mesoglea.
- Tissue level organization.
- Coelom is absent.
- Single gastrovascular cavity.
- Diffused type nervous system.
- Gonads originate from endoderm.

Differences from Cnidaria:

- Presence of oppositely placed aboral tentacles.
- No polymorphism, No colony formation.
- All are monomorphic (Zooids are absent).
- Nematocysts are absent. Instead, special sensory cells or colloblasts are present on tentacles.
- Presence of 8 comb plates for locomotion.
- Mesenchymal muscles are present.
- Statocyst present aborally but not marginally as seen in obelia.
- Presence of anal pores.
- Determinate type of development.

Affinities with Platyhelminthes:

- Platyctenea ctenophores show certain resemblances with Platyhelminthes turbellarians.
- Dorso ventrally flattened body.
- Crawling mode of life. Ciliated ectoderm. Presence of mesenchyme with muscle fibers.

Position in Animal Kingdoms:

Ctenophora are believed to have diverged group from the ancestral medusoid Cnidarians. Later they developed 8 rows of comb plates and specialized capturing lasso cells. However, they represent blind offshoots as they cannot give rise to any higher animals. Presence of mesodermal muscles, gonoducts, and a determinate type of development are the advanced characters of Ctenophores than Cnidaria. Therefore, it is suitable to treat Ctenophora as a separate phylum rather than a subphylum of Coelenterata.

Bioluminescence

*Bioluminescence is a form of chemiluminescence where light energy is released by a chemical reaction. This reaction involves a light-emitting pigment, the luciferin, and a luciferase, the enzyme component. The gut of the deep-sea genus **Bathocyroe** is red, which hides the bioluminescence of copepods it has swallowed. The comb rows of most planktonic ctenophores produce a rainbow effect, which is not caused by bioluminescence but by the scattering of light as the combs move. Most species are also bioluminescent, but the light is usually blue or green and can only be seen in darkness. However, some significant groups, including all known platyctenids and the cydippid genus *Pleurobrachia*, are incapable of bioluminescence. In ctenophores, bioluminescence is caused by the activation of calcium-activated proteins named **photoproteins** in cells called **photocytes**, which are often confined to the meridional canals that underlie the eight comb rows. In the genome of *Mnemiopsis leidyi* ten genes encode photoproteins. These genes are co-expressed with opsin genes in the developing photocytes of *Mnemiopsis leidyi*, raising the possibility that light production and light detection may be working together in these animals. Fireflies, glow worms, railroad worms, certain centipedes such as *Geophilus carpophagus*, certain millipedes such as *Motyxia*, Anglerfish, Lanternfish, Viperfish, Sea pens, *Renilla reniformis*, *Aequorea victoria*, *Tomopteris*, *Hinea brasiliana*, *Latia* are the other animals exhibits bioluminescence.*

SELF ASSESSMENT - CTENOPHORA

1. Ctenophore are commonly called
 1. Jelly fishes
 2. Sea biscuits
 3. Sea walnuts
 4. Sea lions
2. Ctenophores are characterized by
 1. Segmentation
 2. Polymorphism
 3. Cnidoblasts
 4. Bioluminescence
3. Bioluminescence exhibited by
 1. Physalia
 2. Pleurobrachia
 3. Velella
 4. Pennatula
4. Ctenophores differ from cnidarians by the presence of
 1. Choanocytes
 2. Cnidocytes
 3. Comb plates
 4. Tentacles
5. A characteristic feature of ctenophore is
 1. Fresh water habitat
 2. Asexual reproduction
 3. Locomotion by ciliated comb plates
 4. Absence of larval form
6. Ctenophores share more similarities with
 1. Porifera
 2. Platyhelminthes
 3. Cnidaria
 4. Annelida
7. Tentacles are absent in
 1. Pleurobrachia
 2. Hormiphora
 3. Coeplana
 4. Beroe
8. Tentacles of ctenophora bears
 1. Scleroblasts
 2. Colloblasts
 3. Cnidoblasts
 4. Condroblasts

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UNIT - III

HELMINTHES

LEARNING OUTCOMES

By the completion of this unit, the student should be able -

- * to learn the distinctive characters of Platyhelminthes and Nemathelminthes
- * to know the clasification of phylum Platyhelminthes and phylum Nemathelminthes.
- * to learn the morphology, life cycle and pathogenesity of *Fasciola hepatica*
- * to learn the morphology, life cycle and pathogenesity of *Ascaris lumbricoides*.

INTRODUCTION

Helminthes (Gr. helmins means worm) includes two groups of primitive, bilaterally symmetrical and triploblastic organisms, viz., Platyhelminthes and Nemathelminthes. They exhibit organ system grade organisation. Platyhelminths are acoelomates and are mostly parasitic forms. Nemathelminths are pseudocoelomates, in which some are free living and others lead parasitic life.

CHAPTER - 1

PHYLUM - PLATYHELMINTHES

Platyhelminthes (Gr. Platy - flat, helminth - worm) includes the planarians, flukes and tapeworms. They are bilaterally symmetrical and triploblastic acoelomates. The evolution of triploblastic condition and bilateral symmetry coincide with the evolution of organs and organ systems and centralisation of the nervous system. The body of platyhelminths is dorsoventrally flattened (flat worms) with solid bauplan with parrenchyma between the gut and body wall.

3.1.1 General Characters

1. Animals included in phylum Platyhelminthes are commonly called **flat worms** because their bodies are dorsoventrally flattened and leaf like.
2. Most of the flatworms are parasitic. Some are free living. Free living forms are mainly aquatic and majority of them are marine. Few forms live in moist soil.
3. These are triploblastic animals with organ grade organisation.
4. Body of flat worms is bilaterally symmetrical and exhibit cephalisation.
5. Body cavity is absent. Hence these are described as **acoelomates**. Between the body wall and gut, connective tissue is present called parrenchyma.
6. Parasitic forms have hooks and/or suckers for attachment to host tissues.
7. Flatworms have digestive system with mouth and branched intestine. Anus is absent. Ingestion and egestion occurs through mouth. Digestion is intracellular and extracellular. In tapeworms, digestive system is absent.
8. Respiratory and circulatory systems are absent

యూనిట్ - 3 హెల్మింథిస్

చాప్టర్ - 1 వర్గం - ప్లాటీహెల్మింథిస్

సాధారణ లక్షణాలు, వర్గీకరణ :

ప్లాటీహెల్మింథిస్ (ప్లాటీస్-బల్లపరుపు, హెల్మింథ్-పురుగు) వర్గంలోని జీవుల దేహం పుష్టోదరాలుగా అణిగి ఉండటం వల్ల వాటిని బల్లపరుపు పురుగులు అంటారు. వీనిలో అధిక శాతం పరాన్నజీవులు. ఇవి ద్విపార్శ్వ సౌష్ఠ్యం కలిగిన త్రిస్తరిత ఏసీలోమేట్లు. జీర్ణవ్యవస్థలో నోరు, శాఖలు కలిగిన ప్రేగు ఉంటాయి. పాయువు ఉండదు. పూర్వ భాగంలో నాడీ సంధులు మెదడుగా ఏర్పడతాయి. విసర్జన జ్వాలా కణాలతో జరుగుతుంది. (వీని ప్రాథమిక విధి ద్రవాభిసరణ క్రమత). అధిక శాతం బల్లపరుపు పురుగులు ఉభయ లైంగికాలు. పరాన్నజీవుల జీవిత చరిత్ర క్లిష్టంగా ఉంటుంది. లార్వాలు పాలీఎంబ్రియోనీ వ్యక్తం చేస్తాయి. ప్లాటీహెల్మింథిస్ వర్గాన్ని మూడు విభాగాలుగా వర్గీకరించారు. అవి - టర్చల్లెరియా (ముఖ్యంగా స్వతంత్రజీవులు), ట్రెమటోడా (ఘ్రాక్లు-ముఖ్యంగా పరాన్నజీవులు), సెస్టోడా (బద్దెపురుగులు-ముఖ్యంగా పరాన్నజీవులు)

ఫాసియోలా హెపాటికా :

ఫాసియోలా హెపాటికాను సాధారణంగా గొర్రెల లివర్‌ఫ్లూక్ అంటారు. ఇది గొర్రెల కాలేయం, పైతృరసనాళాలలో పరాన్నజీవనం గడుపుతూ ఉంటుంది. దేహం బల్లపరుపుగా దాదాపు అండాకారంగా ఉండి పూర్వభాగాన శంకాకార ఉబ్బెత్తు కలిగి ఉంటుంది. (ఓరల్‌కోక్). దీనిపై నోరు, దీనిని చుట్టి ఓరల్ సక్కుర్ ఉంటాయి. దీనికి వెనకగా ఉదరతరాల ఎసిటాబ్యులం అనే చూషకం ఉంటుంది. ఈ రెండూ పరాన్నజీవి ఆవిధేయ కణజాలాలకు అంటి పెట్టుకొని ఉండటానికి తోడ్పడతాయి. ఎసిటాబ్యులంకు ముందు జనన రంధ్రం, దేహపరాంతంలో విసర్జక రంధ్రం ఉంటాయి.

ఫాసియోలా ఉభయలింగ జీవి. దేహంలో అధిక భాగం ప్రత్యుత్పత్తి అవయువాలతో నిండి ఉంటుంది. ఇది తన జీవిత చరిత్రను పూర్తి చేసుకోడానికి రెండు ఆతిధేయిలు అవసరం-ప్రాథమికతిధేయి గొర్రె, మాధ్యమికతిధేయి-లిమ్నియా, ప్లానార్బిస్ ప్రజాతులకు చెందిన నత్తలు. అంతర ఫలదీకరణం జరుగుతుంది.

9. Cerebral ganglia (brain) are present in the anterior part, from which longitudinal nerve cords extend posteriorly. They are joined by commissures at regular intervals.
10. **Flame Cells** (Protonephridia) are primarily useful in **osmoregulation** and secondarily excretory in function. Most of the excretory materials diffuse across the body wall.
11. Free living flat worms have sense organs like ocelli and ciliary receptros.
12. Turbellarians can reproduce asexually by fission or by budding.
13. Most of the flat worms are hermaphrodites. Few forms (like *Schistosoma*) are unisexual. Fertilisation is internal.
14. Development is indirect or direct. Life history is simple in free living forms and is complex in parasitic forms. In trematodes **polyembryony** is common.
15. Planarians have great powers of regeneration
e.g., *Planaria* (*Dugesia*), *Fasciola*, *Taenia*

3. 1. 2 Classification of Platyhelminthes

Phylum platyhelminthes is divided into there classes, namely, Turbellaria, Trematoda and Cestoda.

Class 1. Turbellaria

1. These flatworms are commonly called **planarians**.
2. These are usually free living forms.
3. Body is unsegmented and is covered by glandular ciliated epidermis. Epidermal cells secrete rod like inclusions called **rhabdites**. When they are released to the surface, they become mucus.
4. Mouth is ventral. In some forms pharynx is protrusible.
5. Most of the planarians are bisexual forms. Some of the turbellarians reproduce asexually.
6. Planarians have remarkable powers of regeneration
7. During development of some forms **Muller's larva** or Goette's larva is formed.
e.g., *Microstomum*, *Prorhynchus*, *Dugesia*, *Planocera*

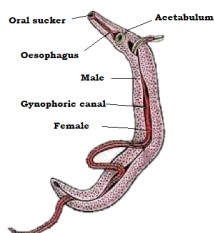


Fig. 3.1.1 a. *Planocera*

Fig. 3.1.1 b. *Schistosoma*

Fig. 3.1.1 c. *Taenia*

గ్రుడ్లను గుళికలు అంటారు. ఇది గొర్రె మలం ద్వారా బయటకు విసర్జితం అవుతాయి. అనుకూల పరిస్థితుల్లో గ్రుడ్డులోని సంయుక్త బీజం అభివృద్ధి చెంది మిరాసీడియం లార్వా ఏర్పడుతుంది. ఇది గ్రుడ్డు నుండి విడుదలై తేమలో ఈదుతూ నివశించే సూక్ష్మమయిన లార్వా. దీని దేహాన్ని ఆవరించి 5 వరసల్లో అమరిన 21 శైలికామయ ఉపకళాకణాలు ఉంటాయి. దీని పూర్వభాగంలో అగ్ర సూక్ష్మాంకురం, దానిపై తెరచుకొని అగ్రగ్రంథి, ఒక జత ప్రవేశక గ్రంథులు, గుంపులుగా జననకణాలు ఉంటాయి.

మిరాసీడియం లార్వా నత్త శరీరంలోకి ప్రవేశించి స్పోరోసిస్ట్గా మారుతుంది. అగ్రసూక్ష్మాంకురం, గ్రంథులు, మెదడు, నాడులు మొదలైనవి అదృశ్యం అవుతాయి. జనన కణాలు రీడియా లార్వాలుగా ఎదుగుతాయి. రీడియాలు స్థూపాకారంగా ఉండి, నోరు, గ్రసని, సంచి వంటి ప్రేగు కలిగి ఉంటాయి. నోటికి వెనకగా కాలర్, దానికి పరభాగంలో జననరంధ్రం ఉంటాయి. వేసవిలో రీడియాల నుండి మరోతరం రీడియాలు ఏర్పడతాయి. శీతాకాలంలో రీడియాల నుండి చూషకాలు, తోక కలిగిన సర్కేరియాలు విడుదలవుతాయి. ఇవి నత్త దేహం నుండి బయటకు వచ్చి, గడ్డి మొక్కల ఆకులకు అంటుకొని, తోకను కోల్పోయి, కోశీభశనం చెంది మెటాసర్కేరియాలుగా మారతాయి. మెటాసర్కేరియాలున్న గడ్డి, ఆకులను గొర్రె తిన్నపడు అవి దాని ప్రేగుల్లోకి చేరి, అక్కడ వికోశీకరణం చెంది, కాలేయాన్ని చేరి ప్రొడజీవులుగా మారతాయి.

ఫాసియోలా వల్ల గొర్రెల్లో కలిగే వ్యాధిని లివర్ రాట్ అంటారు. ఈ పరాన్నజీవులవల్ల కాలేయ వాహికలు, పైత్యరసనాళం యొక్క గోడలు మందంగా మారి, కాల్సిఫికేషన్ వల్ల వాటిలో రాళ్ళు ఏర్పడతాయి. తీవ్రమైన సంక్రమణంలో కాలేయం యొక్క క్రియాత్మకత తీవ్రంగా దెబ్బతిని, రక్తస్రావం కూడా జరుగుతుంది. ఆకలి మందగించడం, జ్వరం, కన్నులోని శుక్లపటలం తెలుపు-పసుపుగా మారటం ఈ వ్యాధి లక్షణాలు. వ్యాధి తీవ్రత వల్ల గొర్రెలు మరణిస్తాయి.

Class 2. Trematoda

1. These flatworms are commonly called **flukes** and are parasitic. (ecto-parasites - e.g., *Diplozoon* or endoparasites - e.g., *Fasciola*).
2. Body is unsegmented and is covered by a thick tegument.
3. Around the mouth there is an oral sucker. A ventral sucker or acetabulum is usually present. Suckers are useful in attachment to host tissues.
4. Intestine is bifid.
5. There are three pairs of longitudinal nerve cords.
6. Few forms are unisexual (e.g., *Schistosoma*) and majority forms are bisexual.
7. In ectoparasites development is usually direct and in endoparasites, it is indirect with many larvae. Life cycle is completed in one or more hosts.
8. In the development of a typical fluke, five larvae are formed, such as miracidium, sporocyst, redia, cercaria and metacercaria.

e.g., *Diplozoon*, *Fasciola*, *Schistosoma*, *Aspidogaster*

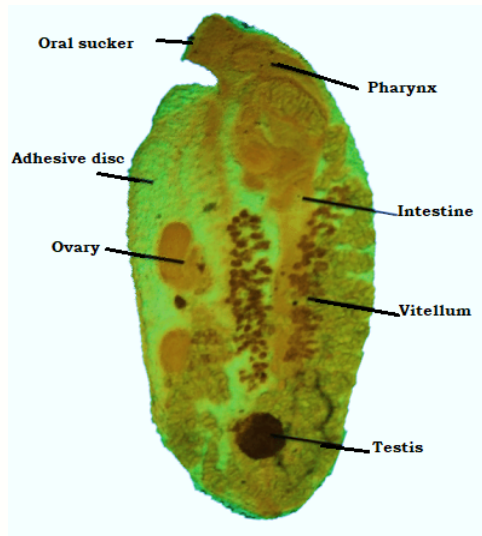


Fig 3. 1. 1. d *Aspidogaster*

Class 3. Cestoda

1. These flatworms are commonly called **tapeworms** and are endoparasitic in the alimentary canal of vertebrates.
2. Body is long, narrow, ribbon like and is segmented (pseudometamerism).
3. Body of tapeworms is divided into scolex, neck and strobila. Strobila is divided into many proglottids
4. Scolex is with suckers and hooks, and is the organ for attachment to host tissues.
5. Digestive system is absent. Sensory structures are also absent.
6. Each mature proglottid contains both male and female reproductive organs. Hence, tapeworms are bisexual forms.
7. Life cycle is complicated with one or more hosts.
8. In the development, onchosphere, hexacanth, cysticercus stages are present. e.g., *Gyrocotyle*, *Taenia*, *Echinococcus*

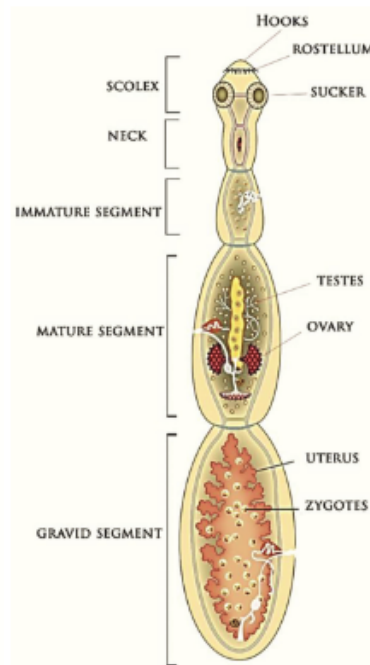


Fig 3. 1. 1. e *Echinococcus*

3. 1. 3 *Fasciola hepatica*

3. 1. 3. 1. Systematic Position

Phylum : Platyhelminthes

Class : Trematoda

Order : Digenea

Family : Fascioliodae

Genus : *Fasciola*

Species : *hepatica*

3. 1. 3. 2. Morphology

Fasciola hepatica is commonly called **sheep liver fluke**. It is an endoparasite. There may be about 200 flukes in the liver and bile passages of the sheep. *Fasciola hepatica* is oval in outline, dorsoventrally flattened and leaf like. At the anterior part of the body, there is a conical projection called **oral cone**. On the tip of the oral cone, mouth is present, which is surrounded by an **oral sucker**. Behind the oral sucker, on the mid ventral side there is a ventral sucker or **acetabulum**. In front of the acetabulum, there is a common **genital aperture**. An **excretory pore** is present at the posterior end on the ventral side. During breeding season only, a temporary opening of Laurer's canal appears little anterior to middle of the body on the dorsal side. Entire body of liver fluke is covered by a thick tegument with backwardly directed spinules.

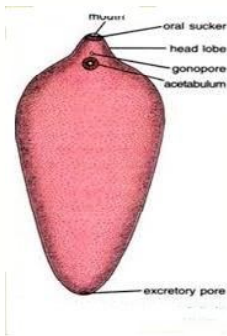


Fig. 3.1.2 *Fasciola hepatica*

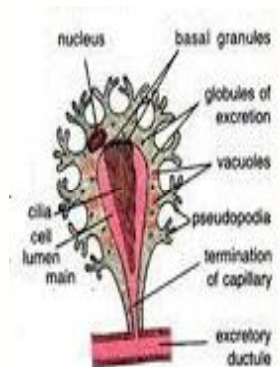


Fig. 3. 1.3. Flame cell

Fasciola is an acoelomate. It has an incomplete gut. Mouth opens into a muscular pharynx. Pharynx leads to an oesophagus. Oesophagus opens into the intestine, and is bifurcated into left and right branches. Anus is absent. Digestion is extracellular. *Fasciola* respire anaerobically. Excretory system consists of large number of **flame cells** or protonephridia.

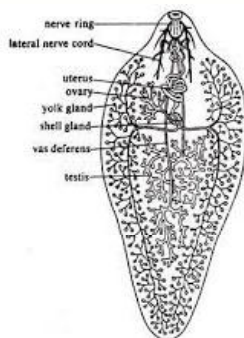


Fig. 3. 1. 4. *Fasciola* Reproductive system

They are connected with each other through an intricate system of ducts. These ducts unite with one another and finally form a median longitudinal excretory canal. It opens out through an excretory pore. Nervous system is in the form of a cerebral ring (brain), from which there pairs of longitudinal nerves extend posteriorly. *Fasciola* is a **hermaphrodite**. Reproductive organs occupy major part of the body. Male and female reproductive organs open out through a common **goropore**.

3. 1. 3. 3 Life Cycle

Fasciola hepatica completes its life cycle in two hosts, viz., sheep (primary/definitive host) and snails of the genera *Lymnaea*, *Planorbis* etc. (intermediate hosts). Genereally cross fertilisation takes place. Self fertilisation is rare. Fertilisation is internal.

1. Eggs or capsules

The fertilised ovum (zygote) is surrounded by yolk cells. Shell globules of yolk cells form a hard shell around the yolk cells and zygote. The egg shell is yellowish brown. The eggs are oval and are provided with a lid or operculum. Each liver fluke can produce about 3,000 eggs at a time.

2. Cleavage and embryonic development

Zygote in the egg begins to cleave in the uterus of liver fluke itself. Cleavages are unequal and holoblastic. After first cleavage, two unequal blastomeres are formed - a larger **somatic cell** and a smaller **propagatory cell**. Somatic cell divides and produce larval ectoderm and tissues. Propagatory cell divide once and form two cells - one cell divide and form the larval body and the other cell divide many times and form a mass of germ cells. Capsules leave the body of the fluke through its gonopore into the intestine of the sheep. From the intestine capsules comes out along with faeces of the host. Further development of the embryo takesplace when the capsules come in contact with moisture.

3. Miracidium

Under favourable conditions the embryo in the capsule develops into a **miracidium larva** in 4-15 days. It hatches out and swims freely in the water film. Miracidium is a minute and richly ciliated larva. It is an oval larva with a broader anterior part and a narrow posterior part. In the middle of the anterior part, an **apical papilla** or terebratorium is present. Body of the miracidium is covered by 21 ciliated **epidermal cells** which are arranged in five tiers. Below the epidermis, there is a fine layer of muscles (formed by outer circular and inner longitudinal muscle fibres).

Opening on the tip of of the apical papilla, there is an **apical gland**. A pair of **penetration glands** or cephalic glands is present one on each side of the apical gland. They also open on the apical papilla. Below the second row of the epidermal cells, brain is present. Associated with the brain nerve fibres are present. Two crescentic pigmented cells or **eye spots** are present. They are visible below the second tier of epidermal cell. A pair of protonephridia or flame cells is present and they open out through a pair of excretory pores. In the posterior half of the body, laterally, germ cells lie in groups (=germ balls).

Miracidium can live for about 24 hrs. It does not feed. If it comes in contact with suitable intermediate host (snails of the genera *Limnaea*, *Bulinus*, *Planorbis* etc), the larva is attached to it and penetrates into its body with the help of flesh dissolving larval secretions. During peneration, it lost its ciliated epidermis. In about 14 days, the miracidium reaches the digestive gland of the snail and develops into a **sporocyst** .

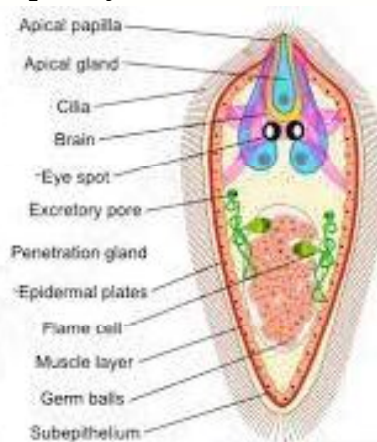


Fig 3.1.5.a. Miracidium

4. Sporocyst

Sporocyst is an elongated sac like larva. In place of ciliated epidermis of miracidium (which is lost during penetration), sporocyst is covered by **cuticle**. Apical papilla, apical gland, penetration glands, brain, eye spots etc., will disappear. Each protonephridium divides into two flame cells and opens out through an excretory pore. Sporocyst absorb nutrients from the host tissues. The germ balls develop into next stage larvae called **rediae**. Each sporocyst can produce about 5 - 8 rediae

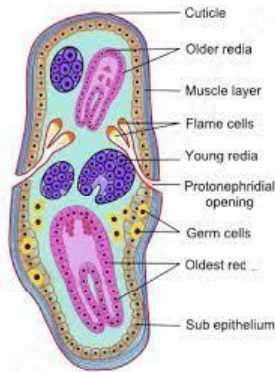


Fig 3.1.5.b. Sporocyst

5. Redia

Redia larvae are released by the rupture of the body wall of sporocyst. Redia is an elongated and cylindrical larva having a mouth at the anterior end. Near the anterior part, redia has a muscular **collar**. Behind the collar, there is a **birth pore**. In the posterior part, towards ventrolateral parts, there is pair of projections called **procruscula** or lappets. Mouth opens into a short, muscular pharynx. Pharynx is continued as a sac like **intestine**, which is lined by a single layer of cells. Opening into the pharynx, there are numerous pharyngeal glands. Protonephridia on each side divide further and form branched system. All the flame cells of each side opens into a common excretory duct. It opens out through a common pore. Inside the redia, germ balls and mesenchyme are present. During summer, the germ balls of redia develop into second generation of redia, which comes out through the birth pore (**polyembryony**). During winter, germ balls develop into the next stage larvae called **cercariae**. Each redia can produce 14-20 cercariae and they come out through the birth pore.

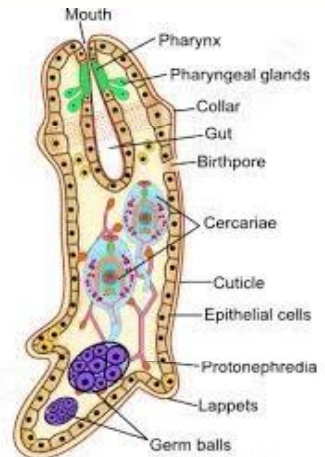


Fig 3.1.5.c. Redia

6. Cercaria

Cercaria larva has almost oval body and a long tail. Body wall is similar to that of sporocyst. On the surface, cercaria has backwardly directed spines. Beneath the body wall of cercaria, there are numerous **cystogenous gland** cells. In the anterior part mouth is present. Mouth is surrounded by an oral sucker. Behind the oral sucker, ventrally there is an acetabulum. Mouth opens into a muscular pharynx. It opens into the intestine, which is divided into two branches. Number of flame cells increase. Flame cells of each side open into excretory tubules. These tubules unite at the base of tail and form an **excretory vesicle**. An excretory duct arises from the vesicle, extends into the tail, divides into two branches and opens out through a pair of excretory pores. Germ cells present in the body represent the rudiments of adult reproductive system.

Fully grown cercariae reach the pulmonary sac of the snail and from where, they escape to the surroundings. Cercaria swims about in the surrounding moisture and crawl about on the leaves of grass. (grass blades). After 2-3 days of active life, the cercaria is attached to the grass blades and loses its tail. The cystogenous gland cells secrete a thick and white cyst around the cercaria. This encysted cercaria is now called metacercaria.

7. Metacercaria

Metacercaria is spherical in shape and is also called **marita**. Cystogenous gland cells disappear. The excretory bladder directly opens out through a single pore. Cyst provides protection.

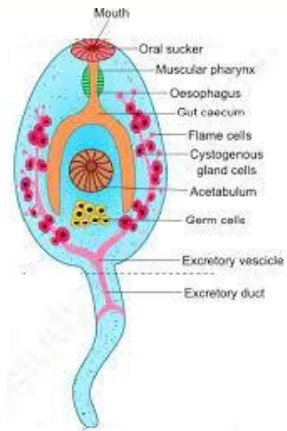


Fig 3.1.5.d. Cercaria

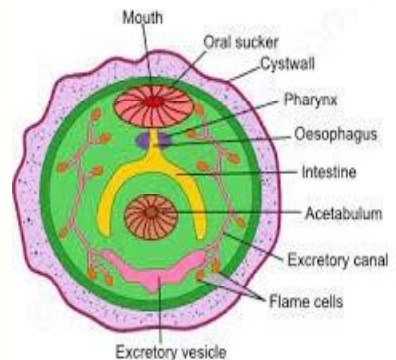


Fig. 3.1.5.e. Metacercaria

8. Infection to the sheep (i.e., primary host)

When the sheep consumes the leaves and grass blades to which metacercariae are attached, the metacercaria reach the anterior part of the intestine of the sheep. In the intestine the cyst dissolves. Then the embryo penetrates through the intestinal wall, reach the coelom and then liver. In liver it feeds on the surrounding tissues and grow. Finally it reach the bile duct and attain sexual maturity.

3. 1. 3. 4. Pathogenicity

The disease caused by *Fasciola hepatica* in sheep is known as **liver rot** or **fascioliasis**.

1. In bile duct and hepatic ducts it causes inflammation and hepatitis resulting in thickening of the wall of the bile duct and then calcification resulting in the formation of calculi.
2. In severe infection, liver flukes upset the normal metabolism of the liver due to haemorrhage caused by the spines on its body.
3. The main symptoms of fascioliasis are loss of appetite, irregular rumination, fever, increased breathing rate, cornea becomes whitish yellow, falling of hair (wool) etc. Other symptoms are oedema of jaws, great reduction in breeding and lactation. Due to all these changes, the sheep generally will die.
4. Infection of *Fasciola hepatica* causes large scale death of sheep every year.

CHAPTER - 2

NEMATHELMINTHES

Formerly the taxa containing pseudocoelomates such as Gastrotricha, Kinorhyncha, Rotifera, Nematoda and Nematonorpha were included in a taxon called Nematelminthes or Aschelminthes. Round worms were included in Nematoda (Gr. nema-thread, eidos - form). Nematoda is one of the largest groups of Metazoa and the nematodes are triploblastic animals with a pseudocoelomate bauplan.

3. 2. 1 General Characters of Nematoda

1. Majority of nematodes are parasitic. Free living forms inhabit marine, fresh water or terrestrial habitats.
2. Parasitic nematodes are much larger, where as, most of the free living nematodes are microscopic.
3. Body is long, cylindrical and unsegmented
4. Nematodes are triploblastic, bilaterally symmetrical animals with organ-system grade organisation.
5. Body cavity is **pseudocoelom** (It is not lined by mesodermal peritoneum internally). It is filled with pseudocoelomic fluid that acts as hydraulic skeleton and also helps in circulation.
6. Body is covered by cuticle. Below the cuticle there is **syncitial epidermis**. It is followed by a layer of longitudinal muscles (circular muscles are absent).
7. Alimentary canal is a straight tube with mouth and anus/cloaca. Digestion is intracellular and extracellular.
8. Specialised respiratory and circulatory systems are absent.
9. Excretory system consists of excretory glands, H-shaped excretory canals or both
10. Nervous system is intraepithelial in the epidermis and in the wall of gut. There is a circum pharyngeal nerve ring, from which nerves are formed anteriorly and posteriorly.

చాప్టర్ - 2 : వర్గం - నిమాట్ హెల్మింథిస్

సాధారణ లక్షణాలు, వర్గీకరణ :

ఏలిక పాములను నెమటోడా (నిమాట్ హెల్మింథిస్) (నీమా-దారం, ఎడియాన్-రూపం) వర్గంలో చేర్చారు. ఇవి త్రిస్తరిత మిథ్యాసీలోమేట్లు, వీటిలో అధిక భాగం పరాన్నజీవులు. కొన్ని స్వతంత్ర జీవనం గడుపుతూ ఉంటాయి. దేహాన్ని ఆవరించి క్యూటికిల్, దానికింద సిన్సీషియన్ స్థితిలో ఉన్న బాహ్యచర్మం, ఆయత కండరాలు ఉంటాయి. నోరు, పాయువుతో కూడిన తిన్నని ఆంత్రనాళం ఉంటుంది. విసర్జక వ్యవస్థలో H ఆకారపునాళాలు ఉంటాయి. ఏంఫిడ్లు, ఫాస్మిడ్లు అనే జ్ఞానాంగాలు ఉంటాయి. ఇవి ఏకలింగజీవులు. లైంగిక ద్వీరూపకత వ్యక్తం చేస్తాయి.

ప్రాథమికజీవితోని కణాలసంఖ్య స్థిరంగా ఉంటుంది. ఈ దృగ్విషయాన్ని యూటెలీ అంటారు.

నిమాట్ హెల్మింథిస్ వర్గాన్ని రెండు విభాగాలుగా విభజించారు. అవి ఏఫాస్మీడియా, ఫాస్మీడియా.

ఆస్కారిస్ లుంబ్రికాయిడిస్ :

ఆస్కారిస్ను సాధారణ ఏలికపాము అంటారు. ఇది మానవుని ప్రేగులో నివశించే సీలో జోయిక్ పరాన్నజీవి. దీని దేహం పొడవుగా (స్త్రీజీవి 40 సెం.మీ. పురుషజీవి 20 సెం.మీ.), స్థూపాకారంగా, ఇరువైపులా మునదేలి ఉంటుంది. పూర్వభాగంలో నోరు, దానిని ఆవరించి చిన్న చిన్న దంతాలతో కూడిన మూడు పెదవులు ఉంటాయి. ఉదరపార్శ్వ పెదవులపై ఏంఫిడ్లు (రసాయన గ్రాహకాలు) ఉంటాయి. స్త్రీజీవి పరభాగం తిన్నగాను, పురుషజీవి పరాంతం కొకీవలే వంపు తిరిగి ఉంటాయి. స్త్రీ జీవి పరభాగంలో పాయువు, పురుషజీవి పరభాగంలో అవస్కర రంధ్రం ఉంటాయి. అవస్కరంలో ఒక జత సంవర్క కంటకాలు ఉంటాయి.

11. Sense organs include papillae, **amphids** and **phasmids**. Amphids are present in all nematodes and are located in the anterior part and are mechano and chemosensory. Phasmids are found in majority of nematodes and are located in the prosterior part. They may be chemosensory, secretory or excretory.
12. Nematodes are unisexual animals. Most of them exhibit **sexual dimorphism**. Fertilisation is internal.
13. Nematodes exhibit **eutely**. It is a phenomenon in which cell divisions (except in gonads) cease near the end of embryonic development. Hence the number of cells in adult is constant and is characteristic of each species. Growth is due to increase in cell size rather than cell number.
14. Development is usually indirect.
e.g., *Ascaris*, *Wuchereria*, *Trichinella*

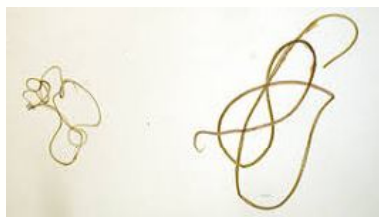


Fig 3. 2. 1 *Wuchereria* male and female



Fig 3. 2. 1 *Trichinella*

3. 2. 2. Classification of Nematoda

Nematoda is divided into two classes, namely Aphasmidia and Phasmidia

Class 1. Aphasmidia or Adenophorea

1. These are mainly free living forms. Few forms are parasitic
2. Amphids are present and are with various shapes
3. Phasmids are absent
4. Excretory system is poorly developed.
e.g., *Greeffia* (free living), *Trichinella* (Parasitic)

Class 2. Phasmidia or Secernentea

1. These are mainly parasitic forms. Few forms are free living.
2. Amphids are pore like.
3. Phasmids are present.
4. Excretory system is well developed.
e.g., *Ascaris*, *Enterobius*, *Ancylostoma*, *Wuchereria*

దేహాన్ని ఆవరించి అవభాసిని, దాని కింద సిన్సీషియల్ బాహ్య చర్మం, దానికింద ఆయత కండరాలు ఉంటాయి. దేహకుడ్య పార్శ్వభాగాలలో విసర్జక కుల్మలు, పుష్ట ఉదర భాగాలలో నాడీదండాలు విస్తరించి ఉంటాయి. దేహకుహరం మిథ్యాసీలోం. నోరు, గ్రసని, ప్రేగు, పురీషనాళం, పాయవు/అవస్కరంతో కూడిన తిన్నని ఆహారనాళం ఉంటుంది. ఇది మామూలుగా అవాయు శ్వాసక్రియ, ఆక్సిజన్ లభించినపుడు వాయుసహిత శ్వాసక్రియ జరుపుకొంటుంది. విసర్జక వ్యవస్థలో H ఆకారపు నాళాలు ఉంటాయి. పురుషజీవిలో ఒక ముష్ఠం, స్త్రీజీవిలో రెండు స్త్రీబీజకోశాలు ఉంటాయి.

ఆస్కారిస్ జీవిత చరిత్ర :

మానవుని చిన్న ప్రేగులో సంపర్కం జరుగుతుంది. అంతరఫలదీకరణం జరుగుతుంది. ఫలదీకరణానంతరం సంయుక్త బీజం చుట్టూ ఖైలినస్ కర్పరం, దాని కింద లిపిడ్లు పలుచని పొరను ఏర్పరుస్తాయి. గర్భాశయం ద్వారా జారేటపుడు గ్రుడ్లు కర్పరం పై ఉబ్బెత్తులతో ఆల్బుమిన్ పొర ఏర్పడుతుంది. రోజుకు 2 లక్షల గ్రుడ్ల చొప్పున పరిణత చెందిన స్త్రీ జీవినుండి 27 మిలియన్ల గ్రుడ్లు విడుదలవుతాయి. అవి మానవ మలం ద్వారా బయటకు విడుదలవుతాయి. అనుకూల పరిస్థితులలో గ్రుడ్లలోని సంయుక్త బీజం అభివృద్ధి చెంది రాబ్డయిటీఫారం లార్వాగా ఎదుగుతుంది. (మొదటి దశ లార్వా) ఇది గ్రుడ్లలో మొదటిసారి నిర్మోచనం చెంది రెండవ దశ లార్వాగా మారుతుంది. సాంక్రమిక ఆహారం, నీరు ద్వారా రెండవ దశ లార్వాలున్న గ్రుడ్లు మానవుని ప్రేగును చేరతాయి. అక్కడ కర్పరం కరిగిపోతుంది. రెండవ దశ లార్వా ప్రేగును చీల్చుకొని రక్తం ద్వారా దేహంలోని వివిధ భాగాల ద్వారా బాహ్యంత్ర ప్రవాసం జరిపి తిరిగి ప్రేగును చేరి ప్రొడజీవిగా మారుతుంది. బాహ్యంత్ర ప్రవాసమార్గం - ప్రేగు - కాలేయ నిర్వాహకసీర - కాలేయం - కాలేయ సిరలు - పరమహాసీర - గుండె - పుపున ధమనులు - ఊపిరితిత్తుల వాయుగోణులు - శ్వాస నాళాలు - వాయు నాళం - కంఠబిలం - గ్రసని - ఆహారవాహిక - జీర్ణాశయం - ప్రేగు

ఆస్కారిస్ వ్యాధికారకత :

ఏలికపాములవల్ల కలిగే వ్యాధిని ఆస్కారియాసిస్ అంటారు. ప్రేగులో సంక్రమణ తక్కువగా ఉన్నప్పుడు రోగ లక్షణాలు వ్యక్తం కావు. ప్రేగులో ఏలికపాములు ఎక్కువగా ఉన్నప్పుడు ఆహార ప్రవాహ మార్గానికి ఆడ్డుపడి, కోలిక్ నొప్పులు, కడుపునొప్పి, వాంతులు, పోషణ లోపాలు కలుగుతాయి. లార్వాలు ప్రేగు గోడ, వాయు గోణులతో రక్తస్రావాన్ని కలుగజేస్తాయి. ఊపిరితిత్తులలో లార్వాలు అధికంగా ఉన్నప్పుడు స్యుమోనియా లక్షణాలు సంభవిస్తాయి. ఆస్కారిస్ విడుదల చేసే రసాయనాలు పీయుష గ్రంథి నుండి పెరుగుదల హార్మోను స్రావాన్ని నిరోధించడం వల్ల పిల్లలో పెరుగుదల మందగిస్తుందని భావించబడుతోంది.

3. 2. 3. *Ascaris lumbricoides*

3. 2. 3. 1. Systematic position

Phylum	- Nematoda
Class	- Phasmodia
Order	- Ascaroidea
Family	- Ascaridae
Genus	- <i>Ascais</i>
Species	- <i>lumbricoides</i>

3. 2. 3. 2. Morphology

Ascaris lumbricoides is commonly called **common round worm**. It is one of the most common endoparasites of man. *Ascaris* is a coelozoic enteric parasite found in small intestine of man, particularly in children. It is cosmopoliton in distribution. Body of *Ascaris* is long (females upto 40 cm and males upto 20 cm), cylindrical and unsegmented with pointed ends. It is light pink or light yellow in colour. Along the lenth of the body, there are four lines (one dosal, one ventral and two lateral). In the anterior end of the body, mouth in present. It is surrounded by there lips - one is dorsal and the two are ventro-lateral. Lips have minute denticles. Outer surface of each lip bears minute sensory papillae. Near the papillae of each lateral lip is an **amphid**. Papillae are tangoreceptors and amphids are believed to be the chemoreceptors.



Fig 3. 2. 3. *Ascaris* male and female

The posterior end of female is straight and that of male is curved like a hooke. In the posterior end of female, there is an **anus** on the mid ventral side. In the posterior part of male, **cloacal aperture** is present, which is a common opening for digestive system (i.e., anus) and male genital ducts. Cloaca contains a pair of chitinous pineal satae, which help in copulation. **Phasmids** are chemoreceptory unicellualr glands present one on each side of the tail

Body wall consists of outer thick, tough, transparent **cuticle**, followed by **syncitial epidermis** and longitudinal muscles. Along the lateral lines, the lateral excretory canals and along the dorsal and ventral lines, nerve cords extend. Body cavity is **pseudocoelom**. It is the persistant embryonic blastocoel. There is a complete and straight alimentary canal with mouth, pharynx, intestine, rectum and anus/cloaca. *Ascaris* respire mainly by anaerobic mode. It is belived that is can respire aerobically whenever free oxygen is available in the intestine of the host. Excretory system is in the form of H - shaped tubes. There in an excretory pore on the midventral side little behind the anterior lip. Male *Ascaris* has a single testis and female has two ovaries. Sperms are amoeboid and ova are elliptical.

Sexual dimorphism in *Ascaris*

Male <i>Ascaris</i>	Female <i>Ascaris</i>
1. Male is (10 cm to 20 cm) shorter than female. Diameter is about 2 mm to 4 mm	1. Female (20 cm to 40 cm) is longer than male. Diameter is 4 mm to 6 mm
2. Posterior end is curved like a hooke	2. Posterior end is straight
3. In the posterior part, cloacal aperture is present. (common for digestive and reproductive system)	3. In the posterior part, anus is present. Little above the middle part of the body, female genital aperture is present.
4. Protruding out from the cloaca, there is a pair of pineal setae.	4. Pineal setae are absent.

3. 2. 3. 3. Life cycle of *Ascaris*

Copulation takesplace in the small intestine of man. Fertilisation is internal. The ovum contains glycogen and lipid globules. After fertilisation, glycogen form a chitinous shell around the egg. Then lipid globules formed into thin layer beneath the shell. When the egg passes through the uterus, the cells of uterine wall form an yellowish brown albuminous coat with rippled surface around the shell. Hence the eggs are descibed as **mamillated eggs**.

1. Eggs

In *Ascaris*, the uteri of a mature female contains about 27 million eggs, with an average production of around 2 lakhs eggs per day. These eggs pass out through the faeces of man. Under favourable conditions the zygote in the egg develops into a larva which resembles the nematode *Rhabditis*. Hence it is called **rhabditiform larva** (First stage). Rhabditiform larva (first stage) undergo **first moulting** in the egg and become **second stage_rhabditiform larva**. It is capable of infecting a new host. Under favourable conditions, the embryonated eggs of *Ascaris* are known to be viable in the soil for about six years.

2. Infection

The eggs of *Ascaris* containing second stage rhabditiform larva reach the small intestine through contaminated food and water. As the eggs are minute and light, they reach human food or water by wind. Insects like house flies also transfer the eggs from faeces to food. In the small intestine, due to the action of digestive enzymes, the egg shell is dissolved and the second stage rhabditiform larva is released.

3. Extra Intestinal Migration

The second stage rhabditiform larva penetrates through the wall of human small intestine, enters the hepatic portal circulation (hepatic portal vein) and reaches the liver. From the liver, it enters the post caval vein through hepatic veins and reach the heart. From the heart, the larva reaches the alveoli of lungs through pulmonary arteries. In alveoli, the larva remains for about 10 days. After 6th day, the second stage rhabditiform larva undergo second moulting and become third stage larva. After four days, the third stage larva undergo third moulting and becomes fourth stage larva. The fourth stage rhabditiform larva leaves the alveoli of lungs and reach the pharynx through bronchi, trachea, larynx and glottis. From the pharynx, the fourth stage larva reaches the small intestine through oesophagus and stomach. In the small intestine, the fourth stage larva undergoes fourth moulting and becomes a young worm. It gradually becomes an adult. The journey performed by the rhabditiform larva of *Ascaris* through various organs of man is known as **extra intestinal migration**.

GLOSSARY

- Acoelomates : The animals in which the space between body wall and gut is filled with parenchyma. Animals without body cavity. e.g., flatworms.
- Amphids : Mechano and chemoreceptors present in the anterior part of nematodes
- Eutely : Cease of cell divisions (except in gonads) near the end of embryonic development.
- Flame cells : A specialised excretory cells found in flat worms. Their primary function in flatworms is osmoregulation.
- Liver rot : Disease caused by *Fasciola* in sheep.
- Mamillated eggs : The eggs with rippled surface.
- Miracidium : Minute ciliated first larval form of *Fasciola*.
- Phasmids : Chemosensory, secretory or excretory structures found in the posterior part of majority of nematodes.
- Polyembryony : Production of same young stages (i.e., larvae) by an young stage (i.e., larva).
- Redia : Larva of *Fasciola* formed from sporocyst in the body of snail.
- Rhabdites : Rod like inclusions formed in epidermal cells of turbellarians.
- Strobila : Part of the body of tape worms excluding scolex and neck. It is divided into segments called proglottids.
- Syncytium : Multinucleate mass of cytoplasm resulting from fusion of cells.

INTERACTIVE LINKS / ONLINE RESOURCES

- * https://www.online_biologynotes.com/phylum-platyhelminthes-general-characteristics-clasification/
- * <https://www.biologydiscussion.com/invertebrate-zoology/platyhelminthes-characters.and-clasification/28930>
- * <https://youtu.be/4cTdYfirBcM>
- * <https://youtu.be/wMMzjUpalE>
- * <https://youtu.be/Yy-SeHxjOjE>
- * <https://youtu.be/k17RxaCrWAc>
- * <https://youtu.be/K-J9DLnCFYM>

CURRICULAR ACTIVITIES

I. Class room seminars

1. General characters and classification of Platyhelminthes.
2. Life history of *Fasciola*.
3. General characters and classification of Nematoda.
4. Life history of *Ascaris*.

II. Group discussion

1. Life history of *Fasciola*
2. Life history of *Ascaris*

III. Field work

1. Visit a nearby Veterinary Hospital and collect the data regarding the cases of sheep suffering from the infection of *Fasciola* and try to learn the symptoms of the disease in live.
2. Visit a nearby clinical laboratory and observe a sample of stools containing eggs of *Ascaris*

IV. SELF ASSESSEMENT

A. Choose the correct Answer

1. Bilaterally symmetrical and triploblastic acoelomates are included in
 1. Nematoda
 2. Nematelminthes
 3. Platyhelminthes
 4. Rotifera
2. Primary function of flame cells is
 1. Excretion
 2. Respiration
 3. Egestion
 4. Osmoregulation
3. Match the following :

List - 1

- A. *Duegia*
B. *Schistosoma*
C. *Taenia*
D. *Ascaris*

List - 2

- I. Nematoda
II. Cestoda
III. Turbellaria
IV. Trmatoda

- | | A. | B. | C. | D. |
|----|-----|-----|----|-----|
| 1. | III | II | IV | I |
| 2. | III | IV | II | I |
| 3. | I | II | IV | III |
| 4. | IV | III | I | II |

4. The following are the different larvae formed during the development of *Fasciola hepatica*
- A. Redia B. Metacercaria C. Sporocyst
D. Miracidium E. Cercaria
- Arrange them in correct sequence.
1. D, C, A, E, B 2. D, C, E, A, B
 3. B, E, A, C, D 4. A, D, C, B, E
5. Polyembryony is seen in
1. Miracidium 2. Sporocyst
 3. Cercaria 4. Redia
6. Bilaterally symmetrical and triploblastic pseudocoelomates belong to
1. Platyhelminthes 2. Trematoda
 3. Nematoda 4. Cestoda
7. Statement I : Male *Ascaris* is longer than the female *Ascaris*
Statement II : Posterior end of male *Ascaris* is curved like a hook, where it has a cloacal aperture
1. Both statements I and II are correct
 2. Both statements I and II are wrong
 3. Statement I is correct, but statement II is wrong
 4. Statement I is wrong, but statement II is correct
8. During the development of *Ascaris*, third moulting of rhabditiform larva takes place in
1. Egg when it is outside the body
 2. The alveoli of lungs of man
 3. The liver of man
 4. The intestine of man
9. Assertion (A) : Due to *Ascaris* infection stunted growth is observed in children
Reason (R) : Chemicals released by *Ascaris* inhibit the secretion of growth hormone by pituitary
1. Both A and R are true R is correct explanation for A
 2. Both A and R are true R is not correct explanation for A
 3. A is true But R is false
 4. A is false. But R is true

10. Extra intestinal migration is exhibited by
 1. *Ascaris lumbricoides*
 2. *Micorfilaria*
 3. *Wuchereria bancrofti*
 4. Rhabditiform larva

B. Fill in the blanks

1. Platyhelminths are commonly called _____
2. _____ is an unisexual trematode
3. In the life history of turbellarians _____ larva is formed
4. Flukes are included in class _____ of Platyhelminthes
5. Suckers present in *Fasciola* are _____ and _____
6. Larva emerged from the egg of *Fasciola* is _____
7. _____ is the tailed larva in the life cycle of *Fasciola*
8. Disease caused by the *Fasciola* in sheep is _____
9. Primary host of *Fasciola* is _____ and intermediate host is _____
10. Flat worms without digestive system are included in the class _____
11. Body cavity found in nematodes is _____
12. Mechano and chemoreceptors present in the anterior part of nematodes are known as _____
13. *Trichinella* belongs to the class _____ of Nematoda
14. Cloaca, curved tail, pineal setae are characteristic of _____ *Ascaris*
15. Epidermis of *Ascaris* is in _____ state
16. Muscles present in the body wall of *Ascaris* are _____ muscles.
17. Total number of moults that take place during development of *Ascaris* is _____
18. Cease of cell divisions near the end of embryonic development in nematodes is called _____
19. Disease caused by common round worm in man _____
20. Number of lips encircling the mouth in *Ascaris* is _____

C. Short Answer Questions :

1. Why Platyhelminths are called flat worms and acoelmates ?
2. What are the primary and secondary functions of flame cells in *Fasciola*?
3. Name the larva formed in *Fasciola*
4. Which larva of *Fasciola* exhibits polyembryony ?
5. Name the suckers of *Fasciola*
6. Which class of Platyhelminthes include the tapeworms ?
7. Name the body cavities of flat worms and round worms ?
8. Explain sexual dimorphism in *Ascaris*
9. Sketch the route of extra intestinal migration
10. What is meant by eutely ?

FOR IGNITED MINDS

Chapter 1

1. Planarians have great powers of regeneration. Linear polarity is maintained due to metabolic gradient. It means in the anterior part metabolic activity is more and gradually decreases towards posterior side. If a planarian is cut into any number of pieces, anterior end of each piece has more metabolic activity and it develops into anterior part of the body.
2. *Schistosoma haematobium* is commonly called **human blood fluke**, which is unisexual flat worm and exhibits sexual dimorphism.
3. *Opisthorchins sinensis* is the human liver fluke. It completes its life cycle in three hosts - man (primary host), snail and fresh water fish (intermediate hosts)
4. *Diphyllobothrium latum* is the longest and most dangerous tapeworm, whereas *Hymenolepis nana* is the dwarf tape worm (2 to 4.5 cm long)
5. Parasitic forms have well developed reproductive system
6. Due to *Fasciola hepatica* number of cells is increased in the wall of bile duct and the phenomenon is called **hyperplasia**
7. Due to larvae of *Fasciola* the size of the host (snail) increased. This phenomenon is called **gigantism**.

Chapter 2

1. *Wuchereria bancrofti* is the filarial worm. It is an ovoviviparous form. Its larva microfilaria exhibits nocturnal periodicity.
2. *Ancylostoma duodenale* is the hookworm found in the intestine of man and is infected when man walks on contaminated soil barefooted. It causes severe anaemia because it sucks the blood from the wall of intestine.
3. Intestinal nematode parasites secrete **antienzymes** to neutralise the enzymes of the host.
4. Rarely the Rhabditiform larva of *Ascaris* fails to follow the usual route of extra intestinal migration and reaches the brain, spinal cord etc (where they die and are enclosed by calcareous cysts). This is called **aberrant migration**.

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FOR IGNITED MINDS

1. Fitness of an individual organism to its environment is known as **adaptation**. As the parasitic helminths live in a very specialised environment, they undergo various modifications to live successfully in it. These modifications are called **parasitic adaptations**. They are classified into two types, viz., morphological and physiological.

A. Morphological adaptations

- a. Body covering of thick tegument or enzyme resistant cuticle
- b. Hooks, suckers or both for attachment to host tissues.
- c. Degeneration of nervous system and sensory structures
- d. Well developed reproductive system

B. Physiological adaptations

- a. Secretion of antienzymes by the gut parasites
- b. Anaerobic respiration
- c. Osmoregulation
- d. Production of vast quantity of eggs

2. Majority of helminths are parasites. Some of them are human parasites and cause various diseases. Some of them are as follows:

- a. *Opisthorchis sinensis* - Chinese liver fluke
- b. *Schistosoma haematobium*- Blood fluke
- c. *Paragonimus westermani* - Lung fluke
- d. *Taenia solium* - Pork tape worm
- e. *Taenia saginata* - Beef tape worm
- f. *Diphyllobothrium latum* - Fish tape worm
- g. *Hymenolepis nana* - Dwarf tape worm
- h. *Echinococcus granulosus* - Dog tape worm
- i. *Ascaris lumbricoides* - Ascariasis
- j. *Wuchereria bancrofti* - Filarial worm
- k. *Ancylostoma duodenale* - Hooke worm
- l. *Dracanculus medinensis* - Guinea worm
- m. *Loa loa* - African eye worm

4.1. Phylum Annelida

General Characters and classification

Learning Objectives:

To Describe the morphological and anatomical features of annelids.

To Understand about true segmentation or metamerism.

To Understand the formation of Coelom.

To Know about different individuals in Annelida Phylum

To Understand the increasing complexity in the organ systems of animal kingdom.

Introduction

The annelids (Latin, annulus : little ring and Greek; edios; form) are also known as the **ringed worms** or **segmented worms**. Annelida is a large phylum, with nearly 22000 extant species including ragworms, earthworms and leeches. They may be aquatic (marine and freshwater) and terrestrial. Most of the Annelids are

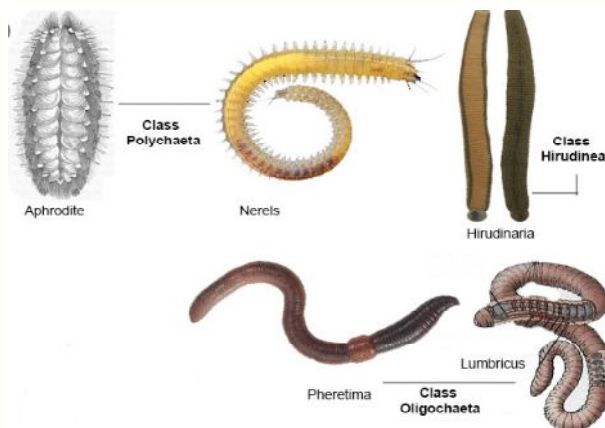


Fig.4.1.1 Annelidans

worm-like hence the early zoologists included other worms in the group of vermes. But in the year 1798 **Cuvier** separated Annelids from unsegmented worms of the vermes group. The term Annelida was coined by **Lamarck** in the year 1809.

General Characters :

1. Annelids are triploblastic, bilaterally symmetrical, coelomates and segmented metazoans.
2. They are mostly free living but leeches are **ectoparasitic**.

3. Mostly aquatic, some are terrestrial burrowing or tubicolous.
4. **Cephalization** is more pronounced with a distinct head, bearing tentacles, eyes and palps in Polychaetes. But the head is indistinct in earthworms and leeches.
5. The body is divided for the first time in the animal kingdom into metamerically arranged segments or **metameres**, which are separated from one another externally by intersegmental grooves and internally by intersegmental septa (septae are absent in leeches). In leeches segments are subdivided externally into annuli.
6. Body is divided into three regions i.e., prostomium, trunk and pygidium. The first segment is **peristomium** and the last segment is **pygidium**.
7. Growth results from the addition of new segments from the teloblastic growth zone located just in front of the pygidium is called **true metamerism**.
8. Body wall consists of cuticle, epidermis, dermis, musculature and parietal peritoneum. Body wall has both Longitudinal and circular muscles which helps in locomotion.

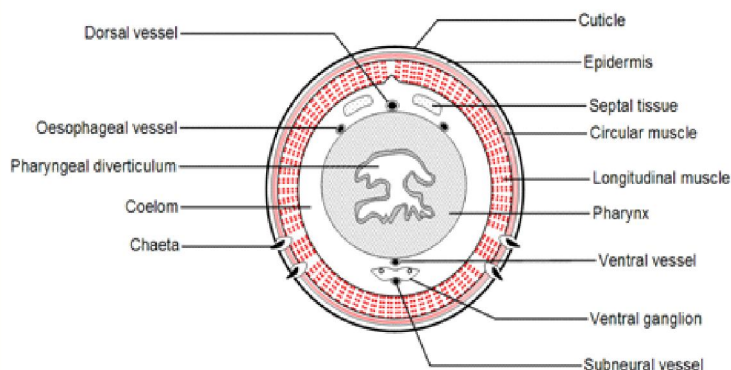


Fig.4.1.2 T.S of Earthworm body wall through pharynx

9. Locomotor organs are segmentally arranged **parapodia** with setae (Ex: olychaetes) or exclusively **setae** (Ex : Earthworms) or **Suckers** (Ex : leeches).

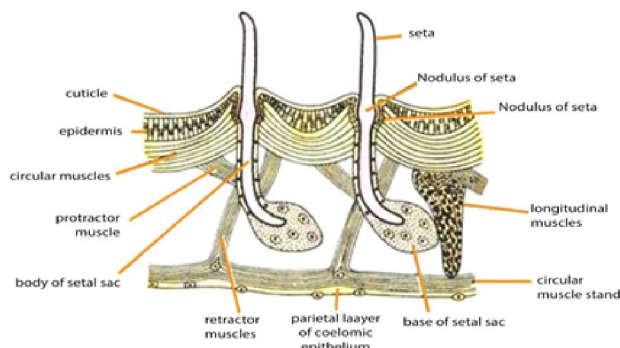


Fig.4.1.3 Setae of Earthworm

వర్గం - అనెలిడా

4.1. అనెలిడా సామాన్య లక్షణాలు - వర్గీకరణ

పరిచయం :

అనెలిడా (లాటిన్ భాషలో అన్యులస్ అంటే వలయాలు అని గ్రీకు భాషలో ఇడియాస్ అనగా రూపం అని అర్థం) జీవులనే వలయాలు గల జీవులు లేదా ఖండిత జీవులు అంటారు. అనెలిడా వర్గంలో ప్రస్తుతం 9000 జాతులు జీవిస్తూ ఉన్నాయి అవి రాగ్ వర్మలు, వానపాములు మరియు జలగలు. ఇవి కొన్ని జలచర జీవులు (మంచినీరు మరియు సముద్రపు నీరు) మరికొన్ని భూచరజీవులు. అనేక అనెలిడా జీవులు పురుగులు వలె ఉంటాయి కనుక పూర్వం జంతు శాస్త్రవేత్తలు వీటిని ఇతర పురుగులతో కలిపి వెర్మిస్ అనే సమూహంలో చేర్చారు. కాని క్యువియర్ 1798 సంవత్సరం లో అనెలిడా జీవులను వెర్మిస్ సమూహంలో గల ఇతర ఖండితరహిత జీవుల నుండి వేరు చేసెను. అనెలిడా అనే పదాన్ని 1809 సంవత్సరంలో లామార్క్ ప్రతిపాదించెను.

సామాన్య లక్షణాలు :

- ❖ అనెలిడా జీవులు త్రిస్తరిత జీవులు, ద్విపార్శ్వ సౌష్ఠవం కలిగిన శరీరకుహర జీవులు మరియు ఖండితాలు కలిగిన మెటాజోవన్లు.
- ❖ ఇవి అనేకం స్వేచ్ఛజీవులు కానీ జలగలు బాహ్యపరాన్నజీవులు.
- ❖ అనేక జీవులు జలచరజీవులు. కొన్ని భూచరజీవులు మరికొన్ని బొరియలు, గొట్టాలలో నివశించును.
- ❖ పాలీకీట్స్ లో శీర్షత (Cephalization) నిర్దిష్టమైనతల, స్పర్శకాలు, నేత్రాలు మరియు పాల్ప్స్ తో నిర్దిష్టంగా ఉంటుంది. కాని ఆలిగోకీటా మరియు జలగలలో నిర్దిష్టమైన తల ఉండదు.
- ❖ శరీరం మొట్టమొదటిసారిగా ఖండితాలు లేదా మెటామియర్స్ గా విభజించబడి ఉంటుంది. ఈ ఖండితాలను బాహ్యంగా వేరు చేస్తూ ఖండితాంతర గాడులు మరియు అంతరంగా వేరు చేస్తూ విభాజకాలు ఉంటాయి. (జలగలో విభాజకాలు లోపించును) జలగలలో ఖండితాలు బాహ్యంగా ఉపఖండితాలుగా విభజింపబడును.

10. Coelom is derived from splitting of mesoderm hence Annelids are **Eucoelomates** and **schizocoelomates**. Coelom is filled with fluid called coelomic fluid that acts as an hydrostatic skeleton and aids in locomotion. In Leeches coelom is reduced and confined only to gonads and haemocoelic ducts due the presence of **botryoidal tissue**, filling the entire coelom.

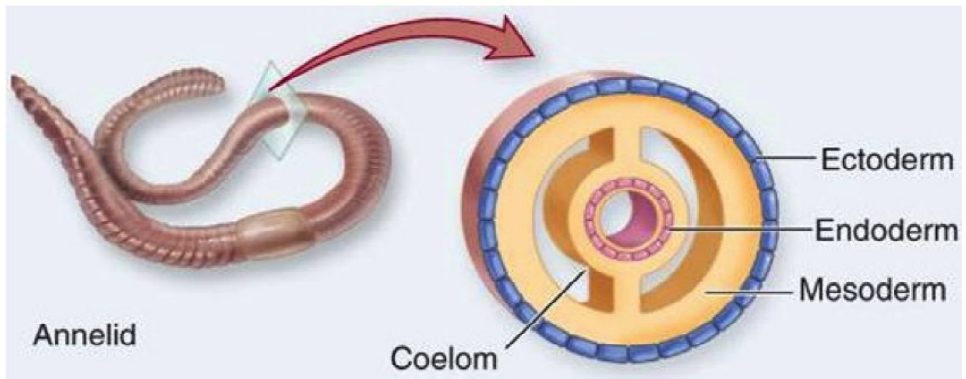


Fig.4.1.4 Coelom in Annelida

11. Alimentary canal is a straight muscular tube. Digestive glands occur in the wall of the alimentary canal. In polychaetes buccal cavity and pharynx are everted as **proboscis** to capture and ingest the prey.
12. Exchange of respiratory gasses takes place by diffusion through the body wall (In most of the annelids) called **cutaneous respiration**. In polychaetes **parapodia** are highly vascular and help in respiration.
13. A closed type blood vascular system appeared for the first time in annelids and **haemoglobin**, dissolved in blood plasma. **Chlorocruorin** (Green) is a respiratory pigment that occurs in **sabella** and **serpula**. Another Violet – pink respiratory pigment **hemerythrin** found in **siphunculata** organisms.
14. Excretory organs are segmentally arranged ectodermal **metanephridia**. Most of the Annelids are ammonotelic but earthworms are ureotelic. **chloragogen cells** that are accessory excretory organs in earthworms. **Botryoidal tissue** in leeches performs excretion for some extent.
15. Nervous system consists of a nerve ring and double ventral nerve cord. Nerve ring comprises a pair of **supra pharyngeal ganglia**, a pair of **circumpharyngeal connectives** and a pair of **subpharyngeal ganglia**. Suprapharyngeal ganglia are generally called the brain in annelids.

- ❖ శరీరం ప్రొస్టోమియం, మొండెం, పైజీడియం అనే మూడు ప్రాంతాలుగా విభజింపబడును. శరీరంలో మొదటి ఖండితం పెరిస్టోమియం గాను చివరి ఖండితాన్ని పైజీడియంగా పిలుస్తారు. కొత్త ఖండితాలు పైజీడియం ముందున్న టీలోబ్లాస్టిక్ పెరుగుదల ప్రాంతం నుండి ఏర్పడడం వలన పెరుగుదల జరుగుతుంది. కనుక దీనిని నిజఖండిభవనం అంటారు.
- ❖ సఖండితంగా అమరి ఉన్న శూకాలతో కూడిన పారాపోడియా (ఉదా : పాలీకిట్స్) లేదా కేవలం శూకాలు (ఉదా : వానపాములు) లేదా చూషకాలు (ఉదా : జలగలు) చలనాంగాలుగా ఉంటాయి.
- ❖ మధ్యస్థ చీలిక వలన శరీర కుహరం ఏర్పడుతుంది. కనుక అనెలిడా జీవులు నిజశరీర కుహర జీవులు మరియు విభక్త శరీరకుహర జీవులు.
- ❖ అనెలిడ్లలో మొట్టమొదటిసారిగా సంవృత రక్తప్రసరణ వ్యవస్థ ఏర్పడెను.
- ❖ బాహ్యశ్చర్మం నుండి ఏర్పడిన సఖండిత నెఫ్రీడియా విసర్జక అవయవాలు గా ఉంటాయి.
- ❖ అనెలిడాలో వివిధ విభాగాలు వేరువేరు జ్ఞానాంగాలను కలిగి ఉండును. పాలీకిట్టాలో రెండు జతల సరళనేత్రాలు, రెండు జతల స్పర్శకాలు మరియు ఒక జతపాల్పాలు ఉండును. వానపాము, జలగలలో సరళ గ్రాహకాలైన కాంతి గ్రాహకాలు మరియు అసిల్లే ఉండును.
- ❖ క్లెటెల్లెమ్ శాస్త్రతంగా (వానపాములలో) లేదా తాత్కాలికంగా (జలగలలో) ఉంటుంది. పాలీకిట్టా జీవులలో క్లెటెల్లెమ్ పూర్తిగా లోపించును.
- ❖ జలగలలో తప్ప మిగిలిన జీవులలో బాహ్యఫలదీకరణం జరుగును. పూర్ణభంజిత, సర్పిలవిదళనం జరుగును.
- ❖ వానపాము, జలగలలో ప్రత్యక్ష అభివృద్ధి ఉంటుంది. అయితే పాలీకిట్టా జీవులలో ట్రోకోపోర్ లార్వా ఉండి అప్రత్యక్ష అభివృద్ధి జరుగును.

ఉదాహరణ : నీరిస్, పెరిటిమా (వానపాము)

హైరుడినేరియా (జలగ)

అనెలిడా - వర్గీకరణ

అనెలిడా వర్గమును 3 విభాగాలుగా వర్గీకరించారు. అవి 1. పాలీకిట్టా 2. ఆలిగోకిట్టా 3. హైరుడినియా

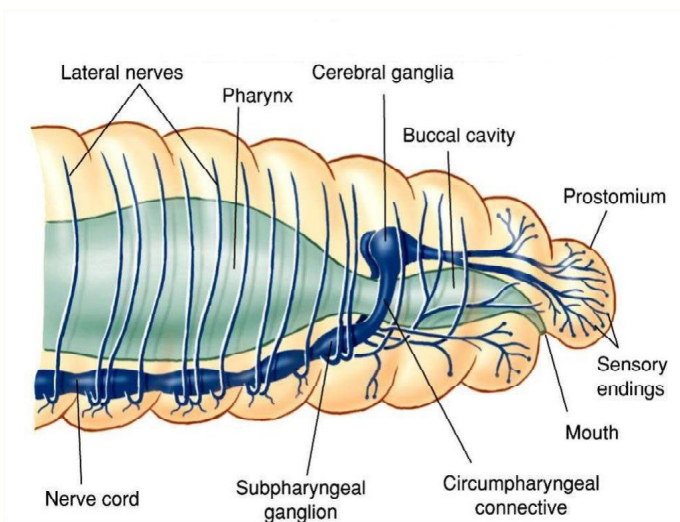


Fig.4.1.4 Annelidan Nervous System

16. In Annelids, different classes contain various sense organs. Polychaetes possess two pairs of **simple eyes**, two pairs of **tentacles** and a pair of **palps**. Earthworms and leeches possess simple receptors like **photoreceptors** and **ocelli**.
17. Reproduction is usually sexual. Polychaetes are dioecious (unisexual), Earthworms and leeches are monoecious (hermaphroditic or bisexual).
18. **Gonoducts** are absent in Polychaetes.
19. Clitellum is present either permanent (earthworms) or temporary (leeches). Clitellum is absent in Polychaetes.
20. Fertilization is external, except in leeches. Cleavage is **holoblastic and spiral**.
21. Development is direct in earthworms and leeches. Whereas indirect in Polychaetes includes a **Trochophore larva**.

Ex : *Nereis*, *Pheretima* (Earthworm), *Hirudinaria* (leech)

Classification of Annelida :

Phylum Annelida is classified into three classes 1. Polychaeta 2. Oligochaeta 3. Hirudinea

Class-1 : Polychaeta (Gr. Poly = many, chaite = setae)

These are commonly known as bristle worms.

All are marine.

They are free swimming, crawling, burrowing or living in tubes.

Segmentation internal and external.

Head is distinct with eyes, tentacles and Palps.

Clitellum is absent.

శరీరకుహరం :

జంతురాజ్యంలో కణజాలాలు ఏర్పడటం (నిడేరియా జీవులలో) మొదటి ముఖ్యమైన పరిణామదశ. ద్విపార్శ్వ సౌష్ఠవం (ప్లాటీహెల్మింథిన్ జీవులలో) ఏర్పడటం రెండవ ముఖ్యమైన పరిణామదశ. జీవి శరీర నిర్మాణంలో శరీర కుహరం ఏర్పడటం మూడవ ముఖ్యమైన పరిణామదశ. శరీరకుహరం శరీర కుడ్యానికి, అహరనాళానికి మధ్యగల ఖాళీ ప్రదేశం. త్రిస్తరిత శరీర కుడ్య జీవులను (వర్గం ప్లాటీహెల్మింథిన్, నిమటోడా, అనెలిడా, ఆర్థోపాడా, మొలస్కా, ఇఖైనోడర్మేటా, హెమికార్డేటా, కార్డేటా) 3 రకాలుగా వర్గీకరించవచ్చు. అవి : 1. ఎసిలోమేటా 2. సూడోసిలోమేటా 3. యూసిలోమేటా

శరీరకుహరం ఏర్పడే విధానాన్ని అనుసరించి యూసిలోమేట్లను రెండు రకాలుగా వర్గీకరించారు. అవి 1. షైజోసిలోమేట్స్ 2. ఎంటిరోసిలోమేట్స్

శరీరకుహరనాళాలు మరియు నెఫ్రీడియా

అనెలిడ్లలో కొన్ని నాళాల వంటి నిర్మాణాలు ఖండితాలలో వరుసగా పునరావృతమవుతాయి వీటినే సఖండిత అవయవాలు (సెగ్మెంటల్ ఆర్గాన్స్) అంటారు. ఈ నాళాలు, ప్రత్యుత్పత్తి మరియు విసర్జనక్రియలో తోడ్పడును. సఖండిత అవయవాలు ప్రాథమికంగా 3 రకాలు.

1. శరీరకుహరనాళాలు (మీసోడెర్మ్ నుండి ఏర్పడును)
2. వృక్కాలు (ఎక్టోడెర్మ్ నుండి ఏర్పడును) 3. నెఫ్రోమిక్సియా

వృక్కాలు - రకాలు

I. నెఫ్రోస్టోమ్స్ ఆధారంగా :

నెఫ్రోస్టోమ్ ఉండడం లేదా లేకపోవడాన్ని ఆధారంగా చేసుకొని వృక్కాలను రెండు రకాలుగా వర్గీకరించారు. అవి : 1. ప్రొటోనెఫ్రీడియా

2. మెటానెఫ్రీడియా.

II. నెఫ్రీడియా పరిమాణం, సంఖ్య ఆధారంగా

నెఫ్రీడియాల పరిమాణం, సంఖ్యను ఆధారంగా చేసుకొని నెఫ్రీడియాలను రెండు రకాలుగా వర్గీకరించారు. అవి 1. మైక్రోనెఫ్రీడియా (మీరోనెఫ్రీడియా) 2. మాక్రోనెఫ్రీడియా(హలోనెఫ్రీడియా).

Each segment has a pair of lateral outgrowths of the body wall called parapodia. **Parapodia** bear numerous chitinous setae. Parapodia help in locomotion and respiration.

Buccal cavity and pharynx are everted as **proboscis** to capture and ingest the prey.

Excretory organs are metanephridia.

They are dioecious. Gonoducts are absent. Gametes are shed into the coelom. They are passed out through nephridiopores of metanephridia or by the rupturing of the body wall.

Fertilization is external.

Development includes a **trochophore larva**.

Polychaeta class is divided into two subclasses according to the habit of organisms.

1. Sub Class :Errantia

Sub Class 2 :Sedentaria

Sub class 1 :Errantia

Free swimming, crawling,
Burrowing, or tube
dwelling.

Prostomium distinct with
Sensory structures.

Subclass 2 : Sedentaria

Sedentary and living in
burrows or tubes.

Prostomium is reduced.

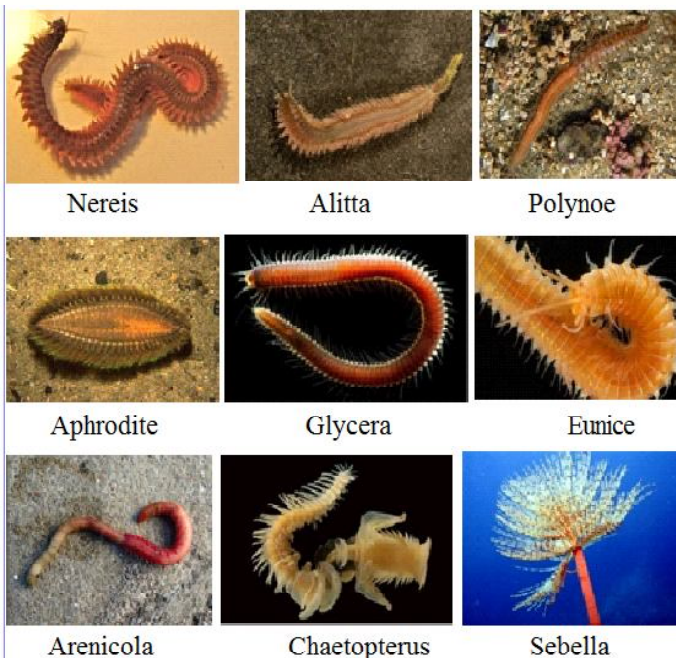


Fig. 4.1.5 Polychaeta Organisms

III. నెఫ్రీడియాలు తెరుచుకునే ప్రదేశం ఆధారంగా :

నెఫ్రీడియా శరీరకుడ్యం ద్వారా బయటకు తెరుచుకోవడం లేదా అహరనాళంలోనికి తెరుచుకోవడం ఆధారంగా వీటిని రెండు రకాలుగా వర్గీకరించారు. అవి 1. ఎక్సోనెఫ్రీడియా 2. ఎంటిరోనెఫ్రీడియా

III. నెఫ్రోమిక్సియా : కొన్ని పాలీకిట్లలో సీలోమోడక్ట్స్ పాక్షికంగా లేదా సంపూర్ణంగా నెఫ్రీడియాతో కలసి మిశ్రమ ఖండిత అవయవాలను ఏర్పరుస్తాయి. వీటినే నెఫ్రోమిక్సియా అంటారు. ఇవి బాహ్యత్వచం, అంతస్త్వచంను కలిగి ఉండి విసర్జన, బీజకణాలను బయటకు పంపడం లో తోడ్పడును. వృక్కాలు, సీలోమోడక్స్ తో కలిసే స్థాయిని ఆధారంగా చేసుకొని నెఫ్రోమిక్సియాను 4 రకాలుగా వర్గీకరించారు.

1. ప్రోటోనెఫ్రోమిక్సియం : సీలోమోడక్ట్స్, ప్రోటోనెఫ్రీడియాతో కలుస్తుంది. ఇది విసర్జన క్రియ మరియు బీజకణాలను బయటకు పంపడంలో తోడ్పడును. ఉదాహరణ : ఫిల్టోడోస్

2. మెటానెఫ్రోమిక్సియం : సీలోమోడక్ట్స్, మెటానెఫ్రీడియాలో కలుస్తుంది.

ఉదాహరణ : హిసియోస్

3. మిక్సోనెఫ్రీడియం : సీలోమోడక్ట్స్ మరియు నెఫ్రీడియా అంతరంగా కలిసిపోయి ఏర్పరిచే సరళ సమ్మిళిత అవయవమే మిక్సో నెఫ్రీడియం. దీని గరాటు వంటి నిర్మాణం శరీరకుహర నాళం ఏర్పరిస్తే దాని నాళం వృక్కం ఏర్పరుచును. ఉదాహరణ : అరెనికోలా

4. సీలియరీ ఆర్గాన్స్ : కొన్ని జీవులలో సీలోమోడక్ట్స్ క్షీణించి సీలియరీ ఆర్గాన్స్ గా మారును. ఇవి పృష్ఠ-పార్శ్వ ఆయుత కండరాలకు అతుక్కొని బాహ్యంగా తెరుచుకుంటాయి.

ఉదాహరణ : నీరిస్

Ex: <i>Nereis</i> (Ragworm (or) Clamworm)	Examples : <i>Chaetopterus</i> (Paddle worm)
<i>Alitta</i> (sand worm)	<i>Arenicola</i> (lugworm)
<i>Polynoe</i> (Scale worm)	<i>Sabella</i> (Fan worm)
<i>Aphrodite</i> (Sea mouse)	(or) Feather duster worm
<i>Glycera</i> (Blood worm)	(or) pencil worm)
<i>Eunice</i> (palolo worm)	<i>Serpula</i>
	(Calcareous tube worm)

Class-2 : Oligochaeta

This class includes earthworms.

They are terrestrial or freshwater (Ex : *Tubifex*) or marine species.

Segmentation is external and internal.

Head is reduced without eyes and tentacles.

Clitellum is persistent throughout life.

Each segment has fewer number of **setae** for locomotion.

A dorsal median fold of the intestine called **typhlosole** is present, helping in increasing the area of absorption.

Nephridia are the excretory organs. They are generally three types i.e., Integumentary nephridia, Pharyngeal nephridia, Septal nephridia

Earthworms are **hermaphrodite** (bisexual).

Fertilization is external and occurs in **cocoon**.

Development is direct i.e., without a larval stage.

Examples: *Pheretima*, *Megascolex*, *Lumbricus*, *Eisenia*, *Tubifex* (Fresh water earthworm).



Pheretima



Eisenia



Lumbricus

Fig. 4.1.6 Oligochaeta Organisms

Class 3 : Hirudinea

This class includes leeches.

All are ectoparasites.

Majority of the leeches live in freshwater, some are marine and others are terrestrial. Body is dorso-ventrally flattened with a definite number of segments.

వర్మికల్చర్

పరిచయం :

అరిస్టాటిల్ “వానపాములు భూమి యొక్క ప్రేగులు” అని పేర్కొనెను. వానపాముల వలె మరి ఏ ఇతర జీవులు భూమిని నిర్మించడంలో దోహద పడలేదని డార్విన్ తెలియజేసెను. వర్మికల్చర్ అనేది వానపాములను పెంచే శాస్త్రీయ పద్ధతి. ఇది వ్యర్థాలను తగ్గించడానికి, ఎరువులను ఉత్పత్తి చేయడానికి అత్యంత ఉపయోగకరమైన మార్గం. వర్మికంపోస్టింగ్ అనేది జీవ శైధిల్య పదార్థాలను వానపాములను ఉపయోగించి సేంద్రియ ఎరువులను ఉత్పత్తి చేసే ప్రక్రియ. వర్మికల్చర్ ఉత్పత్తిని వర్మికంపోస్ట్ అంటారు. వర్మికంపోస్ట్లో పోషకాలు, మొక్కలలో వృద్ధి నియంత్రకాలు సమృద్ధిగా ఉంటాయి. వర్మికల్చర్ కోసం సాధారణంగా ఉపయోగించే వానపాము జాతులు ఐసీనియా ఫోటిడా, లుంబ్రికస్, రుబెల్లస్, యూడ్రిల్లస్ యూజీనియా మరియు పెరియోనిక్స్.

వర్మికల్చర్లో వానపాము జాతులు :

వర్మికంపోస్ట్ ఉత్పత్తి చేయడానికి అనుకూలమైన వానపాము జాతుల ఎంపిక వర్మికల్చర్లో అంత్యంలో ముఖ్యమైన అంశం. వివిధ వానపాములు వర్మికల్చర్లో విస్తృతంగా ఉపయోగించబడుతున్నాయి. అవి లుంబ్రికస్ రుబెల్లస్ (రెడ్వర్మ్), ఐసీనియా ఫోటిడా (బ్రాండ్లింగ్వర్మ్), యూడ్రిల్లస్ యూజీనియా (ఆఫ్రికన్ నైట్ క్రాలర్) మరియు పెరియోనిక్స్ ఎక్స్కావేటస్ (ఇండియన్ బ్లూస్).

వర్మికంపోస్టింగ్ :

వానపాముల నుండి సేంద్రియ ఎరువులను ఉత్పత్తి చేసే ప్రక్రియను వర్మికంపోస్టింగ్ అంటారు. ఇది వ్యర్థ పదార్థాలను మార్చి నాణ్యమైన కంపోస్ట్ చేయడానికి ఉపయోగించే సులభమైన పద్ధతి. వానపాములు బయోమాస్ను ఆహారంగా తీసుకొని జీర్ణం చేసి “వర్మికాస్టింగ్” రూపంలో విసర్జిస్తాయి.

వర్మికల్చర్ ప్రాముఖ్యత :

- ❖ వర్మికంపోస్ట్లో మొక్కల పెరుగుదలకు అవసరమయ్యే నైట్రోజన్, ఫాస్ఫరస్ మరియు పొటాషియంలు అధికంగా ఉండును.
- ❖ నేల నిర్మాణం, ఆకృతి, గాలిప్రసరణ, నీటిని నిలిపి ఉంచే సామర్థ్యంను పెంచును మరియు నేల కోరివేతను నిరోధించును.

Segments are externally sub divided into **annuli**.

Internal segmentation is absent.

Anterior and Posterior suckers help in locomotion.

Salivary glands secrete saliva containing an anticoagulant called hirudin.

Clitellum is conspicuous during the breeding season only.

Coelom is reduced due to the presence of **botryoidal tissue** performing excretion, storage of iron and revascularization in areas of injured blood vessels. Circulatory system contains 4 longitudinal haemocoelic channels hence it is called **Haemocoelic system**.

Excretion is performed by 17 pairs of nephridia. Nephridia are two types i.e., **Testicular nephridia** (11 pairs) and **Pretesticular nephridia** (6 pairs).

Nervous system is of typical annelidan type.

Five pairs of **simple eyes** are present on the first Five pairs of anterior segments. They are monoecious.

Males possess a copulatory organ, the **penis** and females contain **vagina**.

Fertilization is internal, takes place in vagina.

Development is direct.

Examples :- *Hirudinaria* (freshwater leech), *Pontobdella* (marine leech or Skate sucker), *Haemadipsa* (Terrestrial leech), *Hirudo* (medicinal leech), *Ozobranchus* (Gilled leech), *Acanthobdella* (Leech with setae)



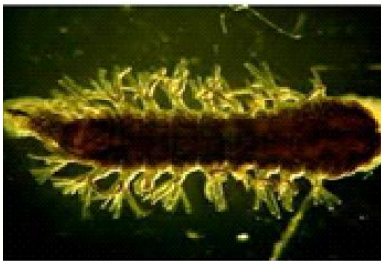
Hirudo



Hirudinaria



Haemadipsa



Ozobranchus



Pontobdella

Fig.4.1.6 Hirudinea Organisms

4.2. Evolution of Coelom and Coelomoducts

Learning Outcomes:

- To Understand the formation of Coelom in animal kingdom
- To Identify the differences between Pseudo coelom and Eucoelom.
- To Know about the significance of Coelom
- To Understand the functions of Coelomoducts and nephridia
- To Know about different kinds of nephromixia.

Coelom :

In animal kingdom evolution of tissues (In Cnidaria) is the **first key transition** in the animal body plan, **second key transition** is appearance of bilateral symmetry (First seen in Platyhelminthes). A **third key transition** in the evolution of animal body plan was the formation of body cavity or coelom. It is the vacant space in between the body wall and Alimentary canal. Triploblastic organisms (Phylum Platyhelminthes, Nematoda, Annelida Arthropoda, Mollusca, Echinodermata, Hemichordata, Chordata) are classified into Three groups according to the presence or absence of coelom. i.e., 1. Acoelomata 2. Pseudocoelomata 3. Ecucoelomata.

1. Acoelomata : Flatworms of Phylum Platyhelminthes are acoelomates. They exhibit a **solid body plan** with a dense parenchyma between the gut and the body wall in the adults. The space around the internal organs is filled with parenchyma or **mesenchyme** tissue. Hence there is no body cavity surrounding the internal organs. (Fig : 4.2.1). Mesenchyma restricts the movement of internal organs and slows down the diffusion of nutrients from the gut towards the body wall.

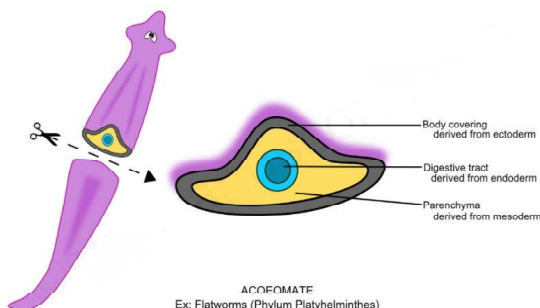


Fig.4.2.1 Acoelom in Platyhelminthes

2.PseudoCoelomates : Animals of Aschelminthes (rotifers, nematodes) possess a Pseudocoelom or blastocoel. It is neither formed from mesoderm nor is lined by mesodermal peritoneum. The mesoderm is present as scattered pouches in between the ectoderm and endoderm. During their development mesoderm only lies with ectoderm. The unoccupied portion of blastocoel persists as Pseudocoelom.

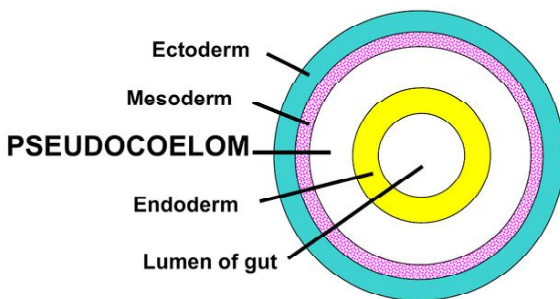


Fig.4.2.2 Pseudocoelom in Nematodes

(Fig.4.2.2). In the evolution of animals, a “**tube within a tube**” arrangement is seen for the first time in Pseudocoelomates.

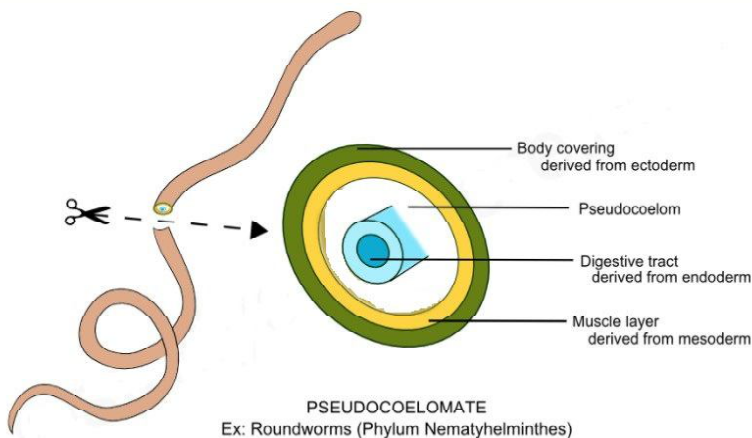


Fig.4.2.3 Pseudocoelom in Nematodes

As mesoderm is confined only with the body wall as parietal peritoneum, the musculature is restricted to the body wall. The gut or intestinal wall is made up of only endoderm. Hence the digested nutrients are directly absorbed into Pseudo coelomic fluid by diffusion through the gut wall. Despite the name “Pseudocoelom”. It is functional body cavity. It serves as a hydrostatic skeleton, protects the internal organs from

mechanical shocks, provides space for the movement of internal organs and helps in circulation of the nutrients and storage of nitrogen wastes.

3. Eucoelomates : The term "coelom" was coined by Ernst Haeckel. Animals containing true coelom are called Eucoelomates. (Ex : Annelida, Arthropoda, mollusca, Echinodermata, Hemichordata, Chordata). A true coelom is lined by outer parietal peritoneum or somatic layer and inner visceral peritoneum or splanchnic layer. These parietal and visceral peritonea are derived from embryonic mesoderm. A double layered peritoneum called **mesentery** connects some visceral organs to the body wall. In Annelids, the dorsal and ventral mesenteries divide the coelom into paired compartments. Some organs of vertebrates (Ex : Kidneys) that occur outside the coelom and are covered with parietal peritoneum only on the surface facing the coelom are called retroperitoneal organs. Based on the mode of formation of coelom, the coelomates are classified into two types.i.e., A. Schizocoelomates B. Enterocoelomates.

A. Schizocoelomates : Annelids, arthropods, molluscs are schizocoelomates. These forms undergo spiral and determinate cleavage. A single blastomere is called **4d blastomere or mesentoblast** present at the rim of blastopore lips. These mesentoblasts are divided further to form mesodermal blocks. A split appears within each block making them hollow.

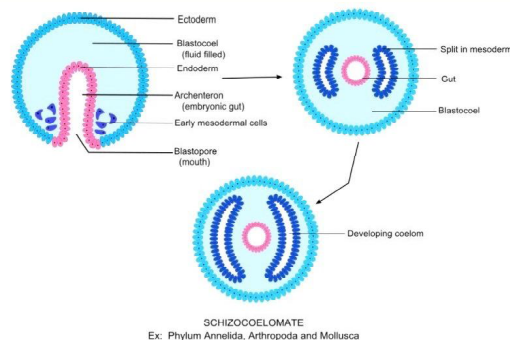


Fig.4.2.4 Schizocoelom in Annelida, Arthropoda, Mollusca

Coelom that arises from splitting of mesoderm is called **schizocoelom**. In arthropods and molluscs schizocoelom is reduced and the functional body cavity is haemocoel. The embryonic blastocoel (primary body cavity replaced with coelom (secondary body cavity) in Eucoelomates. Blastopore is converted into mouth hence these schizocoelomates are proterostomes.

B. Enterocoelomates : Echinoderms, hemichordates and chordates are enterocoelomates. Enterocoelom is also derived from mesoderm but it is formed by the evagination of mesoderm from the wall of archenteron, not from splitting of mesoderm. These mesodermal pouches evaginate from archenteron are extended and fused with

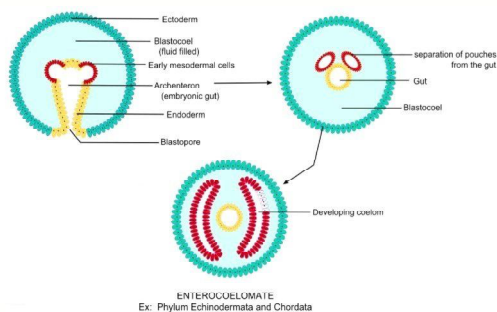


Fig.4.2.5 Enterocoelom in Echinodermata, Hemichordata, Chordata

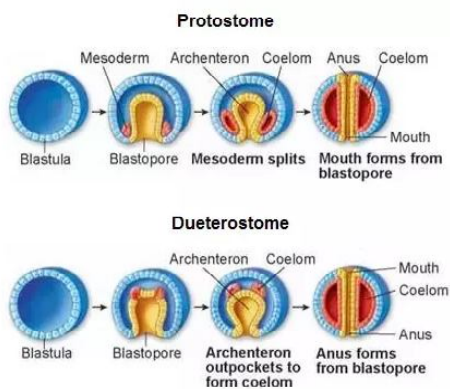


Fig.4.2.6 Proterostomes and deuterostomes

one another to form enterocoelom. All the enterocoelomates exhibit radial and indeterminate cleavage. Blastopore is converted into anus hence these enterocoelomates are deuterostomes.

Advantages of true Coelom over Pseudocoelom

The visceral organs of coelomates are muscular so they contract and relax freely without depending on movements of the body wall.

In coelomates regional specialization of the gut such as the development of gizzard, stomach etc.,

In the case of the pseudocoelomates due to the absence of such a contact between gut and mesoderm, the wall of the gut does not show regional specialization.

Coelomoducts and Nephridia :

In annelids certain tube-like structures are found and they are repeated in successive segments called segmental organs. These tubes help in reproductive and excretory functions. Segmental organs are primarily divided into three types 1. Coelomoducts (derived from mesoderm), 2. Nephridia (derived from ectoderm), 3. Nephromixia

1. Coelomoducts : These are derived from mesoderm. They are formed from coelom. Typically, a coelomoduct opens, to the exterior by a genital pore and into the coelom through a ciliated funnel called coelomostome. These coelomoducts act as genital ducts. These Coelomoducts are confined to only a few reproductive segments. In the earthworms, the reproductive funnel and ducts are coelomoducts. The uriniferous tubules of vertebrate kidney are modified coelomoducts and perform excretion.

2. Nephridia : These are segmentally arranged coiled tubes of ectodermal origin developed as invaginations of ectoderm into coelom. They open outside through nephridiopores located on the body wall. Internally, they may end as a blind tube (Protonephridia) or may open by small ciliated funnels called nephrostomes (metanephridia). Nephridia are primarily excretory in function and secondarily perform osmoregulation and convey the genital products to exterior.

Types of Nephridia :

1. According to the presence or absence of nephrostomes nephridia are classified into two types. A. Protonephridia. B. Metanephridia.

A. Protonephridia : These are more primitive type nephridia. They terminate in the coelom as blind tube. The closed end and the tube are provided with specialized excretory cells called tube cells or solenocytes. Protonephridia are found in some adult polychaetas such as vanadis, phyllodoce, Tomopteris, Glycera, Nephthys.

B. Metanephridia : This type of nephridia is advanced and found in most Polychaetas, all earthworms and leeches. The inner end of metanephridium opens into the coelom by a ciliated funnel called nephrostome. The outer end opens to the exterior through nephridiopore, thus open at both ends. Solenocytes are completely absent.

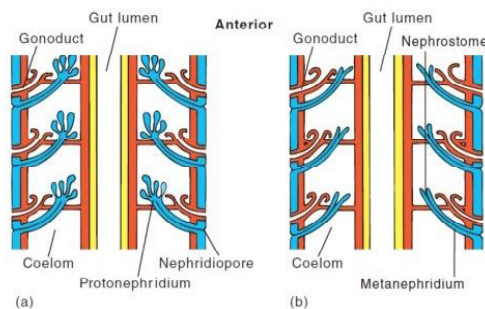


Fig. 4.2.7 Protonephridium and Metanephridium

II. According to their size and number :

Nephridia are classified into two types on the basis of their size and number i.e., A. Micro Nephridia or Mero nephridia B. Meganephridia or Holonephridia.

Micro nephridia

Small in size and numerous

Lying on the body wall and septa

Found in Pheretima.

Mega nephridia

Large in size but generally one pair in each segment.

They usually extend over two segments in each segment and their nephrostomes open into the segments next in front.

Found in Polychaeta, Hirudinia

III. According to the opening of nephridia into exterior or Alimentary canal

Nephridia are classified into two types according to the opening of nephridia into exterior or Alimentary canal i.e., A. Exonephric nephridia B. Enteronephric nephridia.

A. Exonephric nephridia

They are directly open to the exterior through nephridiopores.

Ex :- Hirudinaria, Nereis, Lumbricus and integumentary nephridia of Pheretima.

B. Enteronephric nephridia

They lack nephridiopores and open into the excretory canals or alimentary canal.

Ex : Septal and pharyngeal nephridia of pheretima.

3.Nephromixia : In some Polychaetes, coelomoducts become fused partially or wholly with nephridia to form compound segmental organs called as nephromixia. They consist both of ectoderm and mesoderm and performs both excretion as well as discharge of gametes. Nephridia and the coelomoducts show various degrees of combination. According to the degree of combination the nephromixia are classified into four types.

i) Protonephromixium:Coelomoduct is united with a protonephridium. It performs both excretion and discharge of gametes. Ex :*Phyllodoce*.

ii) Metanephromixium :Coelomoducts is united with metanephridium. Ex : Hesione

iii) Mixonephridium :Coelomoducts and nephridium are internally fused to form a simple composite organ. Its funnel is formed by Coelomoduct and its duct by nephridium. Ex : Arenicola

iv) Ciliated organs : In some forms, coelomoducts are reduced to ciliated organs. They are attached to dorso-lateral longitudinal muscles and open externally. Ex : Nereis, Leech.

4.3. Vermiculture : Scope, Significance, earthworm species, processing

Learning Outcomes:

To Understand the significance of vermiculture in protecting environment.

To Know about the species of Earthworm involved in Vermiculture.

To Understanding the potential of Vermicompost as an alternative to chemical fertilizers.

To Know about the procedure of Vermiculture.

To Understanding the role of Vermiculture in maintain the health of Soil.

Introduction :

Aristotle has said “Earthworms are intestines of the earth”. Darwin was another one who stated "No other creature has contributed to building of earth as earthworm". Vermiculture is the scientific process of breeding and raising of earthworms. It is a substantial way of reducing wastes and producing fertilizers. Vermicomposting is the process of producing organic fertilizers from earthworms by using biodegradable materials. The output of vermiculture is called vermicompost. The product vermicompost is rich in terms of nutrients and other plant growth promoters. The earthworm species typically used for vermiculture are *Eisenia fetida*, *Lumbricus rubellus*, *Eudrilus eugeniae* and *perionyx excavates*.

Scope of Vermiculture :

Vermiculture is the branch of science that studies the importance and utilization of earthworms to solve the problems related to ecology and environment. Vermiculture is the decomposition of organic wastes that depends upon earthworms for fragmentation, mixture and promotion of microbial activity. It's based on the principle that during feeding, the earthworms fragmented the waste materials that results in increase of surface area for colonization of microorganisms. Now a days both developed and developing nations have adapted vermiculture for different organic waste management practices.

Earthworm species in vermiculture

Selection of suitable earthworm species for vermicomposting is the most important aspect of vermiculture. Different earthworms are widely used in vermiculture i.e., *Lumbricus rubellus* (Red worms), *Eisenia fetida* (Brandling worms) *Eudrilus eugeniae* (African night crawler) and *Perionyx excavates* (Indian blues). They can tolerate high temperature at 42°C and low soil temperature below 5°C. These are also having the capacity to stabilize a wide range of toxic organic wastes into value added products.



Lumbricus



Eisenia



Eudrilus



Perionyx

Fig.4.3.1 Different Earthworm species in Vermiculture

Vermicomposting

The process of producing organic fertilizers from earthworms is called vermicomposting. It is one of the easiest methods to recycle agriculture wastes and to produce quality compost. Earthworms consume biomass and excrete it in digested form called “worm castings”.

Process of Vermicomposting

It is an aerobic, bio-oxidation, non-thermophilic process of organic waste decomposition into quality organic fertilizers. The entire process of vermicomposting steps are mentioned below.

A. Requestion selection of site :

Vermicomposting unit should be in cool, moist and shady site. The site should also be nearer to water resource. Vermicomposting production unit may be set up in cement or brick tank, wooden boxes, plastic bins and even in soil pits.

B. Collection of Basic raw material : Any type of biodegradable wastes like cow dung, dry straw and leaves collected from paddy fields, weed biomass leaf litter and soil can be used as basic raw material for vermicomposting.

C. Procedure of Vermicomposting :

Collect the biomass and place it under the sun for about 8-12 days. Now cut it into the required size using cutter.

Cow dung and chopped dried leafy materials are mixed in the proportion of 3 : 1 and kept the mixer for partial decomposition for 15-20 days.

Add a layer of 2-3 inches soil at the bottom of the bed.

Now a layer of 15-20 cm of chopped dried leaves, Should be kept as bedding material on the sand layer.

Continue adding both the chopped dried leaves and decomposed cow dung as layer wise into the bed up to a depth of 0.5-1.0 ft.

After adding all the bio wastes, release the earthworms over the mixture and cover the compost mixture with dry straw or gunny bags.

Water should be sprinkled immediately after the release of worms. Also sprinkle water on a regular basis to maintain the moisture content of the bed. Compost will get ready in 40-45 days.

Harvesting :

When raw material is completely decomposed, it appears black and granular.

Watering should be stopped as compost get ready.

The compost should be kept over a heap of partially decomposed cow dung, so that earthworms could migrate into cow dung from compost.

After two days compost can be separated and sieved for use.

Preventive measures:

The floor of the unit should be compact to prevent earthworms migration into soil.

The organic wastes should be free from plastics, metals, pesticides and chemicals.

Proper aeration should be maintained in the beds.

18-25°C temperature should be maintained for proper decomposition.

Significance of Vermiculture :

Vermicompost is rich in Nitrogen, Phosphorus and Potassium which are essential for plant growth.

Improves soil structure, texture, aeration, water holding capacity and prevents soil erosion.

Prevents nutrient losses and decreases the use of chemical fertilizers.

Vermicompost is free from pathogens, toxic elements weed seeds etc.

Vermicompost minimizes the incidence of pest and diseases.

It contains valuable vitamins, enzymes and hormones like auxins, gibberellins.

Helps in germination of seeds, plant growth and crop yield.

GLOSSARY

Anal pore : Weak point in cell membranes for elimination of solid wastes.

Annelida : A phylum of segmented worms. **Bilateral symmetry** : A symmetry with similarity on both sides.

Blastopore : A mouth like opening of the gastrula.

Blastula : An embryonic stage with blasocoel.

Castings : Undigested solids containing soil.

Chemotaxis : A movement response to a chemical stimulus.

Clitellum : A thick glandular band around an annelid worm it secretes the cocoon.

Coelom: (Gk, koiloma. A hollow) The main body cavity of animals, formed between layers of mesoderm, in which internal organs are suspended. A secondary body cavity of vertebrates and most invertebrates, having a membranous lining composed of specialized cells containing the internal organs; developed between the mesoderm layers and forms, peritoneum and pericardial cavities.

Crop : A thin walled part of the alimentary canal that serves to store the ingested food.

Dermal : pertaining to the skin.

Dioecious : Species population in which the male and female reproductive organs occur in separate individuals.

Epidermis : Outer layer of cells covering the surface of the body. **Evagination** : Out pocketing from any surface

Integument : Covering the body, the skin.

Monoecious : With both male and female reproductive organs.

Nephridium : A tubular excretory organ of the earthworm and other annelids which consists of a ciliated funnel, opening to the coelomic cavity.

Oesophagus : Gullet or food tube leading from the mouth to the stomach

Parapodia : Flesh paddle like segmented appendages of polychaete worms.

Prostomium : Portion of the head situated before the mouth.

Receptor : A sensory end of the organ.

Regeneration : Act of growing a new body part for one which has been injured or lost.

Schizocoel : Coelom formed by the splitting of the embryonic mesoderm.

Septum : An internal body partition.

Tentacles : Flexible arm like projections of coelenterates and some other animals **Trochophore** : A free swimming ciliated larva characteristic of annelida and mollusca.

SELF ASSESSMENT

1. The term Annelida was coined by
 1. Grant 2. Lamarck 3. Aristotle 4. Von siebold
2. Body cavity of annelids is
 1. Enterocoel 2. Schizocoel 3. Pseudocoel 4. Haemocoel
3. First formed eucoelomates are
 1. Flat worms 2. Round worms
 3. Annelids 4. Arthropods
4. Locomotor structures of annelids are
 1. Setae 2. Parapodia 3. Suckers 4. All the above
5. Blood vascular system first appears from this phylum
 1. Platyhelminthes 2. Nematoda
 3. Arthropoda 4. Annelida
6. Excretory organs in annelids are called
 1. Kidneys 2. Renette glands
 3. Green glands 4. Nephridia
7. Nephridia of annelids are derived from
 1. Ectoderm 2. Endoderm 3. Mesoderm 4. All the above
8. In annelids nerve ring is formed around
 1. Oesophagus 2. Pharynx 3. Gizzard 4. Stomach
9. The only annelids with internal fertilization are
 1. Earthworms 2. Bristle worms
 3. Leeches 4. All the above
10. The characteristic larva of annelids is
 1. Muller 2. Planula 3. Nauplius 4. Trochophore
11. Annelids with eyes, tentacles and palps are
 1. Polychaetes 2. Oligochaetes 3. Leeches 4. Archannelids
12. Locomotor structures of Polychaetes are
 1. Suckers 2. Pseudopodia 3. Parapodia 4. Cilia
13. The larva of polychaetes or Bristle worms is
 1. Muller 2. Trochophore 3. Nauplius 4. Bipinnaria

14. Study the following statements regarding Polychaetes.

I. Gonoducts are absent

II. Head is distinct with eye tentacles and pedipalps

III. Clitellum is present

The correct combination is

1. Only I & II are correct 2. Only II & III are correct

3. Only I & III are correct 4. All are true

15. Study the following statements regarding Hirudineans.

I. Clitellum is formed during breeding season only

II. Internal segmentation is almost absent

III. Indefinite number of segments are present.

The correct combination is

1. Only I & II are correct 2. Only II & III are correct

3. Only I & III are correct 4. All are true

16. Match the following and choose the correct combination.

List – I

List – II

A. Parapodia with many setae

I. Archiannelida

B. Setae are the chief locomotor structures

II. Hirudinea

C. Suckers are locomotor structures

III. Oligochaeta

D. Marine annelids without clear external segmentation

IV. Polychaeta

1. A-II, B-III, C-IV, D-I

2. A-IV, B-III, C-II, D-I

3. A-I, B-III, C-II, D-IV

4. A-I, B-II, C-IV, D-III

17. (A) : Clitellum is absent in polychaetes

(R) : Polychaetes are monoecious annelids

1. Both A & R are true. R correctly explains 'A'

2. Both A & R are true. But 'R' cannot explain 'A'

3. 'A' is only true. But 'R' is not true

4. Both A & R are not true

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Phylum : Arthropoda

4.4. General Characters and classification up to classes

Learning Outcomes:

To Identify the members of phylum Arthropoda.

To Describe the characters of Arthropods.

To Know about the heteronomous segmentation.

To Understand the role of trachea in respiration.

To Know about the haemolymph and haemocoel.

To Identify different types of larvae in Arthropoda.

To Understand the significance of chitinous exoskeleton in Arthropoda Phylum.

Introduction : Phylum Arthropoda (Gr., arthros, joint + podos, foot) is the largest phylum of the animal kingdom including about 9,00,000 species in all habitats, which constitute about 80% of all the known species of animals. Arthropoda is a highly successful group of animals on earth. They live in all habitats i.e., terrestrial, aquatic environment. Chitinous exoskeleton and jointed appendages are the keys to the success of Arthropods. The term Arthropoda was coined by **Von siebold**. The phylum takes its name because of **jointed appendages**. Arthropods are advanced over annelids by showing an increasing tendency of cephalization, presence of jointed appendages, striated muscles, chitinous exoskeleton, special respiratory organs and compound eyes.

General Characters

Arthropods inhabit types of habitats, i.e., marine, freshwater and terrestrial.

They are bilaterally symmetrical, triploblastic and metamerically segmented. Unlike Annelids, inter segmental septa are absent. Hence metamerism is called **heteronomous**.

Appendages are jointed, usually one pair to each segment.

Body is distinguished into three **tagmata**: head, thorax and abdomen. Head and thorax often fused to form a cephalothorax.

4.4. వర్గం - ఆర్థోపాడా

4.4. ఆర్థోపాడా సామాన్య లక్షణాలు - వర్గీకరణ

పరిచయం : జంతు రాజ్యంలో అతిపెద్ద వర్గం ఆర్థోపాడా (ఉదా : ఆర్థ్రాస్; కీల్లు, పాడాస్-కాల్లు) దీనిలో దాదాపు 9,00,000 జాతుల జీవులు అన్ని రకాల ఆవాసాలలో నివసిస్తూ భూమి మీద నామీకరించిన జంతుజాతులలో ఇవి 80% వరకూ ఉంటాయి. భూమిమీద అత్యంత విజయవంతమైన జంతు సమూహం ఆర్థోపాడా. ఇవి అన్ని రకాల ఆవాసాలలో అనగా భూచర, జలచర ఆవాసాలలో నివసిస్తాయి. ఖైటిన్ తో కూడిన బాహ్య అస్థిపంజరం, కీళ్ళు కలిగిన కాళ్ళు ఉండటం వీటి విజయానికి కారణం. ఆర్థోపాడా అనే పదమును ప్రతిపాదించినది వాన్ సీబోర్ట్. కీళ్ళు కల కాళ్ళను కలిగి ఉండటం వలన ఈ వర్గానికి ఆర్థోపాడా అనే పేరు వచ్చినది.

సామాన్య లక్షణాలు

- ❖ ఆర్థోపాడన్లు భూమిపైన, సముద్రం నీటిలో, మంచినీటిలో ఇలా అన్ని ఆవాసాలలో నివశిస్తాయి.
- ❖ ఇవి ద్విపార్శ్వ సౌష్ఠవ, త్రిస్తరిత, సమఖండీభవన జీవులు. అనెలిడా జీవుల వలె ఖండితాంతర విభాజకాలు ఉండవు. కనుక వీటిలో ఖండీభవన మును విషమ ఖండీభవనం అంటారు.
- ❖ శరీరం మూడు టాగ్మాటాలైన తల, ఉరం, ఉదరంగా విభజించబడి ఉండును. తల, ఉరం కలసి సెఫలోథోరాక్స్ ను ఏర్పరుచును.
- ❖ శరీరం చుట్టూ ఖైటిన్ నిర్మిత బాహ్య అస్థిపంజరం ఉంటుంది. ఇది శరీరానికి రక్షణ ఇస్తూ, నీరు బయటకు పోకుండా నిరోధిస్తుంది. ఇది నిర్మోచనం జరుపుకొని పెరుగుదలలో తోడ్పడును.
- ❖ పైజోసీలిక్ శరీర కుహరం చాలా వరకు క్షీణించి బీజకోశాలు మరియు విసర్జక అవయవాలకు (కోక్సల్ గ్రంధులు లేదా హరిత గ్రంధులు) పరిమిత మగును. శరీర కుహరం పూర్తిగా రక్తంతో నింపబడుతుంది. కనుక దీనిని హీమోసీల్ అంటారు.
- ❖ జంతురాజ్యంలోనే మొట్టమొదటిసారిగా మెలితిరిగిన ఆహారనాళం ఏర్పడటం ఆర్థోపాడా జీవుల ప్రత్యేకత. ఆహారనాళం 3 ప్రాంతాలుగా విభజింపబడి ఉంటుంది. అవి
1. పూర్వాహారనాళం 2. మధ్యాహారనాళం 3. అంత్య ఆహారనాళం.

Body is covered by a chitinous exo-skeleton which provides protection and prevents dehydration from the body. It undergoes moulting or **ecdysis** to facilitate growth.

Schizocoelic coelom is reduced and associated with gonads and excretory organs (Coxal glands or green glands). Body cavity or coelom is filled with blood hence it is called **Haemocoel**.

First time in the animal kingdom the appearance of **coiled alimentary** canal is seen in arthropods. The Alimentary canal is distinguished into three regions i.e., foregut, midgut and hindgut.

Specialized respiratory organs are first appeared in Arthropods. Aquatic arthropods (Class : crustacea) respire with gills, Terrestrial arthropods respire with Tracheal system (class insecta, diplopoda, chilopoda) and book lungs (scorpions and spiders).

Muscles are mostly **striated**, usually capable of rapid contraction.

Circulatory system is **open type**. Heart is dorsal and tubular with many chambers. Respiratory pigment is absent hence the blood is colourless, called **haemolymph** (class : insect). Haemocyanin is a copper containing bluish respiratory pigments in many crustaceans, arachnids and crabs.

Excretory organs are **green glands** in crustacean **Malpighian tubules** in insects, malpighian tubules and **coxal glands** in scorpions and spiders.

Central nervous system consists of a nerve ring and solid double ventral nerve cord. Nerve ring consists of a pair of **supra oesophageal ganglia** (so called brain), a pair of **circumoesophageal connectives**, and a pair of **suboesophageal ganglia**. Sense organs including antennae, simple eyes, compound eyes and statocysts.

Most of the arthropods are unisexual.

Fertilization is usually internal.

Development is direct or indirect with one-to-many larval stages. Parthenogenesis is seen in some arthropods.

Eggs of insects are centrolecithal.

- ❖ శ్వాసక్రియకోశం ప్రత్యేకమైన శ్వాస అవయవాలు మొదటిసారిగా ఆర్థోపాడా వర్గంలో ఏర్పడెను. జలచర ఆర్థోపాడెన్లు (క్రస్టేషియా విభాగం) మొప్పలు ద్వారా, భూచర ఆర్థోపాడెలు వాయునాళవ్యవస్థ (విభాగం : ఇన్సెక్టా, డిప్లోపాడా, కైరోపాడా) మరియు పుస్తకాకార ఊపిరితిత్తులు (తేలు, సాలెపురుగు) ద్వారా శ్వాసక్రియ జరుపును.
- ❖ వివృత రక్తప్రసరణ వ్యవస్థను కలిగి ఉండును.
- ❖ హరితగ్రంధులు (విభాగం క్రస్టేషియా), మాల్పిజియన్ నాళికలు (ఇన్సెక్టా), మాల్పిజియన్ నాళికలు మరియు కోక్సల్ గ్రంధులు (తేలు, సాలెపురుగు) విసర్జక అవయవాలుగా ఉంటాయి.
- ❖ పిండాభివృద్ధి ప్రత్యక్ష లేదా అప్రత్యక్ష పద్ధతిలో జరుగుతుంది. జీవిత చరిత్రలో ఒకటి నుండి అనేక లార్వాదశలు ఉంటాయి. పార్థినోజెనిసిస్ కొన్ని జీవులలో కనిపించును.
- ❖ కీటకాలలో అండాలు సెంట్రోలెసిథల్ రకానికి చెందినవి.

ఆర్థోపాడా వర్గీకరణ :

ఆర్థోపాడా వర్గాన్ని మూడు ఉపవర్గాలుగా వర్గీకరించారు. అవి

1. ట్రైలోబైటా 2. కెలిసిరేటా 3. మాండిబ్యులేటా

ఉపవర్గం-1 : ట్రైలోబైటా

ఉపవర్గం-2 : కెలిసిరేటా

- ❖ కెలిసిరేటా ఉపవర్గాన్ని రెండు విభాగాలుగా వర్గీకరించారు. అవి

1. మీరోస్టోమేటా 2. అరాక్నిడా

విభాగం - 1 : మీరోస్టోమేటా

విభాగం-2 : అరాక్నిడా

ఉపవర్గం-3 : మాండిబ్యులేటా

- ❖ ఉపవర్గం మాండిబ్యులేటాను క్రస్టేషియా, కైలోపాడా, డిప్లోపాడా మరియు హెక్సాపాడా (ఇన్సెక్టా) అనే నాలుగు విభాగాలుగా వర్గీకరించారు.

విభాగం-1 : క్రస్టేషియా

విభాగం-2 : కైలోపాడా

విభాగం-3 : డిప్లోపాడా

విభాగం-4 : ఇన్సెక్టా లేదా హెక్సాపాడా

Classification : Phylum Arthropoda is classified into three subphyla i.e.,

1. Trilobita
2. Chelicerata
3. Mandibulata.

Subphylum-1 :Trilobita (Gr. Tri – three, lobata – lobe)

These are extinct marine arthropods.

Appendages are numerous, similar and biramous on all segments except the last one.

A pair of longitudinal furrows divides the body of trilobites into three lobes.

Head is distinct, probably with one pair of antennae.

Example :*Triarthrus*, *Dalmanites*



Fig.4.4.1*Triarthrus*



Fig.4.4.2*Dalmanites*

Subphylum-2 :Chelicerata (Gr. Chele = claw; keros = horn; Latinate = bearing)

Body is divided into cephalothorax (prosoma) and abdomen (opisthosoma).

Prosoma has six segments, whereas opisthosoma has thirteen segments .

Opisthosoma is further divided into an anterior mesosoma and posterior metasoma.

Antennae and jaws are completely absent.

Prosoma bears six pairs of appendages of which first pair are chelicerae, second pair are pedipalps and last four pairs of walking legs.

Chelicerata subphylum is divided into two classes i.e., Merostomata, Arachnida.

Class-1 : Merostomata

All are marine, including horseshoe crabs.

Contains simple median eyes and lateral compound eyes.

Prosoma covered by a horse shoe shaped carapace, one pair of **chelicerae**, four pairs of **walking legs** and one pair of **pusher legs** are present on the first six segments of prosoma.

4.5. ఆర్థోపాడాలో దృష్టి, శ్వాసక్రియ

దృష్టి:

అనేక ఆర్థోపాడా జీవులు నేత్రాలను కలిగి ఉంటాయి. ఇవి వాటి సంఖ్య, నిర్మాణం, సంక్లిష్టతలో వ్యత్యాసాలను కలిగి ఉంటాయి. ఆర్థోపాడా జీవులలో నేత్రాలు ఫోటోరిసెప్టార్స్ అయిన సరళ నేత్రాలు లేదా సంయుక్త నేత్రాలుగా ఉంటాయి. ఆసిలైలు తక్కువ కాంతి స్థాయిలను గుర్తించి వేగంగా ప్రతిస్పందనలను ఏర్పరుచును. సంయుక్త నేత్రాలు ప్రతిబింబాలను ఏర్పరిచే సామర్థ్యంను కలిగి ఉండును.

సరళనేత్రాలు (ఆసిలై) :

ఆసిలై అనే పదం లాటిన్ భాష నుండి ఆవిర్భవించినది. ఆసిలై అనగా చిన్న నేత్రం అని అర్థం. అరాక్నిడ్లు, ఎగిరే సాలీళ్ళు సరళ నేత్రాలను కలిగి ఉండును. ఆర్థోపాడా జీవులలో రెండు రకాల ఆసిలై ఉండును.

1. పుష్ట ఆసిలై
2. పార్శ్వ ఆసిలై

సంయుక్త నేత్రం

ఆర్థోపాడా జీవులలో సాధారణంగా ఒక జత సంయుక్త నేత్రాలు తల పుష్ట భాగంపై అమరి ఉండును. ప్రతీ సంయుక్త నేత్రం అనేక నిర్మాణాత్మక, క్రియాత్మక ప్రమాణాలైన ఒమ్మటిడియా (నేత్రాంశాలు) తో ఏర్పడును. సంయుక్త నేత్రం యొక్క వెలుపలి తలంను విభజిస్తూ నేత్రాంశాల సంఖ్యకు సమానమైన షడ్భుజాకార ముఖతలాలు ఉంటాయి. ప్రౌడ కీటకాల సంయుక్త నేత్రంలో ఒమ్మటిడియాలు వందల నుండి వేలసంఖ్యలో ఉండును.

నేత్రాంశం నిర్మాణం

ప్రతీ ఒమ్మటిడియా సాధారణంగా రెండు ప్రాంతాలను కలిగి ఉండును. అవి I. డైఆప్టికల్ ప్రాంతం II. నేత్రపటల ప్రాంతం లేదా రిసెప్టార్ ప్రాంతం

ప్రతిబింబం ఏర్పడే విధానం :

ఒమ్మటిడియాల నుండి గ్రహించిన చిన్న చిన్న ప్రతిబింబాలతో సంయుక్త నేత్రం ఒక పూర్తి ప్రతిబింబంను ఏర్పరుచును. కాంతి తీవ్రతను ఆధారం గా సంయుక్త నేత్రాలు రెండు రకాల ప్రతిబింబాలను ఏర్పరుచును. అవి : 1. ఎపిజెషన్ ప్రతిబింబం
2. సూపర్ పాజెషన్ ప్రతిబింబం

Examples : Limulus (King crab or horseshoe crab), Eurypterus, Pterygotus.

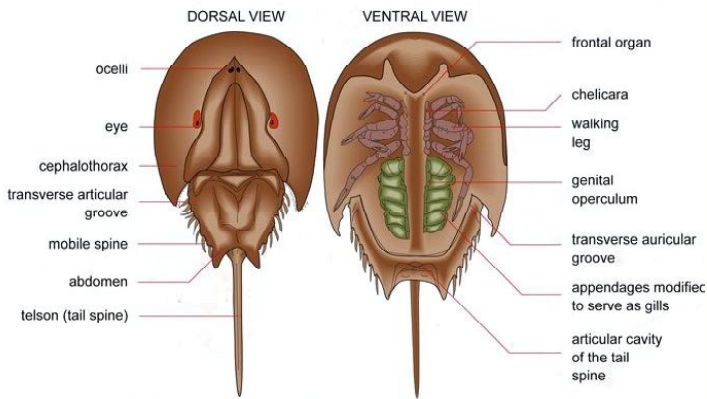


Fig. 4.4.3 *Limulus*

Class-2: Arachnida

This class includes scorpions, spiders, ticks and mites.

These are mostly terrestrial.

Prosoma bears one pair of **chelicerae**, one pair of **pedipalps** and four pairs of **walking legs**.

First pair of mesosomal appendages are modified into **genital operculum**.

Second pair of mesosomal appendages are modified into comblike sensory appendages the **pectines** (scorpions) for exploring the ground and for recognition of sex.

Last four pairs of mesosomal appendages in scorpions are modified into **book lungs**.

In male spiders, pedipalps function as copulatory organs.

Opisthosoma of spiders bears 4 or 6 or 8 pairs of spinnerets are the modified opisthosomal appendages.

In scorpions, respiratory organs are book lungs. Respiratory organs in spiders are book lungs or trachea or both.

In ticks trachea are the respiratory organs.

Excretory organs **coxal glands** and **malpighian tubules**.

Mostly oviparous but scorpions are **viviparous**.

Development is direct.

ఆర్థోపాడా జీవులలో శ్వాసక్రియ :

ఆర్థోపాడా జీవులు జంతురాజ్యంలో 3/4 వంతు ఉండి వివిధ రకాల ఆవాసాలలో నివశిస్తాయి. ఇవి గాలిపీల్చడం, మొప్పల సహాయం తో జలశ్వాసక్రియ జరుపును. నివశించే ఆవాసాన్ని ఆధారంగా చేసుకొని ఆర్థోపాడా జీవులలో క్రింది రకాల శ్వాస అవయవాలు ఉంటాయి.

అనేక క్రస్టేషియా జీవులలో మొప్పలు శ్వాస అవయవాలుగా ఉంటాయి. రొయ్యలలో మొప్పలు శిరోవృక్షమునకు ఇరువైపులా ఉన్న మొప్ప గదులలో ఉండి కేరాపేస్ తో కప్పబడును. ఈ గదుల లోపలితలం రక్తకేశనాళికలతో కూడిన ఉపకళ ఉండి శ్వాసక్రియలో తోడ్పడును. వీటితోపాటు ఎపిపొడైట్స్ కూడా శ్వాసక్రియలో తోడ్పడును. తేలులో పుస్తకాకార ఊపిరితిత్తులు, బొద్దింకలో వాయునాళవ్యవస్థ ద్వారా శ్వాసక్రియ జరుపును.

కీటకాలలో రూపవిక్రియ

అపరిపక్వ లార్వా మార్పు చెంది నిర్మాణం, అలవాట్లలో వ్యత్యాసం చూపించే పరిపక్వ లైంగికత కలిగిన ప్రాథజీవిగా మార్పు చెందడాన్నే రూపవిక్రియ అంటారు. మెటామార్ఫాసిస్ అనగా గ్రీకు భాషలో మార్పు చెందినది అని అర్థం. కీటకాలలో నాలుగు రకాల రూపవిక్రియలు ఉంటాయి.

1. ఎమెటబోలస్ రూపవిక్రియ

2. హెమి ఎమెటబోలస్ రూపవిక్రియ

3. పారా ఎమెటబోలస్ రూపవిక్రియ

4. హోలోఎమెటబోలస్ రూపవిక్రియ

రూపవిక్రియలో హార్మోన్ల నియంత్రణ

1930 సం.లో రూపవిక్రియలో హార్మోన్ల పాత్రను మొట్టమొదటి సారిగా గుర్తించినది వి.బి. రిగెల్స్ వర్త్. కీటకాల మెదడులో నాడీశ్రావక కణాలను ఇతడు కనుగొనెను. రూపవిక్రియ క్రింది హార్మోన్ల సహాయం తో నియంత్రించబడును.

Examples : *Palamnaeus* – Black scorpion, *Buthus* – Red scorpion, *Centruroides*, *Lycosa* – wolf spider, *Achaearanea*– House spider, *Argiope* – writing spider, *Sarcoptes* – Itchmite, *Ixodes* – sheeptick, *Dermacentor* – Dog tick, Argas – Bird tick



Fig. 4.4.4*Palamnaeus*



Fig. 4.4.5*Buthus*

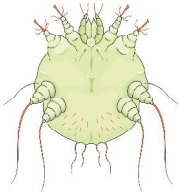


Fig. 4.4.7*Sarcoptes*



Fig. 4.4.6*Lycosa*

Subphylum -3 : Mandibulata

Body divisible into head, thorax and abdomen.

Cephalic appendages are one or two pairs of antennae, one pair of mandibles and one or two pairs of maxillae.

This subphylum includes prawns, crabs, crayfishes, centipedes, millipedes and insects.

Compound eyes are common.

Subphylum Mandibulata is classified into Crustacea, Chilopoda, Diplopoda and Hexapoda.

Class-1 : Crustacea :

This class includes Prawns, Crabs, Cyclops, Lepas, Balanus, sacculina, squilla, shrimps and Lobsters.

All are aquatic.

Head and thorax fused to form **cephalothorax**.

1. బైయన్ హార్మోన్ (BH)

2. ప్రోథోరాసిక్ ట్రాఫిక్ హార్మోన్ (PTTH)

3. ప్రోథోరాసిక్ గ్లాండ్ హార్మోన్ (PGH)

4. జువనైల్ హార్మోన్ (JH)

4.7. పెరిపేటన్-నిర్మాణం, సంబంధ బాంధవ్యాలు

పరిచయం : పెరిపేటన్ ప్రత్యేక లక్షణాలతోపాటు అనెలిడా, ఆర్థ్రోపాడా లక్షణాలను ప్రదర్శించే ఒక బైనైకోఫరా వర్గానికి చెందిన జీవి. కనుక పెరిపేటస్ను అనెలిడా, ఆర్థ్రోపాడా వర్గాలకు మధ్య సంధాన సేతువుగా పరిగణిస్తారు. ఇంతకు ముందు పెరిపేటస్ను ఆర్థ్రోపాడాలో ఒక విభాగంలో చేర్చారు. కాని ఇటీవల దీనికి వర్గపు హోదా ఇచ్చి ఒక బైనైకోఫరా వర్గంలో చేర్చారు. పెరిపేటస్ విచ్చిన్న విస్తరణను ప్రదర్శించును.

పెరిపేటన్ సంబంధ బాంధవ్యాలు : పెరిపేటస్ జాతిని 1826 వ సం॥ లో గిల్డింగ్ కనుగొనెను. అతను ఈ జీవి యొక్క స్లగ్ వంటి స్పర్శశృంగం, తేమతో కూడిన చర్మం ఆధారంగా ఒక మొలాస్కా జీవి అని భావించెను. 1874 సం.లో మోస్లే పెరిపేటస్ను ఆర్థ్రోపాడా వర్గంలో ఒక పురాతన జీవిగా చేర్చెను. పెరిపేటస్ ప్రత్యేక లక్షణాలతోపాటు అనెలిడా, ఆర్థ్రోపాడా, మొలాస్కా జీవులతో పోలికలను ప్రదర్శించును.

వర్గీకరణలో పెరిపేటస్ స్థానం

పెరిపేటస్ పై ప్రత్యేక అసక్తికి కారణం ఇది కొన్ని అనెలిడా లక్షణాల ను, కొన్ని ఆర్థ్రోపాడా లక్షణాలను ప్రదర్శించడం. కనుక అనేక మంది పెరిపేటస్ను అనెలిడా, ఆర్థ్రోపాడా జీవుల మధ్య సంధాన సేతువుగా భావిస్తారు.

అయితే ఒక బైనైకోఫరా జీవులు అనెలిడా జీవుల కంటే ఆర్థ్రోపాడా జీవులతో అధిక సారూప్యతను ప్రదర్శించును. కానీ అదే సమయంలో బాహ్య అస్థిపంజరం లోపించడం, కీళ్లు గల కాళ్ళు లోపించడంతో పాటు ప్రాథమిక అనెలిడా లక్షణాలు కలిగి ఉండటం ఒక బైనైకోఫరా స్థానం సమస్యగా మారింది. అయితే ఒక బైనైకోఫార్లు అనెలిడా జీవులు కాదు మరియు ఆర్థ్రోపాడా జీవులు కాదు. ఇవి ప్రత్యేక లక్షణాలు కలిగి ఉన్న జీవులు. కనుక ప్రస్తుతం ఒక బైనైకోఫరా ను ఒక ప్రత్యేక వర్గంగా పరిగణిస్తారు.

Exoskeleton is chitinous, hard and limy (calcareous).

Head is five segmented, bearing two pairs of **antennae** (antennules and antennae – unique feature) one pair of **mandibles** and two pairs of **maxillae**.

Appendages are typically **biramous**.

Respiratory organs are gills or **branchiae**.

Excretory organs are **green glands** or **antennary glands**.

Sense organs include antennae, compound eyes, statocysts.

Development is direct or indirect involving several larval stages. The basic larva is **nauplius**.

Examples :*Daphnia* (water flea), *Cyclops*, *Lepas* (Goose barnacle), *Balanus* (rock barnacle), *Sacculina* (root headed barnacle), *Squilla* (mantis shrimp), *Palaemon* (Freshwater prawn), *Penaeus* (marine prawn), *Lucifer* (shrimp), *Palinurus* (Lobster), *Astacus* (crayfish), *Cancer* (True crab), *Hipaa* (coconut crab), *Inachus* (spider crab).



Lepas



Palaemon



Cyclops



Daphnia



Sacculina



Cancer



Squilla



Astacus



Balanus

Fig. 4.4.7 Different Crustaceans

తేనెటీగలు, చెద పురుగులలో సాంఘిక జీవనం

ఒక కీటకం (ఉదాహరణకు చీమ, తేనెటీగ, కందిరీగ, చెదపురుగు) అదే జాతికి చెందిన ఇతర జీవులతో కలసి ఒక సహనివేశంలో నివశించడాన్ని సాంఘిక జీవనం అంటారు. ఈ జీవులు ఇన్ సెక్టు విభాగానికి చెందిన ఐసాప్టెరా, హైమనోప్టెరా క్రమాలలో కనిపిస్తాయి. సాంఘిక జీవన కీటకాలు పెద్ద జనాభాలను, సంతానపాలన, గూడు, సమూహ సమైక్యత, ప్రగతిశీల ఆహార సరఫరా, ట్రోఫాల్లాక్సిస్, స్వార్మింగ్, సమాచారం మరియు రక్షణ పరికరాలను కలిగి ఉండును.

తేనెటీగలలో సాంఘిక జీవనం

తేనెటీగ ఒక సహనివేశజీవి. తేనెటీగల గూడునే తేనెపట్టు అంటారు. ఒక తేనెటీగల సహనివేశంలో దాదాపు 35000 నుండి 50000 జీవులు నివశించును. తేనెటీగల సమూహంలో 3 రకాల జీవులు ఉంటాయి. అవి రాణిఈగ, కూలి ఈగలు, డ్రోన్స్ కనుక తేనెటీగల బహురూపక జీవులు.

చెద పురుగుల సామాజిక జీవనం

చెద పురుగులను సామాన్యంగా తెల్ల చీమలు అంటారు. చెద పురుగులు సెల్యులోస్ పై ఆధారపడి జీవిస్తాయి. వీటి పేగులో సెల్యులోస్ ని జీర్ణం చేసే కశాఖయుత జీవులలో (బ్రైకోనింఫా)తో సహజీవనం చేయును. ఇవి టెర్మిటోరియం అని పిలవబడే భూగర్భ గూళ్ళను తయారు చేస్తాయి. చెద పురుగుల సహనివేశంలో మూడు కులాలు ఉంటాయి. అవి ప్రత్యుత్పత్తి జరిపేవి, సైనికులు మరియు కూలీలు. చెదపురుగుల సహనివేశంలో ఒక జీవి యొక్క కులం నిర్ధారించ బడినప్పటికీ అది ఇతర కులాల జీవిగా మార్పు చెందగలగడం వీటి ప్రత్యేకత.

Class – 2 :Chilopoda

This class includes **centipedes** or **hundred leggers**.

They are terrestrial, air-breathing, carnivorous animals.

Body is divided into Head and trunk. Trunk bears 15 to 173 segments.

Each segment of trunk bears a pair of clawed appendages.

First pair of trunk appendages forms **poison claws**.

Respiratory organs are **tracheae**.

Excretory organs are **malpighian tubules**.

Examples :Scolopendra, Scutigera.



Fig. 4.4.8 Scolopendra

Class – 3 : Diplopoda :

This class includes **millipedes** or **thousand leggers**.

These are terrestrial and **detritivorous**.

Body is divided into head and trunk (16 to 100 segments)

Head bears one pair of antennae, one pair of mandibles and one pair of maxillae.

Maxillae are modified into **gnathochilarium**.

Each trunk segment bears two pairs of legs and two pairs of **spiracles**.

Respiratory organs are **tracheae**.

Excretory organs are **malpighian tubules**.

Examples :- *Julus*, *spirostreptus*, *Spirobolus*.

Note :Chilopoda and Diplopoda are grouped under superclass Myriapoda.

Class – 4 :Insecta (or) Hexapoda

Insecta is the largest class in animal kingdom and includes about 80,00,000 species of insects.

They are present in all habitats except **marine habitat**.

Body is divided into head, thorax and abdomen.

Head with one pair of **antennae**, one pair of **compound eyes**, one pair of **mandibles** and two pairs of **maxillae**.

Thorax with three pairs of jointed legs and one or two pairs of wings. Wings are absent in some (Ex : *Lepisma*)

Respiratory organs are **tracheae**.

Blood is colourless hence it is called **Haemolymph**.

Excretory organs are **malpighian tubules**.

They are **uricotelic**.

Development is indirect with various larval stages including **metamorphosis**.

Examples :*Lepisma* (Silverfish), *Poecilocercus* (Grasshopper), *Schistocerca* (Locust), *Periplaneta* (Cockroach), *Gryllus* (House cricket), *Phyllium* (Leaf insect), *Carausius* (Stick insect), *Ephemera* (May fly), *Pediculus* (Human louse), *Cimex* (Bed bug), *Ranatra* (Water scorpion), *Musca* (House fly), *Drosophila* (Fruit fly), *Culex* (Mosquito), *Apis* (Honey bee), *Xenopsylla* (Rat flea)



Fig. 4.4.9 *Spirostreptus*



Poecilocercus



Gryllus



Lepisma



Ranatra



Cockroach



Schistocerca

Fig. 4.4.10 Different insects

4.5. Vision and Respiration in Arthropoda

Learning Outcomes:

- To Know about the different types of eyes in Arthropoda.
- To Describe the structure of compound eye.
- To Understand the mechanism of vision in Arthropoda Phylum.
- To Identify different kinds of respiratory organs in Arthropoda.
- To Know the significance of tracheal system

Vision :

Most of the arthropods possess eyes, which can vary in number, structure and complexity. The eyes of arthropods may be in the form of photoreceptors, i.e., simple eyes or compound eyes. Ocelli can detect lower light levels and have a faster response time, while compound eyes are capable of forming images.

Simple eye (Ocelli):

The word ocelli is derived from the latin word **ocellus** which means little eye. Arachnids and jumping spiders possess simple eyes. Arthropods possess two types of ocelli

- 1) Dorsal Ocelli
- 2) Lateral Ocelli

1. Dorsal Ocelli : These are found dorsally on carapace closely placed together in the middle near the compound eyes. Dorsal Ocelli are not present in those which lack compound eyes. Each Ocelli contains a single corneal lens present may be curved (bees) or flat (cockroach). They are sensitive to a wide range of wavelengths and quickly respond to the changes in light intensity. Simple Ocelli cannot form an image and is unable to recognize the object.

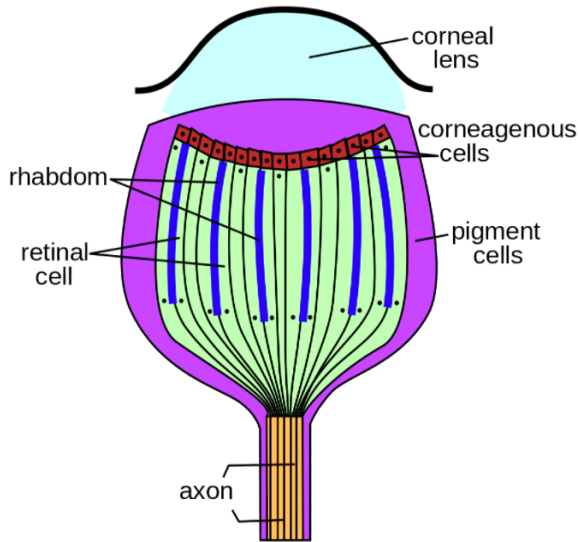


Fig. 4.5.1 Ocelli in Arthropods

2) Lateral Ocelli (Stemmata) : These ocelli are always present at the lateral sides of the head and number varies from 1 to 6 pairs. They are structurally similar with dorsal ocelli except they have a biconvex lens and crystalline cone beneath the cornea with less number of rhabdomes. Sensitive to light intensity and capable of detecting movements of nearby objects.



Fig. 4.5.2 Stemmata in Arthropod larvae

Compound Eye :

In Arthropods generally a pair of compound eyes are present on the dorsal side of the head. Each compound eye is composed of structural and functional units called **ommatidia**. The outer surface of the compound eye is divided into hexagonal facets. Each facet is an outermost portion of a corresponding ommatidium. The number of ommatidia varies from hundreds to thousands in different adult insects.

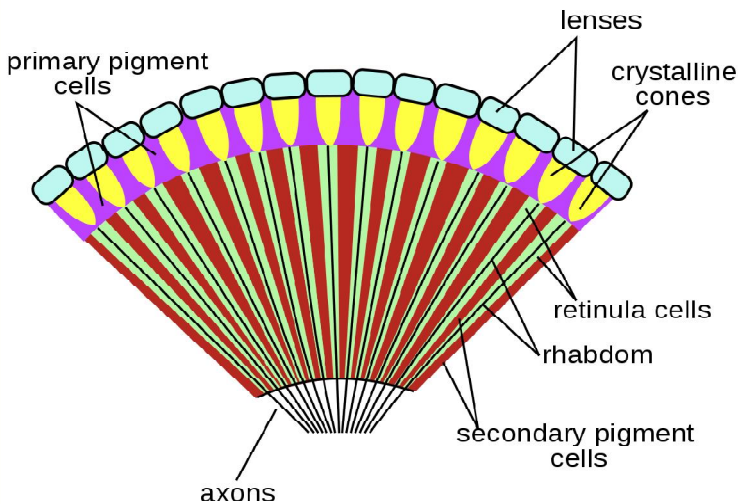


Fig. 4.5.3L.S. of Compound Eye

Structure of an Ommatidium :

Each Ommatidium is basically contains two regions i.e., 1. Dioptical or focussing region 2. Retinal or receptor region. The following structures are seen in dioptical and retinal region of Ommatidium.

- 1. Cornea :** It is the outermost part of ommatidium and corresponds to a “hexagonal facet” of the compound eye. It is biconvex and transparent. Cornea is secreted by corneagen cells.
- 2. Corneagen cells (Lenticular cells) :** These are two transparent specialized epidermal cells that secrete cornea. These cells later secretes iris pigment sheath.

3. Vitrellae or cone cells (semper cells) : These are four conical transparent cells that lie below the corneagen cells. They surrounded the transparent crystalline cone. These cells are protected by iris pigment sheath.

4. Crystalline cone : It is the transparent conical structure that is secreted by the vitrellae. The region containing the cornea and Crystalline cone constitute the dioptical or focusing region of the ommatidium. Crystalline cone focusing the light on to the rhabdome.

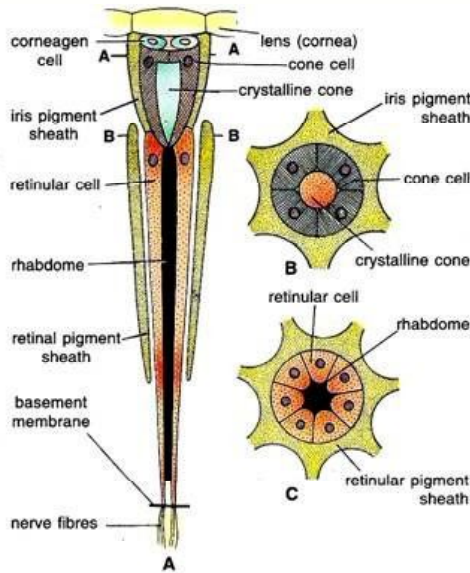


Fig. 4.5.4*Periplaneta* A- L.S of an ommatidium: B- T.S Through cone at A-A; C- T.S through rhabdome at B-B.

5. Retinulae : These are the innermost elongated cells of the ommatidium. They are seven in number and rest on the basement membrane. Inner facets towards the centre of these cells contain microvilli which collectively secrete rhabdome. Retinulae are the nerve fibres from which sensory nerve fibres leave to form optic nerve. Rhabdome and retinulae form the retinal or receptor region. Retinulae are surrounded by retinal pigment sheath which absorbs light and serve to isolate each ommatidium as an individual unit of compound eye. This retinal pigment sheath is movable. In bright light, pigment sheath extends and act as screen to prevent light rays to pass from one ommatidium to other. In dim light, this sheath retracts and allow light to pass from one ommatidium to other.

Image formation

Compound eye form image with help of inputs received from ommatidia. Each ommatidium forms a separate image of a small part of the object. Depending upon the intensity of light compound eyes form two kinds of image i.e., 1. Apposition image 2. Superposition image

1.Apposition image : The compound eye forms an Apposition image in bright light or daylight. In bright light both the iris pigment sheath and reticular pigment sheath extend and act as screen to prevent light rays passing from one ommatidium to another. Hence the light rays remain restricted to the axial region of the **crystalline cone** and **rhabdomes**. As a result the rays which perpendicularly fall on cornea and pass through rhabdome form the part of an image. The rays which fall obliquely on the cornea are absorbed by the pigment sheath and do not produce any visual effect.

The final image formed by the compound eye is a mosaic of several small images. Such an image is called apposition image because it is formed by the juxtaposition of small parts of the visual field. This type of vision is called **mosaic vision**.

2. Superposition image : These images are formed in the dim light. Mostly the nocturnal insects like fire flea forms this type of images. In weak light, both proximal and distal pigments retract. Now the ommatidia do not remain optically isolated and the light rays can pass obliquely from one ommatidium to another. This results in overlapping of images. The image formed by overlapping images is called a superposition image. It is not a clear image other words called as **blurred image**.

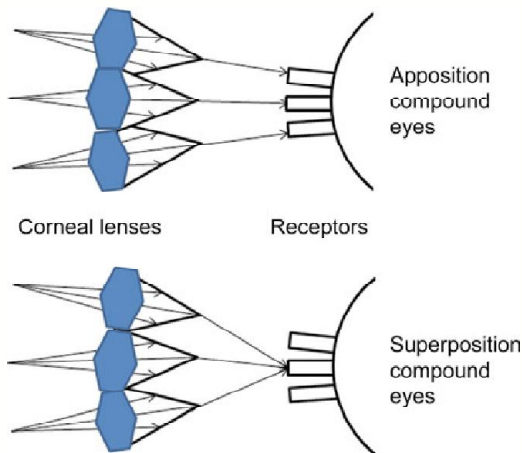


Fig. 4.5.5 Apposition and Superposition images in insects.

Respiration in Arthropods :

Arthropods constitute three-fourth of the animal kingdom and inhabit a variety of habitats that breathe air as well as perform aquatic gill breathing respiration. Their respiratory organs vary according to their way of living as described below.

Respiratory organs of Crustaceans :

In the 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, inner side of which is called branchiostegite and has vascular respiratory epithelium. Epipodites also help in respiration.

Prawn respiration : Respiration in prawn performed by the following structures.

1) Lining of branchiostegite : The richly vascularised membrane of the branchiostegite serves as the respiratory surface, through which gaseous exchange takes place.

2) Epipodites : These are small highly vascularised leaf-like membranous structures, on the coxal segment of each maxilliped. These epipodites being present in the anterior part of the gill chamber carry out respiratory functions.

3) Gills : Among the three respiratory organs in prawn, gills are regarded as primary respiratory organs. There are eight pairs of gills present at the lateral sides of cephalothorax and beneath the branchiostegites. Each gill is attached with the thoracic wall by a gill root. Seven of these eight gills are serially arranged, while the eighth gill remains concealed under the second gill.

Structure : The gills are crescent shaped and their size increases gradually from anterior to posterior direction. Each gill consists of a slender axis or base on which double rows of rhomboidal leaf-like gill plates are arranged like the pages of a book.

Types of gills : In prawn according to their position and the mode of attachment, the gills are three types.

1. Podobranch : This type of gills attached to the coxa of the second maxilliped. Example : first pair gills

2. Arthrobranch : This type of gills attached with the arthroidal membrane of third maxilliped. Ex : Second and Eight gills.

3. Pleurobranch : These gills are attached with the outer border of the thorax and over the articulating surface of the walking legs.

Ex : Third, Fourth, Fifth, Sixth and Seventh gills.

Respiratory organs in Arachnids :

The scorpion Respiratory system consists of 4 pairs of circular pulmonary sacs or book lungs. Each pair lies inside mesosomic segments from 3rd to 6th. Each book lung consists of two pairs. Proximal or ventral part is in the form of a small compressed air cavity, called a tracheal chamber. It communicates with the outer air by a slit-like opening called **spiracle** or **stigmata**. The Dorsal part of the book lung contains nearly 150 vertical folds or lamellae. Exchange of respiratory gasses takes place through the lamella. Spiders are unique regarding their respiration. They are the only animal group that breath simultaneously with lungs and trachea.

Respiratory organs of Insects :

Tracheal system : Most of the insects perform their respiration by means of an elaborate and most efficient gas exchange system known as tracheal system. In its general plan, the tracheal system resembles the circulatory system of vertebrate animals, as it is distributed throughout the body, so that air is brought in direct contact with tissues and cells of the body. In insects tracheal system serves for transport of oxygen and carbon dioxide because the blood of insects lack of respiratory pigment (except chironomus larvae which has haemoglobin in blood plasma) Tracheal system consists of spiracles, Tracheae and tracheoles.

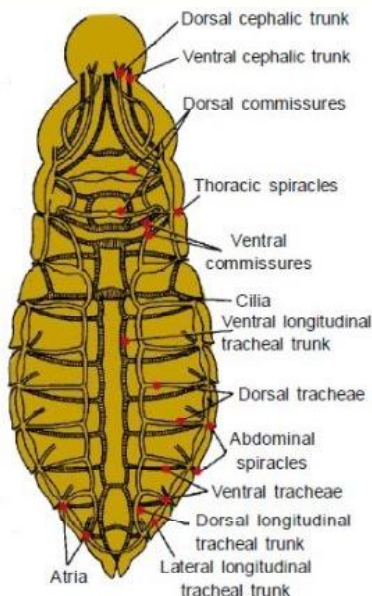


Fig. 4.5.6 Cockroach tracheal system

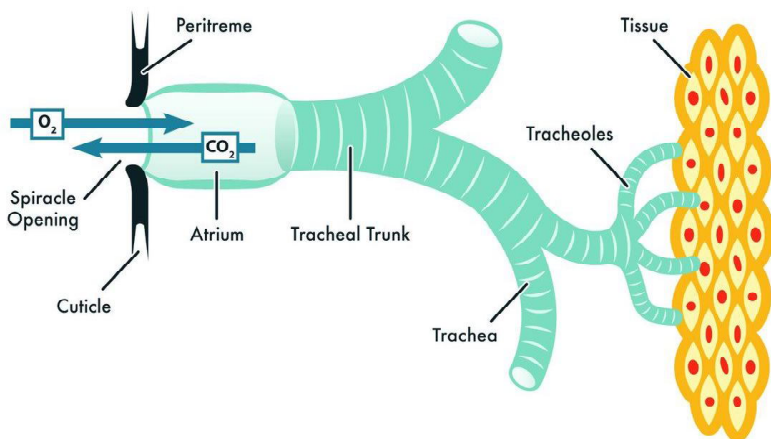


Fig. 4.5.7 Cockroach tracheoles in tracheal system

Types of tracheal system : According to the opening and closing of spiracles.

1. Holopneustic : When all the spiracles remain open.

Example : Cockroach

2. Hemipneustic : When one or pair of spiracles remain closed.

Example : beetles, butterflies.

3. Apneustic : Spiracles are completely absent.

Example : Aquatic larval insects.

Tracheal gills :

The nymphs and larvae of many aquatic insects possess specialized respiratory organs called Tracheal gills. Frequently tracheal gills are located on the abdomen and less frequently on the thorax and head.

Example : larva of plecoptera.

Blood gills : Some aquatic insects such as *Trachipterus tipulid larvae*, possess gills devoid of trachea but containing blood. These are termed as blood gills.

4.6. Metamorphosis in insects

Learning Outcomes:

- To Know about different types of metamorphosis in insects.
- To Understand the role of hormones in insects meta-morphosis
- To Understand the significance of metamorphosis.

The transformation of an immature larval individual into a sexually mature reproducing adult different from structure and habitat is called metamorphosis. The word “**metamorphosis**” comes from the Greek which means to transform. Insects display 4 types of metamorphosis.

1. Ametabolous or No-metamorphosis : This type of metamorphosis is also known as ametabolous development. The newly hatched creature looks exactly similar to an adult except in size and differences in armature of spines and setae.

Ex : Silverfish, Springtail, chewing lice, Sucking lice.

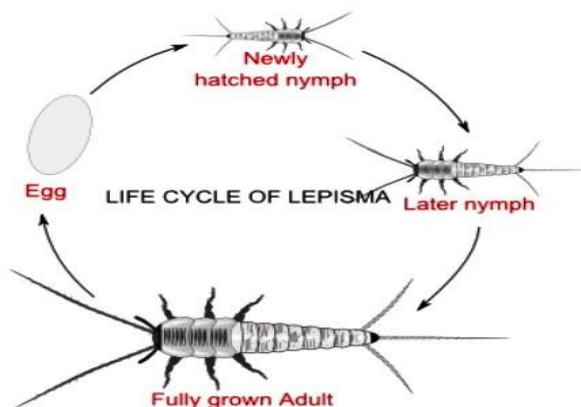


Fig. 4.6.1 Ametabolous development

2. Incomplete metamorphosis or hemimetabolous development : In case of incomplete metamorphosis the immature stages are called as nymphs or naids. These immature stages are aquatic and respire with gills. Whereas the adults are terrestrial and respire with trachea.

Ex : may fly, dragonflies, stone-flies.

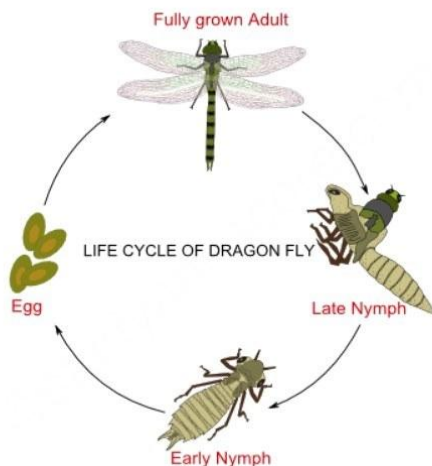


Fig. 4.6.2 Hemimetabolous development

3. Gradual metamorphosis or paurometabolous development : In this type of metamorphosis, the newly hatched creatures resemble an adult in general body form. But lacks wings and external genital appendages. The young **nymphs** undergo several nymphal stages through successive moultings to transform into adults.

Examples : Cockroach, Grasshoppers, aphids, stink bugs.

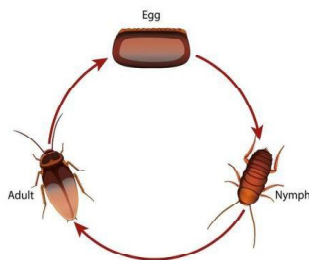


Fig. 4.6.3 Parametabolous development

4. Complete metamorphosis or 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 becomes a pupa within a secreted case called a **puparium**. Inside the puparium the pupa differentiates into adult and then breaks, emerges outside.

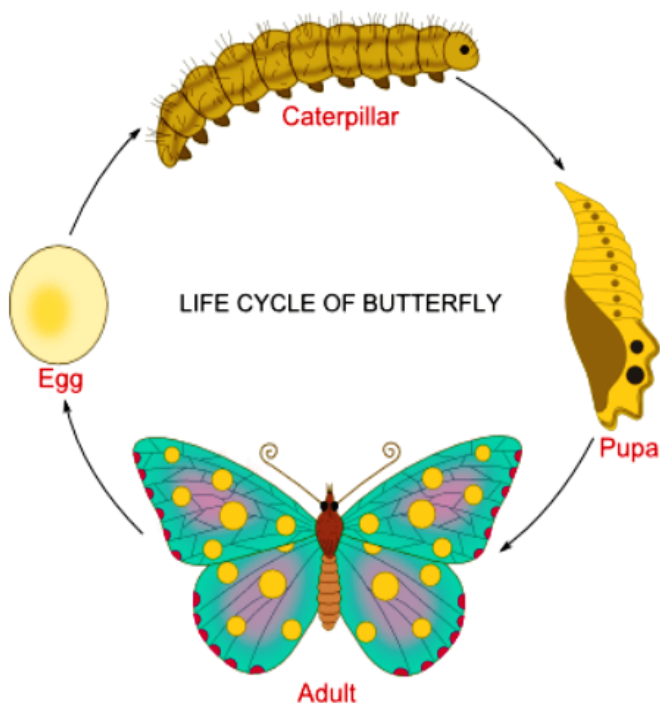


Fig. 4.6.4*Holometabolous development*

Hormonal control of metamorphosis :

The role of hormones in the physiology of moulting was first discovered by **V.B. Wigglesworth** in the year 1930. He discovered neurosecretory cells in the brain of insects. Metamorphosis is under the regulation of following Hormones;

- 1. Brain hormone (BH) :** It is secreted by neuro secretory cells of the brain. This hormone activates corpora cardiaca to release **pro thoracico tropic hormone (PTTH)** into blood.
- 2. Pro thoracico tropic hormone (PTTH):** This hormone is secreted by **corpora cardiaca**, which in turn stimulates prothoracic glands.
- 3. Pro thoracic gland hormone (PGH) :** This hormone secreted by **prothoracic glands** with the stimulation of PTTH. Chemically it is **ecdysone**. This hormone **triggers moulting** hence it is called **moulting hormone**.
- 4. Juvenile hormone (JH) :** This hormone is secreted by another component of the retro cerebral complex, the **corpora allata**. This hormone ensures growth of

4.7. Peripatus structure and affinities

Learning Outcomes:

- To Understand the morphology of peripatus.
- To Understand the evolutionary pattern of animal kingdom.
- To Know about the taxonomic position of peripatus.
- To Describe the structure of peripatus.
- To Know about the unique characters of Peripatus

Peripatus is an interesting animal that exhibits some annelid characters and some arthropod characters, besides its own typical features. Hence peripatus is often referred to as the **connecting link** between phylum Annelida and Arthropoda. Peripatus is conventionally with Arthropoda as one of its classes. But the modern system of animal classification has given it the status of an independent onychophora phylum. There are about 70 species in this phylum belonging to a few genera or possibly to one genus, peripatus.



Fig. 4.7.1 Peripatus

The genus peripatus is found restricted in the various places of the world such as South Africa, Australia, New Zealand, Mexico, Central America, West Indies, Malaya Archipelago and India. Hence it exhibits discontinuous distribution.

Habits and Habitat :

It lives in a terrestrial environment, living in moist places, in crevices of rocks. Under bark, stones and beneath the fallen leaves. It is generally confined to humid habitats. Peripatus is a **nocturnal**, **predaceous** and **carnivorous** animal. It feeds on small invertebrates such as snails, insects and worms.

External Morphology : Body of peripatus is **caterpillar like**. It is soft, elongated and more or less cylindrical. External segmentation is indistinct and marked only by the present of paired appendages. Which number from 14 to 43 pairs. Each leg is a large, hollow, conical un-jointed protuberance bearing a pair of **terminal claws**. At the distal end of each leg on the ventral side are three to six transverse spinaceous pads, on which the leg rests when walking.

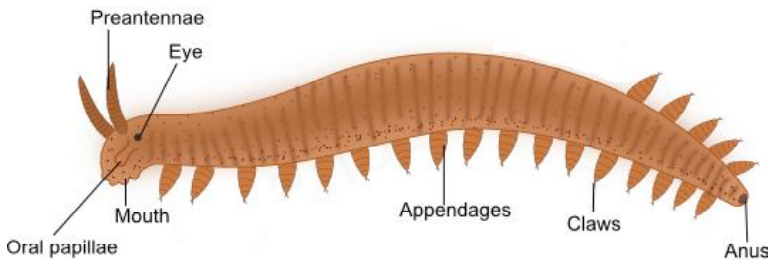


Fig. 4.7.1 Peripatus External morphology

The skin covered by thin cuticle is soft and has a **velvety texture** and is thrown into a number of fine transverse ridges bearing numerous conical papillae or **tubercles** armed with little chitinous spines. The coloration is different in various species from dark grey to brown. The entire body of peripatus may be divided into an indistinctly marked head and an elongated trunk. Head bears a pair of simple eyes, a pair of antennae, a pair of jaws or mandibles and a pair of oral papillae. Jaws are modified as a second pair of appendages. Each jaw is compared to two curved, falciform pointed chitinous plates attached with striated muscles. Third paired appendages are a pair of oral papillae. On the terminal end of each papilla contains an aperture of **slime gland**, which helps in entangling

Body Wall : The body wall is dermo muscular, consisting of cuticle, epidermis, dermis and muscles. All muscles are **non-striated**. Thus, the body wall of peripatus constructed on the typical annelidan plan.

Coelom : A true coelom is in the form of small cavities around the gonads and metanephridia; the body cavity is **haemocoel**.

Digestive System : It consists of Alimentary canal and digestive glands. Alimentary canal is simple and tube-like. Contains mouth, pharynx, esophagus, stomach intestine and rectum. A pair of salivary glands are present, opening into the pre oral cavity of mouth.

Respiratory System : Respiration performed by **tracheal tubes**. These tracheal tubes are delicate and unbranched, communicating to outside through minute spiracles. Spiracles are numerous without any closing valve.

Circulatory System : The coelom of peripatus is filled with colorless blood hence it is called **haemocoel**. A single mid dorsal tube, the heart placed on the dorsal surface of the gut. The heart is tubular and contractile lies within the pericardial sinus. It is provided with a pair of lateral ostia in each segment.

Excretory System : Segmentally arranged **nephridia** are excretory organs in peripatus. A typical nephridium contains a ciliated funnel, a coiled duct and vesicle. A pair of large slime glands opens outside through the apertures located on oral papillae. Slime glands are the modified coxal glands. When the animal is irritated then secretion is discharged in the form of a number of fine viscid threads probably as a measure of defense.

Nervous System : Peripatus contains **Annelidan type nervous system** with a pair of supra pharyngeal ganglia or brain, a pair of circumpharyngeal connectives and a pair of lateral longitudinal nerve cords connected together by transverse commissures. Ganglia on the cords are indistinct.

Sensory Organs : A pair of **simple eyes** are present near the base of the antennae.

Reproductive System : Peripatus is unisexual and **viviparous**. Fertilization is internal. The cleavage is superficial. Reproductive tracts contain cilia.

Affinities of peripatus : The genus peripatus was established in 1826 by Guilding. He regarded it as a mollusc, misled by its slug-like antennae and by its moist skin.

In 1874 Moseley first established the position of peripatus as a primitive member of phylum Arthropoda by discovery of the trachea. Peripatus exhibits affinities with Annelida, Arthropoda and Mollusca as well as with its unique characteristic features.

1) Annelidan characters :

Vermiform body with truncated extremities.

Constant, distinct head is absent.

Dermo-muscular body wall, consisting of a thin flexible cuticle.

Body wall contains smooth muscles only.

Locomotion is slow through peristalsis as in an earthworm.

Appendages are hallow and unjointed.

Simple and straight alimentary canal with terminal mouth and anus.

Paired segmentally arranged nephridia.

Slime glands are the modified coxal glands which are similar with glands of earthworms and leeches.

Structure of the eyes is simple and similar to Polychaetas' eye.

Presence of cilia in the reproductive tracts.

2.Arthropodan Affinities :

Presence of Antenna.

Body is covered with chitinous cuticle like that of arthropods.

Appendages are provided with claws.

Jaws are modified appendages with striated muscles.

Body cavity is haemocoel.

Coelom is reduced to small cavities that surround the excretory and reproductive ducts.

Presence of Salivary glands which opens into the pre oral cavity of mouth.

Presence of tracheal respiratory system.

Heart is dorsal tubular with lateral ostia.

Brain is large and resembles the brain of a typical arthropod.

General structure of reproductive organs and the pattern of development is same as in other arthropods.

3. Molluscan Affinities :

Slug like appearance of the body.

Ladder-Like nervous system as found in Amphineura.

The above characteristics led to the inclusion of peripatus among Mollusca. But according to other evidence, these are only superficial resemblances.

4. Onychophoran Characteristics :

Body shows indistinct segmentation.

Unique skin texture. A rough cuticle covered with numerous velvety processes not known in other phyla.

Antennae are not exactly similar with the antennae of arthropods.

Three segmental head of peripatus exhibit a condition mid-way between that of Annelida and Arthropoda.

Movement of jaws from anterior to posterior end.

Presence of un-jointed legs with claws.

Irregular distribution of spiracles on the body wall and devoid of valves.

Taxonomic position of peripatus :

Peripatus is of special interest because its body exhibits certain structures characteristic of annelids and other structures found in arthropods. Therefore, most of them are regarded as the connecting link between Annelida and Arthropoda.

However, onychophorans appear to be more closely allied to arthropods than to the annelids. But absence of exoskeleton and jointed limbs and the primary annelidan characters present in onychophora produce serious debate. As a matter of fact, onychophorans are neither annelids nor arthropods but possess

4.8. Social Life in Bees and Termites

Learning Outcomes:

- To Understand about division of labor
- To Identify different caste system in insects.
- To Know the characters of social insects.

Insects (such as an ant, bee, wasp & termite) that live in a colony or community with other individuals of the same species are called social insects. They are found in two orders of class insects namely Isoptera and Hymenoptera. Social insects possess large populations, parental care, Rich nest, Polymorphism, Extrapopulation of nests, Cohesiveness of colony, progressive provisioning of food, Trophallaxis, Swarming, communication and protective devices.

General Characters of Social Insects

- 1. Large Populations :** Social insects live in integrated manner in large groups. Individuals in bee hives may range up to 35,000 to 50,000. Termite's colonies may possess millions of individuals.
- 2. Parental care :** Parental care is an insect social behavior whereby the young ones are provided with food, shelter and defense by the parents as a part of the family relationship. Parental care includes activities like providing young ones with food, cleaning the nests, feeding the young, protecting the queen from all adversities, cooling the nest in summer season and removal of debris.
- 3. Rich nests :** The nests of all social insects are rich in structure which helps in protection, storage of food and maintenance of broods.

4. Polymorphism : It may be defined as the occurrence of several forms within the same species. It refers to specialization of individuals within a species, individuals perform different works in the colony so division of labor is prominent. Members are differentiated into distinct castes which are structurally and functionally different from each other. The polymorphic individuals are sometimes called super organisms.

5. Extra Populations : Some aphids, beetles, mites etc. are attracted into the nests of ants and termites by the high temperature and surplus food. These extra populations are protected and fed by the ants and termites. In return the ant and termite populations feed on a fluid secreted by them. Some beetles live in the nest of the ant and feed on the ant larvae. All these forms the extra populations of the social insects.

6. Cohesiveness of the colony : Cohesiveness means living together and cooperating with each other. Various casters in social insects differ in structure and physiology and perform different works for the mutual benefit of each other as a biological unit. Individuals cannot survive independently.

7. Progressive provisioning of food : Most of the social insects daily feed their young ones continuously. The young ones fed until they metamorphose into adults is called progressive provisioning of food.

8. Trophallaxis (Mutual feeding) : Exchange or sharing of liquid material between two individuals (mostly members of the same colony) is called trophallaxis. Mouth to mouth (stomodaeal) transfer of food is common in ants while anus to mouth (proctodaeal) transfer is crucial in termites. Similarly young ones exchange food with the adults. Trophallaxis is an important phenomenon in determination and regulation of castes in termite colonies.

9. Swarming : The behavior of the insects coming out of the nest in large numbers to relieve the overcrowding is called swarming. Swarming occurs for feeding, migration, of reproduction. The queen and male mate during swarming for propagate colonies. Swarming is also known as nuptial flight.

10. Communication : It is an interesting feature found both in social and non-social insects. It is the exchange of information between individuals. Insects use chemical, visual, tactile and auditory signals as a means of communication with each other. Pheromones (Ecto hormones) pass out of the body and help in regulating and coordinating the colony activities. For example, ants deposit substances on their way which act as trail markers and help them return to their homes after a foraging trip.

11. Protective devices : Social insects have protective devices like stings in bees and ants. Mandibles are well developed in most bees, soldiers of ants and termites to kill their enemies. Sometimes guards are posted near the nests to attack the intruders.

Social organization of bees :

Honey bees are social insects. The nest of the honey bee is known as the beehive. The population of an average sized bee colony consists of 35000 to 50000 individuals. Bees are considered to be a polymorphic species because there are three types of individuals in a colony. Namely the queen, worker and drone. All these three individuals depend upon each other for their existence. Drones and queens are concerned only with reproductive function and so workers have to perform all the other duties of the colony. The following is the description of each type of individual in the bee colony.

1. Queen :

It is the only diploid, fertile female in a beehive.

The size of the body of the queen is much larger than other castes of bees of the colony.

The queen is responsible for laying eggs for a colony. She lays about 1000 to 2000 eggs. Every day and lives for about two to three years.

2. Worker bee : It is a diploid, sterile female. The size of the worker bee is the smallest among all the other castes but they constitute the majority population in a bee colony. The following are the functions of worker bees.

Collection of honey, Producing royal jelly

Cleaning the honeycomb, Making wax

Constructing the beehive

Defending and protecting the hive

Cleaning the debris and removing dead bees.

Maintaining temperature of the hive.

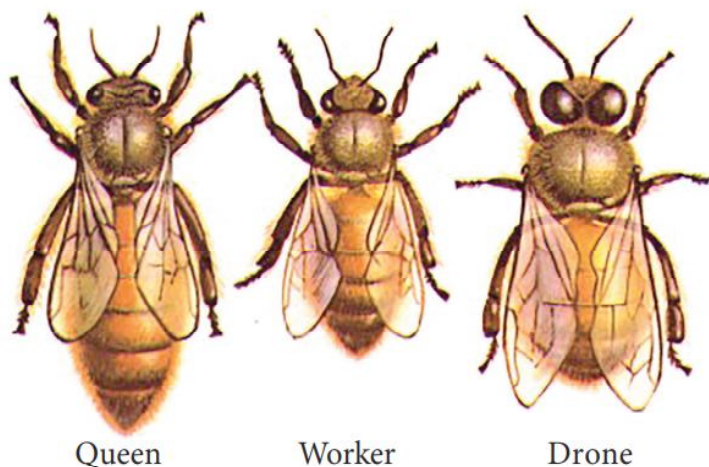


Fig. 4.8.1 Different honeybees in the colony

3. Drone : It is a haploid, fertile male.

Drone is derived from the haploid unfertilized egg through parthenogenesis.

Males are larger than workers.

They have large wings, robust body and reduced mouth parts.

There are usually 100 drones in a typical colony.

They live for about 5 weeks only.

They are designated only for mating. The number of drones in a colony varies from 200-300.

Social Organization of Termites :

Termites are commonly known as white ants. Termites survive exclusively on cellulose and carry cellulose-digesting flagellates inside their intestine symbiotically. They make underground nests called termitarium. The termite life cycle has the three castes, the reproductives, the soldiers and the workers. The unique nature of termite's colony is, once the caste of an individual is determined, development into other castes is still possible. The following are the individuals in the termite's colony.

Workers : They are sterile, wingless and blind males and females. Their cuticle is unpigmented and not hardened therefore the animals are confined to a dark and moist environment. Workers build the nest and galleries, they fetch food, care for the brood and feed reproductives and soldiers. The lifespan of a worker is about one to two years.

Soldiers : Just like workers they are also sterile, wingless and blind males and females with an unpigmented, unsclerotized cuticle. 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 cannot feed themselves; they have to be fed by workers. Usually, the number of soldiers is much smaller than the number of workers. The life span of the soldiers is about one to two years.

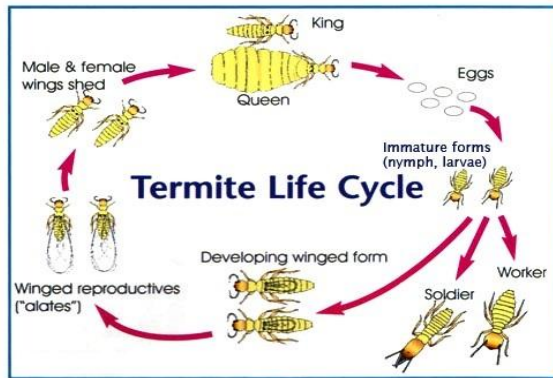


Fig. 4.8.1Life cycle of termites

Reproductives : These have compound eyes and are more or less brown due to their sclerotized cuticle. Developing reproductive have wing buds and wings. Reproductives can be further divided into

- 1) **Alates :** They are young winged reproductives of both males and females. From time to time about 100 to 1000 alates leave the colony for a mating and colonizing flight. After mating the pair settles down at a suitable site to establish a new colony.
- 2) **Dealates :** These are the alates that cast their wings after the colonizing flight and successively turn into queens and kings.
- 3) **Queen and king :** They are the main reproductive individuals in a colony. Once there are many workers to help the queen her only job is to produce a tremendous number of offspring. A large queen may lay more than 4000 eggs per day. The lifespan of a queen can be as much as 6-9 years. The king cohabits with the female for life.
- 4) **Neotenic :** They assist the queen in laying eggs, once her productivity decreases, when the queen has died or deteriorated, one of the neotenics takes her place and so they are also known as secondary queens. Hence, the removal of a queen from her colony does not necessarily mean the end of the colony.

GLOSSARY

Abductor : A muscle that draws and appendage away from the mid line of the body

Antenna : A sensitive feeler from the animal's head.

Anticoagulant : A substance that prevents coagulation of blood.

Appendage : A movable projecting part of the body.

Arthropoda : A phylum of segmented invertebrates with jointed legs.

Articulation : A joint between two structures.

Bioluminescence : Emission of light by living organisms.

Biramous : Possessing two branches.

Carapace : Hard covering of the crustacean Cephalothorax

Caterpillar: Larval stage in the metamorphosis of moths and butterflies.

Cephalic : Relating to or towards the head.

Cephalothorax : The fused head and thorax.

Chelate : Claw – possessing appendage.

Chelicera : A pair of pincer like head appendages of arachnids.

Chemoreceptor : A sense organ or cell that response to chemical stimulus.

Chitin : A polysaccharide protein horny substance that forms the exoskeleton of Arthropods.

Chrysalis : Pupal stage of butterfly.

Compound eye : An eye (In Arthropods with numerous ommatidia)

Crop : A thin walled part of the alimentary canal that serves to store the ingested food.

Ecdysis : Shedding of the outer body layer by an Arthropod.

Egestion : Discharge of undigested food from the alimentary canal.

Endoparasite : A parasite living within the host body.

Enterocoel : A coelom formed by the out pouching of mesodermal sac from the endoderm.

Entomology : Study of insects.

Fertilization : The union of a sperm with an ovum resulting in a zygote.

Fossil : Any remains of the past life of organism.

Ganglion : A mass of the cell bodies of nerve cells located outside the central nervous system.

Haemocoel : Coelom filled with blood.

Imago : An adult insect.

Insecticide : Chemical agent that kills insects.

Insectivorous : Insect eating animal.

Metamorphosis : A marked structural change from a larva into an adult.

Nauplius : First in a series of larval stage in crustacea.

Nocturnal : Active at night.

Nymph : An embryonic stage of insect that resembles an adult.

Ocellus : A small light perceiving eye chiefly of Arthropods.

Ommatidium : A visual unit in the compound eye of Arthropods.

Onychophora : A phylum of caterpillar-like animals structurally intermediate between annelids and Arthropods.

Palaeontology : Study of ancient life.

Palp : A feeler like head appendage.

Papilla : A small nipple like projection.

Parthenogenesis : Development of an egg without fertilization.

Pelagic : Inhabitation in open water as in mid – ocean.

Pharynx : Part of the gut immediately behind the mouth cavity.

Pheromone : A substance secreted by an organisms to the external environment which influence the behaviour of the other members of the same species.

Pupa : Quiescent stage in the complete metamorphosis of an insect.

Puparium : Pupal case.

Spiracle : Surface opening of the tracheal system in insects.

Statocyst : A sense organ of equilibrium.

Telson : Terminal body part of certain Arthropods.

Trachea : Respiratory tube of an insect.

Viviparous : An animal whose female gives birth to young ones.

Zoea : A kind of crustacean larva.

SELF ASSESSMENT

1. The term Arthropoda was coined by
 1. Jacob Klein 2. Lamarck 3. Vonsiebold 4. Aristotle
2. Striated muscles appeared for the first time in
 1. Annelids 2. Arthropods 3. Molluscs 4. Chordates
3. The respiratory pigment present in the blood of crustaceans and arachnids is
 1. Haemoglobin 2. Haemoerythrin
 3. Haemocyanin 4. Chlorocruin
4. Excretory organs of Arthropods are
 1. Green glands 2. Malpighian tubules
 3. Coxal glands 4. All the above
5. In Arthropods nerve ring is formed around
 1. Buccal cavity 2. Oesophagus
 3. Pharynx 4. Stomach
6. Triarthrus and Dalmanites are
 1. Trilobites 2. Arachnids 3. Chilopods 4. Diplopods
7. Arthropods without antennae are
 1. Chelicerates 2. Mandibulates
 3. Trilobites 4. Crustaceans
8. Five pairs of walk legs are present in
 1. Cockroach 2. Limulus 3. Scorpion 4. Spider
9. The number of walking legs present in spiders and scorpions is
 1. Three pairs 2. Four pairs 3. Five pairs 4. Six pairs
10. The respiratory organs of Limulus are
 1. Book lungs 2. Trachea 3. Book gills 4. Gills
11. Root headed barnacle is
 1. Balanus 2. Sacculina 3. Lepas 4. Lepisma
12. Cray fish is
 1. Sacculina 2. Lepisma 3. Astacus 4. Balanus
13. Ship barnacle or goose barnacle is
 1. Balanus 2. Lepas 3. Sacculina 4. Daphnia
14. Respiratory structures of insects are
 1. Lungs 2. Book lungs 3. Trachea 4. Branchiae
15. The largest class in the kingdom Animalia is
 1. Crustacea 2. Nematoda 3. Arachnida 4. Insects

16. The following are the statements regarding Arthropods
- I. These are unsegmented schizocoelomates
 - II. Exoskeleton of these animals helps in protection and prevention of loss of water from the body
 - III. Pharyngeal nerve ring is present
 - IV. Appendages are jointed.
- The correct combination is
1. I and II 2. II and III 3. II and IV 4. I and IV
17. The following are the statements regarding Diplopoda.
- I. These are millipedes or thousand legged worms
 - II. Maxillae fused to form gnathochilarium
 - III. Single genital aperture present at the posterior end of the trunk.
 - IV. The first few trunk segments bear one pair of legs but all other trunk segments bear two pairs of legs each.
- The correct combination is
1. All except – I 2. All except – II
3. All except – III 4. All except – IV
- 18 (A) : Open type of blood vascular system is present in Arthropods.
(R) : In Arthropods blood always flows in blood vessels.
- 1. Both A & R are true. R correctly explains 'A'
 - 2. Both A & R are true. But 'R' cannot explain 'A'
 - 3. 'A' is only true. But 'R' is not true
 - 4. Both A & R are not true

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Learning outcomes

On completion of this unit will be able to

- Understand the general characters and classification of phylum Mollusca.
- Know the natural pearl formation in pelecypods
- Understand the structure of sense organs of molluscs
- Understand the general characters and classification of phylum Echinodermata
- Understand the structure and functioning of water vascular system of Echinoderms
- Differentiate the adaptations of Echinoderm larvae
- Understand the structure and affinities of *Balanoglossus*

PHYLUM MOLLUSCA

Introduction

Phylum Mollusca is one of the most prominent invertebrate animals. The Phylum Mollusca consists of almost 1,00,000 species and is the second largest animal phylum. Individuals of this phylum range from minute planktonic and interstitial species to 20 m long giant squid (Largest invertebrate). Generally have well developed eyes and brain however in some they are absent. (Among invertebrates). They may be found in all habitats; deserts, forests, lakes, rivers, abysses of sea, coral reefs, underground or even as parasites on other animals. They may be found clinging to the rocks, crawling, swimming, burrowing or even digging. . This phylum was established by **Cuvier** (1798).

యూనిట్ -5

ఈ యూనిట్ పూర్తయిన తరువాత

- ఫైలమ్ మొలస్కా సాధారణ లక్షణాలు, వర్గీకరణను అర్థం చేసుకుంటారు.
- పెలేసిపాడ్లలో సహజ ముత్యాల ఏర్పడడం తెలుసుకుంటారు.
- మొలస్కు జ్ఞానేంద్రియాల నిర్మాణాన్ని అర్థం చేసుకుంటారు.
- ఫైలమ్ ఎఛ్టెనోడెర్మాటా సాధారణ లక్షణాలు, వర్గీకరణను అర్థం చేసుకుంటారు.
- ఎకినోడెర్మ్ లార్వా యొక్క అనుకూలతలను గుర్తించగలరు.
- బెలానోగ్లోసస్ యొక్క నిర్మాణం మరియు ఆఫినిటీలను అర్థం చేసుకుంటారు.

మలస్కావర్గం :

జంతు సామ్రాజ్యంలో మలస్కా వర్గం రెండవ అతి పెద్ద వర్గం, పరిమాణంలో ఈ మలస్కా జీవులు అన్ని ఆవాసాల్లోనూ జీవిస్తాయి. షెల్ (కర్పరం) ఉండటం ఈ జీవుల ముఖ్య లక్షణం. జీవుల శరీరం ఖండిత రహితం గానూ మృదువుగానూ ఉంటుంది. ఈ జీవులు నిజమైన శరీర కుహరంగల త్రిస్తరిత జీవులు. కర్పరం కలిగి ఉండటం మలస్కా వర్గ ముఖ్యలక్షణం. ఇది శరీరంపైన గాని ఉండవచ్చు. కర్పరం ఏకకవాటంతోగాని, రెండు కవాటాలతో గాని ఉంటుంది. సెఫాలెజేషన్ ఈ జీవులలో ప్రస్తుటంగా కనిపిస్తుంది. శరీరం, తల, ఉదరపాదం, మాంటిల్ అంతరాంగసముదాయం అనే భాగాలుగా విభజించడం జరుగుతుంది. పాదం ఉదరతలంలో ఏర్పడుతుంది. ఇది మందంగా, కండరయుతమై సాధారణంగా చలనంలో ఉపయోగపడుతుంది.

జీర్ణనాళం సరళంగా నాళంలాగా ఏర్పడి ఉంటుంది. పెలిసిపాడా విభాగానికి చెందిన జీవులలో తప్ప మిగిలిన విభాగపు జీవులలో ఆస్యకుహ రాద్యులా (Radula) అనే నిర్మాణం, ఖైటిన్ నిర్మితమైన పళ్ళతో ఏర్పడి ఉంటుంది. మొప్పలు (Ctenidia) అనేవి శ్వాసావయవాలుగా పనిచేస్తాయి. మలస్కా జీవులలో ఓపెన్ టైప్ రక్తప్రసరణ ఉంటుంది. సెఫలో పొడలో క్లోజ్డ్ రక్తప్రసరణకు ప్రారంభం జరిగింది. నాడిమండలం అభివృద్ధి చెంది ఆస్పరీడియం, స్టాలోసిస్ మొదలయిన జ్ఞానావయవాలు ఉంటాయి. అభివృద్ధి నేరుగాగాని, ఆప్రత్యక్ష పద్ధతిలోగాని జరిగి ట్రోకోఫోర్, వెలిజెర్ మొదలయిన డింభక దశలేర్పడతాయి.

వర్గీకరణ: మలస్కాను జీవుల కర్పర ఆకారం, పాదం, అవి ఉండే ప్రదేశంపై ఆధారపడి ఏడు విభాగాలుగా విభజించారు. ఎప్లాకోఫరా, పాలిప్లాఫారా, మోనోప్లాకోఫారా, గాస్ట్రోపొడా, పెలిసిపాడా, స్కాఫోపొడా, సెఫలోపొడా.

పెరల్ ఏర్పడే విధానం: పెలిసిపాడా విభాగపు జీవులలో సహజసిద్ధంగా పెరల్స్ ఏర్పడతాయి. ముత్యంలో ప్రధానంగా ఉండేది మాంటిల్ పొరలచే స్రవించబడిన నాక్రియస్ పొర. రసాయనికంగా ముత్యంలో CaCO_3 ఉంటుంది. ముత్యపు చిప్పలను కల్చర్ చేయడం ద్వారా కృత్రిమ ముత్యాలను ఉత్పత్తి చేస్తున్నారు.

UNIT- 5

5.1 GENERAL CHARACTERS AND CLASSIFICATION OF PHYLUM MOLLUSCA UPTO CLASSES

General Characters

1. The adults are triploblastic, bilaterally symmetrical animals with a soft unsegmented body. However, the bilateral symmetry may be lost in some adult mollusc due to torsion.
2. Most of them are enclosed in a calcareous shell. The shell may be external or in a few molluscs it may be internal, reduced or absent.
3. They have a well-developed cephalisation
4. The body is divisible into head, mantle, foot and visceral mass.
5. The visceral mass is enclosed in a thick muscular fold of the body wall called mantle which secretes the shell.
6. Body cavity is a haemocoel.
7. True coelom is schizocoel and reduced to cavities of pericardium, gonads and kidneys.
8. The buccal cavity contains a rasping organ called radula. It helps the animal in feeding. In Pelecypoda instead of radula crystalline cone is present.
9. A ventral muscular foot is an adaptation for locomotion, primarily for crawling. In some, it is secondarily modified for swimming or burrowing.
10. Paired gills or ctenidia are the primary aquatic respiratory organs. Some of the molluscs may possess pulmonary sac for breathing atmospheric oxygen.
11. Blood vascular system is of the open type with dorsal heart and a few blood vessels. However, cephalopods have a closed type of blood vascular system.
12. Respiratory pigment is haemocyanin.
13. Excretion is by a pair of kidneys or nephridia or organ of Bojanus.
14. An olfactory organ, the osphradium is situated at the base of the gills. Oosphradium tests the purity of water that enters the mantle cavity.
15. Majority of them are dioecious but a few of them may be hermaphrodite.
16. Development is generally indirect having larval stages but direct development is also found in some molluscs.
17. Trochophore larva, veliger larva and glochidium larva are characteristic larvae of mollusc that have an indirect development.

Classification

Molluscs are classified into seven classes according to their symmetry, shell, mantle, gills, nervous system and radula.

Class 1. Monoplacophora:

- **Gr. Monos means one; plax means plate; pherein means bearing** Body is bilaterally symmetrical and covered by a mantle.
- A single dorsal shell is present which is thin and sub circular.
- Coelom is well developed
- Flat ventral foot is present.
- Mouth and anus are situated at the anteromedian and posteromedian ends of the foot. Example: *Neopilina Galatea*

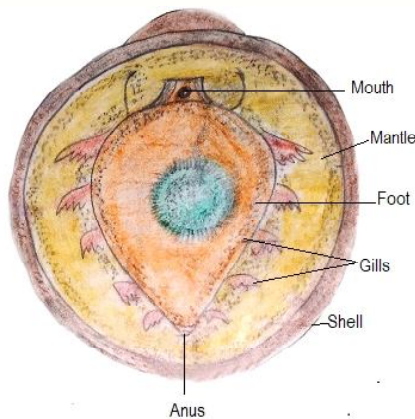


Fig.5.1.1. Neopilina(Ventral view)



Fig.5.1.1a. Neopilina

(Preserved specimen source wikimedia commons)

Class 2. Aplacophora : They are found in oceans at a depth of 9000 meters. Some live on the bottom, and others creep on hydroids and corals.

- They have a poorly developed head.
- Shell, foot and mantle are absent.
- Vermiform body, with a midventral, longitudinal groove containing one or more ridges which are probably homologous to the foot of other molluscs.
- They have calcareous spicules buried in the cuticle.

Example: *Neomenia*



Dorsal (top) and ventral views of a large Neomenia yamamotoi, from the Gulf of Alaska.

The animal is 11 cm in length. Neomenia yamamotoi courtesy of www.jaxshells.org.

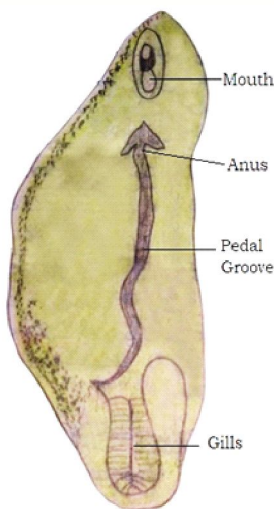


Fig. 5.1.2 Neomenia

Class 3. Polyplacophora:

- Includes Chitons, about 500 living species and 350 fossil species.
- Bilaterally symmetrical, dorsoventrally flattened, ovoid body, with a heavy mantle.
- Indistinct head, with no cephalic eyes or tentacles.
- The mantle cavity is posterior.
- Broad and flat foot present for attachment to the hard substratum.
- Examples: *Chiton*, *Lepidopleurina*, etc.

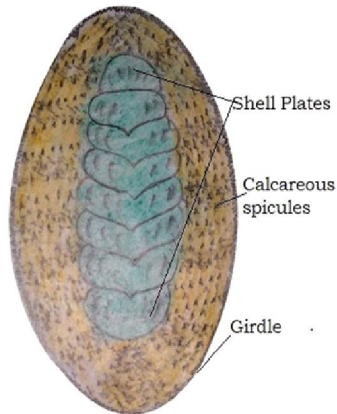


Fig. 5.1.3 Chiton (Dorsal View)



Acanthopleura spiniger
(Sowerby, 1840)



Cryptoplax larvaeformis
(Burrow, 1815)

Source Zoological Survey of India, Poster

Class 4. Gastropoda

- Molluscs with a spirally coiled mantle.
- Shell of one-piece enclosing a corresponding visceral mass.
- Asymmetry of visceropallium is its fundamental feature.
- Predominantly developed head with eyes and tentacles are present.
- Flat Foot is present behind the head.
- Buccal cavity consists of an odontophore with a radula having rows of chitinous teeth.
- Respiration through gills or pulmonary sac or lung.
- Nervous system having cerebral, pleural, buccal, pedal, visceral and abdominal ganglia with their connectives and commissures.

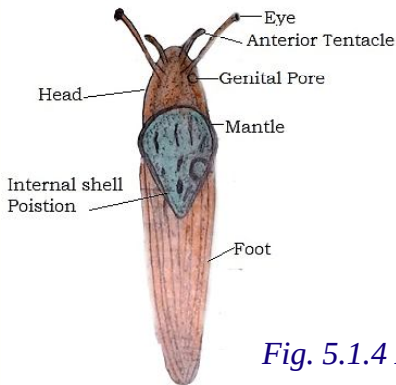


Fig. 5.1.4 Limax



Fig. 5.1.4a Pila

- Kidney is usually unpaired.
- Sexes are either separate or united.
- Larval development includes trochophore and veliger stages.

Examples: *Pila*, *Murex*, *Conus*, *Aplysia* (sea hare) *Doris*, *Helix*, *Lymnaea*, *Limax*, *Planorbis*,



1. *Mitra stictica*
2. *Cypraea tigris*



3. *Cassia cornuta*
4. *Trochus niloticus*



5. *Strombus variabilis*

Source Zoological Survey of India, Poster

Class 5. Scaphopoda

- Consists of Marine molluscs.
- Body elongated worm-like enclosed in a bilaterally cy-lindrical shell.
- Curved tube-like shell open at both the ends, the opening being wider at the oral and narrower at the other end.
- Foot is narrow and trilobed or with a terminal disc which can be protruded through the oral opening of the shell.
- Captacula, modification of foot help in capture of prey
- Mouth opens at the end of a short buccal tube, at the base of which is a circlet of tentacles.
- Gills absent.
- Odontophore is with a simple radula.
- Sexes are separate; the reproduc-tive elements pass out through the right excretory aperture.
- Development includes free-swimming trochophore larva succeeded by a veliger. Examples: *Dentalium*, *Entalina*, etc.

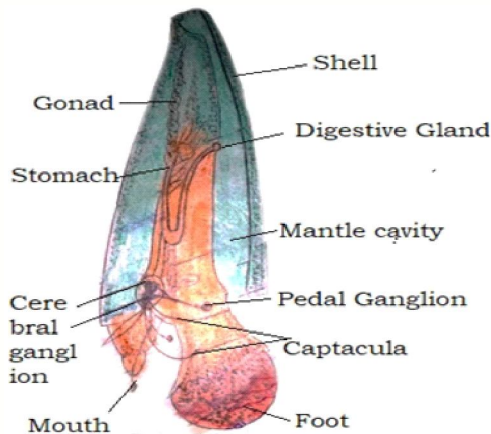


Fig. 5.1.5 *Dentalium*



Source Zoological Survey of India, Poster

Class 6. Pelecypoda or Bivalvia or Lamellibranchiata:

- Molluscs with a laterally compressed body enclosed in a bivalved calcareous shell are included in this class.
- Exhibits bilateral symmetry
- Shell is having a dorsal hinge and ligament, and closed by one or two adductor muscles.
- Head indistinct without eyes and tentacles.
- Foot is ventral and plough-shaped.
- Gills one or two pairs (ctenidia or branchia).
- Radula absent.
- Heart consists of two auricles and a ventricle.
- Nervous system consists of paired cerebral, pedal and visceral ganglia with their connectives.
- Sexes are separate or united; development with a veliger or glochidium larva. Examples: *Lamellidens*, *Unio*, *Anodonta*, *Mytilus*, *Teredo*, *Oyster* etc.

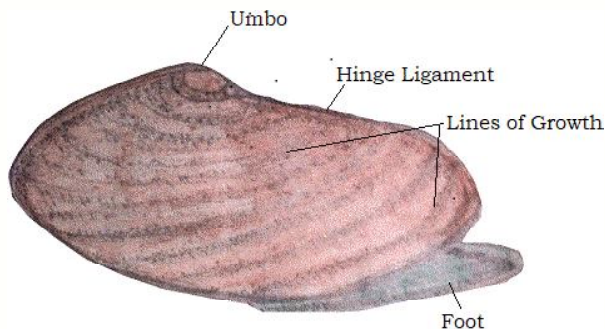


Fig. 5.1. 6 *Unio*

Class 7. Cephalopoda:

- Bilaterally symmetrical, free-swimming, marine molluscs.
- Head is surrounded by a series of arms bearing suckers, which are modified part of the foot, rest of the foot forms a siphon on the ventral surface of the body.
- Mantle encloses a large mantle cavity in which are situated the gills, the renal, reproductive and the anal apertures.
- Shell may be absent or rudimentary; when present may be internal or external, undivided or divided internally into a series of chambers.
- Head bears a pair of large, simple eyes.

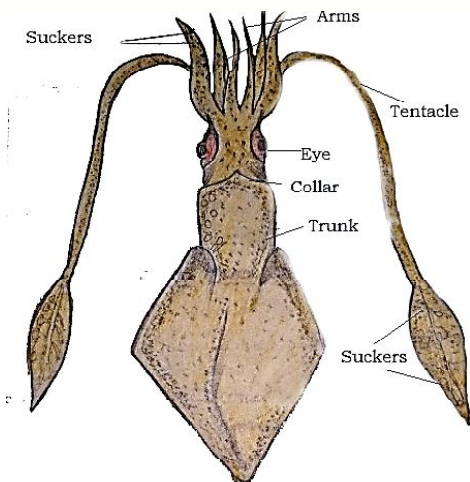


Fig. 5.1.7 *Loligo*



Fig. 5.1.7a *Octopus*

- A pair of horny jaws and an odontophore with a radula are present.
- In majority, there is an ink gland opening in the rectum.
- Nervous system is highly developed; the principal nerve ganglia are aggregated around the oesophagus and a cartilaginous skeleton supports and protects the nerve centre.
- Sexes are separate and development is direct.

Examples: *Nautilus pompilius*, *Loligo*, *Sepia*, *Octopus*

5.2 PEARL FORMATION IN PELECYPODA

Pearls are one of the naturally occurring precious gems. These are round structures formed in bivalve molluscs. Pearls are formed in bivalves of *Pinctada vulgaris*, *Pinctada fucata*, *Pinctada margaritifera* and *Pinctada maxima*.

Natural pearl formation :

Causative factor in pearl formation in a pearl oyster is the presence of a nucleus. It can be of organic or inorganic origin, such as parasites adults or larvae, molluscan eggs, decaying parts of plants, sand grains, epithelium or blood cells of the same animal, etc. These tiny particles or organisms enter the oyster when the shell valves are open for feeding and respiration. These foreign bodies may become embedded between the shell and mantle. In response to this stimulus, the foreign body is invaginated by the outer epithelium of the mantle and a pearl-sac is formed around it.

Pearls are not produced without the formation of the pearl-sac. The pearl-sac is derived from the internal or external layer of the epithelium of the mantle or of the gill plates. The epithelial cells of the pearl-sac secrete the nacre which becomes deposited over the foreign body, forming a pearl in due course of time. These pearls are produced either within the mantle, in other soft tissues of the oyster, or between the mantle, and the interior surface of the shell.

Distribution in Indian Waters:

Two zones in the Indian coast are well-known for pearl oysters.

- a. The Gulf of Kutch along the northern coast of Gujarat.
- b. The Gulf of Mannar adjoining Tamil Nadu coast.

The beds are vast in the Gulf of Mannar. Oyster beds are present at a depth of 10 to 20 metres and at a distance of 11 to 16 kilometres from the coast. The area of continental shelf is maximum at the eastern coast and these beds yield high-quality pearl.

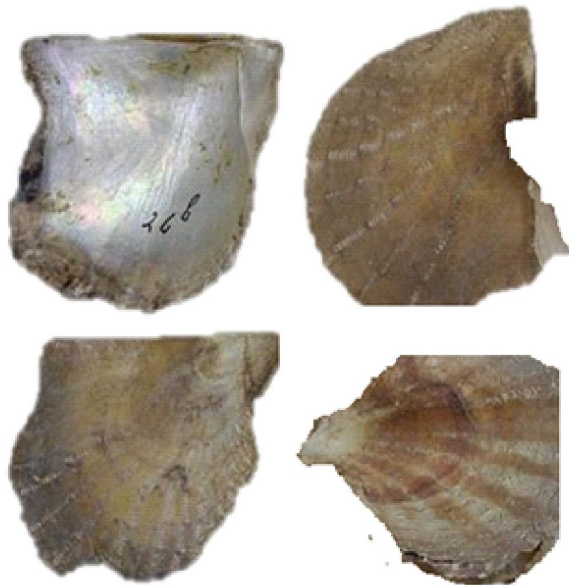
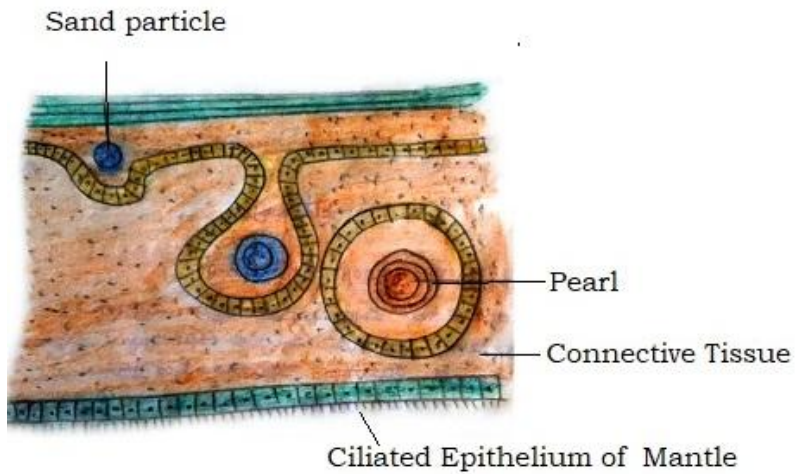


Fig 5.2.1 Preserved specimen of Pinctada fucata

Source: <https://en.wikipedia.org/wiki/en:NaturalisBiodiversityCenter>



5.2.2 Stages in pearl formation

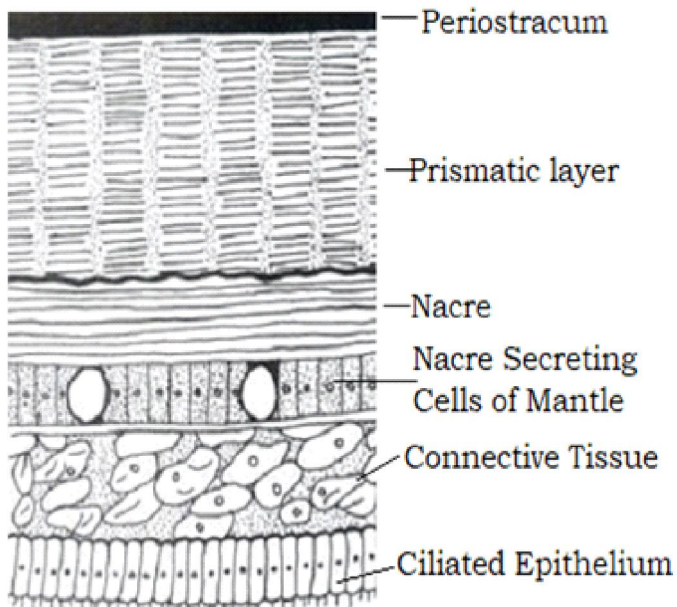


Fig. 5.2.3 TS of Shell and mantle of Pearl oyster

Cultured pearl

The technique of the formation of natural pearl is manipulated in the cultured pearl formation process. Here for the formation of pearl, the two prerequisites are:

- (1) The outer epithelium of the mantle lobe and
- (2) A core substance or nucleus.

Formation of pearl sac

A small piece of mantle from a donor oyster is grafted skilfully into the gonad of the recipient oyster along with a nucleus. The outer epithelium of the grafted mantle piece regenerates itself around the implanted nucleus and forms a pearl sac. This pearl sac secretes and deposits nacre or mother-of-pearl around the nucleus, thus resulting into a pearl

As this pearl is produced through manipulation (surgery) in the oyster and by further cultivation of the seeded oyster, it is thus called the cultured pearl. ***Secretion of pearl forming matters:***

Initially, after the formation of pearl sac, its internal part is alkaline and the secretion contains organic substances such as Keratin. The secretion is due to the prismatic layer containing calcites. The internal part of pearl sac later becomes acidic and subsequently neutral. The secretive matter ultimately becomes pearl forming material.

Calcium absorption and formation of calcium carbonate:

Main ingredient of pearl is calcium carbonate (calcite and aragonite). In pearl oysters the main source of calcium is food. However, the gill, mantle and foot can directly absorb calcium from water.

In case of the gills, the calcium absorption power is strong and its rejection capacity is meagre, while, in the mantle both absorption and rejection of calcium are very strong. Thus, the gills are considered to be the most ideal organ for absorption and storing of calcium in pearl oysters.

Calcium absorbed through food and from water slowly moves into the pallium through blood. The carrying of calcium in the body depends mainly upon the role played by alkaline phosphatase present in the epithelial cells of the connective tissue and mantle of the pearl sac. Alkaline phosphatase combines with the calcium ion (Ca^{+2}) to form phosphate and other salts.

Calcium ion in the presence of phosphatase gains energy and passes through the mantle to be absorbed by its epidermal cells. This is then carried to the connective tissue of the pearl sac.

In the course of its passage the Ca^{+2} also unite with the cartilaginous sulphate (a compound protein of acidic nature). It further induces the calcium ion to become active and is transported to the cytoplasm of nacreous layer and ultimately excreted by the epidermal cells.

The excreted calcium then under the activity of carbonic acid combines with the carbon dioxide (released by the body of the mussel due to metabolic activity) and ultimately forms calcium carbonate.

It has been reported that the concentration of carbon dioxide determines the nature of crystal formation. In the presence of increased CO_2 in the aquatic environment calcium carbonate forms sleek-like crystals, while it takes the shape of calcite when CO_2 decreases in the environment.

The main sites of production of pearl are the Persian Gulf, Gulf of Manaar (Ceylon), Sulusea (near Philippines). Besides these, coast of Australia and shores of Central America (Pennama Bay, Gulf of California) including islands of south Pacific are also important productive places. Nowadays Japan has surpassed all the countries in the bulk of pearl production by invention of pearl culture techniques.

Pearl oyster beds in India are present on both eastern and western coasts. However, the east coast is more productive and extensive than the west coast as it extends from Cape Comorin to Kilakarai. Major sites of pearl fisheries in India are Gulf of Manaar both on Indian as well as Ceylonese sides, Gulf of Kutch, Palk Bay, Baroda and Tuticorin.

5.3 SENSE ORGANS IN MOLLUSCA

Sense organs of molluscs include two pairs of tentacles, osphradium, a pair of eyes (ommatidia), and a pair of statocyst.

TENTACLES :

Two pair of tentacles are present in the head region. First pair of tentacles are contractile and are known as labial palp. Second pair is longer, filamentous and retractile, which is the true tentacle, present behind the first one. Both the tentacles are tactile in nature. Tentacles are innervated by nerves from the cerebral ganglia.

OSPHRADIUM:

There is only one osphradium that lies suspended from the roof of the mantle cavity on the left side. It is oval in shape with inner or right end bluntly rounded while the outer or left end pointed (Fig.5.3.1) It has a central axis to which two rows of thick, fleshy leaflets are attached. Leaflets are larger in the middle of the osphradium. In a transverse section, the osphradium is made up an outer layer of epithelial cells lined internally by a basement membrane.

The epithelial cells are elongate and consists of three types of cells:

1. Sensory cells are devoid of cilia and cover the osphradium.
2. Ciliated cells
3. Glandular cells are found scattered among the sensory cells.

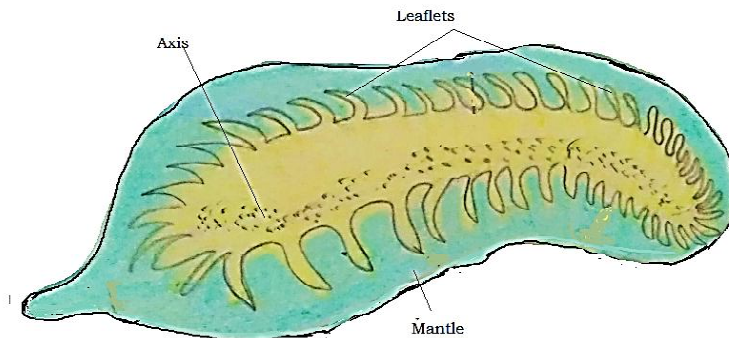


Fig.5.3.1 Osphradium

Osphradium is innervated by a nerve from the left pleural ganglion. The osphradium is an olfactory organ that lies in the path of water current entering the mantle cavity. It enables the animal to test the physical and chemical nature of the incurrent water and also assists in the selection of food. If the incurrent water is foul then it is prevented from entering the mantle cavity by the closure of the left nuchal lobe.

STATOCYST :

A pair of small, pyriform, cream coloured statocyst lie one on either side of the pleuro-pedal ganglionic mass. Each statocyst is a hollow capsule surrounded by thick, tough, leathery covering of connective tissue. The statocyst is ectodermal in origin, filled with a fluid containing calcareous particles known as statolith or statoconia. Statocysts are balancing organs and regulate the position in water and on land. It gets its nerve supply from the cerebral ganglion.

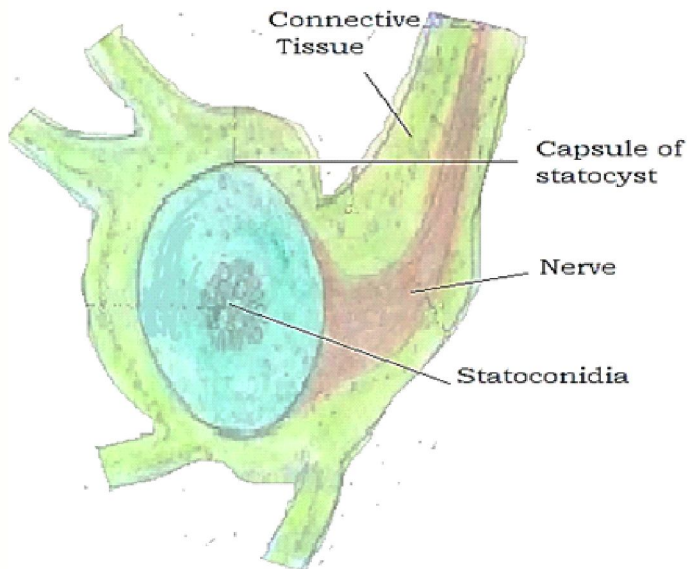


Fig.5.3.2 Statocyst

EYES :

A pair of short, black and stalked simple eyes are present one on either side of the head at the base of each true tentacle. The stalk is known as ommatophore. Each eye is covered in front by the transparent cornea which is actually the part of the general epithelium of the body. In section, eye is in the form of a cup like invagination called the optic vesicle lined by photosensitive or pigmented retinal cells. The cavity of the vesicle is filled with an oval hyaline structure called the lens. The anterior part of the optic vesicle in front of the lens is transparent and forms the inner cornea

The optic vesicle is surrounded by a firm sheath of connective tissue. The optic nerve enters the retina from the posterior end of the vesicle. Although, *Pila* has an elaborate visual organ with all the components for photoreception, it is poor in sight and cannot distinguish objects.

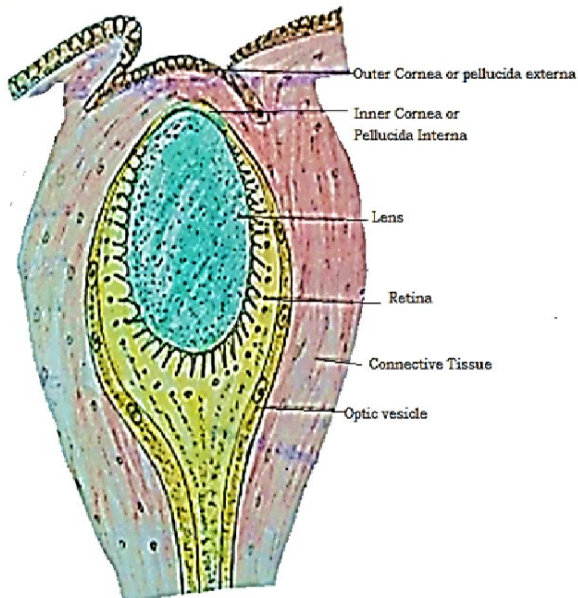
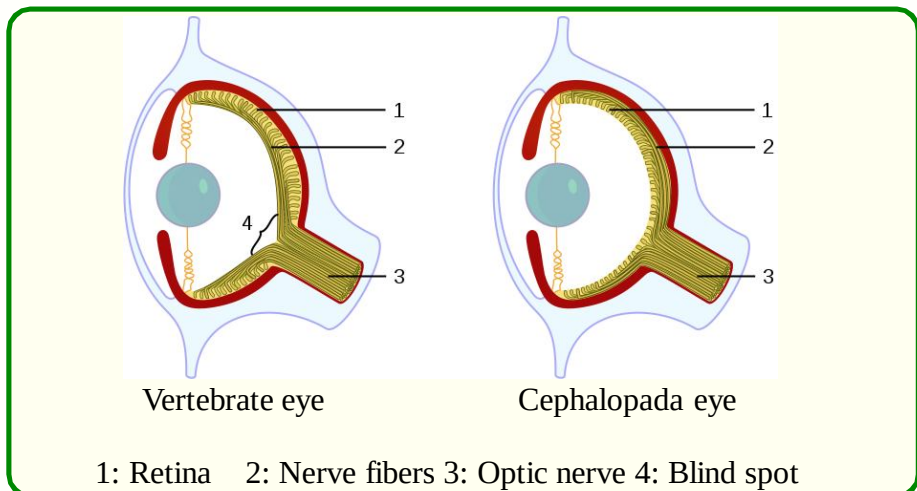


Fig.5.3.3 Eye of Cephalopod Mollusc

It can only respond to variations in light intensity. The eye is chiefly adapted to work in dim light.



GLOSSARY

Captacula:	In the class Scaphopoda foot modified into tentacles with a bulbous end, known as <i>captacula</i> , which serve to catch and manipulate prey.
Ctenidia:	Comb like thin structures resemble gills – meant for respiration.
Foot:	Muscular structure for locomotion
Hinge ligament:	Ligament Connecting the two halves of the shell found in class Pelecypods.
Mantle:	The mantle cavity characteristic feature of phylum Mollusca. This cavity contains the mollusc's gills, anus, osphradium, nephridiopores, and gonopores.
Ommatophore:	Eyestalk is referred to in Mollusca as ommatophore.
Osphradium:	A sensory structure found in the mantle cavity of most living molluscs, broadly characterized as a pigmented patch of epithelium on or adjacent to the ctenidia (gills).
Pearl:	Bivalve molluscs secrete a fluid to coat on the foreign particles entered into the mantle cavity. Layer upon layer of this coating is deposited on until a lustrous pearl is formed.
Radula:	Structure used by molluscs for feeding, compared to a tongue. It is a minutely toothed, chitinous ribbon, which is typically used for scraping or cutting food before the food enters the oesophagus.
Spiral cleavage:	Cleavage pattern seen in the development of Molluscs.
Statoconia:	Statocyst consists of a sac-like structure containing a mineralised mass (statolith) and numerous innervated sensory hairs (setae).
Statocyst:	It is a balance sensory receptor present in Molluscs.
Torsion:	Rotation of the visceral mass, mantle, and shell to 180° with respect to the head and foot of the gastropod. This brings the mantle cavity and the anus to an anterior position above the head.

Veliger: Larva typical of certain molluscs. Veliger develops from the trochophore larva and has large, ciliated lobes (velum). The velum forms from the ciliary ring (prototroch), a characteristic of the trochophore stage.

4. In the evolutionary point of view which of the following character first is seen molluscs. ()
- a. Chambered heart. b. Triploblastic nature
c. Bilateral Symmetry c. Coelom Schizocoel
5. Radula absent in the class ()
- a. Gastropoda b. Pelecypoda
c. Cephalopoda c. Monoplacophora
5. Gills of molluscs referred to as ()
- a. radula b. osphradium
c. ctenidia d. crystalline cone
6. Larval forms seen in development of molluscs are ()
- a. Veliger b. Trochophore
c. a b & d d. Glochidium
7. Excretory structures of molluscs ()
- a. Gills b. ctenidia
c. Mantle d. nephridia
8. Closed blood vascular system is seen in the class ()
- a. Cephalopoda b. Gastropoda
c. pelecypoda d. aplacophora
9. Heart of molluscs consists of ()
- a. Single chamber b. two ventricles
c. two atria d. one atrium and one ventricle
- Key: 1-Triploblastic, 2- c, 3-c, 4-c, 5-c, 6-c, 7-d,8-a, 9-d

FOR IGNITED MINDS

1. <https://vikaspedia.in/agriculture/fisheries/fish-production/culture-fisheries/culture-techniques-of-fishes/pearl-culture/economics-of-freshwater-pearl-culture>. Visit this site for resources entrepreneur opportunities for pearl culture.

2. Visit this site for understanding artificial pearl formation https://www.youtube.com/watch?v=2_oA7XzW3bQ
3. <https://www.youtube.com/e2e6ffd8-8815-4207-a72d-175801f33b4e>
4. Visit this site for additional information on the general characters and classification of phylum Mollusca. <https://www.onlinebiologynotes.com/phylum-mollusca-general-characteristics-classification/>
5. Visit this site for understating artificial pearl culture <https://biologyeducare.com/phylum-mollusca/>
6. Visit the site for additional information of the phylum Mollusca, general characters, classification and pearl culture. <https://link.springer.com/chapter/10.1007%2F978-94-011-6035-310>
7. Aplacophora characters and examples details <https://ucmp.berkeley.edu/taxa/inverts/mollusca/aplacophora.php>
8. The classification of Mollusca followed here is from Invertebrate Zoology by Robert D. Barnes 5th edition.



PHYLUM - ECHINODERMATA

Learning outcomes

On completion of this unit will be able to

- Learn general characters and classification of phylum Echinodermata
- Study the structure and functioning of water vascular system of Echinoderms
- Understand the structure and adaptations of different Echinoderm larvae

INTRODUCTION

Phylum Echinodermata consists exclusively marine animals. Echinoderms are distinguished by a pentamerous radial symmetry, water-vascular system of coelomic canals. Tube feet of water-vascular system used in feeding and locomotion. Another unique feature is the presence of bilateral symmetry in the larva. The name Echinodermata was first coined by Jacob Klein in 1734.

5.4 GENERAL CHARACTERS AND CLASSIFICATION UP TO CLASSES WITH SUITABLE EXAMPLES

Greek: echinos, hedgehog; derma, skin.

General Characters of Phylum Echinodermata:

1. Exclusively marine forms.
2. Adults with radial and five-rayed sym-metry while the larvae are bilaterally symmetrical.
3. Body distinguishable into oral and aboral surfaces and are without any differen-tiated head.
4. Body is covered by calcareous ossicles or plates, often bea-ring projecting tubercles or spines.
5. Pedicellaria are the complex calcareous structures meant for protection and cleaning of the body.
6. Digestive canal is mostly a coiled tube with the anus placed on the aboral side.
7. A characteristic water vascular system is present, which performs many functions.

వర్గం - ఇఖైనోడర్మేటా

ఇఖైనోడర్మేటా జీవులు ఖండితరహిత, త్రిప్లాజ్లాస్టిక్, ఎంటిరోసీలోమిక్ జీవులు, ఇవి ప్రాథమికంగా బైలాటెరల్ సిమెట్రీని కలిగి ఉంటాయి. ద్వితీయంగా రేడియల్ సిమెట్రీని పొందాయి. శరీర కుహరం నుంచి ఏర్పడ్డ వాటర్ వాస్కులర్ వ్యవస్థ ఇఖైనోడర్మేటా జీవుల విశిష్ట లక్షణం.

ఇఖైనోడర్మేటా స్వేచ్ఛగా జీవించే సముద్ర జంతువులు, వీటి డింభకాలు బైలాటెరల్ సిమెట్రీని కలిగి ఉంటాయి. ప్రాథమిక జీవులు పెంటమీరస్ రేడియల్ సిమెట్రీని కలిగి ఉంటాయి. దేహాన్ని మధ్యం అక్షం చుట్టూ అమరి ఉన్న ఐదు సమాన భాగాలుగా విభజించవచ్చు. కాబట్టి వీటి సౌష్ఠవాన్ని పెంటమీరస్ రేడియల్ సిమెట్రీని అంటారు. శరీరం కల్కరేయస్ ఆసికిల్స్ లేదా ఫ్లేట్ల ద్వారా కప్పబడి ఉంటుంది, పెడిసెల్లేరియా అనేవి శరీరాన్ని సంరక్షించడానికి మరియు శుభ్రం చేయడానికి ఉద్దేశించిన సంక్లిష్టమైన కల్కరేయస్ నిర్మాణాలు. జీర్ణనాళం అబోరల్ వైపు ఉన్న చుట్టబడిన గొట్టం. ఒక విలక్షణమైన వాటర్ వాస్కులర్ సిస్టమ్ ఉంటుంది. ఇది అనేక విధులను నిర్వహిస్తుంది. ట్యూబులర్ కాంట్రాక్టైల్ ట్యూబ్ ఫీట్ లోకోమోటరీ ఆర్గాన్ లేదా ఫీడింగ్ ఆర్గాన్ గా ఉపయోగపడతాయి ఇవి వాటర్ వాస్కులర్ సిస్టమ్ లో ప్రధానభాగం. హిమల్ సర్క్యులేటరీ సిస్టమ్ సరిగ్గా అభివృద్ధి చెందలేదు. ఖచ్చితమైన స్వాస మరియు విజర్ణక వ్యవస్థలు ఏర్పడలేదు. నాడీ వ్యవస్థ అన్నవాహిక చట్ట ఉంగరం రూపంలో పెరిస్టోమియల్ నాడీవలయం, దాని నుండి ప్రతి ఆంబులాక్రల్ నాళం వెంబడి వ్యాపించిన రేడియల్ నాడి ఉంటాయి. ప్రత్యుత్పత్తి లైంగికమైనది. గోనాడ్స్ సరళమైనవి. ఫలదీకరణ బాహ్యం. క్లీవేజ్ రేడియల్. అభివృద్ధి పరోక్షమైనది, అభివృద్ధిలో లార్వా రూపాలను కలిగి ఉంటుంది. కొన్ని ఆలోటోమీ మరియు పునరుత్పత్తిని ప్రదర్శిస్తాయి.

వర్గీకరణ :

రెండు ఉపవర్గాలుగా పెల్మటోజోవా, ఎల్మ్యాథిరోజోవా వర్గీకరించారు పెల్మటోజోవా జీవులు సెడెంటరీ జీవులు, ఎల్మ్యాథిరోజోవా జీవులు ఫ్రీస్విమ్మింగ్ జీవులు. పెల్మటోజోవాలో జీవించి ఉన్న ఒకే ఒక విభాగం క్రైనాయిడియా. ఎల్మ్యాథిరోజోవా ఉపవర్గంను నాలుగు విభాగాలుగా వర్గీకరించారు. అవి : ఏస్టెరాసియా ఒఫియురాయిడియా ఎఖైనాయిడియా, హెలోతురాయిడియా

8. Tubular contractile tube feet or podia of water-vascular system used as locomotory organ and/or feeding organ.
9. Haemal circulatory system poorly developed.
10. There are no definite respiratory and excretory systems.
11. Nervous system sub-epidermal, in the form of a circum-oesophageal ring from which arises diffused nerve along each ambulacrum.
12. Reproduction is sexual. Gonads simple in nature. Fertilization external.
13. Cleavage is radial.
14. Development is indirect, includes bilateral-ly symmetrical, free swimming larval forms.
15. Some exhibits autotomy and regeneration.

Classification of Phylum Echinodermata:

The classification based on the classificatory plan of (Hyman 1995)

This phylum is divided into two sub phyla

1. Pelmatozoa
2. Eleutherozoa

Sub phylum: Pelmatozoa

- All are stalked and sedentary forms
Both mouth and anus are present on the dorsal surface of the body.
- Tube feet absent
- Tubular ciliated appendages when present are without suckers.
- Mostly extinct
- Body not pentamerous

This subphylum includes 4 classes

Class 1. Cystidea – All Extinct

Class 2. Blastoidea- All Extinct

Class 3. Edriosteroidea – All Extinct

Class 4. **Class Crinoidea** (Greek: lily-like):

- This sub phylum divided into 4 classes Stalked and free moving forms, the oral side of the body directed upwards.

వాటర్ వాన్సులార్ సిస్టమ్ (అంబులాక్రల్ సిస్టమ్)

ఈ వ్యవస్థ ఇన్జెనోడర్మేటా వర్గంలో మాత్రమే ఉంటుంది. ముఖతలంలో అయిదు భుజాలు కుల కుల్య ఉంటుంది. దీన్ని అంబులేక్రల్ వలయనాళం అంటారు. దీని నుంచి ఐదు రేడియల్ అంబులేక్రల్ కాలువలు భుజాగ్రం వరకు వ్యాపిస్తాయి. వీటి నుంచి రెండు వైపులా లాటెరల్ నాళాలు ఏర్పడి నాళికా పాదాల కలశికలతో కలుస్తాయి. ఈ సూక్ష్మనాళాలన్నీ శైలికలతో కూడిన (శిలాకుల్యతో) కలిసి ఉంటాయి. అంబులేక్రల్ వ్యవస్థలో ఉన్న అన్ని నాళాలు కండర నిర్మితమై లోపలి భాగాన ఉపకళతో ఉంటాయి. ఇలాంటి కండరాలు నాళికా కలశికల్లోను, ఫోలియన్ వెసికిల్స్లోను బాగా ఏర్పడినట్లు కనిపిస్తుంది. రంధ్రఫలకం ద్వారా నీరు శిలాకుల్యంలోకి ప్రవహించి అంబులేక్రల్ వలయ నాళాన్ని చేరుతుంది. తరువాత అంబులేక్రల్ కాలువల ద్వారా నాళికా పాదాలను చేరి, వాటి పలచని గోడల ద్వారా బయటకు పోతుంది. జలప్రసరణవ్యవస్థకు అనుబంధంగా ఉన్న నాళికాపాదాలు చలనం, ఆహార సేకరణకు, శ్వాసక్రియకు, విజర్షనకు తోడ్పడతాయి.

ఇన్జెనోడర్మేటా లార్వాలు :

ఇన్జెనోడర్మేటా జీవులు ఏకలైంగిక జంతువులు. అభివృద్ధి ప్రత్యక్షంగా లేదా పరోక్షంగా ఉండవచ్చు. అభివృద్ధి పరోక్షం అయితే, దీనిలో లార్వా దశలు ఉంటాయి. వివిధ తరగతుల ఎకినోడెర్మీలలో, వివిధ రాకాల లార్వాలు అభివృద్ధిని పూర్తిచేస్తాయి. లార్వా రూపం బైలాటిరల్ సిమెట్రీతో ప్రొడజీవి అభివృద్ధిచెందును.

ఫైలమ్ ఎకినోడెర్మాటా యొక్క తరగతి మరియు లార్వాల్ ఫార్మ్

ఆస్టరాయిడియా - బైపిన్నేరియా, బ్రాకియోలారియా,

ఓఫియురాఇడియా - ఓఫియోప్లాటియస్

ఎఖినాయిడియా - ఎఛైనోప్లాటస్

హెమిలోథురోడియా - ఆరిక్యులేరియా

క్రైనాయిడియా డోలియోలారియా మరియు పెంటాక్రైనాయిడ్

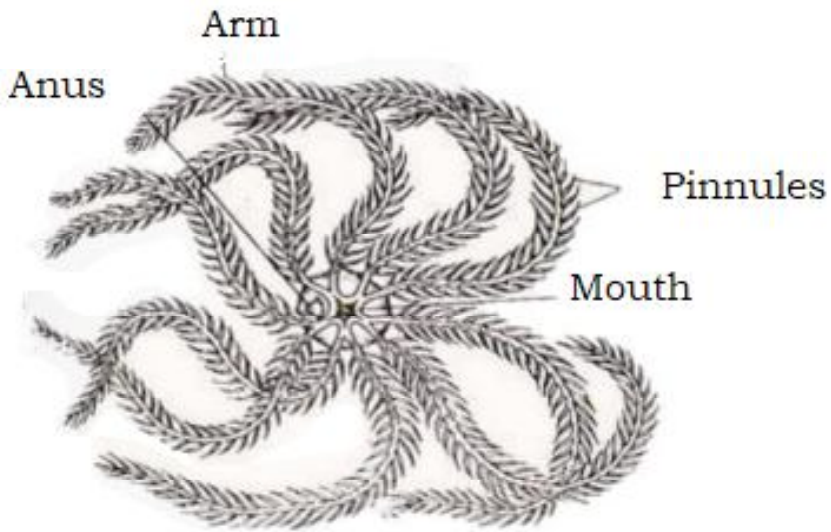


Fig.5.4.1 Antedon

- Arms branched (10 to 200 or more) and bearing pinnules.
The ambulacral grooves radiate from the mouth and extend to the tip of the pinnules.
 - Madreporite is absent
 - A non-contractile aboral stalk bearing whorls of cirri help for attachment.
 - The arms, body and stalk contain heavily calcified plates.
 - Development includes pentacrinoid larva
- Examples: *Antedon*, *Metacrinus*, *Rhizocrinus*

Subphylum Eleutherozoa:

- This sub phylum includes free living echinoderms
- Radially symmetrical having a body composed of a flattened disc and radial-ly arranged arms.
- Body star shaped and remains un-attached.
- On the oral surface in the ambulacral groove, tube feet are present.
- Anus is present on the aboral surface
- This sub phylum divided into 4 classes

Class 1. Asteroidea (Greek: star-like):

- Referred as sea star or star fish
- Arms not clearly demarcated from the central disc.

Ambulacral grooves are open and a large coelomic cavity is present in the arms.

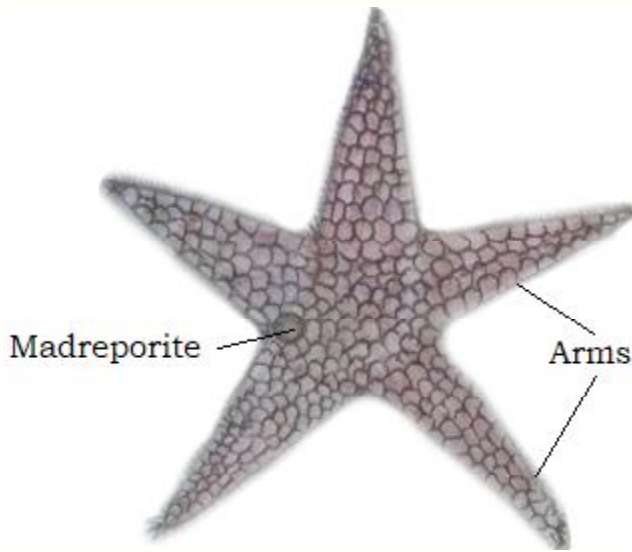


Fig.5.4.2 Asterias

- Each ambulacral groove contains two or four rows of tube feet.
- Tube feet with or without suckers.
- Anus and madreporite are present on the aboral surface.
- Larvae are Bipinnaria and Brachiolaria.
- Examples: *Asterias*, *Astropecten*, *Heliaster*, *Platyasterias*, *Asterina*

Class 2. Ophiuroidea (Greek: snake-like):

- Includes serpent stars & Brittle stars
- Arms sharply differentiated from the central disc.
- Ambulacral grooves absent the arms are filled by vertebral ossicles.
- No spacious prolongations of the coelom into the arms
- Mouth and madreporite are situated on the oral surface of the body.
- Anus lacking.
- Larva is Ophiopluteus

Examples: *Ophiura*, *Ophiothrix*, *Ophioderma*, *Ophionereis*, *Asteronyx*.

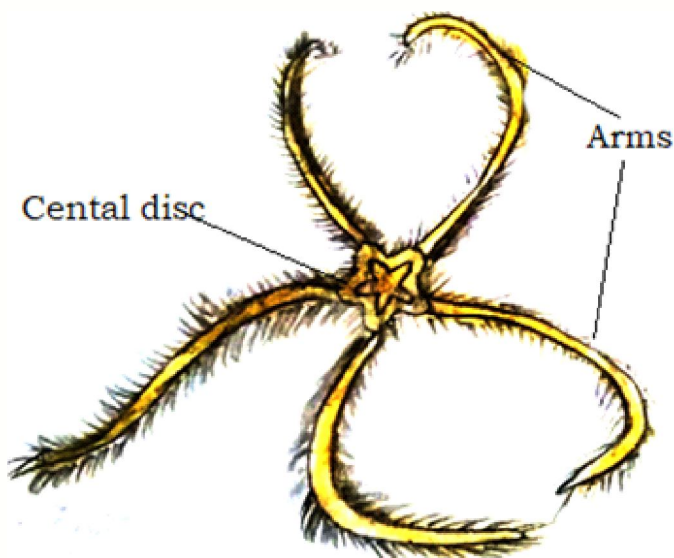


Fig.5.4.3 Ophiothrix

Class 3. Echinoidea (Greek: spiny):

- Includes sea-urchins, sand dollars, heart urchins.
- Body more or less spherical, flattened orally/aboral.
- Ossicles fused to form an internal test on which moveable spines are mounted.
- Although the ambulacral grooves are absent, the body surface is divided into alternate ambulacral and inter-ambulacral areas.
- The ambulacral areas extend from the oral to the aboral sides of the body.
- Ambulacral plates have pores for the passage of the tube feet.
- Mouth is having a five jawed apparatus Aristotle's lantern for rasping the food. In heart urchins it is absent.
- The tube feet possess suckers.

Examples: *Echinus*, *Clypeaster*

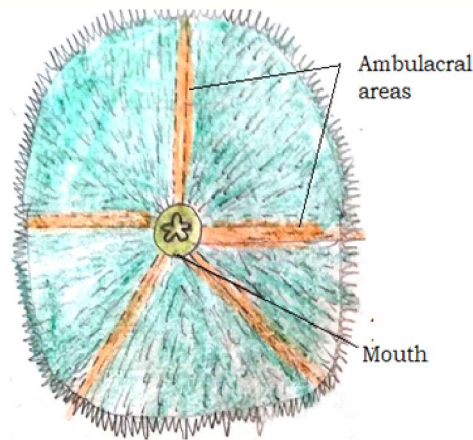


Fig.5.4.4. Echinus

Class 4. Holothuroidea (Greek: violent expulsion)

- Includes sea cucumbers
- Body elongated along the oral/aboral axis.
- Surface of the body may exhibit five ambulacral areas.
- Mouth and anus present at opposite extremities of the body.
- Oral podia modified as tentacles which may be simple or dendritic and may or may not be provided with ampullae.
- Skeleton reduced to microscopic ossicles.
- Examples: *Holothuria*, *Cucumaria* *Thyone* *Molpadia*

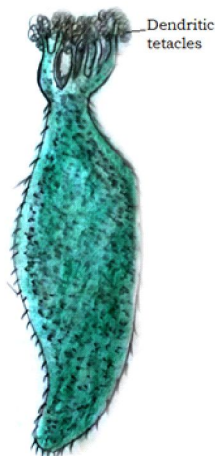


Fig.5.4.5 Thyone

5.5 WATERVASCULAR SYSTEM IN STAR FISH

Introduction to water vascular system:

Water vascular system (Ambulacral system) is enterocoelic in origin and arises from the left hydrocoel. It exhibits radial symmetry from the beginning and is equally developed in all echinoderms. This system lies just above the haemal system. It is primarily locomotory in function and also sub-serves the function of tactile and respiratory organs in some cases.

General plan of water vascular system:

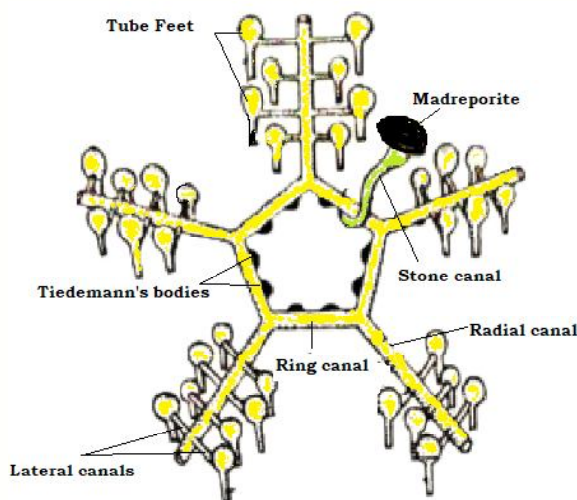


Fig. 5.5.1 Water vascular system in Asterias

The water vascular system in different classes of Echinodermata has almost the same structural organisation. It comprises of a few canals together with some appendages attached to these canals. The typical arrangement of the water vascular system is exhibited by asterias is explained as follows

The water vascular system includes a **circum-oral canal** (circular ambulacral or ring canal) situated around the mouth which gives tubular radial extensions, called **radial canals**. The number of the radial canals is usually five. But the number corresponds to the number of the radii of the body. Each radial canal ends blindly at the end of the arm and gives off along its course lateral vessels, each joining a tube-foot. Each tube-foot is a hollow conical or cylindrical process with an ampulla and a terminal sucker.

The junction between the lateral vessels and the tube-feet is provided with valves which assist in locomotion. The contraction of the ampullae results in the extension of the tube-feet. A short, slightly curved, cylindrical and vertically disposed **stone or sand canal** is present between the madreporite and the ring canal. The stone canal opens into the ring canal at the oral end and into the madreporite ampulla at the aboral end.

Madreporite is a skeletal plate-like structure placed at the aboral side. It is perforated by pores, called the madreporic pores, which lead into madreporic ampulla or vesicle from where the stone canal starts. The stone canal is surrounded by a wider canal, called axial sinus, the wall of which becomes folded to form the axial organ or **dorsal organ or ovoid gland or heart**. The role of axial organ is not fully known.

Besides the main vessels, some appendages become associated with the system. Inter-radially located and connected with the ring canal, there are **polian vesicles and tiedemann's bodies**. The polian vesicles are bladder-like sacs with narrower neck. They are contractile and usually manufacture amoeboid cells. The tiedemann's bodies are glandular in nature and consist of a number of branched tubules. They are yellowish in colour and give origin to cells for the water vascular system.

Functions of the water vascular system:

1. Locomotion

- The main function of the water vascular system is to help in locomotion.
- Echinoderms having suckorial podia (tube-feet) can adhere to the substratum temporarily.

2. Respiratory and sensory:

- In Ophiuroidea and Holothuroidea the tube-feet (podia) are primarily sensory in function. In echinoidea (Sea urchins), the tube-feet of the aboral side lack terminal disc and are sensory in function.

3. Excretory:

- Nitrogenous wastes are eliminated through the thin areas of the body surface such as the walls of tube-feet.

5.6 LARVAL FORMS OF ECHINODERMATA

Echinoderms are unisexual animals. Sexual dimorphism is absent. Fertilisation takes place in water. The development may be direct or indirect. If the development is indirect, it includes larval stages. In different classes of echinoderms, different types of larvae complete the development. The larval form is bilaterally symmetrical. It undergoes metamorphosis and radial symmetrical adult is developed.

Class of Phylum Echinodermata	Larval form
1. Asteroidea	Bipinnaria & Brachiolaria
2. Ophiuroidea	Ophiopluteus
3. Echinoidea	Echinopluteus
4. Holothuroidea	Auricularia
5. Crinoidea	Doliolaria & Pentacrinoid

1. Bipinnaria Larva:

It is the larval form seen in the life history of Star fish. The fertilised egg is homolecithal. It undergoes holoblastic cleavage and develops into blastula and gastrula stages. The gastrula elongates in length and it gives rise to Bipinnaria larva.

- It is a bilaterally symmetrical free swimming pelagic larva.
- The pre-oral region is elongated.
- Post-oral region is broad.
- The anterior end forms pre-oral lobe.

The ciliated band at the pre-oral lobe forms into 2 separate bands, pre-oral band of cilia, and post oral band of cilia. These 2 bands of cilia are drawn into many arms. They are nothing to do with the arms of the star fish. They are,

- Ventro-median arms.

- A pair of pre-oral arms.
- Median dorsal arms.
- A pair of antero-dorsal arms.
- A pair of postero-dorsal arms.
- A pair of postero-lateral arms.
- A pair of post oral arms.
- The digestive system is developed with mouth and anus.
- This larva resembles Tornaria larva of Balanoglossus.

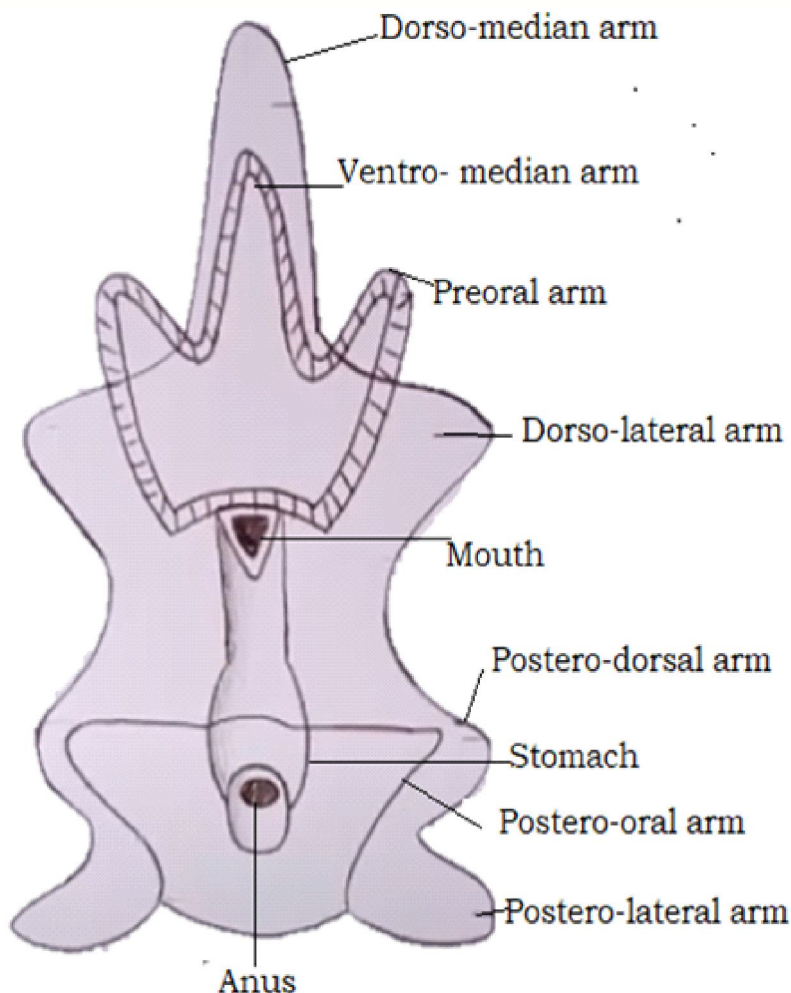


Fig 5.6.1. Bipinnaria Larva

- This larva slowly grows into the next larval form called Brachiolaria larva.

2. **Brachiolaria Larva:**

- Bipinnaria larva swims for few weeks in the marine water and finally transforms into next larval stage called **Brachiolaria larva**.
- It is bilaterally symmetrical larva.
- It is pelagic larval form, it shows 3 brachiolar arms with suckers. They are one median and two lateral in position.

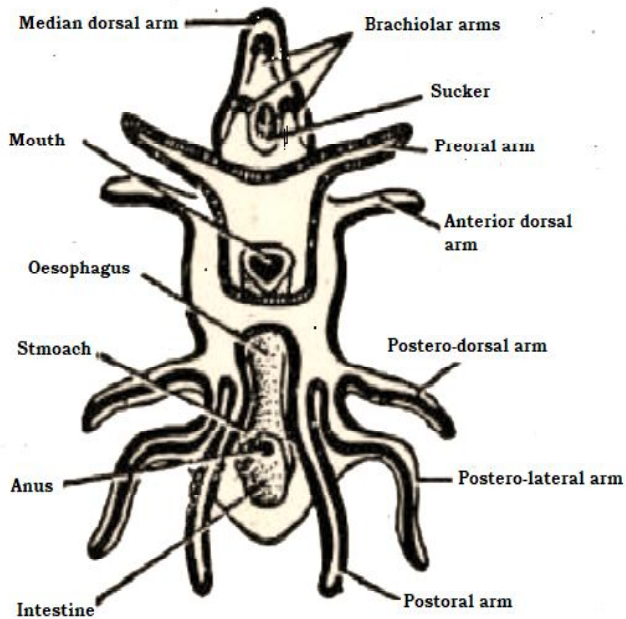


Fig. 5.6.2 Brachiolaria larval form is seen

- At the tip of brachiolar arms adhesive structures will make their appearance and they are for attachment.
- The larva shows all the arms that are seen in the Bipinnaria, but these arms are very long and hanging. These ciliated arms will be helpful for swimming in the water.
- The digestive system is completely developed with definite stomach and intestine.
- This larva after swimming for some time settle-on a solid object and gets attached to it by its adhesive arms.
- Posterior end of the larva enlarges and lifts to the right-side. From these rudiments of 5 arms will arise. Thus, slowly the larva metamorphosis into an adult.

3. Auricularia Larva:

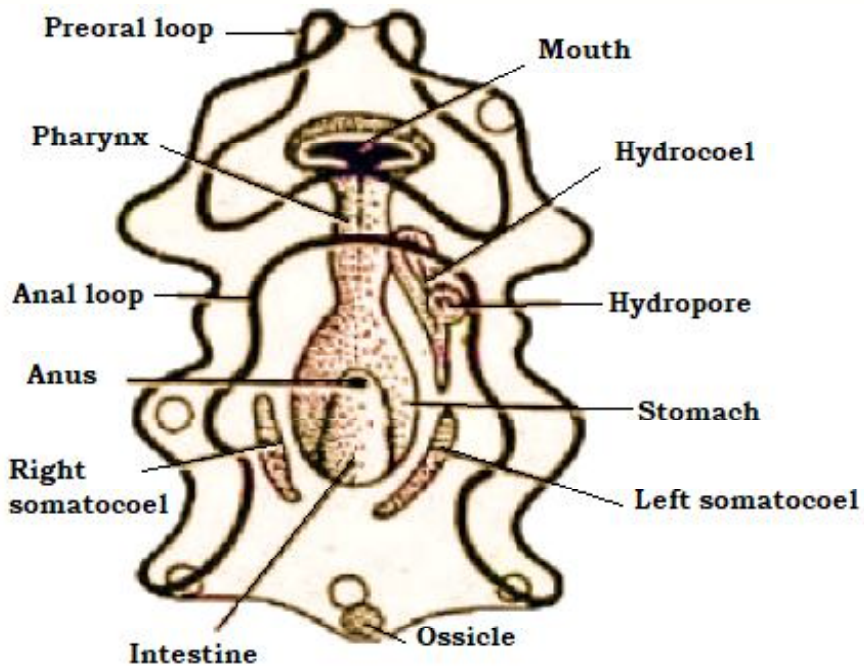


Fig.5.6.3 Auricularia larva

- It is a free-swimming pelagic larva.
- Arms are absent. Alimentary canal is developed. It opens with mouth and ends with anus.
- Intestine is curved.
- Usually, this larva is 1 mm in length.
- Ciliated bands are well-developed. Ciliated band continues through oral loop and anal loop.

4. Ophiopluteus Larva:

- This larva is seen in the life history of Ophiuroidea (Brittle star).
- It shows many long arms. It is bilaterally symmetrical. It is transparent.
- It is Pelagic. The arms are supported by calcareous rods.

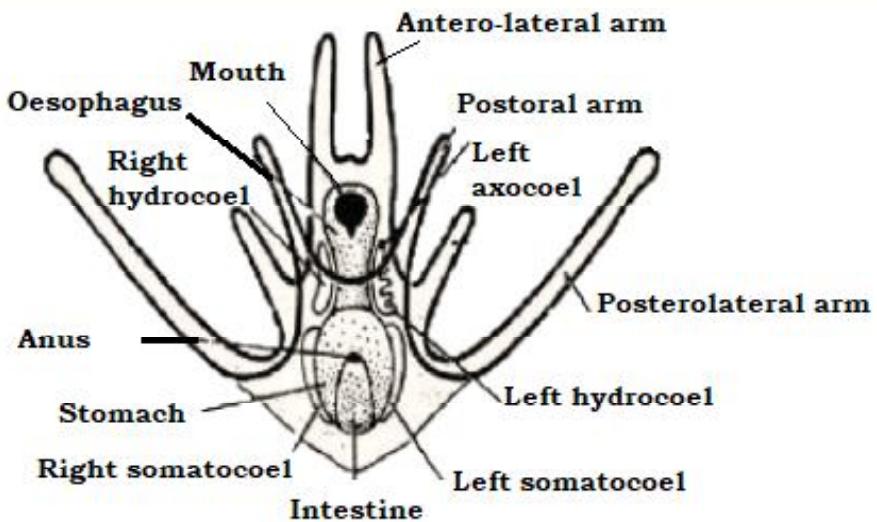


Fig.5.6.4 Ophiopluteus Larva

- The arms are directed upwards.
- Preoral loop is reduced.
- Ciliated band is undivided.
- Postero-lateral arms are very long and they are directed forwards.
- Digestive system is developed.
- It opens with mouth and ends with anus.
- This larva swims for some time before undergoing metamorphosis.

5. Echinopluteus Larva:

- It is seen in the life history of Echinoidea.
- It is a microscopic larva.
- It swims in water.

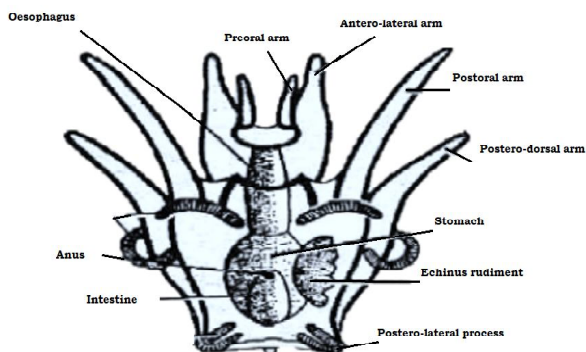


Fig. 5.6.5 Echinopluteus Larva

- This larva shows ciliated bands which are developed into arms.
- In fully developed larva 4 or 5 pairs of arms are present.
- The arms are supported by (CaCO₃) Calcareous rods.
- The digestive system is developed which shows mouth and anus.
- It develops hydrocoel and vestibule. These parts grow on the oral side of the animal. From the hydrocoel five radial canals will develop.
- This larva undergoes rapid metamorphosis and develops into an adult.

6. Doliolaria Larva:

- In Crinoidea group of animals the larval form is Doliolaria larva.
- It is a free-swimming larval form.
- It contains an apical tuft of cilia which will be sensory.

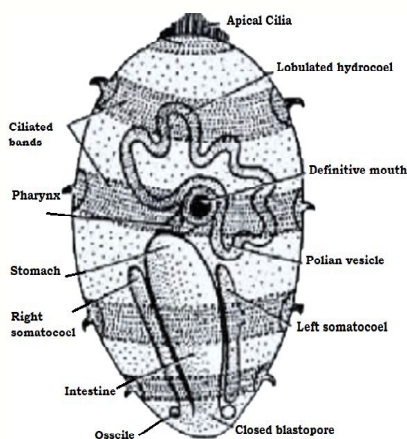


Fig. 5.6.6. Doliolaria Larva

- On the mid ventral line near apical plate adhesive pit will be present.
- The body shows 4 or 5 ciliated bands
- In between 3rd and 2nd ciliated bands vestibule is present.
- After swimming for some time, it will develop a stalk. It is called Pentacrinoid larva. It will attach to the substratum. The internal organs will rotate at 90°. It develops into an adult.

Significance of Echinoderm larvae: The larval forms of all classes in Echinodermata will show general resemblance. The Crinoidea larva differs from this pattern. In general, all the larvae show that they might have come from same ancestor. Hence the common ancestor is coelomate, bilaterally symmetrical and free swimming. These larvae also show resemblance with Toronaria of Balanoglossus. Thus, the study of Echinoderm larva has a phylogenetic significance.

Ecological role of Echinoderms

Echinoderms play numerous ecological roles. Sand dollars and sea cucumbers burrow into the sand, providing more oxygen at greater depths of the sea floor. This allows more organisms to live there. In addition, starfish prevent the growth of algae on coral reefs. This allows the coral to filter-feed more easily. And many sea cucumbers provide a habitat for parasites such as crabs, worms, and snails.

Echinoderms are also an important step in the ocean food chain. Echinoderms are the staple diet of many animals, including the sea otter. On the other hand, echinoderms eat seaweed and keep its growth in check. Recall that the sea urchin is a grazer, mainly feeding on algae on the coral and rocks. Recently, some marine ecosystems have been overrun by seaweed. Excess seaweed can destroy entire reefs. Scientists believe that the extinction of large quantities of echinoderms has caused this destruction

GLOSSARY

- Aristotle's lantern:** Aristotle's lantern is a five jawed conical structure of calcareous plates and muscles supporting the rasping teeth of a sea urchin.
- Madreporite:** It is the opening of the water vascular system. It takes in water that passes through the system and allows the sea star to move using its tube feet.
- Autotomy:** It is an adaptive detachment of animal body parts where this serves a defensive function, is achieved by an intrinsic mechanism, and is nervously mediated. Also known as self-amputation of body parts as defensive mechanism
- Pedicellaria:** Minute pincerlike structures common to starfish and sea urchins, used for cleaning and to capture tiny prey.
- Pentaradial symmetry:** It is a type of radial symmetry, which is a characteristic of echinoderms, in which body parts are arranged along five rays of symmetry. It means the organism is in five parts around a central axis.
- Radial Canal:** In water vascular system from the ring canal five radial canals arise and run throughout the entire length of the arm. Each radial canal lies below the ambulacral groove of the oral surface of the arm. Each radial canal ends at the tip of the arm as a tentacle. It is olfactory in function
- Regeneration:** Echinoderms can regenerate body parts and even complete individual from a fragment following self-induced or traumatic amputation processes
- Ring canal:** It connects the radial canals, and the radial canals move water into the ampullae, which have tube feet through which the water moves. By moving water through the unique water vascular system, the echinoderm can move and force open mollusc shells during feeding.
- Stone canal:** Water enters the madreporite on the aboral side of the echinoderm. From there, it passes into the stone canal, which moves water into the ring canal.

Tube feet:

Small tube-like projections on the underside (oral side) of echinoderms. They are part of the water vascular system of echinoderms. Tube feet are used to move, feed and breathe. Tube feet allow these animals to stick to the ocean floor and move slowly.

Water vascular system:

Echinoderms possess a unique ambulacral or water vascular system, consisting of a central ring canal and radial canals that extend along each arm. Water enters the madreporite on the aboral side of the echinoderm. From there, it passes into the stone canal, which moves water into the ring canal.

SELF ASSESSMENT

1. In the animal kingdom complete marine animals are found in this phylum
a. Mollusca b. Annelida c. Echinodermata d. Porifera
2. Echinoderm larvae exhibit the following ()
a. Biradial symmetry b. Bilateral symmetry
c. Peta radial symmetry d. Radial symmetry
3. Which of the following not related to tube feet? ()
a. Feeding b. Respiration c. Locomotion d. Reproduction
4. Blood vascular system of Echinoderms is. ()
a. Closed type b. Semi closed type
b. Open type d. Chambered
5. Excretion in Echinoderms is assisted by ()
a. Ring canal c. Stone canal
b. Tube feet d. Madreporite
6. Through this water enters into the water vascular system ()
a. Pedicellaria c. Madreporite
b. Mouth d. Anus
7. S- shaped canal of the water vascular system is ()
a. Radial canal c. Ring canal
b. Stone Canal d. Lateral canal
8. Larva of sea lilly is ()
a. Bipinnaria c. Doliolaria
b. Pentacrinoid d. Echinopleuteus

9. Larva of Star fish ()
a. Bipinnaria c. Doliolaria
b. Penta crinoid d. Echinopleuteus
10. Larva of sea cucumber is ()
a. Bipinnaria c. Doliolaria
b. Penta crinoid d. Echinopleuteus

KEY: 1-c, 2-b, 3-d, 4-b, 5-b, 6-c, 7-b, 8-b, 9-a, 10-c

INTERACTIVE LINKS

1. [https://bio.libretexts.org/Bookshelves/Introductory and General Biology/Book%3A Introductory Biology \(CK-12\)/11%3A Invertebrates/11.12%3A Echinoderms](https://bio.libretexts.org/Bookshelves/Introductory_and_General_Biology/Book%3A_Introductory_Biology_(CK-12)/11%3A_Invertebrates/11.12%3A_Echinoderms) Detailed notes on Echinodermata characters and classification.
2. <https://youtu.be/D3W4OCnHyCs> Sea-urchin video BBC
3. <https://youtu.be/OqUI4lvkDew> Echinoderm Larva
4. <https://youtu.be/rRej1VKDgcE> Feather star movement.

FOR IGNITED MINDS

1. <http://bncollegebgp.ac.in/wp-content/uploads/2020/04/BSc-Zoology-Part-I-Larval-forms-in-Echinoderms.pdf> For additional information on the general characters and classification of Echinoderms.
2. <https://www.onlinebiologynotes.com/phylum-echinodermata-general-characteristics-classification/> For additional information on the general characters and classification of Echinoderms.
3. <https://www.bioscience.com.pk/topics/zoology/item/565-forms-of-echinodermata-larva> for additional information on Echinoderm larvae.

PHYLUM - HEMICHORDATA

Learning outcomes

On completion of this unit will be able to

- Understand the structure and affinities of *Balanoglossus*
- Follow the classification of hemichordata

5.7 General characters and classification up to classes with suitable examples

Introduction:

Hemichordata (Gr., hemi, half; chorde, cord) means they are ‘half’ of ‘part’ chordates, a fact that is disputed. They are usually vermiform, solitary, or colonial enterocoelous coelomate animals with an intra-epidermal nervous system and a pre-oral with or without gill-slits and without typical nephridia.

General Characters:

1. They are exclusively marine, solitary or colonial, mostly tubicolous.
2. Body is soft, fragile, vermiform, unsegmented, bilaterally symmetrical, and triploblastic.
3. The body is divisible into proboscis, collar, and trunk.
4. Body wall with a single-layered epidermis with mucous glands. No dermis.
5. Coelom enterocoelous, divisible into protocoel, mesocoel and metacoel.
6. Buccal diverticulum, earlier considered as the notochord, present in the proboscis.
7. The alimentary canal is a straight, complete, or U-shaped tube.
8. Dorso-lateral pharyngeal gill-slits, when present, one to several pairs. Ciliary filter feeders.
9. Simple, open, and well-developed circulatory system, including a dorsal heart and 2 longitudinal vessels, one dorsal and one ventral.

సాధారణ లక్షణాలు :

- అవి ప్రత్యేకంగా సముద్ర జీవులు, ఒంటరి లేదా సహనివేశాలు, ఎక్కువగా ట్యూబికోలోస్.
- దేహం మృదువుగా పెళుసుగా, వెర్మిఫార్మ్, సెగ్మెంట్ చేయబడనిది, బైలాటెరల్ సీమెట్రీ ఉంటుంది మరియు ట్రిపోజ్లాస్టిక్.
- శరీరం ప్రోటోసిస్, కాలర్ మరియు ట్రంక్ గా విభజించబడుతుంది.
- సీలోమ్ ఎంటరోసీలస్, ప్రోటోసీల్, మెసోసీల్ మరియు మోటాసీల్ గా విభజించబడుతుంది.
- నోటోకార్డ్ గా పరిగణించబడే బక్కుల్ డైవర్టికులమ్, ప్రోటోసిస్ లో ఉంటుంది.
- అలిమెంటరీ కాలువ తిన్నగా, పూర్తిగా లేదా యు ఆకారంలో ఉండే ట్యూబ్
- డోర్సో- లాటరల్ ఫారింజియల్ గిల్-స్లిట్స్, ఉన్నప్పుడు, ఒకటి నుండి అనేక జతలు ఉంటాయి.
- సిలియరీ ఫిల్టర్ ఫీడర్లు
- సరళమైన, బహిరంగమైన మరియు బాగా అభివృద్ధి చెందిన ప్రసరణ వ్యవస్థ, ఇందులో డార్ఫల్ గుండె ఉంటాయి.
- ప్రోటోసిస్ లో ఉన్న ఒకే గ్లోమెయులస్ ద్వారా విజర్జన్ జరుగుతుంది.
- ప్రీస్విమ్మింగ్ టోర్షియూ లార్వాతో నేరుగా లేదా పరోక్షంగా అభివృద్ధి ఉంటుంది.
- ప్రత్యుత్పత్తి ప్రధానంగా లైంగికమైనది. విడితాయి. గోనాడ్స్ ఒకటి నుండి అనేక జతలు.
- సముద్రపు నీటిలో బాహ్య ఫలదీకరణ జరుగును.

వర్గీకరణ : హెమికార్డేటాలో సుమారు 80 తెలిసిన జాతులు ఉన్నాయి మరియు 4 తరగతులుగా విభజించబడ్డాయి. అవి 1. ఎంటిరోస్యస్టా, 2. టీరోట్రాంచకియా 3. ప్లాంక్టోసీనపరాయిడియా 4. గ్రాప్టొలైట్

నిర్మాణం : బాలానోగ్లోసస్ శరీరం మృదువుగా, పొడవుగా, స్థూపాకారంగా ఉంటుంది. అంతటా సమృద్ధిగా సిలియేట్ చేయబడుతుంది మరియు క్లేప్టంతో కప్పబడి ఉంటుంది. జంతువు పొడవు 2 సెం.మీ॥ నుండి 2.5 సెంటీమీటర్ల వరకు ఉంటుంది. చాలా రూపాలు బ్రాచ్ రంగులో ఉంటాయి, ఎరుపు రంగులు ఉన్నప్పటికీ క్లేప్టం కారణంగా అనేక జాతులు ప్రకాశవంతం అవుతాయి. వీరికి అభ్యంతరకరమైన వాసన ఉంటుంది. శరీరం బైలాటెరల్ సౌష్టవంగా ఉంటుంది. మరియు మూడు ప్రాంతాలుగా విభజించబడుతుంది, అవి ప్రోటోసిస్ లేదా ప్రోటోసోమ్, కాలర్ లేదా మెసోసోమ్, మరియు ట్రంక్ లేదా మోటాసోమ్.

వివిధ వర్గాలతో ఆఫినిటీ : హెమికార్డేటా జీవులకు కార్డేటా, అనిలెడా, ఇఖైనోడెర్మెటా వర్గపు జీవులతో కొన్ని అంశాలలో ఆఫినిటీ కనిపిస్తుంది.

10. Excretion by a single glomerulus situated in the proboscis.
11. Primitive type nervous system consisting mainly of subepidermal nerve plexus. Dorsal collar nerve cord hollow.
12. Reproduction is mainly sexual. Sexes usually separate. Gonads one to several pairs.
13. External fertilization in seawater.
14. Development direct or indirect with a free-swimming tornaria larva.

Phylum Hemichordata Classification :

Hemichordata includes about eighty known species and has been divided into 4 classes.

Class 1. Enteropneusta

(Gr., enteron, gut +pneustos, breathed)

- Commonly called “acorn” or “tongue worm”.
- Solitary, free-swimming, or burrowing animals.
- Elongated, vermiform body with no stalk.
- The body consists of the proboscis, collar, and trunk; collar without tentaculated arms (lophophore).

- Proboscis cylindrical and tapering.
- Straight alimentary canal; mouth and anus at opposite ends. Filter feeding.
- Numerous pairs of U-shaped gill-slits.
- Two pairs of hepatic caeca present in the middle of the trunk.
- Sexes separate. Gonads numerous sac-like.
- Development with or without tornaria larva.
- Asexual reproduction is lacking.

Examples: *Balanoglossus*, *Saccoglossus*, *Protoglossus*, *Ptychodera*.

Class 2. Pterobranchia (Gr., pteron, feather + branchion, gill)

- Sedentary, solitary or colonial, sessile, and tubicolous.
- Living inside secreted chitinous tubes.
- Body short, compact, with stalk for attachment.
- Proboscis with ciliated tentacles to produce ciliary feeding currents of water.
- Collar bearing ciliated arms(lophophore).
- One pair of gill-slits or none.
- U-shaped alimentary canal. Anus dorsal lying near the mouth.
- Separate or united sexes. Gonads single or one pair.

- Development direct, may or may not include a free-swimming larval stage.
- Asexual reproduction by budding in some form.
Example: *Rhabdopleura*.

Class 3. Planctosphaeroidea

- Class is represented by a few small, rounded, transparent, and pelagic larvae, supposed to be specialized tornaria of some unknown hemichordate termed *Planctosphaera pelagica*.
- Larval body covered by extensively branched ciliary bands.
- The alimentary canal is L-shaped.

Class 4. Graptolite

- Extinct colonial hemichordates, mainly known from fossil structures of their tubes.
- These are abundant in the Ordovician and Silurian periods.
- Each animal is housed in a zooid.
- Their tubular chitinous skeleton and colonial habits show an affinity with Rhabdopleura.

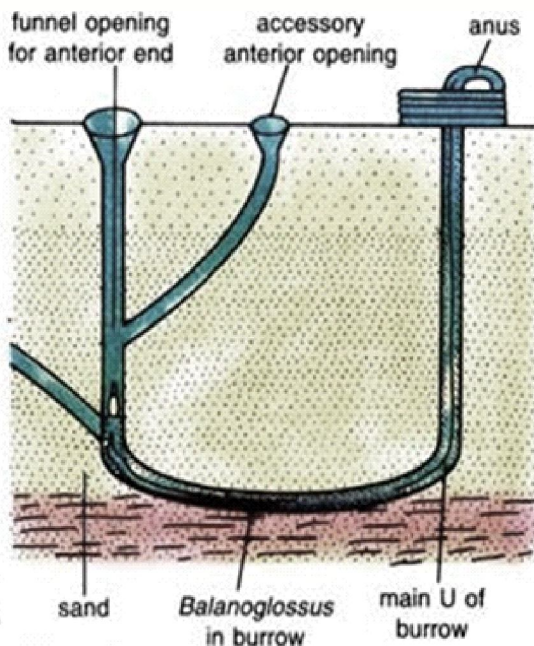
Example: *Dendrograptus*.

5.8 BALANOGLOSSUS - STRUCTURE AND AFFINITIES

Habit and Habitat :

Balanoglossus is a burrowing and exclusively marine animal. It is found in shallow waters between tide marks along the coast of warm and temperate oceans. *Balanoglossus* is world-wide in distribution. *Balanoglossus* is tubicolous living in U-shaped burrows excavated in the sandy bottom. The walls of the tube are lined with mucus secreted by the mucous gland of the animal.

The burrows are open at both ends, and spiral coils of faeces like the castings of earthworms may be seen at the posterior opening. In its burrow, *Balanoglossus* lies in a twisted condition but its anterior and posterior extremities are straight. Knight Jones (1952) reported that the animal moves in its burrow with the help of cilia present all over the body.



5.8.1 Tubicolous *Balanoglossus*

External Morphology of *Balanglossus*:

- The body of *Balanoglossus* is soft, elongated, cylindrical, being richly ciliated all over and covered with mucus.
- The length of animal varies from 2 cm to 2.5 meters.
- Most forms are drab coloured, though reddish tints are present, several species are luminescent due to mucus. They have an offensive odour.
- The body is bilaterally symmetrical and divided into three regions, viz., **proboscis or protosome, collar or mesosome, and trunk or metasome.**

Proboscis:

- The proboscis forms the anterior part of the body and is either rounded or conical in shape. It is continued posteriorly into a short, narrow neck or proboscis stalk.
- Proboscis is hollow and has thick muscular walls. Its cavity opens to the outside by means of a small opening called the **proboscis-pore**. In certain cases, there are two proboscis-pores.
- Proboscis sits in the collar somewhat like an acorn in its cup, a character that has given the name "acorn worms" to the group.
- Mouth, which is always wide open and incapable of closing completely, lies on the ventral side and its lips are the ventral edges of the collar region.

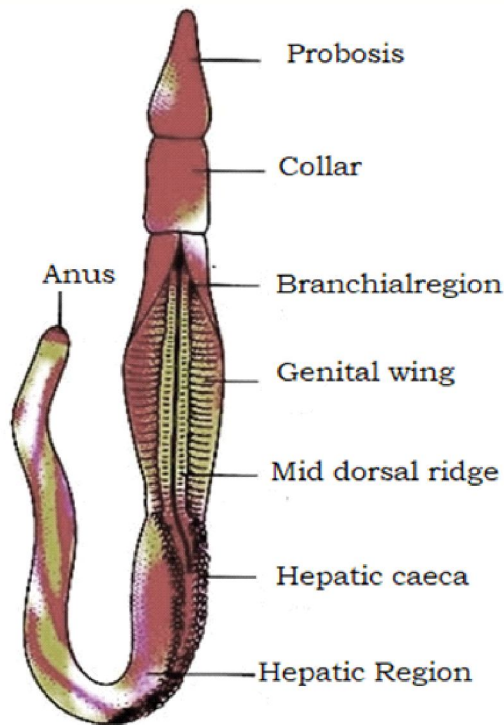


Fig 5.8.1 Balanoglossus external characters

Collar:

- The collar lies posterior to the proboscis and anterior to the trunk.
- It is a short cylinder usually about as wide as long and mostly shorter than the proboscis although sometimes longer.
- The funnel-like anterior part of the collar, the collarete, embraces the proboscis stalk and usually also the posterior part of the proboscis.
- Posteriorly the collar is sharply demarcated from the trunk by a circular indentation.
- Surface of the collar is often marked with elevations, depressions, and specially circular grooves. It is also muscular and possesses two coelomic cavities. The right and left coelomic cavities are separated from one another by dorsal and ventral mesenteries. The coelomic cavities of collar are completely cut off from the proboscis cavity.
- The collar cavity as well as the proboscis cavity are crossed by numerous strands of connective tissue which give the region a spongy appearance. The collar cavity communicated with the exterior by a pair of collar-pores, and short ciliated tubes (canals) leading into the first gill pouches.

- The functional significance of the cavities and water pores in the proboscis and collar may best be explained through a description of the burrowing habits. When on the surface of the sandy bottom *Balanoglossus* pushes the tip of the proboscis into the sand, moving it around by muscular contractions until a shallow, cylindrical hole is made.
- Then the proboscis empties its water content through its pore and collapses. This allows the collar to enter the hole. By taking in water through the pores the collar expands so as to fit lightly into the hole like a cork in a bottle. The well-filled collar then gives a point of resistance for further rooting movements of the refilled proboscis, which loosens sand and stows it into the scoop-shovel mouth.
- Then both proboscis and collar relax and the latter squirms deeper into the hole before tightening its hold again. Once the collar gets a firm grip, the animal makes rapid progress and soon buries itself. The tail end is left near the surface, and at intervals comes out and deposits a pile of castings somewhat after the fashion of earthworms.

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.
- Trunk is divisible into three parts, an anterior branchio-genital region, a middle hepatic region, and a posterior abdominal or post-hepatic region.
- On the dorsal of the branchio-genital region of the trunk is a double row of small pores the branchial apertures. Each row is situated in a long furrow. These pores increase in number during growth. In some species the most anterior are overlapped by a posterior prolongation of the collar called the operculum.
- A pair of longitudinal genital ridges or genital wings extends throughout a considerable part of the body behind and in the region of the branchial apertures. In these genital ridges, gonads are situated. In some genera, the genital ridges are so prominent that they form a pair of wing-like lateral folds, the genital wings, but in other genera folds are absent.
- The hepatic region is marked externally with irregular elevations due to sacculations produced by projecting hepatic caeca of the intestine. The abdominal region is longest and cylindrical. It tapers gradually and has a terminal anus. The coelom of the trunk is divided into two lateral closed cavities by vertical partition.

Affinities of *Balanoglossus* (Enteropneusta, Hemichordata) with chordates and non-chordate phyla are as follows:

Affinities with Chordata:

Bateson (1887) included Hemichordata in phylum Chordata, since then a close relationship has been acknowledged between hemichordates and chordates. This arrangement exists even today in most of the text books.

Resemblances:

The phylogenetic relationship of hemichordates and chordates is based on the supposed presence of the three fundamental chordate characters in both groups, viz., a notochord, central nervous system and gill-clefts.

The buccal diverticulum or stomochord of hemichordates has been regarded as the equivalent of a notochord since the time of Bateson.

Modern workers of hemichordates do not accept this idea and have raised many objections:

1. The buccal diverticulum is a hollow evagination of the anterior wall of the buccal cavity, and it is not definite whether it is endodermal or ectodermal in origin, whereas the notochord is a long solid rod formed from the roof of the archenteron.
2. The buccal diverticulum is generally made of ordinary epithelial cells, while the notochord of vertebrates consists of large vacuolated cells.
3. The buccal diverticulum has no enclosing sheath as found around the notochord.
4. The buccal diverticulum lies ventral to the dorsal blood vessel, whereas the vertebrate notochord is always dorsal to the main dorsal blood vessel.
5. The buccal diverticulum is small and confined to the proboscis, while the notochord extends far backwards. It can be safely concluded that there is no representative of the notochord in hemichordates.
6. There are certain resemblances between the nervous system of hemichordates and chordates, such as its position, formation of the dorsal nerve cord from the dorsal epidermis, and the hollow collar cord which often has a neuropore and is comparable with the neural cord of vertebrates. But there are major differences, such as its superficial position in contact with the epidermis, possession of a main ventral nerve cord, and a circumenteric nerve ring, in these features the nervous system is distinctly invertebrate.
Thus, the invertebrate features of the nervous system of hemichordates outweigh its chordate characters.
7. The chief link between the hemichordates and chordates lies in the pharynx and its gill-clefts.

The details of the branchial apparatus having tongue bars, M-shaped skeletal rods and synapticula are exactly like those of Amphioxus. But the endostyle and epibranchial groove are absent from the pharynx of hemichordates. Such similarity can be only due to common ancestry, and phylogenetic relationship of hemichordates and chordates cannot be denied.

Differences:

The inclusion of hemichordates in phylum Chordata cannot be justified on the basis of a few similarities which are more than outweighed by important differences.

The main differences are:

1. Chordates do not have the body and coelomic regions corresponding to those of hemichordates.
2. The circulatory and nervous systems of hemichordates are like those of invertebrates.
3. There is no post-anal tail in hemichordates.
4. Chordates are metamerically segmented animals, this segmentation is clearly shown by the muscular, nervous, circulatory, and excretory systems, whereas there is a total absence of segmentation in hemichordates.

Affinities with Annelida:

Resemblances:

The main resemblances of Hemichordata with Annelida are as follows:

- The general body form and burrowing habit of tubicolous forms are alike and mud is ingested in burrowing. It is passed out from the anus as castings.
- The vascular system of most hemichordates is like that of annelids with blood flowing anteriorly in the dorsal vessel and posteriorly in the ventral vessels.
- 3. The hemichordate tornaria larva appears like a modified trochosphere larva of polychaete worms.

Differences:

The differences between two groups are so great that there can be no phylogenetic relationship between them.

The differences are as follows:

1. Gill-slits are absent in annelids.
2. Paired nerve cords are present in annelids.
3. The larva of Hemichordata and Annelida also differ in the following ways:
 - (i) Nephridia are absent in tornaria larva.
 - (ii) Pre-oral coelom is absent in trochosphere larva.

(iii) In trochosphere blastopore becomes the mouth, while in tornaria it becomes the anus.

Affinities with Echinodermata:

The adult hemichordate and adult echinoderm are so different, only anatomical similarity between them is their nervous system which in both cases consists of nerve net lying near the surface embedded in the epidermis.

But there is a strong affinity between the two phyla on embryological evidence, the method of formation of the gastrula and the coelom is very similar in the two phyla and for years the tornaria larva was considered to be the larva of an echinoderm. The tornaria larva shows a very striking resemblance with the Auricularia larva and specially with bipinnaria of Asteroidea.

Resemblances:

The resemblance extends into the following details:

1. The ciliated band is identical and follows the same course in the tornaria and the auricularia and bipinnaria, though the telotroch and eye spots of the tornaria are absent in echinoderm larvae.
2. The alimentary canal has the same shape and the same divisions into foregut, stomach, and intestine in hemichordate and echinoderm larvae.
3. In both groups the blastopore becomes larval anus.
4. The cleavage and gastrulation follow the same pattern in both.
5. The greatest and the most convincing resemblance lies in the method of formation and arrangement of coelomic cavities.
6. In both the coelom is of enterocoelous origin and it divides into three antero-posterior parts. Proboscis coelom and collar coelom of hemichordates open to the exterior by pores through short hydroporic canals, as does the hydrocoel in echinoderms.
6. The heart vesicle of hemichordates is related to the proboscis coelom and is homologous with the madreporic vesicle of echinoderm larvae, and both these structures are closely connected to the glomerulus of hemichordates and the axial gland of echinoderms which combine the vascular and excretory functions.

Differences:

There are following differences between two groups:

1. Eye spot is absent in bipinnaria.
2. The apical plate and telotroch are absent in bipinnaria.
3. The protocoel is paired in echinoderms, while unpaired in tornaria larva.

The many embryonic resemblances between hemichordates and echinoderms cannot possibly be accidental or due to convergent evolution. The only infallible conclusion is that the two groups are closely related and that they arose from a common ancestor.

Echinoderms have deviated greatly from the ancestral type, while hemichordates are closer to it. The common ancestor gave rise to echinoderms as a blind side branch, while the main line of evolution produced the hemichordates and chordates.

Conclusion:

The above affinities have led to the conclusion that echinoderms, hemichordates and chordates have arisen from a common ancestral stock, the dipleura larva. Further, the echinoderms deviated greatly from the ancestral stock and formed blind branch in the main line of evolution. The main line of evolution continued to give rise to hemichordates and chordates.

It appears most reasonable to place them in the invertebrates as an independent phylum which has arisen from an ancestral stock that has given rise, on the one hand, to echinoderms and, on the other hand, to hemichordates and chordates.

GLOSSARY

Buccal diverticulum: It is a hollow preoral outgrowth, extending from the roof of the buccal cavity into the proboscis. It was for a long time also called a notochord or a stomochord on the assumption that it represents the anterior portion of the notochord of chordates.

Collar: It lies posterior to the proboscis and anterior to the trunk. It is a short cylinder usually about as wide as long and mostly shorter than the proboscis although sometimes longer.

Hepatic caeca : The hepatic region of the intestine is highly vascular. Its epithelial cells are dark green or dark brown and its dorsal wall forms numerous prominent sacculations called hepatic caeca which push the body wall outwards and are, thus, visible externally.

Proboscis: It is the most active part of the body of *Balanoglossus*. Burrowing is exclusively done by the proboscis. The proboscis becomes elongated by the contraction of circular muscles and

the shortening of the proboscis is caused by the contraction of its longitudinal muscles.

Tornaria larva: Planktonic larva of some Hemichordata such as the acorn worms. It is an oval shaped, transparent larva. The diameter of the body is about 3 mm. It has an apical plate, which is a thickened region provided by a tuft of cilia and a pair of eye spots. The larva has a complete alimentary canal.

Tubicolous: Living in a mucus lined U shaped tube is regarded as Tubicolous nature

SELF ASSESSMENT

1. Body of hemichordates is
 - a. Tube like
 - b. Ovoid
 - c. Rectangular
 - d. Flat slipper like
2. Coelom of Hemichordates is
 - a. Acoelomate
 - b. Enterocoel
 - c. Schizocoel
 - d. Absent
3. Type of muscles found in hemichordates are
 - a. Radial muscles
 - b. Radial and longitudinal muscles
 - c. Longitudinal muscles
 - d. Striated and smooth muscles
4. Buccal diverticulum of hemichordates originates from.....
 - a. Notochord
 - b. Buccal cavity
 - c. Nerve cord
 - d. Gills
5. Excretory organ of hemichordates
 - a. Nephridia
 - b. Green gland
 - c. Ectoderm
 - d. Glomerulus
6. Fertilization in hemichordates is
 - a. External
 - b. Absent
 - c. Internal
 - d. On the collar
7. Characteristic larva of hemichordates is
 - a. Bipinnaria
 - b. Auricularia
 - c. Tornaria
 - d. Doliolaria

Nonchordates at a glance

PHYLUM	HABITATE/ HABIT/COMMONLY KNOWN AS	LEVEL OF ORGANISATION	SYMMETRY	COELOM	DISTINCTIVE FEATURES	EXAMPLES
PORIFERA	Generally Marine	CELLULAR	Mostly Asymmetrical	ABSENT	Pores are present on body wall called as Ostia Water transport canal system is present Water enters through minute pores (Ostia), enters into spongocoel and eliminates outside through Osculum. Canal system helpful in food gathering, respiratory Exchange and removal of waste from body. Choanocytes or collar cells line the spongocoel and the canals.	Sycon (scypha) Spongilla (Fresh water sponge) Euspongia (Bath sponge)
CNIDARIA	Mostly marine Sessile of free living	TISSUE LEVEL AND DIPLOBLASTIC	RADIAL SYMMETRY	ABSENT	The Name derived from the Cnidoblasts or Cnidocytes present on tentacles and the body. Cnidoblasts are used for Anchorage, defence and for the capture of prey. Some of the Cnidarians forms corals composed of CaCO_3. Cnidarians consisting two basic forms i.e ; Polyp and Medusa. Polyp - Sessile and Cylindrical Ex . Hydra, Adamsia Medusa - Free swimming and Umbrella shaped Ex:- Aurelia (Jelly fish) Both forms are seen in Obelia - Exhibits Alternation of Generation (Metagenesis).	Physalia (Portuguese man of war) Adamsia (Sea Anemone) Pennatula (Sea Pen) Gargonia (Sea Fan) Meandrina (Brain Coral)
CTENOPHORA	Exclusively Marine Commonly Known as Sea Walnuts or Comb Jellies.	TISSUE LEVEL AND DIPLOBLASTIC	RADIAL SYMMETRY	ABSENT	Body bears eight external rows of ciliated Comb plates which help in locomotion. Exhibits Bioluminescence.	Pleurobrachia. Ctenophora.

Nonchordates at a glance

PHYLUM	HABITATE/ HABIT/COMMONLY KNOWN AS	LEVEL OF ORGANISATION	SYMMETRY	COELOM	DISTINCTIVE FEATURES	EXAMPLES
PLATHELMINTHES	Mostly Endoparasitic Commonly called as Flatworms	ORGAN LEVEL AND TRIPLOBLASTIC	BILATERAL SYMMETRY	ACOELOMATES	Planaria possess high regeneration capacity.	Taenia (Tape worm) Fasciola (Liver Fluke)
ASCHELMINTHES	Free Living or Parasitic in plants and Animals Aquatic or Terrestrial Roundworm	ORGAN SYSTEM LEVEL AND TRIPLOBLASTIC	BILATERAL SYMMETRY	PSEUDOCOELOMATES	Tube within tube organisms. Pharynx first appeared in alimentary canal of animal Kingdom, Eutely.	Ascaris (Round worm) Wucheraria (Filaria worm) Anchyllostoma (Hook worm)
ANNELIDA	Free Living or Parasitic Aquatic or Terrestrial	ORGAN SYSTEM LEVEL AND TRIPLOBLASTIC	BILATERAL SYMMETRY	COELOMATES	True Metamerism, Setae are locomotor organellies, Cutaneous respiration	Nereis Pheritima (Earthworm) Hirudinaria (Blood sucking leech)

Nonchordates at a glance

PHYLUM	HABITATE/ HABIT/COMMONLY KNOWN AS	LEVEL OF ORGANISATION	SYMMETRY	COELOM	DISTINCTIVE FEATURES	EXAMPLES
ARTHROPODA	Mostly Terrestrial Some are aquatic Largest phylum of Annelida	ORGAN SYSTEM LEVEL AND TRIPLOBLASTIC	BILATERAL SYMMETRY	COELOMATES	The Largest Phylum in Animal Kingdom, Tracheal System, Chitinous Exoskeleton, Striated muscles first appeared in animal kingdom.	1) Economically Important Insects: Apis (Honey bee) Bombyx (Silk worm) Laccifer (Lac insect) 2) Vectors Anopheles Culex Aedes 3) Gregarious insects Locusta (Locust) 4) Living fossils Limulus (King crab)
	Over two third of species are Arthropods					
MOLLUSCA	Terrestrial or Aquatic Second Largest phylum in Animal Kingdom	ORGAN SYSTEM LEVEL AND TRIPLOBLASTIC	BILATERAL SYMMETRY	COELOMATES	A soft spongy layer of skin forms a mantle over the visceral hump. The space between the hump and the mantle is called the Mantle cavity in which feather like gills are present. They have respiratory and excretory in function.	Pila (Apple snail), Pinctada (Pearl Oyster), Sepia (Cuttle fish), Loligo (Squid), Octopus (Devil fish), Aplysia (Sea hare), Dentalium (Tusk shell), Chaetopleura (Chiton).
ECHINODERMATA	Spiny bodied animals all are marine	ORGAN SYSTEM LEVEL AND TRIPLOBLASTIC	BILATERAL SYMMETRY (LARVA) RADIAL SYMMETRY (ADULTS)	COELOMATES	Presence of water vascular system which helps in Locomotion, Capture and transport of food and Respiration.	Asterias - Star fish Echinus - Sea urchin Antedon - Sea lily Cucumaria - Sea cucumber Ophiura - Brittle star.
HEMICHORDATA	Worm like marine animals	ORGAN SYSTEM LEVEL AND TRIPLOBLASTIC	BILATERAL SYMMETRY	COELOMATES	The body is cylindrical and is composed of an anterior Proboscis , a collar and a long trunk .	Balanoglossus Saccoglossus

Nonchordate Larve at a glance

Phylum	Class	Organism	Larva
Porifera	Calcarea	Sycon	Parenchymula, Trichimella, Amphiblastula
Cnidaria	Hydrozoa	Obelia	Planula, Actinula
	Scyphozoa	Aurelia	Planula, Scyphistoma, Ephyra
	Anthozoa	Sea Anemone	Planula
Ctenophora	Tentaculata	Pleurobrachia	Cydippid
Platyhelminthes	Turbellaria	Dugesia	Muller
	Trematoda	Fasciola	Miracidium, Sporocyst, Redia,
	Cestoda	Taenia solium	Hexacanth, cysticercus, Onchosphere
Nematoda	Phasmodia	Ascaris	Rhabditiform larva
	Phasmodia	Wucheraria	Micro filaria larva
Annelida	Polychaeta	Nereis	Trochophore
Arthropoda	Xiphosura	Limulus	Trilobite larva
	Crustacea	Penaeus monodon	Naplius, Protozoa, Zoea, Mysis, Megalopa
		Crab	Megalopa
		Palinurus	Phyllosoma
		Squilla	Alima
		Lepas	cypris
	Insecta	Anopheles	Rigler, Tumbler
		Musca	Maggot
		Beetles	Grub
		Butterfly	Caterpillar
Mollusca	Gastropoda	Snail	Veliger (Modified Trochophore)
	Bivalvia	Unio	Glochidium larva
	Polyplocophora	Chiton	Trochophore
Echinodermata	Crinoidea	Sea lily	Doliolaria, Pentacrinoid larava
	Asteroidea	Asterias	Bipinnaria, Brachiolaria
	Echinoidea	Echinus	Echinopluteus larva
	Ophiuroidea	Ophiothrix	Ophiopluteus
	Holothuroidea	Holothuria	Auricularia larva
Hemichordata	Enteroneusta	Balanoglossus	Tornaria larva

Respiratory organs in Nonchordates

Phylum	Class	Organism	Respiratory organ
Porifera	All	All	Diffusion
Cnidaria	All	All	Diffusion
Ctenophora	All	All	Diffusion
Platyhelminthes	All	All	Diffusion
Nematoda	All	All	Diffusion
Annelida	Polychaeta	Nereis	Parapodia, Skin
	Oligochaeta	Earthworm	Skin (Cutaneous Respiration)
	Hirudinaria	Ozobranchus	Gills
Arthropoda	Xiphosura	Limulus	Book Gills
	Crusacea	Penaeus monodon, Crab, Palaemon	Gills
	Insecta	All insects	Tracheal System
		Larva of May fly	Tracheal gills
		Nymphs of insects	Rectal Gills
		Tripulid Larva	Blood Gills
	Arachnida	Scorpion	Book Lungs
		Spider	Book lungs and Trachea
Mollusca	All Classes	Snail, Unio, Chiton,	Ctenidia, Mantle
Echinodermata	Crinoidea, Asteroidea, Echinoidea, Ophiuroidea	Sea lily , Asterias, Echinus, Ophiothrix	Papulae or Dermal branchiae
	Holothuroidea	Holothuria	Respiratory trees
Hemichordata	Enteroneusta	Balanoglossus	Gills

Hormones in insects Metamorphosis

Hormone	Secreted by	Chemical Nature	Function
Brain Hormone (B)	Neuro Secretory cell	Lipid	Activates corpora cardiaca
Pro Thoracic Trp	Corpora cardiaca	Ecdysteroid	Stimulates Prothoracic glands
Prothoracic Gland	Prothoracic glands	Ecdysone	Triggers moulting
Juvenile Hormone	Corpora allata	Lipid	Regulates metamorphosis

Excretory organs in Nonchordates

Phylum	Class	Organism	Respiratory organ
Porifera	All	All	Diffusion
Cnidaria	All	All	Diffusion
Ctenophora	All	All	Diffusion
Platyhelminthes	All	All	Protonephridia (Flame cells)
Nematoda	All	All	Renette gland cells
Annelida	All	All	Nephridia
Arthropoda	Crusacea	All	Antennary glands or Green glands
	Insecta	All insects	Malpighian tubules
	Arachnida	Scorpion	Coxal glands and Malpighian tubules
		Spider	Malpighian tubules
Mollusca	All Classes	All except unio	Renal organs or Nephridia
		Unio	Organs of bojanus and kebers organ (Pericardial gland)
Echinodermata	All	All	Water vascular system. .
Hemichordata	Enteroneusta	Balanoglossus	Glomerulus



ANDHRA PRADESH STATE COUNCIL OF HIGHER EDUCATION

(A Statutory body of the Government of Andhra Pradesh)

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REVISED SYLLABUS OF B.Sc. (ZOOLOGY) UNDER CBCS FRAMEWORK WITH EFFECT FROM 2020-21

PROGRAMME: FOUR-YEAR UG HONOURS PROGRAMME

ZOOLOGY

*(With Learning Outcomes, Unit-wise Syllabus, References, Co-curricular Activities &
Model Q.P.)*

For Fifteen Courses of 1, 2, 3 & 4 Semesters)

(To be Implemented from 2020-21 Academic Year)

AP STATE COUNCIL OF HIGHER EDUCATION

w.e.f. 2020-21 (Revised in April, 2020)

ZOOLOGY – SEMESTER I

PAPER – I: ANIMAL DIVERSITY – BIOLOGY OF NONCHORDATES

HOURS: 60 (5X12)

Max. Marks: 100

Course Outcomes: By the completion of the course the graduate should able to –

- CO1** Describe general taxonomic rules on animal classification
- CO2** Classify Protozoa to Coelenterata with taxonomic keys
- CO3** Classify Phylum Platy hemninthes to Annelida phylum using examples from parasitic adaptation and vermin composting
- CO4** Describe Phylum Arthropoda to Mollusca using examples and importance of insects and Molluscans
- CO5** Describe Echinodermata to Hemi chordata with suitable examples and larval stages in relation to the phylogeny

Learning objectives

1. To understand the taxonomic position of protozoa to helminthes.
2. To understand the general characteristics of animals belonging to protozoa to hemichordata.
3. To understand the structural organization of animals phylum from protozoa to hemichordata.
4. To understand the origin and evolutionary relationship of different phyla from protozoa to hemichordata.
5. To understand the origin and evolutionary relationship of different phylum from annelids to hemichordates.

ZOOLOGY SYLLABUS FOR I SEMESTER

PAPER – I: ANIMAL DIVERSITY – BIOLOGY OF NONCHORDATES

HOURS:60 (5X12)

Max. Marks: 100

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 Skeleton 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 pathogenicity 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 *Ascarislumbricoides*

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

Co-curricular activities (suggested)

- Preparation of chart/model of phylogenetic 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 termitarium (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*

APS CHE

A \ Accessible and affordable Higher Education ensuring Accountability

P \ Perspective plan for effective governance in Higher Education

S \ Strengthening institutional networking and global linkages

C \ Curricular restructuring and Technology Enabled Learning

H \ Human Resource potential enrichment

E \ Enhancing quality and accelerating research

• Significance of the Emblem •



The Emblem Symbolizes Three Components:



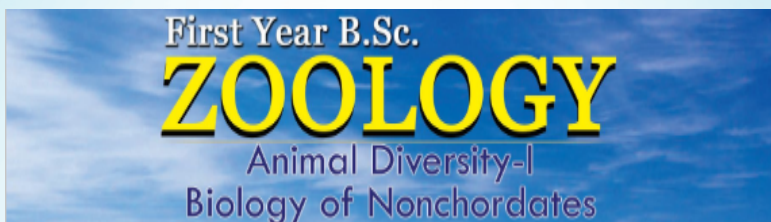
DISSOLVING
IGNORANCE



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OF IDEAS



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