BIO 221:
BIOLOGY OF LOWER ANIMALS I

NATIONAL OPEN UNIVERSITY OF NIGERIA

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COURSE GUIDE

NATIONAL OPEN UNIVERSITY OF NIGERIA

This study guide is written to give you a lead into how to study, understand and enjoy this course. This course on invertebrates I is written in (9) units each dealing with a particular type of invertebrates. Each unit deals with the general characteristics of each class of organisms, their structures, modes of nutrition, locomotion, excretion and reproduction.

Unit 1 starts with the classification of Animals. Biological names are assigned to each animal and the native names are not used in scientific circles. This is because of the confusion this would have generated as one animal would have different names under different dialects.

The biology student is faced with a barrage of names. There is nothing to be scared of concerning this. Imagine you are working at a very public place where you meet a lot of people with different faces and names. If you need to know each by name, l am sure you would device a way to remember the names along with each face. You should use the same method of association in remembering the names of the animals you meet in this course. In reading about any organism you should have its diagram in front of you to bring about this “associative recognition”. There are numerous diagrams in the texts of this course.

Each unit starts with an introduction which leads you into the main body of the text. Following the introduction is the objectives which set out what you are expected to grasp from the main text. The objectives are set standards which you should be able to fulfill to fully accomplish your mission in this course.

The text follows the objectives. It is broken down into sections containing specific and related topics. There are numerous diagrams that are put in each section. Make sure you have the diagrams in front of you and relate what you are reading to the diagrams.

You should also attempt practicing how to draw the diagrams and label them correctly. Where it is possible to get living samples, it is advisable you get them, or if you work in a laboratory that has a stock of the organism you are to study in this course, then make use of these facilities.

The conclusion gives you a review of the points treated in the text while the summary links the unit to others in the course. The self assessment questions (SAQ) are set to test your level of understanding the text. They are related to the objectives set at the start of the unit. Answer can be found within the text. It is advisable you attempt answering these SAQ to the test your level of achieving the objectives of the unit. Where you cannot fully understand the SAQ, go back to the relevant section and re-read to a level of understanding. Then go come back and to answer the SAQ.

The Tutor Marked Assignment is set to exercise your deductive reasoning and how well you have assimilated the unit. You may need to consult further references to fully answer the TMA's.

The university will set a time table as to when you are supposed to send in your answers to the TMA's. The marks will farm part of your final grades in the course. Hence you are adviced to send in your answer on time.

I wish you happy reading and fruitful study of this course.

UNITS	**TITLE**
1.	Classification of animals
2.	Structural organization and function of protozoans
3.	Metazoa – Origin and Evolution
4.	Classification of Multicellular Animals
5.	Phylum Platyhelmintes, Nematodes and Rotifera
6.	Phylum Annelids
7.	Arthropoda and Onychophopra
8.	Phylum Mollusca
9.	Phylum Echinodermata

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NATIONAL OPEN UNIVERSITY OF NIGERIA

Unit 1

CLASSIFICATION OF ANIMALS

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1.0 Introduction

Because of the vast number of organisms that live in our world, it became necessary in the scientific world to give a name to each organism to be able to distinguish it from all other organisms the naming of organism is know as **taxonomy.**

Carolus Linnaeus (1707 – 1778), a Swedish botanist is universally acclaimed as the father of taxonomy. He proposed a system of nomenclature for organism where two names are used to specify and distinguish each organism from another one. This system of classification, known as **binomial nomenclature,** was proposed by Linnaeus in 1758 in his book Systemae Naturae. This system used morphological characteristics to group and name organisms.

Under the Binomial Nomenclature, Linnaeus proposed that each type of organism should be given a unique Latin binomial (consisting of two names) to represent an organism and distinguish it from other organism. The first name in the binomial stands for the **genus** (plural genera) to which the **species** (plural species) belongs. The species is the lowest unit of living organisms. The species represents a group of isolated interbreeding organisms.

The species are grouped into genera and genera into higher categories based on their similarities and relationship to one another. A number of closely related genera are grouped together into a **family;** a number of closely related families are grouped into an **order;** orders are grouped into a **class**; classes into a **phylum** or **division** in plants; and closely related phyla into **kingdom.**

Thus, the kingdom is the highest category of classification. The order of classification from highest to the lowest is thus:

- Kingdom
- Phylum
- Class
- Order
- Family
- Genus
- Species.

1.1 System of Classification

Aristotle was the first to attempt a logical system of classification. He divided all living organisms into two broad kingdoms, namely, **plantae** and **Animalia.** The kingdom plantae consisted mainly immobile forms, while kingdom Animalia included mobile forms.

Kingdom plantae was later divided by biologists into two sub- kingdoms.

Sub – kingdom:

I. **Thallophyta** containing phylum Algae (with chlorophyll) and phylum fungi (without chlorophyll).

Sub – Kingdom and 11)

Embryophyta with phylum Bryophyta (liverworts and mosses) and phylum Tracheophyta (vascular, plants).

Kingdom Animalia was also divided into two sub - kingdoms namely; sub – kingdom **protozoa** and sub – kingdom **metazoa.** Protozoa contain unicellular (a cellular) organisms while metazoan included sponges and other multicelluar organisms.

On the long run, it was found that the two kingdom classification failed to establish a clear – cut distinction between plants and animals, and did not indicate correct, relationship among organisms. The two kingdom system could not easily define and categorise unicellular organisms, for example Euglena and Volvox both contain chlorophyll and are photosynthetic (just like most plants).

On the other hand they are mobile, and actively swim like animals. Due to this reason zoologists classified them with animals under phylum protozoa while botanists include them as plants under Thallophyta.

In addition to this there are some organisms, like peranema which loosely resemble Euglena instructure but lack chlorophyll. These were not classified as plants but were classified under protozoa.

The inadequacy of the two – kingdom system of classification prompted Haeckel, in 1866, to propose a third kingdom, **protista** (meaning the very first to include all thallophytes and protozoans, Also included in this kingdom are bacteria and blue – green algae. The old kingdom plantae included only the members of Embryophyta while Animalia was left only with parazoa and metazoa. Thus, the three kingdoms are.

Kingdom	1. ANIMALIA	2. PLANTAE	3. PROTISTA
	Parazoa & metazoa	Embryophyta	Bacteria & blue-green algae

The three – kingdom classification did not prove satisfactory because many forms such as blue – green algae and bacteria of protista lack membrane bound nuclei; such forms, as you already know are called prokaryotes. This necessitated Whittaker to propose a fourth kingdom **Monera** to accommodate these forms from the evolutionary point of view the monera is regarded appears to be the most, primitive. So the four – kingdom classification consist of:

KINGDOM: 1. ANIMALIA
Parazoa and metazoan

2. PLANTAE
Ebryophyta (flowering plants, ferns, conifers)

3. PROTISTA
Green algae and fungi (marine algae Amoeba)

4. MONERA
Blue green algae and bacteria

Still, the four – kingdom classification was not satisfactory enough. So, in 1969, Whittaker proposed a five – kingdom classification in which he placed fungi in a different kingdom from the protista. Thus, Whittaker's five – kingdom classification include, from the lowest to the highest:

Kingdom Monera, containing prokaryotes

i. Kingdom protitsta, unicellular eukaryotic organisms (protozoa and unicellular eukaryotic algae)

ii. Kingdom fungi, moulds, yeast mushrooms e.t.c. which contain no chlorophyll and obtain their food by absorption.

iii. Kingdom plantae, multicelluar, photosynthetic organisms, multicelluar algae and higher plants.

iv. Kingdom Animalia, most of these organisms ingest their food and digest it internally, although some parasitic ones are absorptive.

Some scientists are intending on further dividing the kingdom monera into two sub – kingdoms namely, Eubacteria and Archaebacteria (fig1.1)

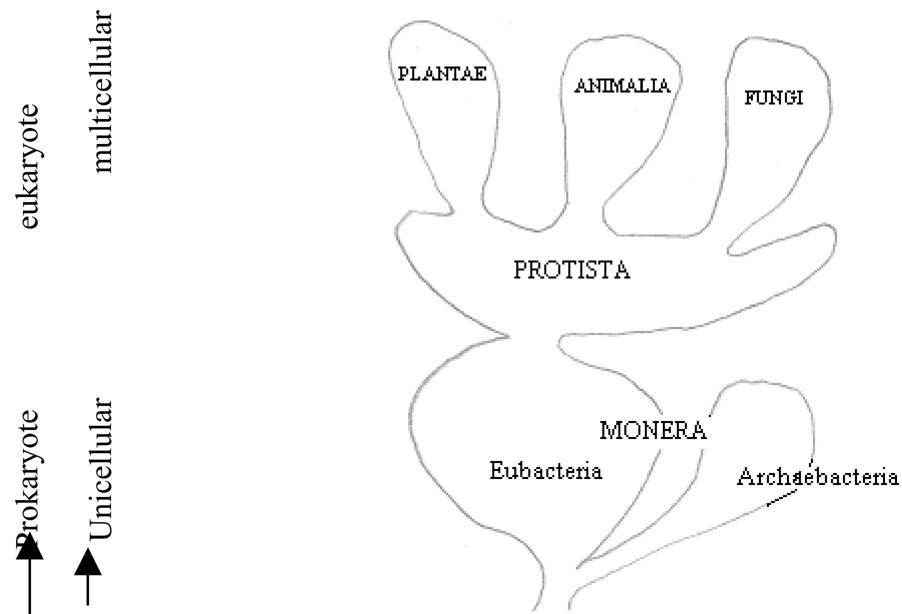


Fig1.1. Whittaker's five – kingdom system of classification and its relationship to the plant/animal dichotomy.

1.2 Kingdom Animalia

This kingdom can be divided into two sub – kingdoms namely;

1. Sub Kingdom protozoa (acellular)
2. metazoa (multicellular)

Sub – kingdom 1 has only one phylum – protozoa
Sub – kingdom 2 has many phyla.

1. Porifera or sponges
2. Coelenterata – e.g. hydra, obelia
3. Platyhelminthes – flatworms e.g. planaria, fasciola and taenia.

4. Nematoda – rounding e.g. Ascaris, hook – worm

5. Annelida - e.g. Lumbricus, nereis, leech

6. Arthropoda - insects, flies, spider, centipedes

7. Mollusa - e.g. starfish

8. Chordata - Amphioxus, fish, rats, man e.t.c

You should by now, be able to distinguish between the prokaryotes and the eukaryotes. Prokaryotes represent only a few thousand of the estimated 2 million species of living things known on the earth today. The rest are mostly eukaryotes that form the subject matter of this course.

Protista, as you have just learnt, are the primitive unicellular eukaryotes. Some have given rise to fungi, others to plantae, yet others have given rise to Animalia (fig 1.1), all three groups being multicellular. However, some of the protista though unicellular, still so much resemble Animalia, this group used to be designated **Protozoa** and was treated under kingdom Animalia of the two –m kingdom classification. Now we know that the protozoans are really a heterogeneous group of unicellular organisms and the term has no biological status.

Even then, because of their similarity to animals and most zoologists are interested in this group of organisms too and for convenience, this group is treated along with animals and thus continues to find a place in zoology (animals biology) text books. Following this practice we shall deal with protozoans also in this course.

2.0 Objectives

At the end of this unit you should be able to:

1. Distinguish between "protozoans" and "metazoans".

2. List the general characteristics of protozoans.

3. Enumerate and distinguish between various protozoan phyla.

3.0 Content

3.1 Phylum protozoans

3.1.1 General characteristics of protozoans

1. The protozoan are eukaryotic acellular organisms in which the body is not divided into cells or tissues i.e. they are single – celled. There are about 80,000 of them.

2. The unicellular level of organization is the only character which is common to all members of protozoa. In all other aspects they show great diversity. Protozoans exhibit all types of symmetry and great range of complexity in their microanatomical structure.

3. The great majority of protozoans are microscopic they range in size from one micron (1µ) as in the case of the planktonic micromonas to a few millimeters like some Amoeba species and cilliates.

4. Most protozoans occur as solitary individuals but there are numerous colonial forms e.g. volvox. This is the earliest indication of division of labour among cells.

5. Protozoans are found wherever life exists and is a fluid medium or moist medium. Free – living protozoa occur in the sea, in various types of fresh – water bodies and inn the soil. There are also commensals, mutualistic and many parasitic species. Nutrition may be autotrophic, heterotrophic or saprophytic.

6. Reproduction is universally asexual by mitotic division through budding, fission and cyst formation. Sexual reproduction by conjugation or zygote formation (syngamy) is found in some species.

7. Various means of locomotion, using pseudopodia, flagella and

cilia and direct movement have evolved in this group.

8. A protozoan, although unicellular, must be recognized as being complete organisms, carrying out all functions found in any multicelluar organisms.

Apart from all the usually intracellular structure common to all cells, protozoans possess specialized organelles differentiated for performing specific functions.

Sub – phylum

3.1.2 Classes

Phylum protozoa is divided into four classes

3.1.2.1. Rhizopoda or sarcodina (Amoeba group)

1. Amoeboid protozoans are distinguished by the presence of flowing extension of their body known as pseudopodia. These tubular cytoplasmic projections are used as locomotory organelles. For performing slow, sluggish movement called amoeboid movement.

2. The group includes the familiar Amoeba (fig 1.2) and other marine, fresh water and terrestrial taxa. The amoeboid form may be the result of retention of the ancenstral protistan condition in some species.

   In some others it may be secondarily acquired through the loss of flagella, as many groups have flagellated gametes in their life cycle.

3. The body is simple and not highly differentiated. Amoeboid protozoans are either asymmetrical or show spherical symmetry and may be the simplest of the protozoans.

However the majority of the species have evolved complicated skeletal structures that make them uniquely beautiful organisms. There are four groups of amoeboid protozoans: amoebae, foraminiferans, helizoans and radiolarians. For these the amoebae and foraminiferans belong to the superclass Rhizopoda while the radolarians and helizoans belong to the superclass actinopoda, as they have axopods.

Reproduction is simply by asexual method only and it is by binary transverse fission. Multiple fission may occur during the encystment stage.

I. Amoebae

May be the naked or enclosed in tests or shells. The marine, freshwater and parasitic naked amoebae have large commonly tubular lobopodia or fine straplike filipodia that are used for locomotion and feeding (fig 1.2). The shelled amoebae are found in the sea, freshwater and soil. They are covered by a shell made up of secreted organic material or foreign mineral matter cemented together (fig 1.3).

A large aperture in the shell permits protusion of lobopodia or filipodia. A number of commensal and parasitic amoebae inhabit the gut of different animals and humans. **Entamoeba coli** (fig 1.4), a commensal in human gut feeds on bacteria and intestinal debris while **E.histolytica,** a parasite causes amoebic dysentery.

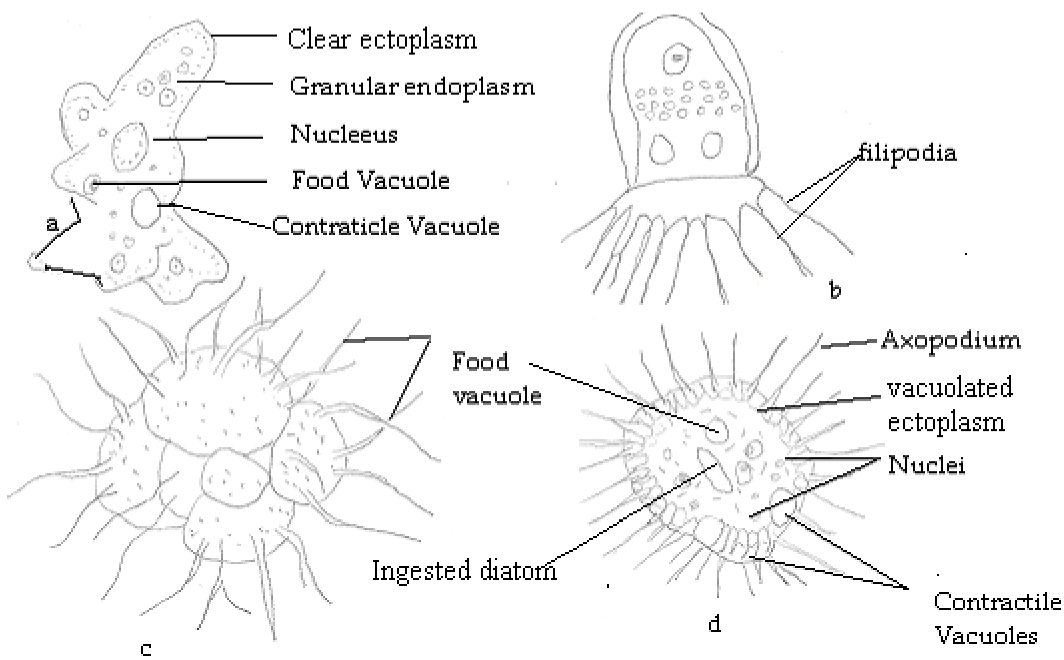


Fig. 1.2: Pseudopodia

a) Lobopodia in **Amoeba**
b) Filipodia in **chlamydophrys** a fresh water amoeba
c) Reticulopodia of **Globigerina**
d) Axopodias of **Actinophrys sol** often called sun animals

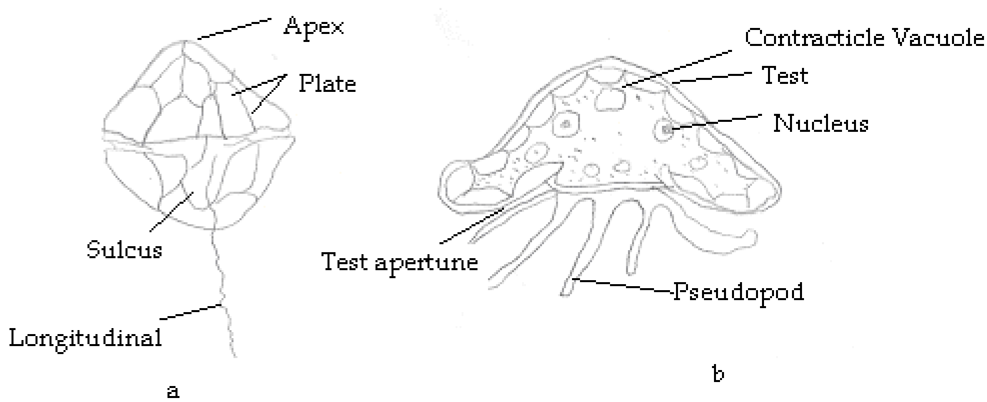
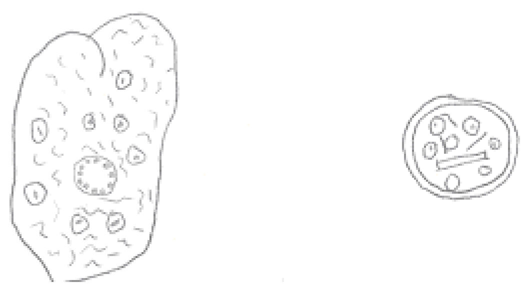


Fig. 1.3: exoseleton of protozoans

a) Ornamental theca in **Glenodium**
b) Pseudochitin in **Arcella**

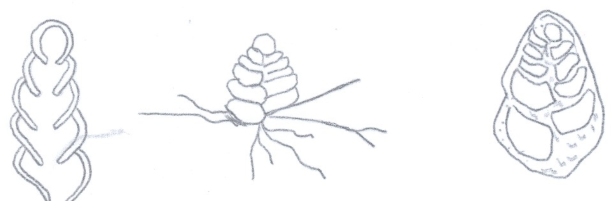


Entamoeba Coli **Cyst**

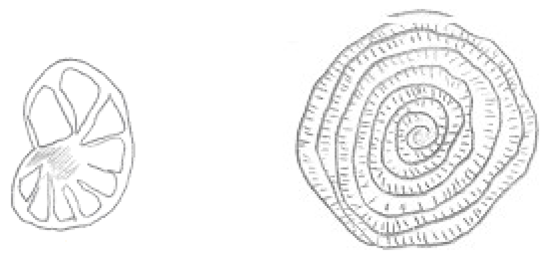
Fig. 1.4: **Entamoeba Coli a common dweller in the human gut.**

II Foraminiferans

Are largely benthic marine species. They have multichambered calcareous tests or shells with numerous pores, hence the name foraminifera or pore bearer. Single large opening allows the cytoplasm to protrude out. The chalk cliffs of Dover England and many coral reefs are formed form deep sediments of foraminiferan shells fig 1.5.



Nodosaria (section) **Nordosaria** (Live) **Textularia** (section)



1) Elphidium **2) Nummulities (section)**

Fig 1.5 various types of foraminiferan shells formed chiefly of calcium carbonate. A fossil species – Nummulites is an important contributor to great limestone deposits in certain parts of the world.

III **Radiolarins**

Are entirely marine planktonic species with spherical bodies and radiating pseudopodia known as axopods. The spherical body is divided into inner and outer parts. The inner regions contain one to many nuclei and is surrounded by a central capsule with membranous wall. This is a distinctive feature of radiolarians. The capsule membrane is perforated with openings continuous with the cytoplasm is called calymma.

Their skeleton is formed of silicon dioxide or strontium sulphate organized in the form of lattice spheres or radiating spines. (Fig 1.6. a, b).

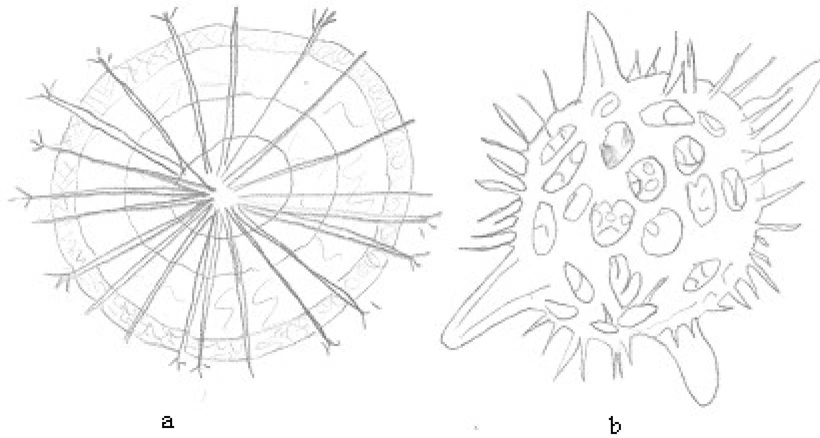


Fig 1.6 skeletal structure of radiolarians. Concentric spheres along with radiating spines are common patterns.

The skeletons of radiolarians and forminiferans form a primary constituent of ocean bottoms where they form 30% or more of the sediment. The shelled amoeboid protozoa are the only large group of protozoa that have a fossil record. The radiolarians are amongst the oldest known fossils. The quarries from which Egyptian pyramids were built are composed mainly of foram shells.

IV Heliozoans

Are spherical protozoans that occur in the sea or in still bodies of fresh water. They are mainly located in the bottom debris. Fine needle – life pseudopodia radiate from the surface of the body. These are known as axopodia. Each axopod has central axial rod covered by a moving cytoplasm.

The body of the heliozoans consists of outer vacuolated ectoplasmic cortex and inner dense medulla. The medulla contains a dense cytoplasm, one to several nuclei and bases of axial rods. (fig. 1. 7)

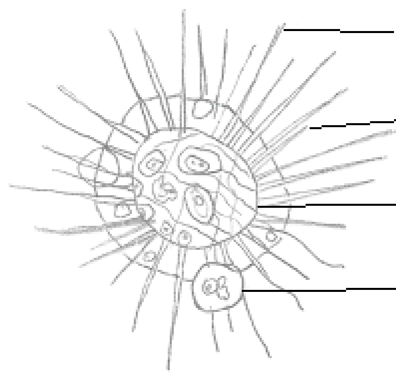


Fig. 1.7: Multinucleate heliozoan, Echinisphaerium

Mastigophora (or flagelleta)

1. These are protozoans that move by means of one or more flagella which are whip – like protoplasmic projection.

2. Reproduction is asexual by longitudinal binary fission as in euglena or multiple fission as in trypanosoma. In sexual reproduction isogametes are produced.

3. They are commonly divided into two groups on the basis of nutrition:

a) Phytoflagellates are autotrophs

That possess chlorophyll or other related pigments and store food as fats, oils and starches (other than glycogen). They are free – living and assigned often to the algal phyla.

Examples are **Euglena, chlamydomonas, volvox, peranema, gonium, pandorina**, dinoflagellates (fig 1.8)

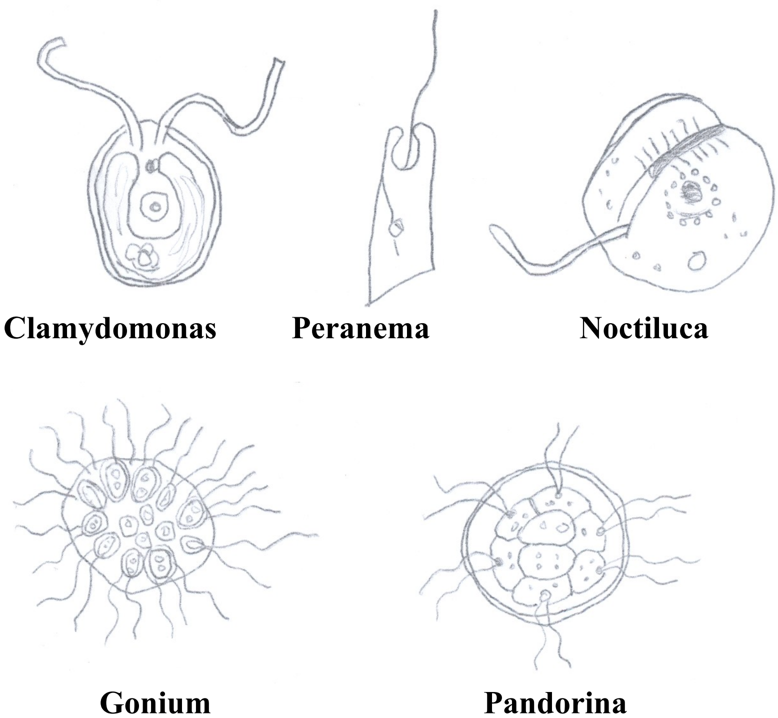


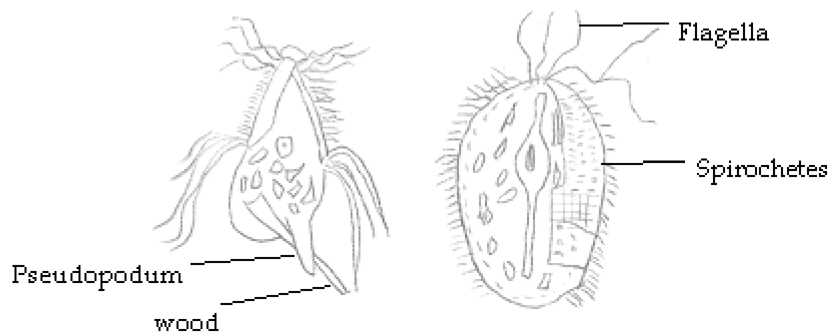
Fig. 1.8: Diversity among phytoflagella. Gonium and Pandorina are colonial. Noctitula is a dinoflagellate

b) Zooflagellates

Are heterotrophs that are free–living, commensals or symbiotic or parasitic in other animals. A number of species e.g. **Trichonympha** and **myxotricha** (fig. 1.9) live within the gut of termites and digest cellulose digest for themselves. **Trichonympha** lives as a mutualistic symbiont in the hindgut of wood – eating insects (termites and woodroaches). The anterior end of these large, complex flagellates (sometimes over 30mm long) is covered with an elaborate pellicle and hundreds of flagella, but the posterior end extends pseudopods and ingests bits of wood.

The flagellate is able to produce cellulose digesting enzymes, but the insect host cannot; and therefore, depends on carbohydrates released by its symbionts. Each time the insect molts, it loses the lining of the hindgut and all its symbionts. If it is unable to acquire new ones, it will starve to death, even though it continues to feed normally, for it cannot digest the wood. The flagellate are equally dependent on the mutualism and die within minutes termite acquires symbionts by feeding directly from the anal opening of other termites in the colony.

Myxotricha appears to be covered with flagella. But only four of these are true flagella; the others are a kind of bacteria or spirochetes attached to its surface. (Fig. 1.9) their lashing movements enable the flagellate to swim about, and its own flagella help in steering (spirochetes are long helix – shaped bacteria ranging in length up to 500mm.



Trichonymopha **Mixotricha**

Their cells are not rigid, therefore they can bend easily. Though most spirochetes are harmless and live in water, soil or bodies of other animals, some are services parasites, syphilis, one of the sexually transmitted disease is caused by a spirochete).

Other well – known parasite species of flagellate are **Trypanosoma** and **Leishmania** found in humans cattle in Africa and Asia. Trypanosoma (fig. 1.10) which is transmitted by the tsetse fly causes sleeping sickness in humans and nagana in cattle, Leishmania is the agent for the wide – spread kala–azar and related disease. It affects the nervous system and causes skin lesion among other effects. The vector for this protozoans is the blood – sucking sand fly.

Fig.1.10: Trapanosomia causative agent of sleeping sickness

Ciliophora (the ciliates)

Ciliates are the largest and most homogenous groups of protozoans with over 7200 species found in fresh and marine waters, and the water film of soil. About a third of the ciliates are ecto – or endoparasites or commensals.

The classic example of this group is the flipper – shaped paramecium; other well – known examples are vorticella, stentor, Didinium, Balantidim (fig. 1.11).

All ciliates possess cilia as their locomotive organelles; these are short, hair – like protoplasmic projections which are used for producing a very rapid movement.

The body is firm, being enclosed in a firm but flexible outer covering called pellicle.

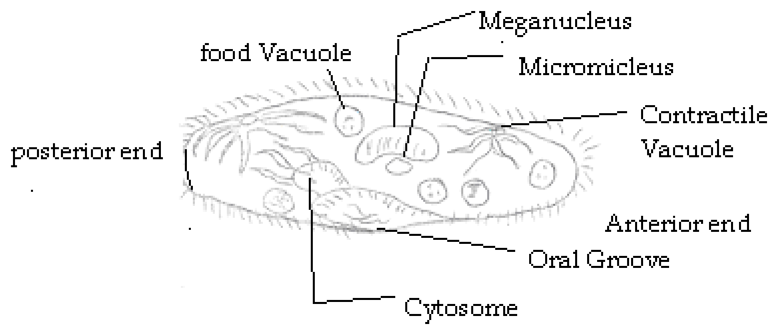
The cytoplasm has a clear distinction in to ectoplasm and endoplasm, but unlike the members of the Rhizopoda, there is a high degree of differentiation of the body into definite organelles.

Usually there are two types of nuclei:

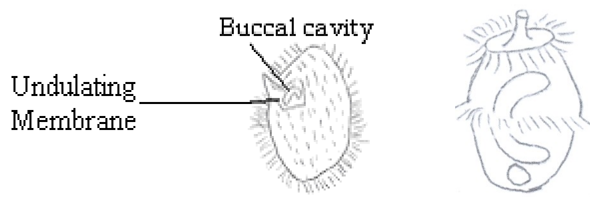
1) A large **meganucleus** for vegetatives activity and

2) A small **micronucleus** concerned with reproduction.

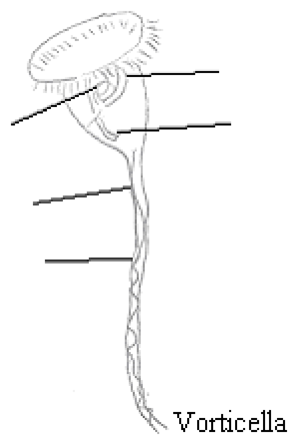
Asexual reproduction is by simple transverse binary fission. There is also sexual reproduction called **conjugation.**

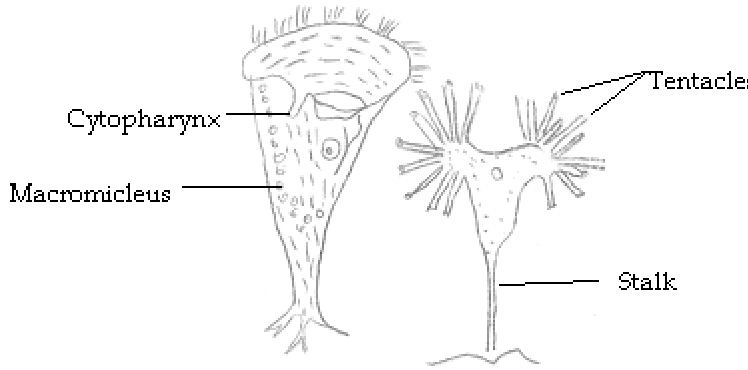


(a) Paramecium



Tetrachymena **Didinium Nasutum**





Stentor Acineta

Fig. 1.11 Various ciliates vorticella and stentor are sessile ciliates; stentor can also release itself and swim about. Didinium is a rapotal ciliate. Tetrachymena and Acineta have bundles of tentacles.

Sporozoa

There are about 4000 species of protozoa that have spore – forming stages in their life cycles. They are all parasitic animals.

They have no locomotive organelles (no pseudopodia, flagella nor cilia).

Reproduction is by means of uninucleate bodies called spores. Reproduction by asexual method is by multiple fission and sexual reproduction is by conjugation. Sporozoans are haploid except for the zygote. The zygote undergoes meiosis that results in an infective spore – like stage the **sporozoite** which, by multiple fission produces more sporozoites. They invade the host and become feeding **trophozoites**. In some sporozoans the trophozoites, by multiple fission known as schizogony produces merozoites.

Each merozoite undergoes multiple fission to produce more merozoites that eventually undergo gamogony or multiple fissions to form gametes that fuse to form zygote (fig. 1.12)

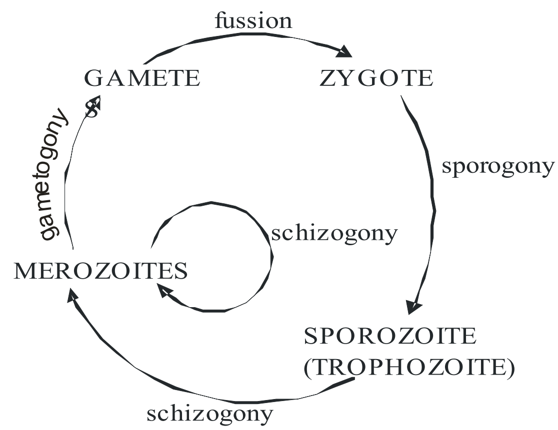


Fig.1.12: Life cycle of coccidian sporozoans. All stages are haploid except zygote.

SAQ 1

A. Indicate whether the followings statements are true or false

1. All flagellate protozoan are autotrophic (T/ F)

2. Some of the flagellates living as symbionts in the gut of termites are capable of digesting cellouse (T/ F)

3. Flagellate and amoeboid protozoans are currently included under a single phylum. (T/ F)

4. All amoeboid protozoans have one or other forms of pseudopodia (T/F)

5. All amoeboid protozoans lack symmetry or shoe spherical symmetry. (T /F)

6. Radiolaroius have a spherical body and radiating pseudopodia known as axopodia. (T/F)

7. Foramninferan and radiolarian protozoans ar e the only large group of protozoa that have a fossil record (T/F)

8. There is no sexual reproduction in zooflagellates (T/F)

B.1. What are the functions of cilia of ciliophorans?

____
____
____
____
____
____

3.2 Summary of classification scheme of protozoa

Kingdom Protista – Single celled eukaryotes

1. Phylum Sarcomastigophora

Locomotry organelles – flagella, pseudopodia or both types, usually with one type of nucleus; typically no spore formation, sexual reproduction through syngamy.

i) Subphylum Mastigphora

One or more flagella present in adult stages; autotrphic or heterotrophic nutrition; reproduction usually asexual by fusion.

Class – Phytomastigophorea

Plant like flagellates; usually bearing chlorophyll or other pigments. Examples: Euglena, Volvox, Chilomonas, Noctiluca, Peranema, Chlamydomonas.

Class – Zoomastigophorea

Flagellates without chloroplasts; one to many flagella; amoeboid forms without flagella in some groups. Species mostly symbiotic.

Examples: Trichomonas, Trichonympha, Leishmania, Giardia.

ii) Subphylum Opalinata

Body covered with longitudinal rows of cilium like organelles but true ciliature absent. Parasitic; cytosome lacking; two to many nuclei of one type. Examples opalina Protopalina (fig. 2.22)

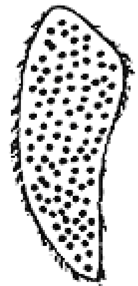


Fig 2.22: Opalina a multi-nucleate endozoic flagellate, parasitic in frogs and toad.

iii) Subphylum Sarcodina

Pseudopodia typically present; flagella present in development stages of some species; free living or parasitic.

1. Superclass – Rhizopoda

Locomotion by lobopodia, filopodia or reticulopodia or by protoplasmic flow without production of pseudopodia.

Example: Amoeba, Entamoeba, Difflugia, Arcella, Globigerina, Nodosaria

2. Superclass – Actinopoda

Often spherical; usually planktonic; pseudopodia in form of axopodia; skeleton when present composed of organic matter and/ or cells rarely flagellated; in many species small flagellated stages whose exact nature (gametes or spore) is still uncertain.

Example: Acanthometra, Actinophrys, Echinospherrium

ii) Phylum Labyrinthomorpha

Trophic stage, ectoplasmic network with spindle shaped or spherical nonamoeboid cells. Small group living on large; mostly marine or estuarine. Example *Labyrinthula.*

111) Phylum Apicomplexa

Characteristic set of organelles (apical complex) associated with the anterior and present in some developmental stages. Cilia and flagella absent except for flagellated microgametes in some groups; cysts often present; all species parasitic

1. Class – perkinsea

Small group parasitic in Oysters

.

2. Class - Sporozoa

Spores or oocysts present that contain infective sporozoites that result from sporogony; locomotion of nature organisms by body flexion. Gliding or undulation of longitudinal ridges; flagella present they are used for feeding not locomotion; one or two host life cycles.

IV) Phylum Myxozoa

Parasites of lower vertebrates especially fish and invertebrates

V) Phylum Microspora

Parasites of invertebrates especially arthropods and lower vertebrates

VI) Phylum Ascetospora

Small group that is parasitic in invertebrates and a few vertebrates

VII) Phylum Ciliophora

Simple cilia or compound ciliary organelles typical in at least one stage of life cycle; subpellicular cilia present even if surface cilia are absent; two types of nuclei, with rare exceptions; binary fission transverse but multiple fission and budding also occur; sexuality involving conjugation, autogamy' and cytogamy; nutrition heterotrophic; contractile vacuole typically present; most species free living but many commensal. Some truly parasitic.

This is a very large group divided by the society of protozoologists into three classes and numerous orders and suborders. The classes are separated on the basis of characteristics of the ciliary pattern especially around the cytostome.

Example paramecium, Didinium, colopoda, Balantidium, Stentor, Epidinium, Vorticella, Trichodina, Ephelota, Tetrahymena.

4.0 Conclusion

1. The five – kingdom system of classification groups living organisms into the following kingdoms:

   i) Monera ii) protista (iii) Fungi iv) Plantae v) Animalia

2. The kingdoms Animalia can be divided into two sub – kingdoms
   i) protozoa ii) metazoa.

   Sub – kingdoms protozoa has only one phylum – protozoa.

3. Protozoans are unicellular eukaryotic animals in which the body is not divided into cells or tissues.

4. The unicellularity is the only common feature among protozoans, which show great diversity in all other aspects.

5. Protozoans exhibit all types of symmetry and great range of complexity in their microanatomiscal structure.

6. Locomotory organelles, where present, include cilia, pseudopodia and flagella.

7. Protozoans show great diversity in their spread existing wherever there is a fluid or moist medium.

5.0 Summary

The study of protozoans is very necessary to us since they are everywhere around us. They exist from the ocean depths to any moist medium on earth. They are also important to us in that some of them cause diseases that may lead to death. They are the causes of malaria, sleeping sickness and even sexually transmitted diseases.

6.0 Tutor Marked Assignment

1. Explain the differences between phytoflagellates and zooflagellates giving examples.

2. Write briefly the five – kingdom system of classification

7.0 References and Further Reading

Bareness, R. D. 1994. Invertebrate zoology, 6th edn. Saunders college publishing.

Kimbell, J. W. 1994. Biology Wm.c. Brown publishers

Indira Gandhi National Open University School of science Diversity of Animal Life – 1 (Organization) LSE – 09.

Answers to SAQ

SAQ1.

A. 1. F; 2-T; 3-T; 4-T; 5-T; 6-T; 6- T;7- T; 8-F

B. Locomotion and suspension feeding.

Unit 2

STRUCTURAL ORGANISATION AND FUNCTION OF PROTOZOANS

Table of contents

1.0 Introduction

This unit is concerned with protozoans or the "animals protistans" which, as you will remember, are unicellular animals. You will study in this unit the general characteristics of protozoans, how to distinguish between the different types of protozoan phyla. Their special characteristics will help you to learn the classification of the group.

2.0 Objectives

At the end of this unit you will be able to:

1. List the general characteristics of the protozoans.

2. Use these characteristics to classify them

3.1 Body Structure of Protozoans Animals

Protozoans could be divided into two according to the simplicity or complexity of their structure. In the more complex ones there is a greater, more highly specialized portion of the protoplasm for performing definite functions effectively:

1. SIMPLE PROTOZOANS e.g. **Trypanosoma, Monocystis** and **plasmodium** (parasitic animals) and **Amoeba** (free – living.)

2. COMPLEX PROTOZOANS e.g.**Eugelna**

The parasitic protozoans have simple undifferentiated bodies. Since they do not have to search for food, they do not develop food – catching organelles; they simply absorb food over their body surface food catching and food ingesting organelles such as are found in their free- living counterpart protozoan are absent.

Also, the osmotic pressure of the fluid in their environment is isotonic to that of their protoplasm, hence osmoregulatory organelles such as contractile vacuoles found in the free –living ones are absent.

Each parasitic protozoans consists of a mass of protoplasm with a simple nucleus. Both **Trypanosoma** and **Monocystis** are elongated cells pointed at both ends, but plasmodium is spherical (fig. 1. 10). **Plasmodium** has a thin membrane and its shape is not definite **Trypanosoma** and **Monocystis** are covered by a firm but flexible pellicle which maintains a definite form.

The trophozoite stage of **plasmodium** occurs in an erythrocyte. **Tryapnosoma** is a flagellate with a long flagellum which arises from a darkly staining object, the blepharoblast, located in the anterior end. It then runs along the side of the body pulling out part of the body as an undulating membrane, before becoming free at the other end (fig.1.10). Around the nucleus, which is located in the center, are certain granules called metachronal granules. This darkly staining object from which the flagellum arises lies in front of a large object called the parabasal body.

In the cytoplasm of **Monocystis** are certain contractile filaments called myonemes running longitudinally and transversely. Also in the cytoplast are paramylum granules which are reserved food substances.

3.1.1 Amoeba (a free – living protozoan)

This is a free – living protozoan with a more complex structure than any of the parasitic ones. Being free – living it also searches for its food, hence the pressure of locomotory organelles in form of pseudopodia. Which give the animal an irregular outline (fig1.2a). Unlike the parasitic ones it feeds on solid organic food, hence it has food – catching and food ingesting organelles such as pseudopodia. and food vacuoles.

Living in fresh water where the osmotic pressure is hypotonic to that of its protoplasm there is a continuous inflow of water by osmosis. Therefore it has developed a contractile vacuole to eliminate the excess water.

Amoeba in uninucleate with cytoplasm clearly differentiated into an outer, clear **ectoplasm** and an inner granular fluid, the **endoplasm,** in which lies the nucleus. There is only one contractile vacuole which appears as a large, clear spherical area in the endoplasm. The ectoplasm is covered by a thin membrane, the plasmolemma. The pseudopodial projection from the body gives the organism an irregular outline.

3.1.2 Euglena and Paramecium

Euglena and **paramecium** have reached a greater state of morphological differentiation and physiological division of labour than **Amoeba** and the parasitic group. Both are active animals. They are non- parasitic and so have to search for their food, hence the development of locomotory organelles such as flagellum in euglena and cilia in paramecium. They have also developed food – catching and food – ingesting organelles e.g. oral groove, cytopharynx, cytostome and cilia in paramecium (fig.1.11a) and chloroplast in Euglena by means of which it manufactures its organic food from simple inorganic materials ($C0_2$ & H_2O). They both live in fresh water and therefore possess contractile vacuoles for the elimination of excess water from their cytoplasm.

Both have pellicles and therefore maintain definite outlines.

3.1.2.1Euglena

At the anterior end is a gullet leading into a reservoir. From the reservoir the flagelluim arises by two roots from the basal granules. (fig1.12).on one side of the gullet is the eye – spot or stigma and in the vicinity of the reservoir is the contractile vacuole.

The chloroplast may consist of scattered elements in the cytoplasm, or may take the form of a star. In the posterior part of the organism lies the nucleus, and scattered throughout the cytoplasm are the paramylum granules.

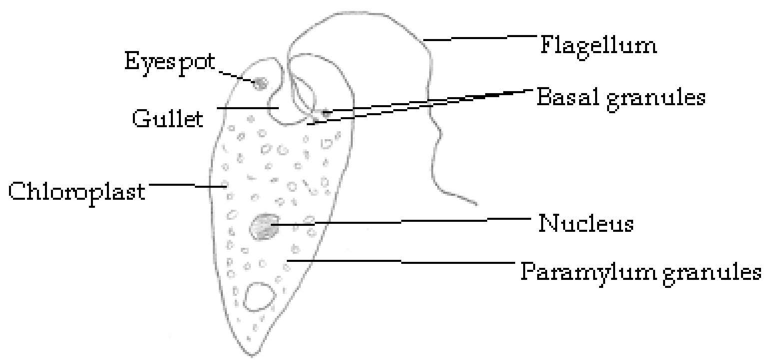


Fig.3.1 Euglena

Paramecium

It has a definite shape similar to the sole of a slippers, hence it is often referred to as slipper – animacule. The rounded end is the anterior and the pointed and is the posterior. The whole body is covered with cilia (fig. 1.11a). On the ventral side in the highly developed food – ingesting organelles in the form of the oral groove leading into the cytopharynx, which terminates in a small rounded end, the cytostome, the portion where the pellicle is lacking.

In the cytopharnyx is a special type of cilia, the undulating membrane, by the movement of which food is wafted into the pharynx. Near the cytostome is a definite spot, the anal pore, through which egestion takes place. There are two contractile vacuoles, complex in structure, one anterior, one posterior. The anterior one is more complex consisting of a central path with a number of radiating chandelles. The nuclear structure is unique; there are two nuclei, one large, kidney – shaped meganucleus, and a small spherical micronucleus located in the depression of the meganucleus.

The cytoplasm is clearly differentiated into ectoplasm and endoplasm. At right angles to the cell membrane in the ectoplasm are the trichocysts used as organelles of offence and defence. When the animals are irritated it discharges the trichocysts treads. Running longitudinally in the cytoplasm are myonemes. There are also paramylum granules.

3.2 Nutrition in Protozoan Animals

Protozoa may be divided into two groups according to their mode of nutrition:

3.2.1 **Heterotrophic organisms** e.g **Monocystia. Trypanosima plasmodium. Amoeba** and **Paramecium.**

Heterotrotis depend on organic foods from external sources. They are divided generally into two sub – groups:

a) Saprozoic or Osmotrophs e.g parasitic protozoa which take in organic food solution by absorption. Examples are Monocystis. Trypanosoma and plasmodium.

b) Holozoic or phagotrophs: they ingest solid food particles of animals or plant origin. Thus they may also feed on bacteria or other small protistans which are ingested whole and digested within food vacuoles e.g Amoeba, paramecium.

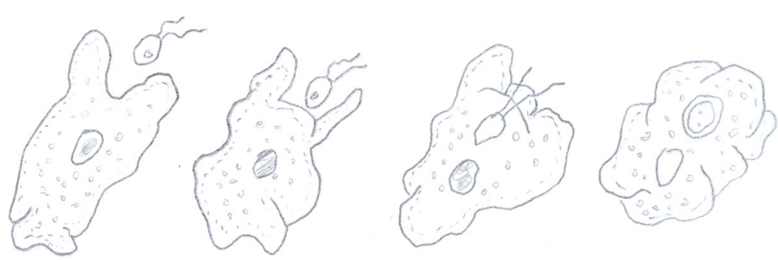


FIg. 3.1: Phagocytosis in Amoeba

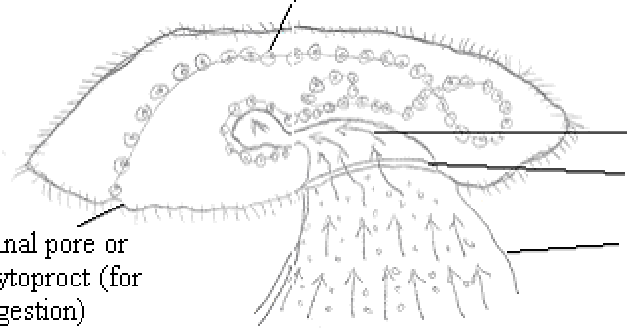


Fig. 3.3 Feeding, digestion and egestion in paramecium

Of naked non – cellular protoplasm of many protozoa (and also some slime fungi, some plants and animals gametes and of certain wondering cells of higher animals of leucocytes). The movement is one of protoplasmic streaming or cyclosis without active proportion by any specializes part of it. The most widely held explanation of protoplasmic streaming relates to the property of protoplasm in effecting gel – sol transformation.

A concept that attempts to explain the series of events in amoeboid movement is called the "change of viscosity theory". This essentially suggests that amoeba consists of an outer firmer gelatinous layer, surrounding an inner fluid mass. In some manner the outer layer becomes liqnified locally i.e isolation occurs and an outward flow of protoplasm is induced in that area and pseudopodia are produced.

As the outward flow continues, solidification occurs along the sides while the centre remains fluid. Hence a pseudopodium can be regarded as a gelatinous tube provided with a liquid interior and a solid exterior.

The local liquifaction or isolation of the gelatinous layer possibly results from a chemical reaction which induces the gelatin to become a solution, a mere change of phase of the colloid being involved.

Some authorities state that the protoplasm of **Amoeba** is taken as a mass of protein molecules, some straight chains and others very much folded chains of linked atoms. The unfolded or straight ones are thought to form a more rigid colloid abounding in the plasma gel, while the folded ones abound in the plasma solution.

3.2.2 Myxotrophic Animals

Organisms which are both heterotrophic and autotrophic i.e. they are also able to manufacture their own food. e.g. Euglena viridis which is both holophytic (autotrophic) and saprophytic (heterotrophic).

When the chlorophyll fails Euglena becomes heterotrophic and saprophytic absorbing organic food from the watery environment.

Monocystis (saprozoic) is a parasite in the seminal veside of the earthworm and feeds on sperm – mother cells called sperm morulae. Being saprozoic the food is digested outside and taken in solution or absorbed throughout the body surface into the endoplasm. There is no need to develop digestive organelles.

On the other hand Amoeba and paramecium are holozoic, feeding on solid organic food, hence locomotory, food – catching, food – ingesting and food – digesting organelles are developed e.g. pseudopodium and food cups in Amoeba, cilia and oral groove, cytopharynx and cytostome in paramecium. In both, food vacuoles are the organelles in which digestion takes place.

3.3 Locomotion in protozoa

The protozoan locomotor organelle may be **flagella, cilia** or pseudopodia; these are of considerable value in classification of protozoans.

There are two primitive types of movements in the protozoa 1). Amoeboid 2). Ciliary flagellate

3.3.1 **Amoeboid movement:** - e.g. by **Amoeba** is characteristics

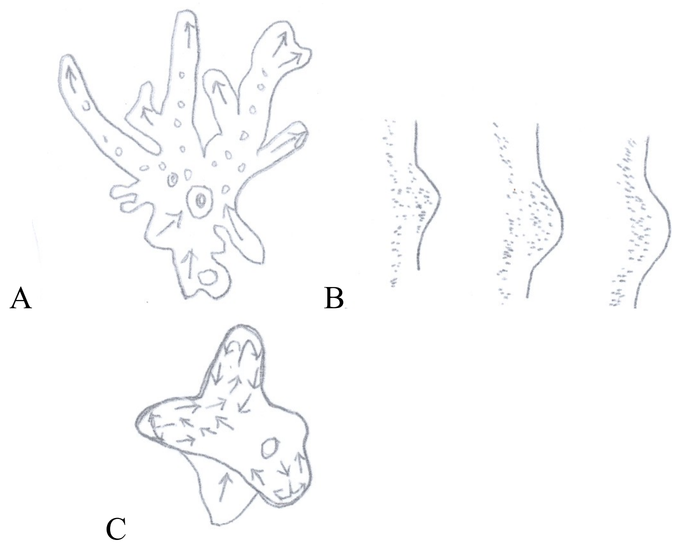


Fig. 3.4 Amoeboid locomotion in Amoeba.
A. lobose pseudopodia in Amoeba protens.

B. Formation of lobose pseudopodia by sudden flow of endoplasm (dark zone) into ectoplasm (light zone).

C. streaming of protoplasm in an Amoeba.

3.3.2. Euglenoid Movement

Euglenoid and greagarines movements exhibited by Monocystis and euglena are worm – like processor of local expansion and contractions that suggest the peristalsis invertebrate intestine. They seem to be varieties of amoeboid movement within a semi – rigid pellicle, the presence of myonemes also assisting in local expansions and contraction.

3.3.3 Ciliary and Flagellal Movement.

Cilia and flagella basically have a similar structure of two inner rings and peripheral bends or outer ring of spirally arranged longitudinally strengthening structures.

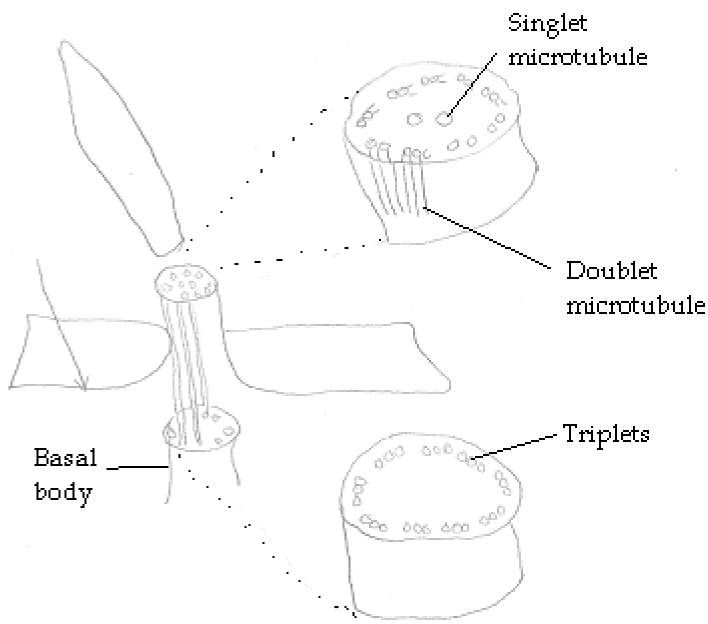


Fig. 3.5 Diagramatic representation of the ultrastructure of cilia or flagella.

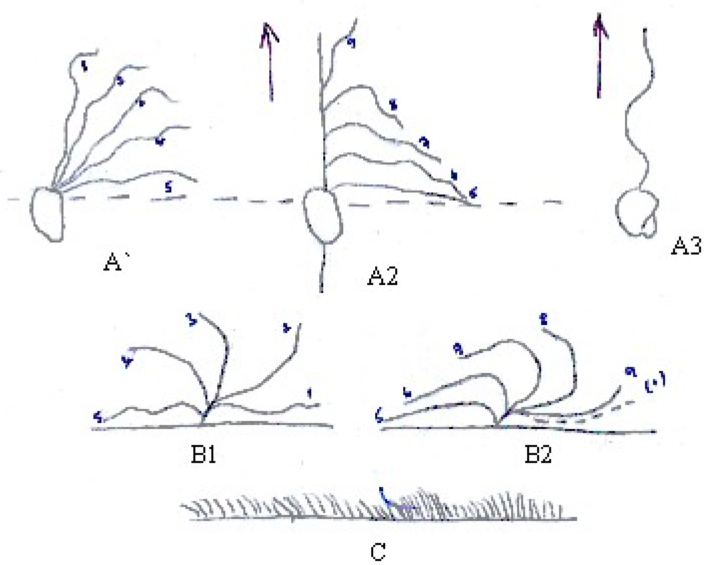


Fig. 3. 6 Activities of flagella and cilia. A. 1. Propulsive stroke and A2. recovery stroke of a simple flagellum. A3. Several waves of bending creating continuous movement. (Arrows indicate the direction of water and locomotion. B1. and B2. Propulsive and

recovery strokes respectively of a single cilium. C. metachronal rhythm of ciliary beating.

3.4 Osmoregulation and Excretion

Osmoregulation or water balance in protozoa is accomplished by contractile vacuoles. One to several contractile vacuoles may be present within the animal which may or may not have fixed sites in the cytoplasm and may have contributory canals or other vesicles opening into it. These are water and ion regulating structures, acting as pumps to remove excess water from the cytoplasm. All freshwater protozoans have functioning systems of contractile vacuoles whereas, marine and parasitic forms have these less frequently.

Excretion of metabolic wastes is done almost exclusively by diffusion. All protozoans are ammonotelic i.e., the end product of their nitrogen metabolism is ammonia, which is readily diffused in the surrounding medium.

The contractile vacuoles may differ in complexity in various groups of protozoans. In amoebae the vacuoles are carried around in the cytoplasm. Small vesicles join them emptying their contents into the vacuoles till the vacuoles join the membrane emptying its content to the outside (fig. 2.9).

In ciliates (e.g. paramecium) the contractile vacuoles have a more complex structure. The contractile vacuoles is located in a fixed position with an excretory pore leading to the outside surrounded by ampullae of feeder canals (fig. 2.10). The feeder canals are surrounded by a network of fine canals (20nm) in diameter, which are also connected to the tubular system of endoplasmic reticulum. The ampullae are surrounded by a bundle of fibrils that may have a role in contraction of the ampullae. The ampullae contract thereby, filling the vacuoles and when the contents of the vacuole are discharged to the exterior the ampulae get disconnected so that back flow is prevented.

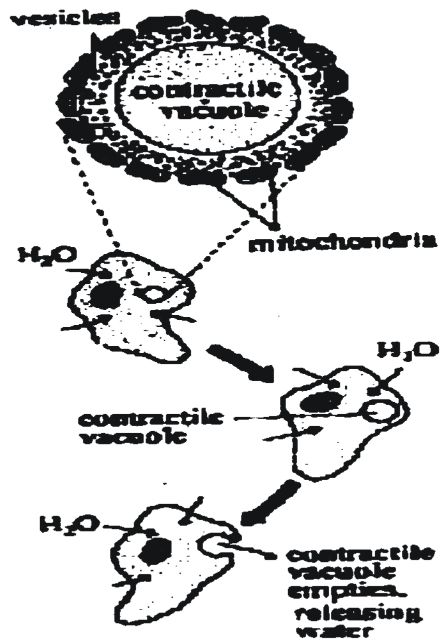


Fig. 3.7 the contractile vacuole of Amoeba proteus is surrounded by tiny vesicles that fill with fluid, which is then emptied into the vacuole. Note the numerous mitochondria that are believed to provide energy needed to adjust the salt content of the tiny vesicles.

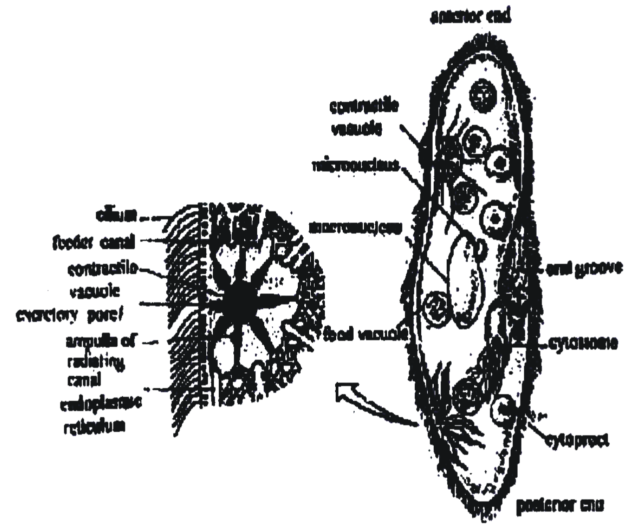


Fig.3.8 a) paramecium with cytopharynx, food and contractile vacuoles and nuclei.

b) Enlarged section of a contractile vacuole in paramecium which collects water and expels it outside, performing osmoregulatory functions.

SAQ 1

What are the main functions of contractile vacuoles in protozoa?
……………………………………………………………………………………
……………………………………………………………………………………
……………………………………………………………………………………

3.5 Respiration

Gas exchange occurs by the diffusion of oxygen across the cell membrane. Some protozoans utilize this oxygen but are also capable of anaerobic respiration. Examples are parasitic protozoans like *Monocystis*. Metabolic wastes such as carbon dioxide and ammonia diffuse out of the organism.

3.6 Mechanisms for Reponse

Protozoa are sensitive to many kinds of stimuli like touch, temperature changes, light, chemicals, e.t.c. it is not clear how they do so but amoebae are constantly changing and their protoplasmic mass can receive stimuli as well as conduct them. Cilia and flagella are highly sensitive to touch. One special sensory organelle is the stigma or eyespot. The stigma is a redish body found in photosynthetic flagellates and usually located near the root of the flagellum. The stigma is often cupped shading the light sensitive area from one side. Again it is not clear how the stimulus is conducted from the point of reception to another point where activity may change.

3.7 Reproduction and life cycles

Asexual reproduction occurs in all protozoans through fission, budding and cyst formation. In this method the organism reproduces to form its own type without forming gametes. The parent organism transfers an entire set of diploid chromosome to the daughter cell (fig. 2.11).

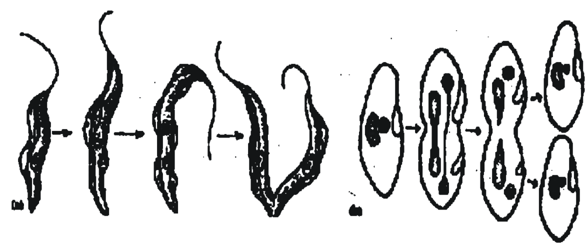


Fig. 3.9: Binary fission in protozoans a) in a flagellate Trypanosoma b) in a ciliate, paramecium.

Sexual reproduction involves meiotic nuclear divisions that give rise to haploid gametes from the diploid nucleus and the union of gametes then restores diploid. It may involve gametes from different parents in which case it is called amphimictic or may involve gametes that may arise from the same parent i. e. automitic. The uniting gametes may be the whole organism or only the nuclei. Where the whole organism unites the process is termed **syngamy** and where only the nuclei unite the process is termed **conjugation**. Syngamy occurs in all groups where sexual reproduction occurs except in ciliates where conjugation occurs.

3.7.1 Synagamy

The two gametes may be morphologically similar **(isogametes**) or dissimilar, (**anisogametes**). The gametes also vary in form, they may be flagellated or amoeboid. The zygote usually enters into a quiescent state and later gives rise to new individuals.

3.7.2 Conjugation

Conjugation is characteristics of ciliates. The details vary from species to species. The general features can be observed in paramecium sps. Which has one macronucleus and one micronucleus. (Fig. 2.12). Two ciliates ready for conjugation partially unite. The body surface and pellicle undergo considerable changes. The macronucleus disintegrates and the micronucleus divides twice to give rise to four haploid pronuclei. Three of these disintegrate and the fourth forms a stationary and a migratory pronucleus. The latter moves into the other conjugant. Two organisms now separate and the pronuclei unite to form zygote. After several post conjugation divisions the macronucleus and micronucleus are formed restoring the normal nuclear complement.

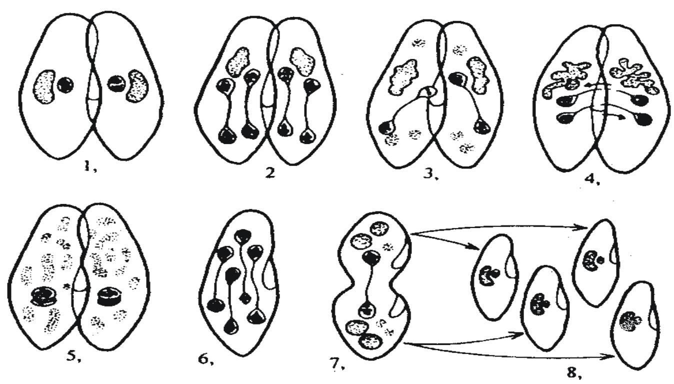


Fig.3.10. Conjugation in paramecium caudatum.

3.8 Encystment

Encystment is characteristics of the life cycle of many protozoans. The protozoan secretes a thickened envelope (cyst) around itself and becomes inactive with almost a complete shutdown of metabolic activity. This protective cyst is resistant to either desiccation or low temperature and enables the animal to pass through unfavrourable environmental conditions like food deficiency, desiccation, decreased oxygen concentration, pH, etc.

Reproductive phases such as fission, budding and syngamy may occur inside the cysts of some species .Encystment is however, not found or is very rare in marine species.

Protozoa may be dispersed long distances in either the motile or encysted stages. Water currents, wind, mud, debris, the bodies of birds and animals are common agents of dispersal.

Cysts of some soil inhabiting and freshwater protozoa show amazing durablilty. The soil ciliate Colpoda has been known to survive in dried soil for upto 38 years! On the other hand not all cysts are as durable. Cysts of Entamoeba histolytica can tolerate the acidic medium of the stomach but do not survive desiccation, temperature above 50°C or sunlight.

A return of favourable conditions initiates excystment (escape from cysts) in those protozoa in which the cysts are a resistant stage.

SAQ 2

1. Fill in the blanks using words from the text.
   1) The protozoa are members of kingdom ………………………….
   2) Volvox is one of the …………………………..forms of protozoa.
   3) ……………………………………form a rigid skeleton in some ciliate protozoans.
   4) Pseudopodia bring about locomotion by …………………movement
   5) Division of an organism into two similar progeny cells is called ………………………………..
   6) ………………………… is an exchange of haploid nuclei between two ciliates
   7) Nutrition is ……………………………………..in Amoeba
   8) ………………………….. is the locomotory structure in Euglena.

11. Match the items given in A with the ones given in B.

A	**B**
a) Microtubules	i) Holozoic nutrition
b) Dependence on other organism for food	ii) Exoskeleton
c) Tests of foraminiferans	iii) Parasitic protozoa
d) Ingestion of solid food	iv) Contractile vacuoles
e) Anaerobic respiration	v) Cytoskeleton

f) Osmoregulation vi) Heterotrophic nutrition

Osmoregulation and Excretion

Osmoregulation or water balance in protozoa is accomplished by contractile vacuoles.

4.0 Conclusion

1. Protozoans are an assemblage of unicellular animals like heterotrophic organism, belonging to the eukaryote protists.

2. Most protozoan group are distinguished by the type of locomotor organelles.

3. The locomotory organelles are flagella, cilia and pseudopodia.

4. Digestion is intercellular, within a food vacuole, and food reaches this vacuole through a cell mouth or by engulfment.

5. Water and ion regulation are accomplished by contractile vacuoles.

6. Reproduction is by fission. Depending on the group, meiosis occurs resulting in the formation of gametes or in the formation of haploid spores. Encystment is common.

7. Protozoan phyla were formerly placed in your groups:

   i) Flagellates – Locomotion by flagella

   ii) Amoeboid – Locomotion by pseudopodia

   iii) Ciliates – Locomotion by cilia

   iv) Sporozoans – parasitic protozoa, hence no specialized locomotory organelles

5.0 Summary

The study of protozoans is very important to us humans because of their large number and ubiquitous presence, since they are made up of only one cell, they add muscle to the biological rule that the cell is the basic functional and physiological unit of life. This is because they are able to carry out all activities characteristics of life.

6.0 Tutor Marked Assignment

1. Describe, with annotated diagrams locomotion in protozoans……………………………………………………………………… …….
………………………………………………………………………………… ………

2. Discuss Reproduction and life cycle in protozoans…………………………..

7.0 References and Further Readings

Roberts, M. B. V. 1995. Biology: A Functional Approach. The English Language Book Society and Nelson, London.

Indina Gandhi National Open University School of Sciences. Diversity of animal Life I (organization) LSE – 09.

Answers to SAQs

SAQ 1.

Contractile vacuoles have an osmoregulatory rather than excretory role. They regulate the water content of the cell eliminating excess water.

SAQ2.

1. Protista
2. Colonial
3. Microtubules
4. Amoeboid
5. Binary fission
6. Conjugation
7. Holozoic
8. Flagellum.

Answers to TMA

1. Refer to section 3.3
2. Refer to section 3.7

Unit 3

METAZOA - ORIGIN AND EVOLUTION

Table of contents

1.0 Introduction

You have already seen in Unit-1 that in the two kingdom classification, the unicellular `animals' used to be clubbed together under a single phylum Protozoa that constituted sub-kingdom - Protozoa. The rest of the animals, all multicellular, were grouped under the sub-kingdom Metazoa under various phyla (the corresponding grouping for plants was Protophyta and Metaphyta).

However, under the present concept of Five Kingdom Classification, this grouping has no relevance. Still, we often continue to use the term Metazoa to refer to the Animalia of the five kingdom classification. In this Unit we start with an explanation of the levels of body organisation in animals and the basic animal body plan.

However diverse the different invertebrates and vertebrates may appear to the eye, it is possible to group them in four master body plans. These are the unicellular plan, the cell aggregate plan, blind sac plan and tube within a tube plan. The protozoans fall into the first category and the rest three structural plans are seen in the metazoans. We next list out the characteristic features of metazoans.

We shall also discuss those features that are considered of fundamental importance for describing and understanding the structure and classification of any animal. These characters are:

(i) Cleavage patterns and number of germ layers it has been derived from;

(ii) Its body symmetry;

(iii) Nature of body cavity;

(iv) Segmentation and cephalisation.

It would be useful if you revise the unit on classification system before reading this unit as most of the concepts discussed there would help you to understand this Unit better. In later sections of the unit we will consider the various theories related to origin and evolution of metazoans or the Animalia.

2.0 Objectives

After studying this unit you should be able to:

- Describe various levels of body organization of animals;
- Describe the various cleavage patterns found in animals;
- Identify the various types of germ layers and Describe the functions of their derivatives
- Identify the animal groups based on their symmetry;
- Describe the different types of body cavities, segmentation, cephalisation and their functional significance;

- Classify animals on the basis of their structural organisation;
- Discuss the origin and evolution of Animalia.

3.1 Levels of body organization

You have learnt in your earlier course about the levels of organisation of matter. You may recall that the smallest structural units of all matter are subatomic -particles, mainly electrons, protons and neutrons. The next larger units are atoms and many atoms get together to form combinations called compounds which are variously joined together to give a higher level of organisation called complexes of compounds. Such levels of matter can be viewed as a pyramid (Fig. 3.l).

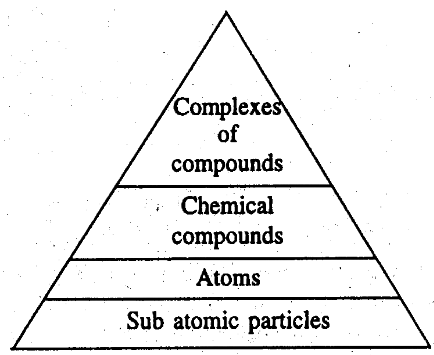


Fig. 3.1: Levels of organisation of matter.

In this pyramid any given level contains all lower, levels as its component and itself is also a component of all higher levels. For example, atoms contain subatomic particles as components, and atoms are themselves components of chemical compounds. Similarly, in living matter, complexes of compounds occur as submicroscopic and microscopic bodies called organelles, capable of carrying on specialized functions within the cell.

Organisms which are made of just one cell are the simplest and the most primitive creatures called unicellular organisms. Their level of body organisation is at the lowest and is called protoplasmic level of body organisation. If we try and fit the metazoan body organisation into a pyramid mode, the protoplasmic level will be at the bottom. As the organisms evolved from unicellular to multicellular grade their level of body organisation also changed from simple to complex.

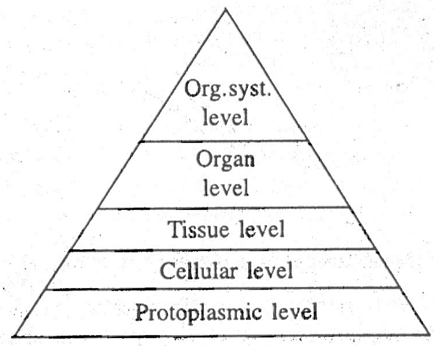


Fig. 3.2: Level of body organisation.

Look at the Figure 3.2, the next higher level of organisation is the cellular level. This is really an aggregation of cells that are functionally differentiated. A division of labour is evident so that some cells are specialised for reproduction some for nutrition. Among the metazoans, Placozoa and Mesozoa are said to belong to the cellular level of body organisation (Fig. 3.3 a and b).

Some authorities place the sponges (porifera) among this group too because they have several cell types differentiated for various functions but there is no true tissue organisation yet. (Fig. 3.3 c).

The phylum Placozoa contains a single species of a minute marine animal Trichohlar adharens composed of a dorsal and ventral epithelial layer enclosing loose mesenchyme like cells. Mesozoans comprise some 50 species of small parasitic worms that have simple structures made up of 20-30 ciliated cells covering a few reproductive cells.

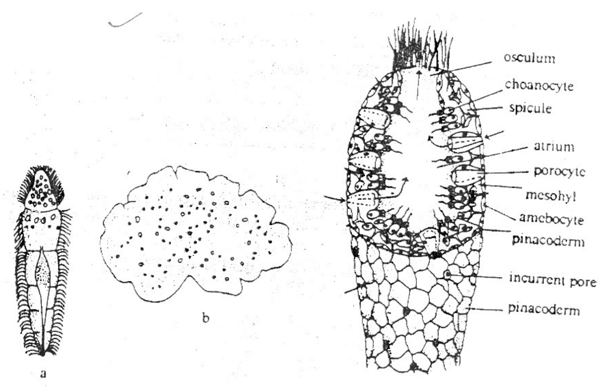


Fig. 3.3 :(a) Cellular level of body organisation in mesozoan-Rhopalura. (after Hyman)

(b) A placozoan (after Margurlis & Schwartz 1982)

(c) L.S. asconoid sponge.

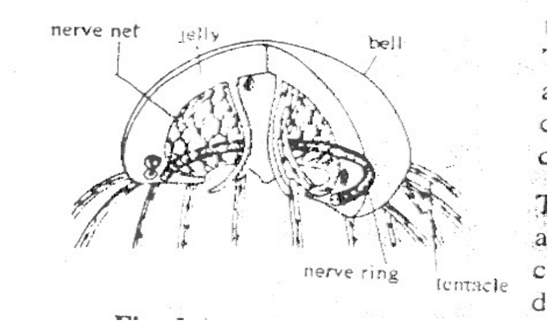


Fig. 3.4: Tissue grade of organisation - nerve net in jelly fish.

As you already know a tissue is a group of cells similar in origin and structure that perform a specific function. The next level, is the tissue level of body organisation which can be seen in coelenterates (Cnidaria and Ctenophora). These are made up of two germ layers ectoderm forming epidermis and endoderm forming the gas rodermis. The jelly fishes and their relatives are considered as the beginning of tissue organisation and an expellent example of tissues, in Cnidarians is the nerve net in which the nerve cells and their processes form a definite tissue structure with the function of coordination (Fig. 3.4).

The next higher level of body organisation as seen in the pyramid is the organ. Organs are usually made up of more than one kind of tissues. This is already seen in some cnidarians, ctenophores and the flatworms or Platyhelminthes in which there are well defined organs such as the eye and reproductive organs (Fig. 3.5)

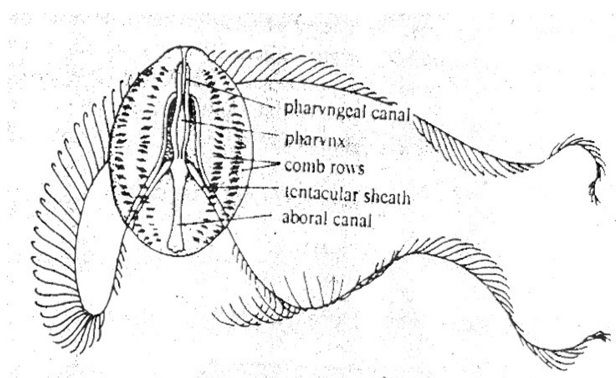


Fig.3.5: Organ level of organisation in a typical ctenophore.

When organs work together to perform a specific function we have the highest level of body organisation i.e. the organ system level of body organisation. The systems are associated with basic body functions.

This type of body organisation is seen for the first time in Platyhelminthes (Fig: 36) which have for example, a digestive system distinct from well developed reproactive system. From this phylum to mammals, all animals have the highest level of body organisation.

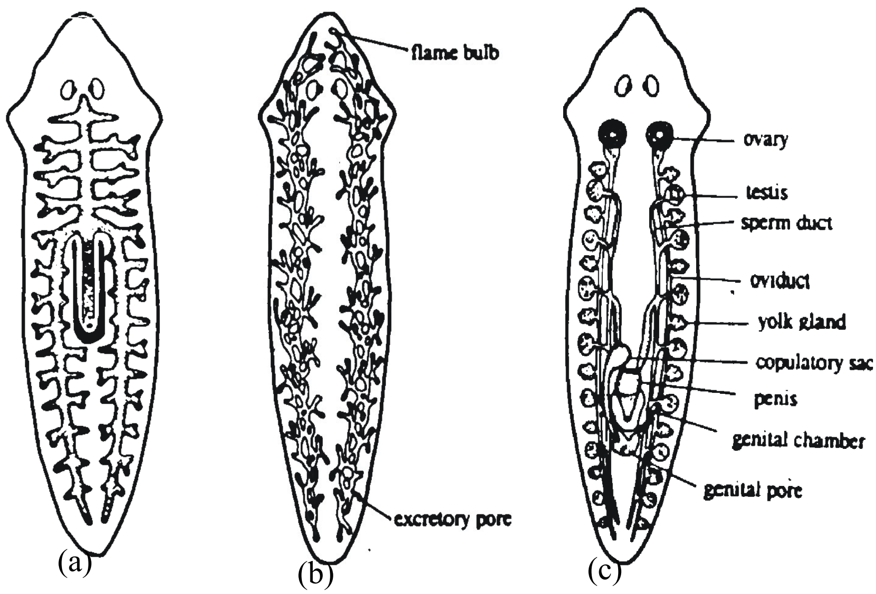


Fig. 3.6: Organ system level of organisation in Planaria

a) Digestive system
b) Excretory system
c) Reproductive system.

3.1 **Characteristics of metazoa**

From Unit-2 you know that the unicellular protozoans are highly versatile and successful organisms that show remarkable organisation and division of labour within the confines of the single cell. This diversity is achieved by varying the structure of their organelles at the sub-cellular level. The Metazoa or the multicellular animals have achieved their structural diversity by varying their cells that have become specialised to perform different functions. These cells are normally incapable of independent existence.

Let us list out some of the features that characterise metazoans.

Members of Metazoa possess a complex multicellular structural organization which may include the presence of tissues, organs and organ systems.

1. In the life history of metazoans, typically a fertilized egg passes through a blastula stage in the course of its early embryonic development before changing into an adult.

2. Since metazoans are multicellular they are relatively larger in size than unicellular protozoans. Naturally, their nutritional requirements are more and they have to search for food. Consequently, locomotion in metazoans is highly developed and for this purpose they have evolved contractile muscular elements and nervous structures.

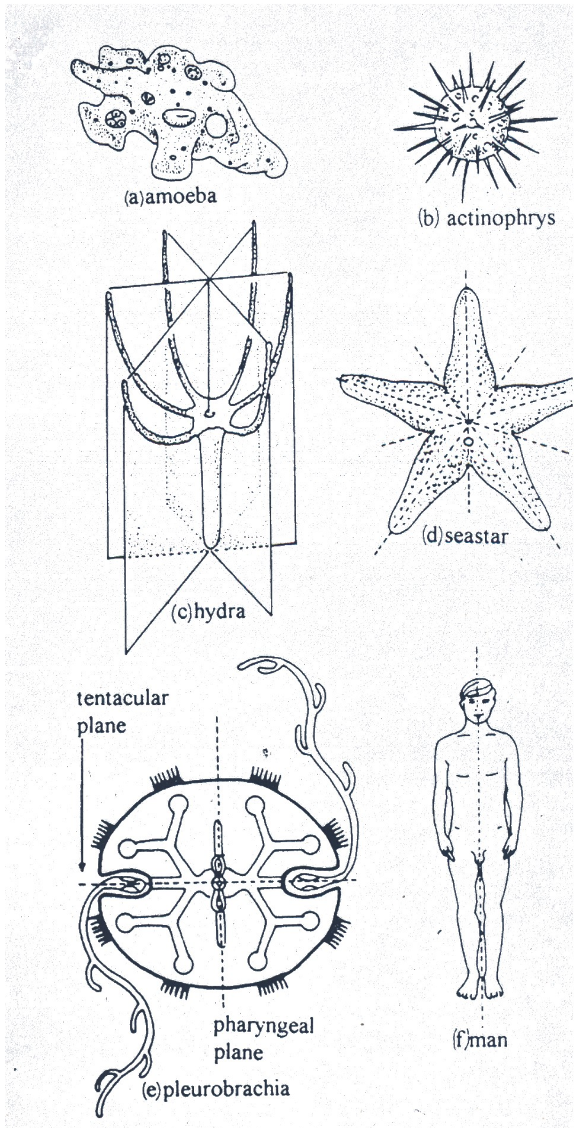
3. The ability for locomotions has influenced the shape of the metazoan animals which in turn has conferred specific types of symmetries to metazoan groups.

4. Most of the metazoans show differentiation of the anterior end or head (cephalization); associated with cephalisation, there is the centralization of the nervous system in the head region.

Although all metazoans share some characteristic features, their body plans differ in symmetry, internal organisation, developmental patterns and modes of formation of body cavity. These differences provide us a means of grouping them or organising them into different phyla. Let us discuss these, features one by 'one.

3.1 Symmetry

All living organisms have some body shape and form. The general body plan of animals may be organized in one of several ways (Fig.3.7.a.f).



(a) Amoeba (b) actinophrys

Fig. 3.7: Different types of body symmetries a) asymmetrical b) spherically symmetrical (c-d) radially symmetrical. (e) biradially symmetrical (f) bilaterally symmetrical.

Arrangement of parts or organs on either side of an imaginary dividing line or around common axis or radially around a point so that opposite parts are mirror images of one another is called symmetry. There are two broad divisions of symmetry,

(i) Primary or embryonic

(ii) Secondary or adult.

The latter may or may not be the same as the primary one. For example, the larva of starfish is bilaterally symmetry but the adult starfish is radially symmetrical.

The primary symmetry is bilateral and secondary symmetry is radial. With regard to symmetry animals can be basically of five types:

(i) Asymmetrical

(ii) Spherical

(iii) Bilateral

(iv) Radial and

(v) Biradial.

3.3.1 Asymmetrical and Spherical

Some creatures are asymmetrical: no matter which way we try to divide them through the middle, no two halves would appear alike (Fig. 4.7 a). In simpler words: these at animals which cannot be cut into two identical halves through any plane or axis (longitudinal, sagittal or transverse). Amoeba and most of the poriferans are examples

At the other extreme, is spherical symmetry. The animals with spherical symmetry can be divided into identical halves along a number of planes which pass through the centre or in other words every plane through the centre will yield two halves which are min images of each other. This type of symmetry is found chiefly in some protozoa and i rare in other groups of animals. Actinophrys (Fig. 3.7 b) and colonial Volvox are typical, examples.

3.3.2 Radial and –Biradial

Radial symmetry is the symmetry in which the parts are so arranged around a central axis or shaft, like the spokes of a wheel, that any vertical cut through the axis would divide the whole animal into two identical halves. The common jelly fish and hydra (cnidaria) - exhibit radial symmetry (Fig. 3.7 c). The starfish and their relatives have a modified form of radial symmetry. They can be divided along 5 planes, each giving. Two distinct halves.

This is known as pentermerous symmetry. One side of the body has the mouth and is known as the oral Surface; the opposite side is aboral (Fig. 3.7). Cuts made along the oral-aboral axis will result in identical halves.

Biradial symmetry is a variant of this and it is found in sea anemones and ctenophores. Though the animal appears to be radially symmetrical, it can be divided only into two equal halves along two per-radial positions - along the tenticular plane and along the sagittal plane at right angles to it. (Fig. 3.6 e).

Radial and biradial animals are usually sessile, floating freely or weak swimmers. These animals are called the **Radiata.**

3.3.3 Bilateral

Bilaterally symmetrical animals have the major axis running from head (anterior) to tail (posterior). They have a ventral (lower) and dorsal (upper) surface that are different from each other. They have only two sides that look alike, the right and left. The animal can be divided into just two identical halves through a plane which passes from anterior to posterior end. Almost all animals including human beings (Fig. 3.6 e) except for sponges, ctenophores and cnidarians show bilateral symmetry.

Adult echinoderms, though radially symmetrical (pentamerous) have larvae that are bilateral. This is because they have evolved from bilaterally symmetrical ancestors. In general, bilateral animals that adopt a sessile existence commonly exhibit a shift towards radial symmetry. The shift may be slight as in acorn barnacles where only protective circular wall plates are arranged radially or the shift may be profound as in the case of sea stars or starfishes. Bilateral animals are called **Bilateria.**

SAQ I

Match the term on the left with correct statement from the list on the right.

(a) Asymmetrical	i) Can be divided into many identical halves.	

(b) Bilaterally Symmetrical — ii) Can be divided into two identical halves but not more. ☐

(c) Biradially symmetrical — iii) Echinoderms ☐

(d) Pentamerous radial symmetry — i v) Ctenophores ☐

(e) Spherical — v) Cannot be divided into two identical halves ☐

3.3 Developmental patterns

In the last section you learnt how the metazoans or Animalia can be divided into two groups on the basis of body symmetry. The bilateral metazoans can be divided into two great assemblages: the **Protostomia** and the **Deuterostomia.** Platyhelminthes, Mollusca, Annelida, Arthropods and a number of minor phyla are classified as Protostomes while Echinodermata, Chordata and at least two minor phyla are included in the deuterostomes. The features used to place animals in these group are largely developmental. We consider the cleavage patterns first.

3.4.1 Cleavage

You have learnt in Developmental Biology that the unicellular zygote begins cell division (cleavage). First, the single cell divides forming two cells, these redivide further to form four, then eight cells and so on till it gets converted into a ball of cell. The cells are called **blastomeres**.

The planes of the first and second cleavage are vertical passing through the axis, but at right angles to one another. These two cleavages together result in four blastomeres lying side by side around the axis. The plane of the third cleavage is at right angles to the first two planes and to the axis and is horizontal and hence parallel to the equator of the zygote. This results in eight blastomeres. Of the eight blastomeres four lie on top of the other four.

The pattern of cleavage and arrangement of blastomeres around an imaginary central axis in a zygote can be one of two types radial or spiral.

Radial cleavage produces tiers or layers of cells one on top of another (Fig. 3.8a). Radial cleavage is also said to be **indeterminate**

or **regulative** because each of the blastomeres of the early embryo, if separated from the other, can regulate its development and form a complete well proportioned embryo.

This happens because the blastomeres are **equipotent**; their final fate is not yet determined and there is no definite relation between the position of early blastomeres and specific tissue it will form in the embryo (hence indeterminate). This type of cleavage is found in some cnidarianes, echinoderms and all chordates.

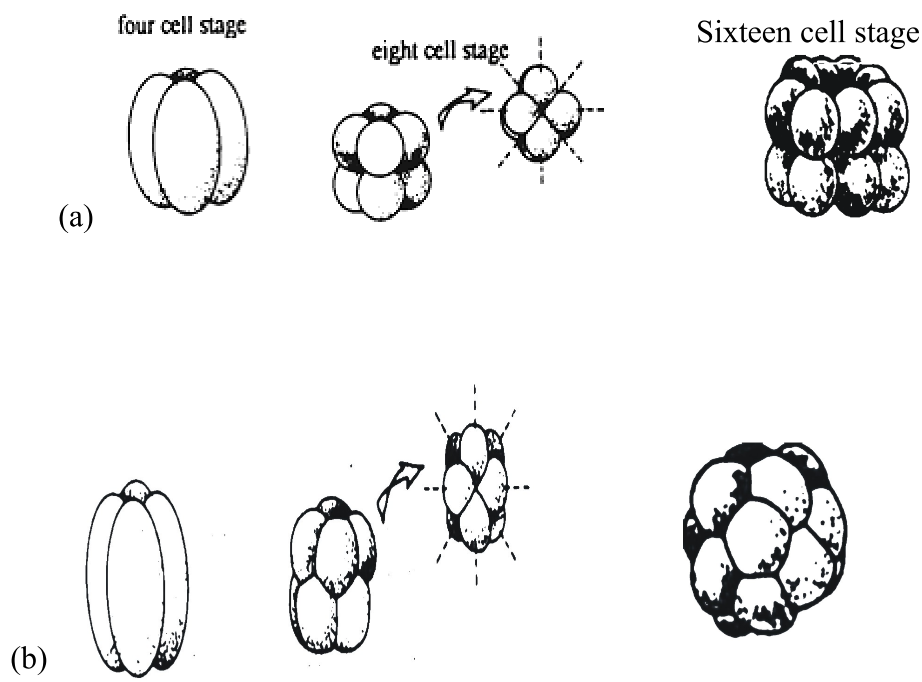


Fig. 3.8: (a) Radial cleavage shown at 4, 8 and 16 cell stage.

(b) Spiral cleavage showing transition from 4 to 8 to 16 cell stage.

In **Spiral Cleavage,** however, the third and fourth cleavage planes are oblique to the polar axis and the resulting blastomeres do not lie on top of one another but above the furrows between the cells (Fig. 3.8 (b)). The spindles during the third cleavage, are arranged in the form of a spiral, therefore, the name spiral cleavage. This type of cleavage is seen in all invertebrate except the echinoderms (i.e. in annelids, molluscs, arthropods nemertenes and polyclad planarians).

Spirally cleaving embryos are said to have **mosaic** or **determinate** form of development. This means that the organ forming regions of the egg are strictly localised in the egg from the very beginning and the fate of the blastomere is determined early. If the blastomeres are separated, each will continue to develop up to a certain time as though it was a part of the whole and give rise to defective, partial embryos. In the early embryos an unidentified cytoplasmic factor is segregated into one of the blastomeres, the mesentoblast (this is also called the `4 d' cell) which gives rise to the future mesoderm.

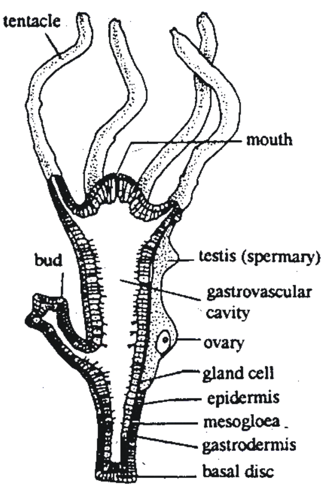


Fig.**3.9:L.S.Hydra**

3.4.2 Fate of Blastopore

Cleavage results in the formation of a ball of cells called **morula** (resembling mulberry hence the name). A space appears in the morula changing it to a hollow **blastula**. The central cavity is called the **blastocoel** and the layers of cells surrounding it the **blastoderm.** Invagination or in folding of the blastoderm gives rise to a double walled **gastrula**.

The cavity of this double walled cup is called archenteron and the opening of the archenteron to the outside is called the **blastopore** (Fig. 3.9). As the gastrula develops further, parts of' the embryo give rise to different structures to ultimately form a complete young one. In platylielmintlis, nematodes, annelids, arthropods and molluscs that have spiral cleavage, the embryonic blastopore forms the mouth of the animal and the anus is formed secondarily (Fig. 3.9). Because the mouth forms first these animals, are included in **‘protostomia'** (mouth first) division of' Animal Kingdorn.

Fig. 3.9: Early embryology of a nemertean worm a protostome.

In echinoderms, chaetognaths, hernichordates and chordates where radial cleavage takes place, the blastopore forms the anus of the animal and the mouth is formed secondarily, as an independent opening on the body wall as seen in Fig. 3.10. Therefore, these animals are included in `**Deuterostomia**' (mouth second), division of the Animal Kingdom.

The fate of' the blastopore thus determines two fundamental lines of evolution. The protostornes in which the cleavage is generally mosaic (determinate and spiral) and the deuterostornes in which the cleavage is usually regulative (radial and indeterminate) type.

Holoblastic cleavage

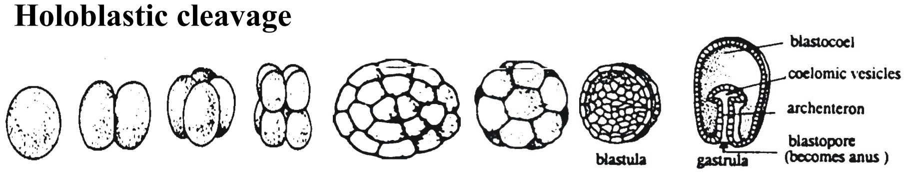


Fig. 3.10: Blastopore formation in sea-star a deuterostome.

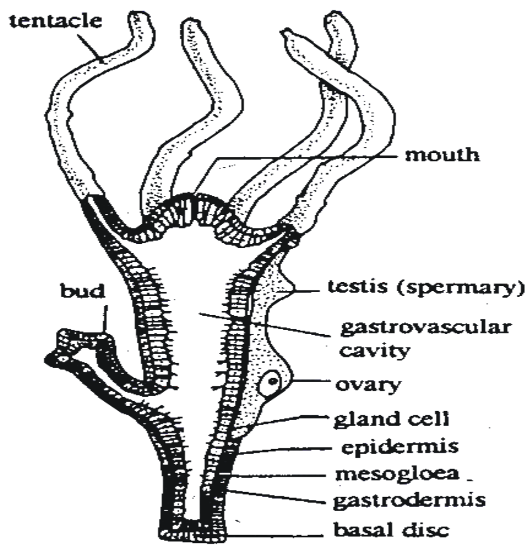
3.2 Germ layers

In the earlier section you have learnt that infolding of .the blastoderm of the blastula forms a gastrula with two or more layers. The outer layer is the ectoderm and the endoderm lines the inner cup. Later in development a third layer, the mesoderm, typically develops between the two. The details are mentioned in subsection 3.6 of this Unit. These three embryonic layers from which various organs of the animal are developed are called **germ layers**.

You must know at this point that animals of phyla Cnidaria and Ctenophora are made up of only two germ layers: **ectoderm** which forms the outer covering of the animal and **endoderm** which is the inner layer and is also known as the **gastroderm**. However, a non-cellular jelly like substance **mesoglea** is present between ectoderm and endoderm which acts as a cement to bind the two layers.

This layer should not be confused with the third genii layer i.e. **mesoderm**. Since animals of these two phyla do not have mesoderm, they are said to be **diploblastic**. If we cut a longitudinal section through Hydra we see two distinct layers bound together by a non-cellular mesoglea. The two germ layers give rise to many different cell types - as evident from figure 3.11.

Rest of the animals (platyhelminths to mammals) are all made up of three germ layers viz. ectoderm, endoderm and mesoderm. These animals are **triploblastic**. If we cut a, . section say through a horse (a mammal and diploblastic) can we expect to see three layers like you see two layers in diploblastic Hydra? No-we will not, because these; three germ layers do not remain as such„they differentiate and modify, to give rise to different structures and organs! And the body 'of the horse. The these layers will be distinct only during early embryology) Hence we call them the embryonic layers.



Fate of tl

In cnidarians and ctenophores, all the cell types develop from either ectoderm or endoderm. Similarly all the tissues and organs in the rest of the animals develop from the three germ layers. Perhaps you would like to know how the three germ layers contribute to the different body structures as you grew from embryo to infant. Table 3.l will illustrate this.

Table 3.1: Derivatives of the three germ layers.

Ectoderm	Endoderm	Mesoderm
i) Epidermis of the skin	i) Epithelial parts of the thyroid, thymus. Parathyroid, middle ear eustachean tube.	i) Dermis of the skin.

ii) Brain and spinal cord.	ii) Epithelial portions of the liver and pancreas	ii) Skeletal sytem
iii) Cranial and spinal nerves oral epithelium of oral glands	iii) Epithelial lining of the respiratory system beginning with the larynx	iii) Most muscles as well as adipose tissue and all other varities of connective tissue.
iv) Nasal and olfactory epithelium	iv) Epithelial linning of the vagina urinary bladder	iv) Certain types of scales, horns in animals.
v) Epithelium of anal canal	v) Epithelial lining of the gut, except the mouth and the anal canal.	v) Definite portion of teeth
vi) Lens and retina of the eye	vi) Auditory tube and middle ear cavity in mammals, etc.	vi) Blood vascular system including blood.
vii) Epithelium of sweat, sebaceous and mammary glands		vii) Greater part of the urino – genital system .
viii) Hair, nails, (feathers, hooks, scales in animals).		viii) Adrenal cortex
ix) Adrenal medulla anterior and posterior pituitary and pigment cells		ix) Coelomic epithelium mesenteries, and outer layers of the gut.
x) Inner ear vesicle (labyrinth)		x) Lining of gonads
xi) Enamel of teeth		
xii) Cutaneous sense organs		

By going through this table you must have realized the significance of the germ layers. We now proceed to another important characteristics of animals – the cavities and coleom.

SAQ2

Fill in the blanks using words from the text

1. Archenteron appears in the................... and is the future................
2. Animals of phylum Cnidaria have a middle layer called .... and on the number of germ layers, they are called...............................
3. All chordates, including human beings have .... germ layers and are called -------------------

4. Nasal epithelium, retina and inner ear vesicles are the derivatives of.........................

5. Dermis, adrenal cortex, most muscles are derivatives of..........................

6. Middle ear, epithelium of vagina and respiratory tract are derivatives of ………………

3.6 Body cavity and coelom

Vacuoles, spaces, lacunae and cavities have been of importance in all organisms, be it plant or animal. All animals have cavities. The cavities perform different functions in different animals. But most of these are not usually considered body cavities. Spongocoel for example, a cavity in sponges, is really a system of water canals.

Generally by the term body cavity we mean a large fluid filled space lying between the body wall and the internal organs. Bilateral animals are classified according to the presence or absence of body cavities. There are two types of body cavities in animals the **pseudocoelom** and the coelom.

3.6.1 Pseudocoelom

The platyhelminths which do not have a body cavity surrounding the gut, have a solid type of body constitution (Fig. 3.12 a). The mesoderm completely fills the space between body wall and alimentary canal in the form of a network of cells called parenchyma. Such animals are called **acoelomates**. In nematodes, there is a different situation: the mesoderm is confined to specific circumscribed regions within the body cavity, and this cavity is neither lined nor filled with mesoderm. The cavity is in fact a persistent blastoporl of the embryo and is called pseudocoel. The internal organs are free within the pseudocoel. The body cavity has no lining of peritoneum derived from mesoderm. Animals so constructed are called **pseudocoelomates** (Fig.3.12 b).

3.6.2. Coelom

True coelom is a body cavity which arises within the embryonic mesoderm so that the cavity lies between the body wall (integument; ectoderm) and gut (endoderm) and is lined by mesodermal cells. This lining is called peritoneum in higher animals. Various internal organs are housed in the coelom and are lined by peritoneum along with many mesenteries (Fig.3.l2 c), thin membranes that keep the internal organs in place. The fluid inside the cavity acts as a shock absorber and gives rigidity to the body as well as functions in circulation, excretion and respiration in invertebrates.

There are two patterns of coelom formation in animals **schizocoelous** and **enterocoelous**. In schizocelous pattern, two teloblasts cells (primordial mesodermal cells) are given out (Fig.3.13 A) from close to the blastopore. These proliferate into a pair of teloblastic bands. At first the bands are solid but later each splits forming a cavity within. This cavity enlarges to form the coelom. Such a coelom is known as **schizocoel** and animal characterized by body cavities of this type are designated as **schizocoelomates** - For example annelids arthropods and molluscs.

Schizo comes from Gk. Schizein to split; Entero is fon Greek enteron i.e. gut.Coelous comes from Greek Koilos, hollow or cavity.

In enterocoelous development of coelom the mesoderm arises in the embryo as paired lateral pouches growing out from the archenteron, (Fig.3.13 B). The pouches grow and later get disconnected from the archenteron. The cavity of the pouch becomes the coelom. The inner wall of the pouch surrounds the developing alimentary canal and the outer layer lines the developing body wall. Those two layers become the future mesoderm.

The animals possessing such cavities are known as **enterocoelomates.** Echinoderms hemichordates and chordates show this pattern of coelom development.

The two different patterns of origin of coelom are another expression of the protostome - deuterostooic dichotomy in evolution. Protostomes typically show schizocoelous origin of coelom while in deuterostomes the coelom arises usually by enterocoely.

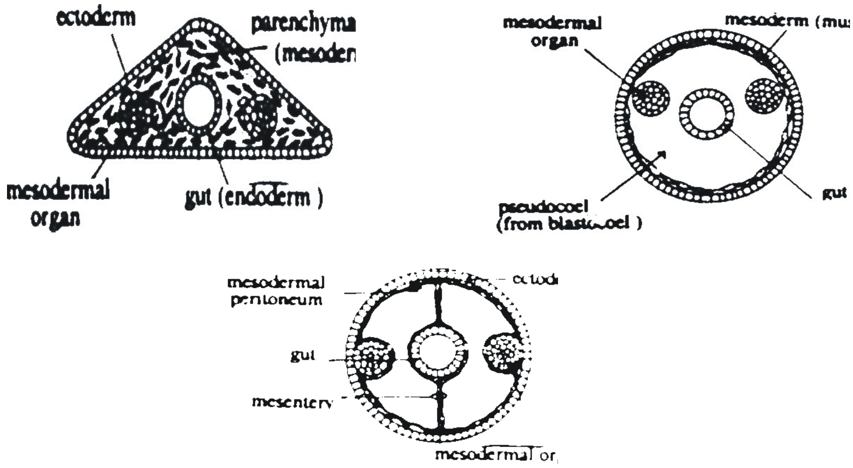


Fig. 3.12: Section of

a) Acoelomate,
b) Pseudocoelomate and
c) Eucoelomate animals.

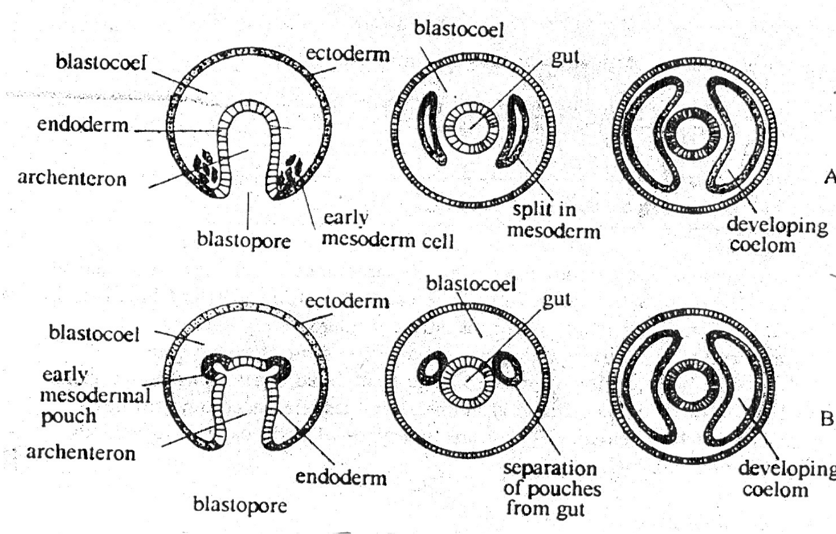


Fig 3.13: Development of Coelom

a) Schizocoelous origin
b) Enterocoelous origin

The coelom provides the coelomic animals with a tube-within a tube body plan that allows greater flexibility when compared to animals that do not have internal body cavity. The fluid filled coelom additionally serves as a hydrostatic skeleton, in some forms such as worms, aiding in burrowing and inmovement. The coelom is of great significance in animal evolution. It is a stepping stone for evolution of more complex and larger forms.

SAQ 3

Mark true (T) or false (F) in the space provided against each statement.

1. True coelom is found in all triploblastic animals. ☐
2. Diploblastic animals which do not possess a true coelom are called acoelomates. ☐
3. Schizocoelous coelom is formed from embryonic teloblasts. ☐
4. Enterocoelomates are also called Protostomes. ☐
5. Nematodes have a body cavity between the ectoderm and endoderm but it is not lined by mesoderm. ☐
6. In pseudocoelomates the cavity between ectoderm, and endoderm is completely filled with mesoderm. ☐

3.7 Cephalisation and segmentation

Bilateral animals when creeping or swimming have a tendency to keep the same end of the body forward and the same surface down towards the substratum. In such a case the sensory organs and nervous system would also have a tendency to be concentrated at the anterior end. This differentiation of a `head end' is known as **cephalisation** (literally head development). Cephalisation has evolved to various degrees in bilateral animals.

The mouth is usually located at the leading end with which become associated the organ:, for food capture, as the sensory organs on the head can detect food. Neurons become organised into brain in this region for rapid coordination; longitudinal nerve cords are developed for rapid transmission of information throughout the length of the body. Cephalisation in its most primitive form can be seen in Platyhelminthes (Fig.3.14)

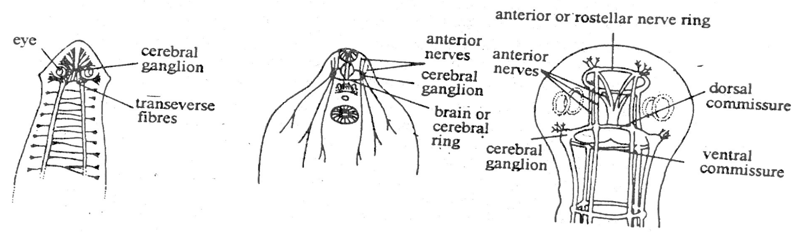


Fig. 3. 14: Concentration of nervous system in anterior region of

a) Liverfluke **b) Tapeworm** **c) Planaria**.

Segmentation or **metamerism** is the division of the body into smaller transverse compartments along the anterior-posterior axis. Segmentation is widespread among animals, with true segmentation occurring in annelids, arthropods and most chordates though some other groups show superficial segmentation of ectodermal body wall.

Fundamentally there are three body forms. First, monomeric where there is no division of the large body cavity at all. Ascaris has this type of body form. Second, oligomeric where the body cavity is divided into three and each region has a separate body cavity with no divisions on the abdomen Phorona is a worm with this body plan. Third, metameric in which the body is divided into head, thorax and abdomen and where abdomen is further divided into a chain of segments.

Segmented body forms can be seen in tape worms, annelids arthropods and chordates. Of these segmentation in tape worms is quite different from that seen in the others. We can observe that segmentation in tape worm is superficial, a series of ring like creases develop in the cuticle and the body wall which facilitate bending and telescoping of the body. But this segmentation is strictly ectodermal (Fig: 3.15) and this segmentation is a reproductive adaptation.

The segments of the entire boy are in a continuous process of being produced matured and discarded. The new segments grow in the neck region and the older ones are detached from the posterior end. Each segment functions as an independent unit without having any vital connections with the other.

On the other hand true metameric segment as best observed in annelids has separate schizocoelic body cavity of mesodermal origin in each segment.

Individual segments are budded off in linear sequence from a proliferation region just in front of the posterior end.

Segmented animals have a specialised anterior **acron** (prostomium) and posterior **pygidium** or **telson** both of which are not segments. In between there are a varying number of segments. In near perfect segmentation, appendages, musculature, ganglion, nerves, blood vessels, coelom and all body organs are replicated in each segment. This arrangement is best seen in annelids. In chordates, segmentation is usually apparent in the axial skeleton, muscles and nerves.

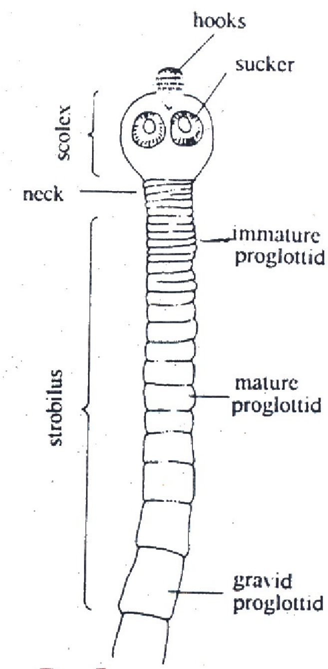


Fig. 3.15 Superficial segmentation set in tape-worms.

Why did segmentation evolve in animal groups? What advantages does it confer on the animals in which it is seen? Let us examine this a little closely. The most important advantage is that segmentation divides a body into a series of compartments, each of which can be regulated almost independently. This in a way provided the framework for **specialisation.** In colonial animals this specialisation is seen in polymorphism of zooids while in segmented animals **regional specialisation of segments occurs.**

For example in annelids, the body is divided into a head and trunk region (Fig.3.16). The divisions are better defined in insects and many crustaceans. In extreme cases i.e., in higher vertebrates regional specialisation has occurred to the extent that segmentation is lost even in muscle arrangement.

Regional specialisation takes place usually by three processes.

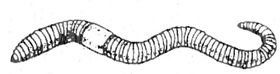
1. Restriction of certain structures to a few segments, for example, gonads are restricted to a few specialised genital segments in annelids (e.g. earthworm).

2. Structural divergence of segmental structures to perform different functions. For example some segmental appendages may be modified from those suitable for locomotion to those adapted for grasping or chewing, (e.g. insects)

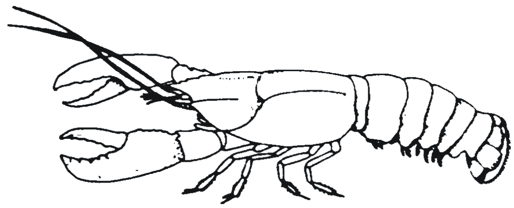
3. Fusion of segments along the length of the animal. For example, fusion of anterior segments to form the head. The head of Nereis consists of the acron and two other segments while that of Drosophila is composed of five segments.

The second significant feature of metameric segmentation is its importance in the locomotion of soft bodied animals. The acoelomate animals use their musculature of longitudinal and circular muscles for locomotion but the evolution of a coelomic cavity has allowed the fluid to act as hydraulic skeleton. In invertebrates like annelids, muscles of the body wall act against this pressure. When circular muscles contract, hydrostatic pressure on coelomic fluid will result in lengthening of the body; when longitudinal muscles contract, it will result in widening of the body.

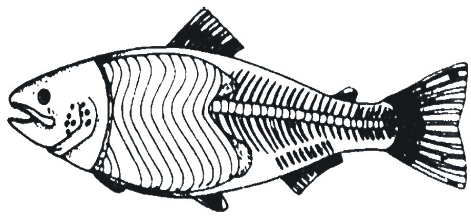
Since metameric segmentation results in compartmentalization of the body, this elongation and widening of the body can be restricted to a few segments at a time. This local change in the shape of the elongate body increases the locomotory efficiency. The broadened part of the body can be firmly fixed against the burrow especially if there are clinging structure such as setae and the lengthening of the body will produce considerable thrust resulting in progression of the animal. Thus the alternate peristaltic waves enable the animal to move forward faster and efficiently.



Annelida



Arthropoda



Chordata

Fig.3.16: Phyla showing segmentation. Annelids and arthropods are related but chordates have acquired metamerism independently.

So far in this unit we have considered the characteristic of body designs that are shared by various animals and the different body plans that distinguish major groups of animals. We can now use those characteristics to group and classify the animals as given in the accompanying chart.

Ancestral Unicellular Organism

Unicelluar
(Protozoa)

Multicelluar (metazoa)

Cell Aggregate
No germ layer,
no true tissue or organs
asymmetrical, intracellular digestion
(Mesozoa, sponges)

Eumetazoa
Germ layers, true tissue,
mouth, digestive system

Radiata
Radial symmetry

Bilateria
Bilateral symmetry

tissue level organization (Ctenpohora, Cnideria)

organ – system level organisation.

Protostomia

Blastophore forms mouth
And the anus is a new formation

Spiral cleavage
Determine type of development

Deuterostomia

Blastopore does not form mouth but anus. Mouth formed later From independent opening body wall.
Radial cleavage
Indeterminate type of development

Acocelomata	**Pseudocoelmata**	**Schizocoelomata**	**Enterocoelomata**
(E.g. Platyheminthes Nemertea Gnathostomulida)	cavity derived from blastocoel Non peritoneal lining (e.g Nematoda, Rotifers)	Coelom derived from splitting of mesodermal bands (E.g. annelida, Arthropoda, Mollusca).	Coelom from fusion of entreocoelus pouches. (e.g. Echinoderms to chordales)

3.8 Origin and evolution of metazoa

Most of the early metazoans were soft bodied and so their fossils are rare. The extremely fragmented fossil record does not shed any specific light on their origin. Therefore, most of the explanations on their origin are based on their embryology and comparative morphology.

A series of theories have been put forward to explain the origin of multicellular metazoans from unicellular organisms. Of these, three principal theories could be considered.

1. **Syncytial theory**: That the ancestral metazoans have arisen ciliate by compartmentalization or cellularization.

2. **Colonial Theory:** That the ancestral metazoans have arisen flagellates by cellular specialisation and interdependency.

3. **Polyphyletic Theory:** That the metazoans have arisen from more than one group of organisms.

3.8.1 Syncytial Theory

This thëory suggests that the ancestral metazoan was at first Syncytial in structure but later became cellularised by formation of cell membranes around individual nuclei thus producing a typical multicellular body (Fig.3.17a). Hadzi (1953) and Hanson (1977) have been the chief proponents of this theory.

As many ciliates tend to have a bilateral symmetry, the advocates of this theory maintain that the ancestral metazoan was bilaterally symmetrical similar to the present day acoelous flatworms.

The theory receives support from the fact that acoelous flatworms are:

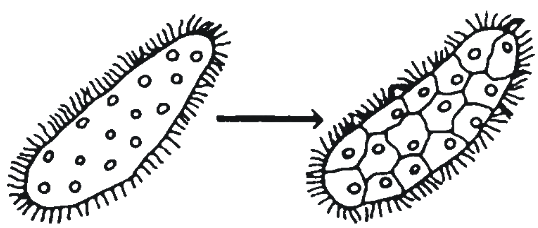
(1) Of the same size range as the ciliates,

(2) Are bilaterally symmetrical

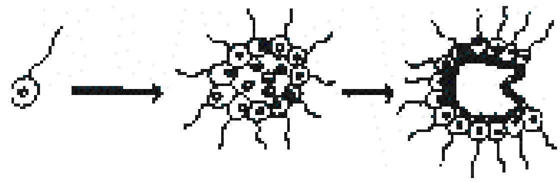
(3) Are ciliated and

(4) Tend towards a synctial condition.

There are several objections to this theory. It ignores the embryology of flatworms in which nothing similar to cellularisation occurs, nor does it explain the presence of flagellated sperms in metazoans. Perhaps the most important objection to this theory is that it assumes that acoelous flatworms are the most primitive metazoans and therefore, presumes bilateral symmetry to be more primitive than radial symmetry and thus radial coelenterates must have been derived from bilateral flatworms. But then it is accepted that radial symmetry is more primitive than bilateral symmetry and radial coelentrates could not have evolved from flatworms.



a. cellularisation



b. colonial

Fig.3.17: Possible routes for evolution of animals.

3.8.2 Colonial Theory

This is the most popular theory on the origin of metazoa. The idea was conceived by Haeckel (1874) modified by Metschnikoff (1886) and revived by Hyman (1940).

This theory considers the flagellates to be the most probable ancestral group of metazoans. For support of this theory the following evidences are cited:

1. Flagellated spermatazoa occur throughout the metazoan series.

2. Monoflagellated cells (with a single flagellum) are also common in lower metazoans (especially among sponges and coelenterates).

3. True sperms and eggs (feature of metazoans) are present in phytoflagellates.

4. Phytoflagellates also display a type of colonial organization that could have led to a multicellular construction. In fact, differentiation between somatic and reproductive cells has been attained in Volvox. Although Volvox is often used as a model for the flagellated colonial ancestor, it is not the likely ancestor of metazoans.

Ultrastructural evidence points to the Choanoflagellates (a small group of animal like flagellates) as the probable ancestor. Choanoflagellates have mitochondria and flagellar structures very similar to those in metazoan cells. Also choanocytes i.e. cells with a collar of microvilli are found in a number of groups of metazoans notably the sponges.

According to the colonial theory the ancestral metazoan arose from the round or oval hollow colonial flagellate (Fig.3.17b). In this primitive metazoan:

1. The cells on the outer surface were mono-flagellated (like in Volvox).

2. There was a distinct antero-posterior axis and it swam with the anterior pole forwards.

3. A differentiation between somatic and reproductive cells was also present.

This hypothetical organism was termed blastaea by Haeckel, and is generally believed to be represented in the development of rnetazoa as the blastula stage.

Further division of labour in the somatic cells led to increasing interdependence till what was a colony of unicellular organisms become a multicellular organism. This super organism provided the transition to a new level of organisation in which specialisation occurred by differentiation of cells rather than differentiation of cell organelles.

According to Haeckel, the blastaea invaginated (bending of the posterior half into the anterior half) to form a double walled, gastraea, equivalent to the embryonic gastrula stage. The gastraea also had a close similarity with the double walled, single cavitied hydrozoan coelenterates arid some sponges.

Metschnikoff, however, opposed Haeckel's ideas. He pointed out that digestion is intracellular and phagocytic in the lower metazoans and so they would not have required a digestive sac or mouth. He believed that certain cells of the blastaea might wander into the interior (ingression) filling up the blastocoel resulting in a solid gastrula (Fig. 3.18). Invagination is considered a secondary process for cavity development. Thus etschnikoff argued that the gastraea was solid rather than a hollow organism.

Following Metschnikoff's view modern workers believe that evolution of metazoans commenced with Haeckel's blastaea and then by ingression of cells into its hollow interior, a solid hypothetical organism evolved with the following features:

1. Body was ovoid and radially symmetrical.

2. Exterior cells were mono-flagellated and performed locomotor and sensory functions.

3. Solid mass of interior cells functioned in nutrition and reproduction,

4. A mouth was absent and food could be engulfed anywhere from the external surface and passed to the interior.

This hypothetical form, since it closely resembled the free swimming **planula** larva of coelenterates, is referred to as the **Planuloid ancestor**

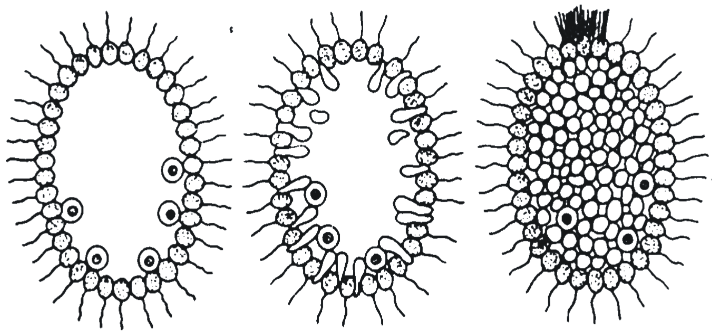


Fig.3.18: Formation of solid gastraea.

From such a free-swimming, radially symmetrical planuloid ancestor, the lower metazoans could have arisen. Thus the primary radial symmetry of coelenterates could have been directly derived from the planuloid ancestor and the bilateral symmetry could have evolved secondarily in flatworms, which later gave rise to the rest of the metazoans.

Hyman (1951) has proposed that certain of the ancestral planuloid stock could have taken up a life on the ocean bottom, a consequence of which a creeping mode of movement developed. This led to a differentiation between dorsal and ventral surfaces and the development of a ventral mouth. This change in mode of life could have resulted in acoelid flatworms which are considered to be the forerunners of the bilateral phyla.

3.8.3 Polyphyletic Theory

This theory was suggested by Greenheig (1959) and some other workers. According to this theory, sponges, coelenterates, ctenophores and flatworms have each evolved independently from protozoans.

Sponges and coelenterates have probably arisen through colonial flagellates, while ctenophores and flatworms through ciliates or even mesozoans. It is apparent that this theory is a compromise between the syncytial and colonial theory.

3.8.4 Evolution of Metazoa

The sponges, coming under phylum Porifera are the closest to Protista, and can perhaps be regarded even as a colony of protists rather than being multicellular. No other group has evolved from them.

The coelenterates consisting of the Cnidaria and the Ctenophora, which are both diploblastic and primarily radially symmetrical, can be regarded as truly the most primitive of the Metazoa. They have evolved from the ancesteral planuloid metazoans as an offshoot.

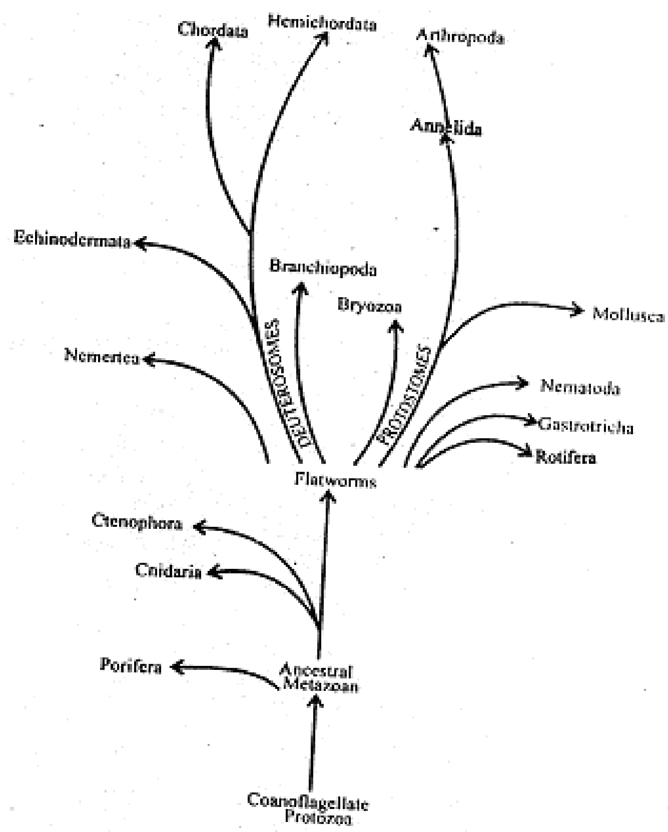


Fig. 3.19: Phylogeny of the animals

The Platyhelminthes (flatworms) have also evolved from planuloid ancestor. They do not have a coelomic cavity (acoelomates) but the mesoderm is cellular, they are triploblastic and are bilaterally symmetrical. This group and all higher metazoa can be grouped as Grade **Bilateria**. (See chart in Sec.3.7).

The **pseudocoelomate** phyla which include the nematodes and the rotifers are supposed to have evolved as an offshoot from the flatworms.

The **Eucoelomata** constitute the remainder of the Metazoa. The acoeloid flatworm like ancestors have given rise to two main stocks:

1. The molluscan - annelidan, arthropodan stock with schizocoelous coelom.

2. The echinoderm, hemichordate, chordate stock with enterocoelic coelom. The coelom serves as skeleton in the more. primitive of the coelomates. Such as the polycheate worms, earthworms etc. In arthropods and molluscs the coelom becomes reduced to the point of being represented by the cavity of the gonads. The other space in arthropod body is only a haemocael which is a mere space in the tissue filled with blood. The phylogeny of Metazoa can be summarised in Fig 4.19.

SAQ 4

Choose the correct answer from the alternatives provided.

1) Of the large number of phyla included under the kingdom Animalia only one is an invertebrate/a chordate phylum.

2) Most of the early metazoans have an extremely fragmentary/rich fossil record.

3) "The metazoans have arisen from a multinucleate ciliate by compartmentalisation" is the essence of colonial/syncytial theory of origin-of metazoa.

4) In a syncytium membranes are present/absent between the adjacent nuclei.

5) The polyphylectic theory states that the metazoans have arisen from one group/many groups of organisms.

6) The hypothetical metazoan proposed by Haeckel was named blastaea/ gastraea.

4.0 Conclusion

In this unit you have learnt that:

- The term Metazoa does not have currently any formal biological status, but is still used to refer to the organisms included in kingdom Animalia of the Five - Kingdom Classification. Increasing complexity of organisms is an evident feature in animal phylogeny. Thus we see that protoplasmic level of body organisation found in protozoans is simplest. Cellular level is found in sponges (Porifera). The cnidarians and ctenophores have attained tissue level of organisation and some of them even have organs, while the rest of the animals i.e., from platyhelminthes to mammals have the highest evolved organ system level of body organisation

- Metazoans are characterised by a complex multicellular structural organisation. They are heterotrophic sexually reproducing diploid organisms. Many of them reproduce asexually too. Their embryos undergo progressive stages of growth and development.

- Animals have a basic body plan which is described in terms of symmetry based on which they can be identified as asymmetrical, spherically symmetrical, radially, biradially and bilaterally symmetrical. The distinction is based on, along how many planes the animal can be divided into to get equal halves: none (asymmetrical), many (spherical and radial), one (bilateral), and two (biradial).

- In Platyhelminthes, the space between the body wall and the gut is filled with mesodermal parenchymal cells; it has no body cavity. Animals above the level of Platyhelminthes have body cavity.

- The body cavity can be of two types: pseudocoel and true coelom. Pseudocoel is a remanant of the blastocoel, and is not lined with coelomic epithelium. It is found in nematodes. However, true coelom is lined with a mesodermal coelomic epithelium. In annelids; arthropods and molluscs coelom is schizocoelic whereas in echinoderms and all the chordates it is enterocoelic.

- Two quite different patterns of cleavage are recognised among animals that show a fundamental division in their evolution. Protostome embryos typically show spiral cleavage with what is called mosaic development and deuterostome embryos show radial cleavage with regulative embryonic development.

- The animals are basically either diploblastic i.e., made up of two germ layers viz. ecto and endoderm (e.g., poriferans and cnidarians) or are diploblastic i.e., made up of three germ layers viz., ecto, endo and mesoderm (e.g., Platyhelminthes to mammals). The various structures of the whole body are derived from these three fundamental germ layers which can only be seen in embryonic conditions.

- Cephalisation with concentration of sense organs and nervous tissues at the head region is characteristic of bilateral animals. It distinguishes an anterio-posterior axis in the animal's body. Segmentation or metamerism in bilateral animals provides a framework for specialisation of body regions for different functions. True segmentation is found in annelids, arthropods and chordates.

- Multicellular metazoans have arisen from unicellular organisms. Three theories have been suggested to explain their evolution; a) syncytial theory; b) colonial theory; c) polyphyletic theory.

- It is generally accepted by most zoologists that metazoans have originated from colonial choanoflagellates. The hypothetical ancestral metazoan was probably a planula like organism. Which gave rise to the sponges as a separate branch. The cnidarians and ctenopleores are probably the most primative metazoans. These form the Radiata while the Platyhelminthes and all other higher groups that have evolved from the flatworms form the Bilateria.

5.0 Summary

From the simplest of all animal forms, the unicellular protests we moved on to the more complicated unicellular organisms, the protozoa. We have now moved to more complicated organism with body structure showing differentiation. You will remember that the more complicated organisms evolved from the simpler ones.

Hence we have, in this unit treated the evolution of thses more complicated organisma. We have also classified them according to their degree of body segamntation.

6.0 Tutor Marked Assignment

1. What do you understand by terms diploblastic and triploblasitc? give example.

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……………………………………………………………………………

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2. In this unit we have explained three different kinds of germ layers. Write the names of any three derivatives from each kind.

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3. What is coelom? Differentiate between true and false coelom.

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4. Distinguish between bilateral, radial and biradial symmetries.

……………………………………………………………………………

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5. Distinguish between schizocelous and enterocoelous coelom.

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7.0 References

Answers

Self Assessment Questions

i) (a)................................. (v)
(b)................................ (ü)
(c)................................ (iv)
(d)................................ (iii)
(e)................................. (i)

(i) Gastrula, alimentary canal.

(ii) Mesoglea, diploblastic

(iii) Three; triploblastic

(v) Ectoderm

(v) Mesoderm endoderm

3)

1. F
2. F
3. T
4. F
5. T
6. F

4) 1. Chordate

2. Fragmentary

3. Syncytial

4. Absent

5. Many groups

6. Blastaea

Unit 4

CLASSIFICATION OF MULTICELLUAR ANIMALS -1

Table of contents

1.0 Introduction

In the previous unit you have studied how the multicelluar animals (Animalia) originated from the simpler protozoan protists. You have also learnt how the simpler multicelluar animals further evolved, giving rise to the diversity of the animal life which came to exist on the earth.

In the present unit you will study the characteristic features of some of the phyla comprising this animal diversity namely, **Porifera, Cnidaria** and **Ctenophora** and also study their further classification into classes.

2.0 Objectives

After studying this unit you should be able to:

- Recongise characters which differentiate one phylum described in this unit, from any other;
- Describe the characteristic features of different classes of animals coming under each phylum described in this unit;
- Give example of various classes of animls treated in this unit;
- Give a basic idea of the organization of the body of animals belonging to different classes of animals treated in this unit;
- And explain the mode of formation of coral reefs and their significance.

3.1 Metazoan Branches: Mesozoa, Parazoa and Eumatazoa

We have already seen that the Kingdom Animalia comprises all the multicellular animals (metazoans). These are divided into three branches: 1) Mesozoa: 2) Parazoa and 3) Eumetazoa. The Mesozoa comprise a tiny single phylum (Phylum Mesozoa): the Parazoa comprise two phyla: a tiny single phylum Placozoa and the rest make up the phylum Porifera comprising the sponges. Most of the metazoans come under the major branch Eumetazoa.

You must note that the cellular layers of Porifera (sponges) are not homologous to the germ layers of Eumetazoa: Their developmental pattern is also quite different from that of the Eumetazoa. The Parazoa are regarded as an early evolutionary side branch of the animal kingdom, which did not give rise to any other group of animals.

Distinctive features of phylum porifera and eumatazoa

Phylum Porifera	Eumetazoa
1. Animals are sessile, with irregular shape and mostly with no symmetry	Animal are mostly mobile, with regular shape and some form of symmetry.
2. Tissues are absent or poorly defined.	Tissues are well defined.
3. There are no organs.	Well-defined organs are present.
4. There is no mouth and digestive tract.	Animals are provided with mouth and digestive tract.
5. Body surface is porous.	Body surface is not porous.
6. No sensory cells or nerves, little coordination.	Sensory cells & nerves, with better co-ordination.
7. Internal cavities lined by lined choanocytes.	Body cavities are not By choanocytes.
8. Physiological division of labour is not well marked.	Physiological division of labour is well marked.
9. Cellular layers not homologous to germ layers.	Cell layers homologous to germ layers.

The branches Eumetazoa, as we have seen above, consist of metazoans with organs, a mouth and digestive cavity. These can be divided into two groups : Radiata and Bilateria. Radiata are characterised by radial (or biradial) symmetry: they have tentacles and a limited number of organs. They have also a digestive cavity with mouth opening to the exterior. The Radiata include two Phyla: Cndaria and Ctenophora. The Bilateria are bilaterally symmetrical animals and include the rest of the eumetazoans

3.2 Parazoa – Phylum Porifera – Sponges

You have just now read that Parazoa comprise two phyla: a tiny phylum Placozoa and Phylum Porifera comprising the sponges. Of these two phyla. We will be dealing here with only one phylum namely, phylum Porifera, the sponges.

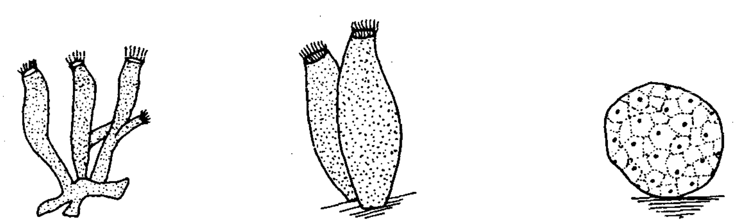
The word "porifera" has been derived from Latin words 'pores' (pore) and 'fera' (bearing), meaning pore - bearing organisms. Porifera are multicellular animals incapable of making movement as they are attached to the substratum like a plant. Porifera present a great variety of forms and have 5000 species or more described species.

They may be cup-shaped, saucer-shaped, mushroom-shaped, lobed digitate branched or irregular. As a general rule, the form is extremely variable even in the same species and is, therefore, of little use in identification. They are almost always attached to foreign objects. With the exception of the fresh water spongillidae, they are marine, and are found at all depths. Individuals of the family Clionidae bore into shells and. stones.

3.2.1 Characteristic features

As the name of the group indicates, the surface of the body presents a large number of minute pores called ostia (sing. ostium). Through these ostia, water current enters the body cavity. These pores actually lead into a system of channels which, after permeating almost the whole body, open to the exterior by one or more large exhalent openings called **oscula** (sing. osculum).

This system of spaces connecting the inhalent pores or ostia with the exhalent oscula, is the **canal system**. The canal system may be simple as in the asconoid type or more complex as in syconoid and leuconoid types (Fig. 4.1).Through the canal system a continual stream of water is maintained by the action' of the flagella.Thus the water enters the canal system through ostia and passes out through the oscula.



Asconoid (Leucosolenia) | Syconoid (Sycon) | Leuconoid (Euspongia)

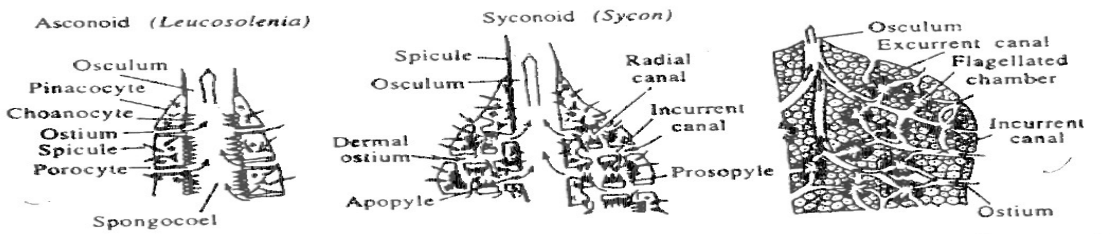


Fig.4.1: Three types of sponge structure. The degree of complexity from simple asconoid to complex leuconoid type has involved mainly the water-canal and skeletal systems, accompanied by outfolding and branching of the collar cell layer.The leuconoid type is considered the major plan for sponges, for it permits greater size and more efficient water circulation.

The sponge body is covered externally by an epithelial layer called Pinacoderm. This layer is made up of flattened cells called pinacocytes (Fig. 3.2). Some of the pinacocytes are modified into porocytes by the formation of intracellul canal opening out through the ostium (Fig.4.l). Some are modified as contractile myocytes arranged around oscula.

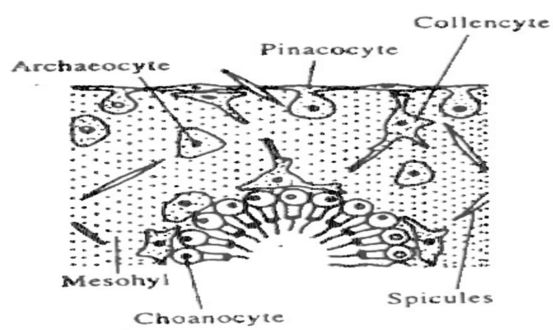


Fig. 4.2: Small section through sponge wall, showing four types of sponge cells. Pinacocytes are protective and contractile; choanocytes create water currents and engulf food particles; archaeocytes have a variety of functions; collencytes secrete collagen.

The flagellated chambers of the canal system are lined by ovoid, collar cells or choanocytes (Fig.3.3), resembling in structure the choanoflagellate protozoans. The: cells carry a flagelum surrounded by a contractile collar projecting into the sponge cavity. These cells are responsible for producing water current of the canal system,for food capture.

Smaller food particles are engulfed by the choanocytes whereas th larger particles are passed on to archaeocytes or amoebocytes (Fig. 3.3). which are principal sites of digestion.

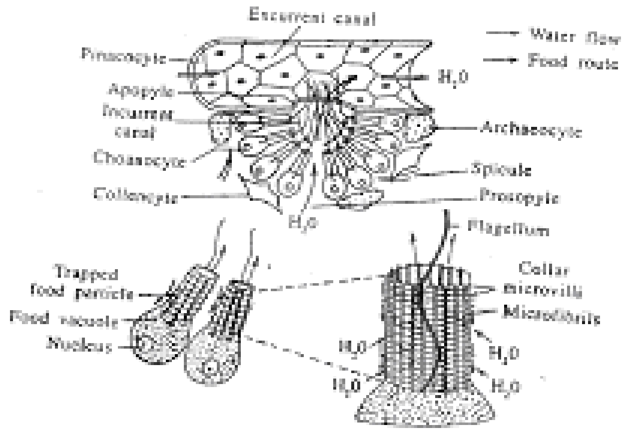


Fig.4.3: Food trapping by sponge cells. A, Cutaway section of canals showing cellular structure and direction of water flow. B, Two choanocytes and, C, structure the collar. Small red arrows indicate movement of food particles.

Between the epithelial layer and the choanocyte layer, is a mesohyal layer consisting gelatinous protein matrix, which contains amoeboid cells (archaeocytes) and skeletal elements. Archaeocytes are amoeboid cells modified to carry out different functions they engulf food articles and are hence digestive in function, as we have already Sclerocytes (Fig.4.4) are specialised for secretion of spicules of the skeleton; spongocytes secrete spongin fibres of the skeleton; collencytes and lophocytes secrete collagen.

Fig.4.4 A, Types of spicules found in sponges.There is amazing diversity, complex and beauty of form among the many types of spicules.

B, Section through a calcareous sponge.

The skeleton supporting the sponge bode is mainly composed of spicules of various sizes and shapes. The spicules (Fig.4.4) may be siliceous, or of calcium carbonate. The skeleton also consists of collagef and spongin.The spicules may have one, three, four or six rays. The structural variation of the spicules is of considerable importance in classification.

Sperms arise from choanocytes; oocytes arise either from choanocytes or archaeocvtes. In addition, internal buds or gemmules are formed from archaeocytes.

You have to clearly understand, in connection with histology of sponges; that the layers of the sponge body,' namely, pinacoderni. Mesohyal and choanocyte layer are not comparable to ectoderm, mesoderm and endodenn of higher annuals.

3.2.2 Classification

Now that we have studied the characteristic features of Porifera. We shall discuss here the classification of Porifera, giving examples of different classes.

Phylum porifera is divided into four classes: Calcarea, Hexactinellida, Demospongiae and Sclerospongiae

1. **Class Calcarea** (Calcispongiae): These are characterised by the presence of **spicules of calcium** carbonate. Spicules are needle-shaped, or three- or four **rayed.** All these sponges are marine, small, mostly less then 111 cm in height. **These may be asconoid,** syconoid or leuconoid. Examples Leucosolenia (Fig. 4.5). Sycon (Fig.4.1).

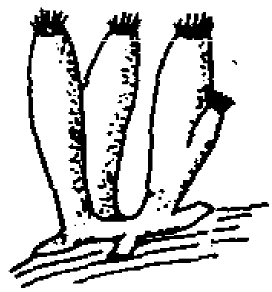


Fig.4.5 Leucosolenia

2. **Class Hexactinellida** (Hyalo-spongiae): These are commonly known as glass sponges. Skeleton is made up of six-rayed siliceous spicules. Mostly deep sea **sponges, radially symmetrical, with vase** - or funnel - like bodies attached by stalks to substratum.**Examples:** Euplectella (Venus's flowerbasket) (Fig.4. 6), Hyàloneura (Fig.4.7). Mostly syconoid, 10-3ft cm. No pinococytes, but the outer layer is made up of net-like syncitium derived from interconnecting **pseudopodia of amoebocytes.**

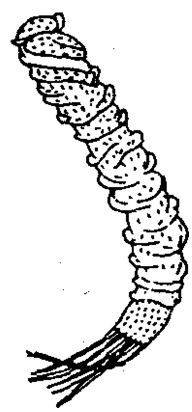


Fig.4.6: Euplectella

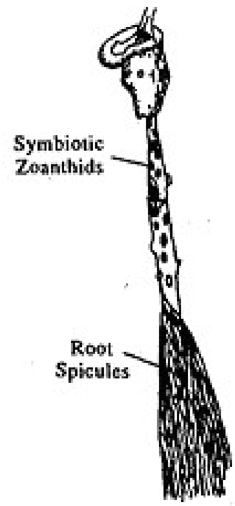


Fig. 4.7: Hyalonema

3. **Class Demospongiae: This constitutes the largest class, with over 90% of all sponge species. The skeleton is made up of spicules of spongin or which are siliceous, or both; spicules not six-rayed. The bath sponges belonging to the family Spongidae eg.** *Spongia* **have skeleton of spongin only. All Demospongiae are leuconoid. Some reach lm in size; usually brilliantly coloured. Some are fresh water eg.** *Spongilla* **(Fig.4.8), some bore into corals**.

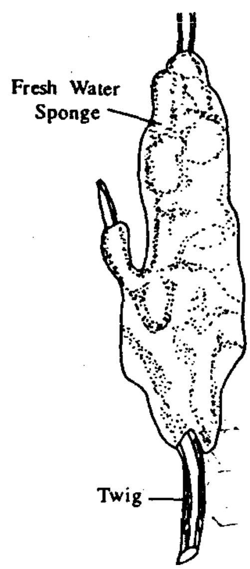


Fig.4.8: Spongilla

4. **Class Sclerospongiae: These consist of a very small group of sponges which secrete a massive calcareous skeleton (Fig. 4.4). Compound skeleton of siliceous spicules and spongin fibres is also often present. The living tissue is limited to a thin superficial layer on the skeleton. All are leuconoid. They live hidden in crevices, caves and tunnels among coral reefs eg.** *Merlia.*

SAQ1

Complete the following sentences inserting appropriate words in blanks

i) Porifera are --------------- cellular animals incapable of ------------- as they remain --------------- to the substratum like a ----------------

ii) The sponge body is covered by an outer epithelial layer made up of ----------------------------

iii) Sponges with skeleton made up of spicules of calcium carbonate belong to the class ----------------------

iv) Hexactinellida are characterised by the presence of ---------------- spicules.

v) The flagellated chamber of the canal system of sponges is lined by ----------------------

3.3 Phylum Cnidaria

You have already seen above; how sponges coming under phylum Porifera, are organized. You shall now see the organization of animals coming under phylum Cnidaria. Phylum Cndaria, along with phylum Ctenophora, together constituting Radiata, is some times referred to as coelenterates. They include more than 9000 living species, all aquatic, mostly marine but also some fresh-water forms. Their fossils date back to more than 700 million years.They are a successful group of animals, though of great structrual and functional simplicity among metazoans.They include hydroids, jelly fishes. sea anemones and corals etc.

3.3.1 Characteristic Features

1. All are aquatic animals.

2. Radial or biradial symmetry around an oro-aboral axis, but no head.

3. Diploblastic with an epidermis and a gastrodermis, and a less cellular or noncellular, gelatinous mesoglea in between.

4. A gastrovascular cavity with a single opening, the mouth; tentacles encircling the oral region.

5. No coelom, or separate excretory or respiratory system.

6. Nerve net, for diffuse conduction only, present. Some sensory organs also occur.

7. No distinct muscle tissue, but an epithelio - muscular system is present.

8. Two forms of individuals - benthic polyps and pelagic medusae - occur. Polyps usually reproduce asexually, budding sexual medusae. Sexual reproduction in all medusae and some polyps involving gametes. Cleavage holoblastic and indeterminate. A free swimming planula larva present.

There are two forms of individuals in Cnidaria: the polyp and the medusa. Polyp is tubular, the oral end being free carrying a whorl of tentacles, and the aboral end attached to the substratum by the basal disc. The polyp is the sedentary, benthic form. The medusa is the free-swimming umbrella-like pelagic form, with mouth at the end of the manubrium on the subumbrellar side.

Though polyp and medusa may appear to be quite different in form, they have basically the same plan with an outer layer of epidermis, and a gastrodermis lining the gastrovascular cavity, with a gelatinous layer of mesoglea in between them. The mesoglea in the medusa is, however, thicker (hence the term.jelly fishes), and one form can be theoretically derived from the other, as could be easily understood from Figure 4.9. The gastrovascular cavity serves as the alimentary canal, opening to the outside through only one opening, the mouth.

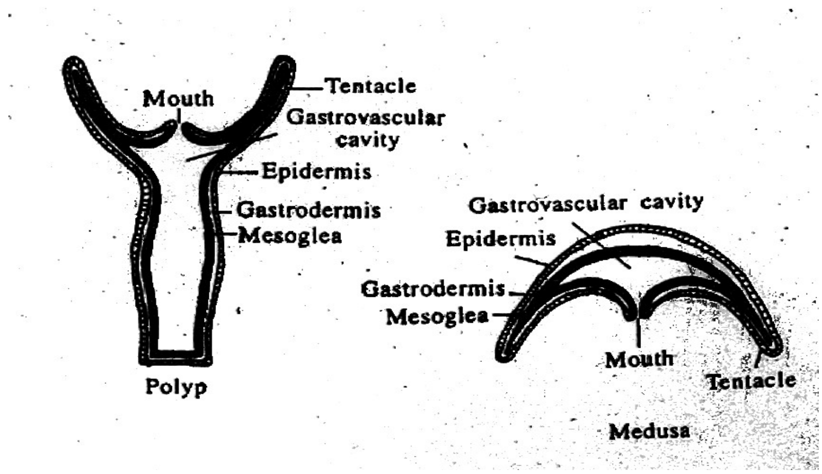


Fig.4.9: Comparsion of polyp amd Medusa

Body wall

Structure of the body wall of cnidarians can be easily understood from a portion of the cross sections of hydra (fig. 4.10). The outer, epidermal layer is made up of five types of cells.

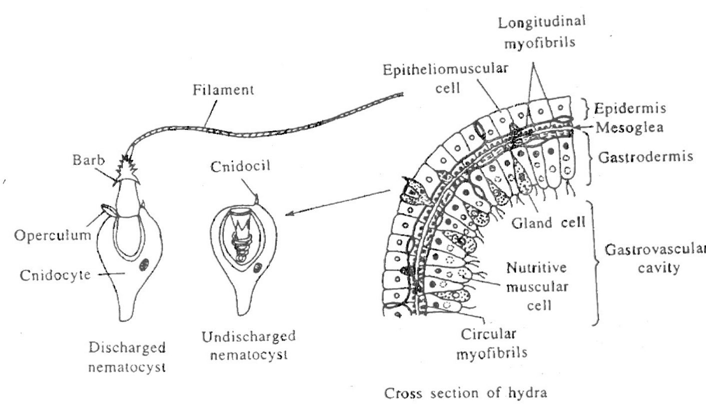


Fig. 4.10: At left, structure of a stinging cell. At right, portion of the body wall of a hydra. Cnidocytes, which contain the nematocysts, arise in the epidermis from interstitial cells.

Epithelio muscular cells: These are columnar cells with basal contractile myofib extending parallel to the oro-aboral axis and are hence longitudinal fibres. Their contraction results in shortening the length of the animals.

Interstitial Cells: These are undiffrentiated cells found among the bases of the epithelionurscular cells. These give rise to other types of cells.

Cnidocytes: During development these are called cnidoblasts. When fully formt cuidocyte contains a stinging capsule called nematocyst containing a coiled tube 4.11).This tube can be everted when discharged at will. At the base of the tub are tinç sharp barbs. The capsule is covered with a lid, the operculum. Cnidocyte, has a hair-like cnidocil which acts as a trigger. The nematocyst contains a fluii high osmotic pressure.

When the prey touches the cnidocil, the permeability of the membrane covering the nematocyst changes and there is a sudden uptake of water into the nematocyst.This results in the eversion and discharge of the coiled tube, which is extended during the process.The coiled tube turns inside out like the sleaves of a shirt during the process.

Once the nematocyst is discharged into the prey, the cindocyte is absorbed and a new one is formed in its place.There are a variety of nematocysts in the cnidarians: they are important in classification of these animals. These structures are the weapons of offence and defence in the group. Some are sticky and are used for food capture.

Fig.4.11: Several types of nematocysts shown after discharge. At bottom are two views ofa type that does not impale the prey, rather it recoils like a spring, catching any small part of the prey in the path of the recoiling thread.

Mucous gland cells: They are gland cells which secrete mucous useful in protection, adhesion and for capture of the prey.

Sensory and nerve cells: The sensory cells are scattered among epidermal cells. Nerve cells are usually multipolar and their processes synapse with those of the sensory cells and of other iterve cells. They form a network in the epidermis.

Gastrodermis consists of: i) Nutritive - muscular cells. These cells engulf food particles and digest them. They have also muscular processes at the base. These processes extend at right angles to the oro-aboral axis. Hence they are called circular muscle fibers, and their contraction results in decreasing the diameter of the body.ii) Gland cells secrete enzymes into the gastrovascular cavity; iii) Mucus secreting cells.

3.3.2 Classification of Phylum Cnidaria

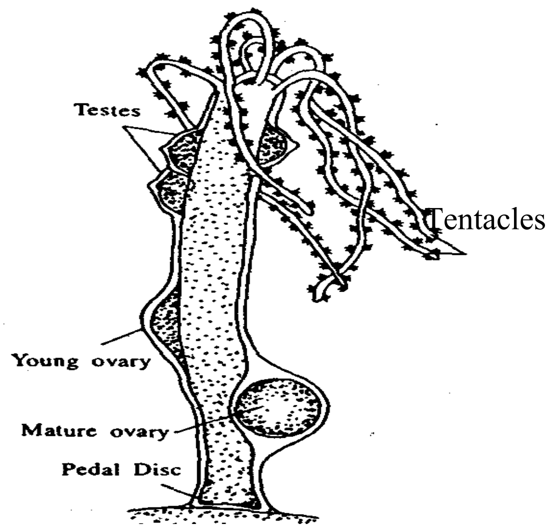
Depending mainly upon whether polyp or medusa is the dominant form in the life cycle, Cnidaria are divided into four classes (1) Hydrozoa; (2) Scyphozoa; (3) Cubozoa and (4) Anthozoa.

1. **Class Hydrozoa. They may be solitary or colonial forms. There are asexual polyps and sexual medusas, though one type may be suppressed. The feeding zooids (hydranths) do not have mesenteries. Medusa, when present, has a velum (the margin of the umbrella projecting inward in the form of a shelf). Animals may be either fresh water or marine.**

Hydra (Fig.4.12) is a common fresh water form, but atypical, being solitary and without a medusoid form, Obelia (Fig.4.13) is a colonial form. It has feeding polyps with tentacles (gastrozooids or trophozooids), and reproductive zooids without tentacles, which bud off medusae (gonozooids). These individuals are Connected-to root-like hydrorhiza with a stalk-like hydrocaulus.

The gonozoids bud off small medusae with epidermal gonads. The testes and ovaries are borne on different medusae (gonochorism). The medusae have light-sensitive ocelli statocysts sensitive to gravity (Fig. 4.14). In Tubularia, another colonial for gonozooids do not release medusa, the medusae remain attached to the gonozooids from where gametes are released. Then the gonozooids are called gonophores.

Individuals belonging to the order siphonophora show highest degree of polymorphism. They form floating or swimming colonies made up of see types of modified medusae and polyps. Physalia (the Portugese man-of war) (fig.4.15) is such a colony with a big bright float and long tentacles arising fror clusters of polyps modified differently for carrying out various functions.*Velella* (Fig.4.16) with a small saucer shaped float (modified gastrozooid) carrying gonozooids and dactylazooids (club shaped polyps with batteries of cnidocytes (which are defensive in function) is another example.



4.12: Hydra

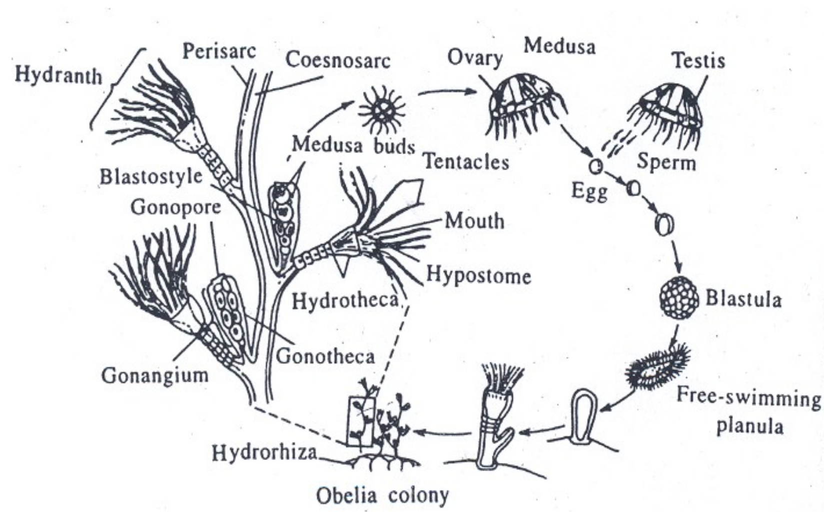


Fig.4.13: Life cycle of Obelia• showing alternation of polyp (asexual) and medusa stages. Obelis is a calyptoblastic hydroid; that is, its polyps as well as are protected by continuations of the perisarc.

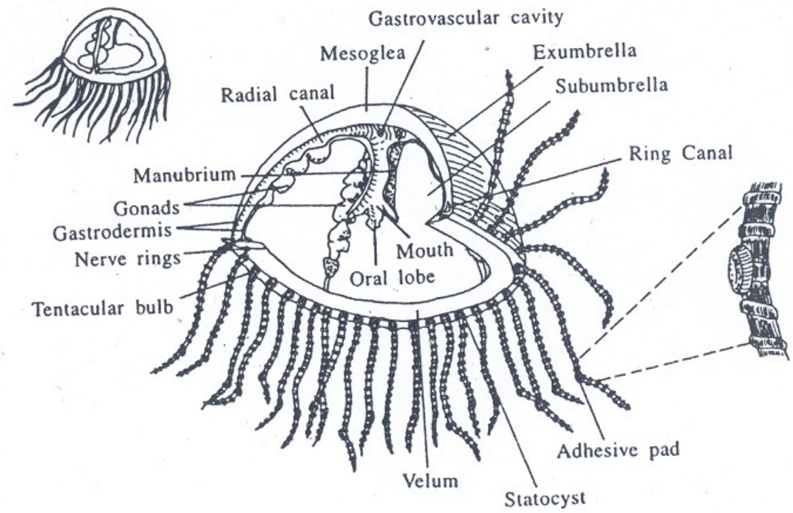


Fig.4.14: Structure of Gonionemus. A, Medusa with typical tetramerous arrangement, B, Cutaway view showing morphology. C, Portion of a tentacle with its adhesive . pad and ridges of nematocysts.

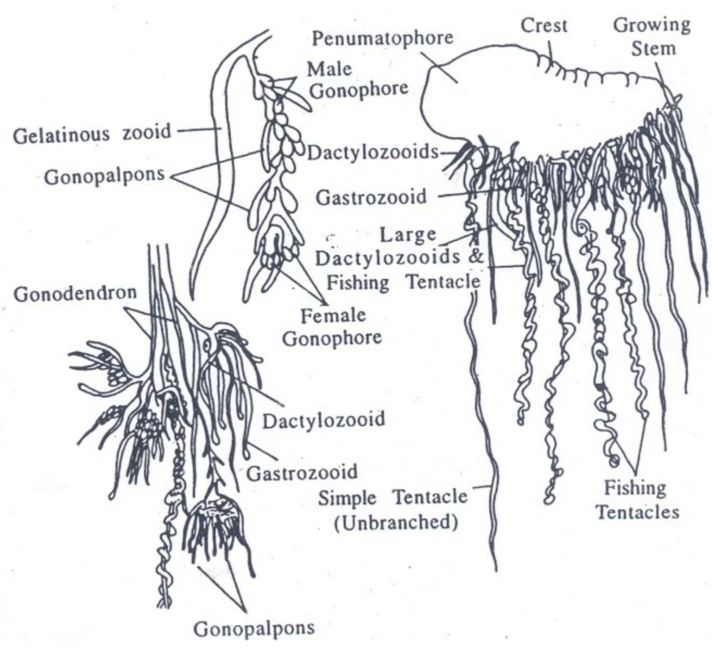


Fig.4.15: Physalia A - Young; B - Part of gonodendron; and C - A cluster of individuals from sexually matured Physalia.

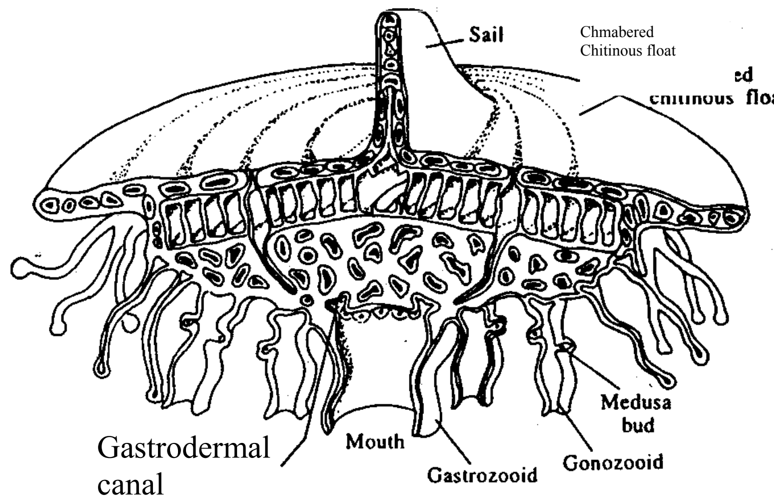


Fig.4.16: Velella (by-the-wind sailor), a pelagic hydroid. These pelagic hydroids float near the surface, and the aboral surface bears a sail.

Colonials hydrozoans also include the hydrocorals (orders Milleporina and Stylast secreting internal epidermal calcareous skeleton attaining considerable size. Since have dactylozooids and can inflict painful sting, they are also called stinging coca

2. **Class Scyphozoa. These are solitary cnidarians, with polyp stage reduce absent. Medusae do not have velum. Gelatinous mesoglea is very mucl enlarged. Margin of the umbrella has usually eight notches with sense organs. All are marine**.

Aurelia is a typical example. Medusa is the dominant individual, 10-30 cn diameter. The marginal club-shaped sense organs called rhopalia (Fig.4.17) neuronal concentrations, statocysts and ocelli. Gonads are gastrodermal. Zygote develops into a planula larva which attaches to the substratum and develop polypoid scyphistoma (Fig 4.17). The scyphistoma buds off ephyra larvae are juvenile medusae. Ano er example is *Rhizostoma.*

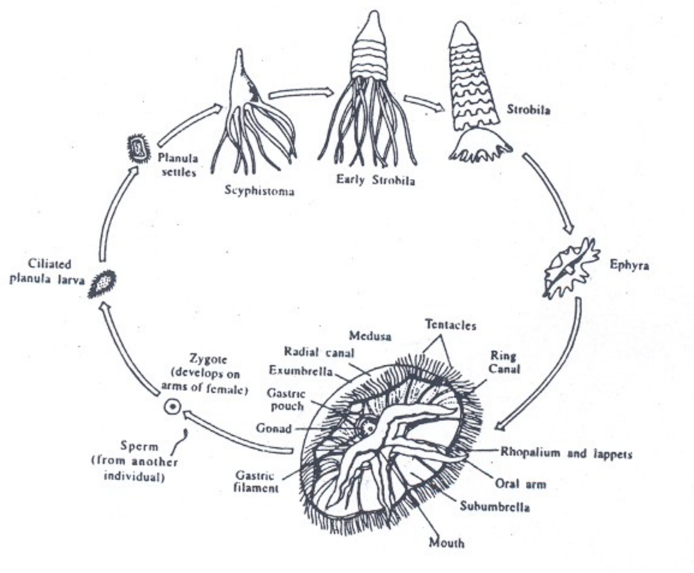


Fig.4.17: Life cycle of Aurelia, a marine scyphozoan medusa. Tentacle

2. **Class Cubozoa. These are also solitary medusoid forms with reduced polyp stage. But the medusa is square in cross section. Tentacles or groups of Animal tentacles hang from tough flattened pedalia which occur at the corners of the umbrella. All are marine. Example Carybdea (Fig.4.18).**

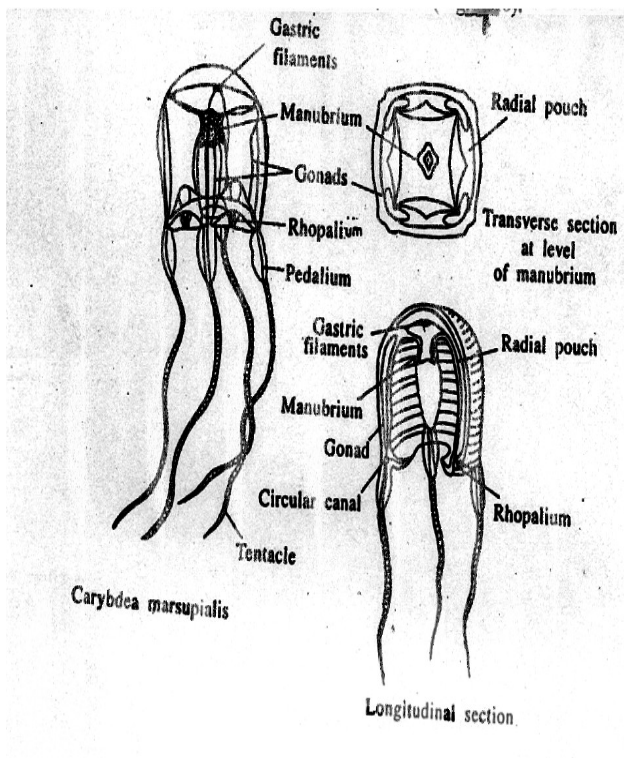


Fig.4.18: Carybdea, a cubozoan medusa.

4. Class Anthozoa. All are polyps. They are solitary or colonial. Mesenteries or septa subdivide the enteron. Septa bear nematocysts. Gonads are gastrodermal. All are marine.

The anthozoan polyps are larger and more complex (Fig.4.19). The flattened oral disc bears tentacles and a slit like mouth. The mouth leads into a flattened stomodaeum. A ciliated groove called syphonoglyph extends from the mouth into the stomodaeum along one or both the edges.

The syphonoglyphs and the flattened slit-like mouth give biradial symmetry to these animals. Mesenteries, which are folds of gastrodermis with mesoglea in between, extend into the gastrovascular cavity. Complete mesenteries extend between the outer wall of the column and the stomodaeum. Incomplete mesenteries, however, are not attached to the stomodaeum.

The edges of the mesenteries become filamentous carrying enidocytes and enzyme secreting cells. The septa may also have threads or acontia to kill the prey. Mesoglea in these animals is thick, cellular and fibrous. There are well-developed longitudinal retractor blocks of muscles on the mesenteries. Gonads also occur in the mesenteries. Fertilization and development result in a planula larva.

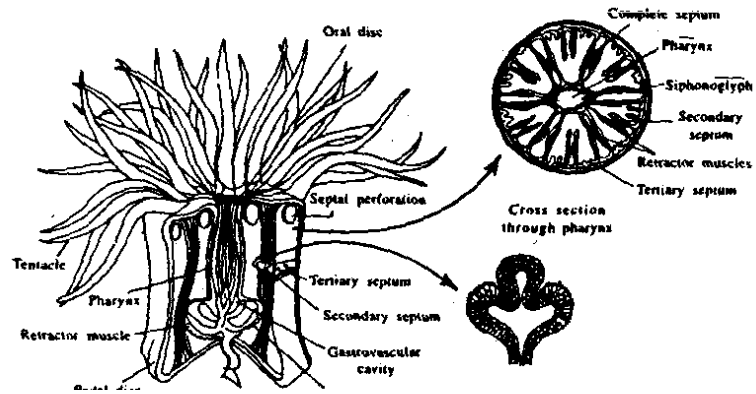


Fig.4.19: Structure of the sea anemone. The free edges of the septa and the acontia threads are equipped with nematocysts to complete the paralyzation of prey begun by the tentacles.

Examples: Sea anemones are common. They are solitary, occurring along the coast attached to rocks in the littoral region. Metridium and Tealia are typical. Other examples of the class are Cerianthus, Antipathes, Tubipora, Alçyonium, Gorgonia Renilla etc. (Figs.4.20, 4.21, 4.22, 4.23).

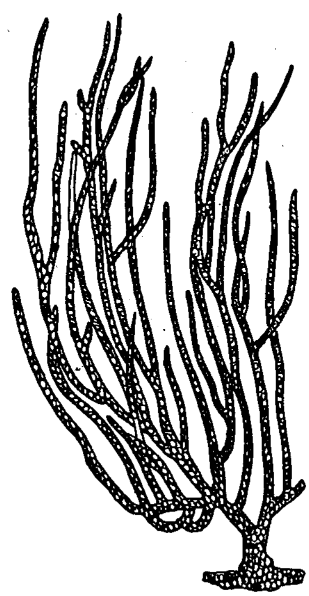


Fig. 4.20: Gorgonia

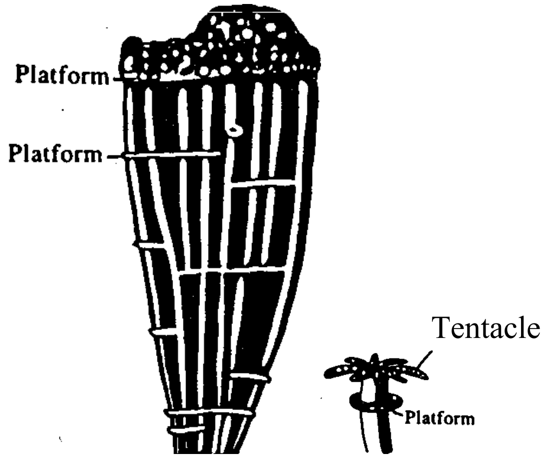


Fig.4.21: Tubipora musica: A, skeleton of entire colony B, single polyp with tube and commencement of platform.

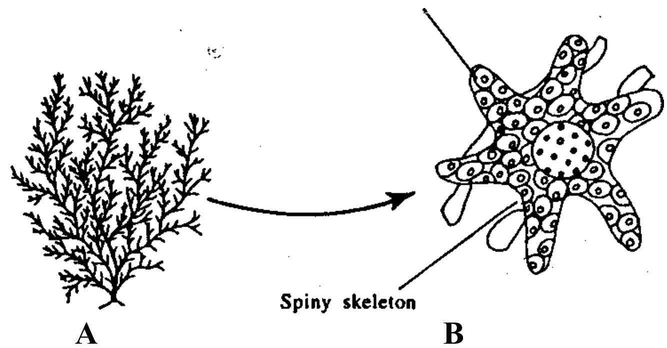


Fig.4.22: A, Colony of Antipathes, a black or thorny coral (order antipatharia, class Anthozoa). B, the polyps of Antipatharia have six simple, nonretractile tentacles. The spiny processes in the skeleton are the origin of the common name thorny corals.

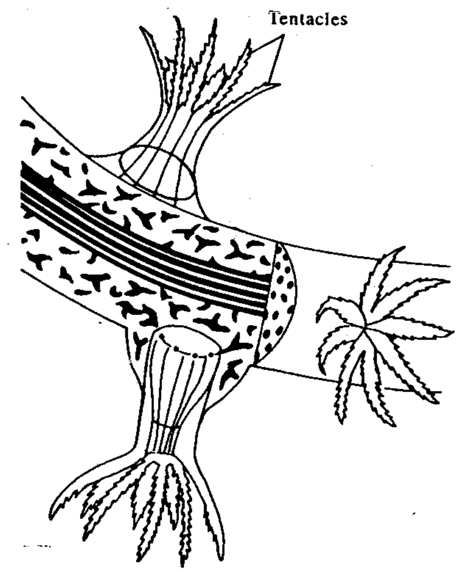


Fig.4.23: Polyps of an alcyonarian coral (octocoral). Note the eight pinnate tentacles, coenenchyme, and solenia.They have an endoskeleton of limy spicules often with a horny protein, which may be in the form of an axial rod.

Some animals coming under this class are colonial coral formers. In the true corals or stony scleractinian corals polyps are connected with one another laterally and they sit upon calcareous cups they have secreted outside. The skeleton here is secreted by the epidermis of the base of the column below to living tissue rather than within.So it is an exoskeleton.The polyps can be withdrawn into the skeleton.The skeleton of the colonial corals becomes massive over the years, with the living tissue covering it as a sheet outside.

Alcyonarians, usually referred to as octocorals as they have eight tentacles, are also colonial, connected laterally in a branching form (Fig.4.23). Here the amoebocytes of the mesoglea secrete the calcium carbonate skeleton, which is internal. Corallium is the precious red coral whose skeleton is used to make coral jewelry. The alcyonarians are soft corals, containing fewer spicules of calcium carbonate. Antipatherians form the thorny or black corals.

3.4.2 Coral Reefs

At least some of you must have had the opportunity to see coral reefs.The coral reefs are built mainly of stony corals (*scleractinians or madreporarians*).Some of the examples are *Fungia, Diploria* (brain coral), *Montastrea, Agaricia* (lettuce coral), *Favia, Porites* etc (over eighty genera). But many other organisms are also involved in coral-reef formation.

Certain rapidly growing calcareous red and green algae impregnated with lime grow upon coral colonies and contribute considerably to the formation of reefs. Foraminifera shells, calcareous sponges, alcyonarians, the gorgonians, *Millepora, Tubipora* and *Heliliopora* etc. also form major part of such Coral reef is a highly productive ecosystem, and consists of large formations stone in shallow sea.It is built up by organisms over thousands of years, bul plants and animals occupy only the toplayer of the reef where they go on add to the calcareous mass already deposited.

The nutrient needs of most of the reef building (hermatypic) corals are suppli by plankton caught by them and in part by many symbiotic algae (zooxanthellae these algae are harboured within the gastrodermal cells of the coral polyps. algae require sunlight for photosynthesis.The carbon fixed by them during photosynthesis is passed on to corals.

The association of the algae also helps in deposition of the coral skeleton utilising the carbondioxide generated durinl respiration by secreting calcium carbonate. The planktonic food caught by the corals is made use of by the algae also.This is the chief source of nitrogen and phosphorous, which are cycled and shuttled between the algae and the coral polyps. In addition, the crevices and caves of the coral reefs harbour a variety of invertebrates and fis great numbers.The reefs of the open seas are washed by waves containing relatively poor nutrients.However, they form a rather closed and self sufficient but effi interacting system from which little nutrients are lost. So the reefs maintain species diversity and productivity.

Because of the above factors the herniatypic corals need shallow waters rangii water surface to 10-60 to depth, with light, warmth and high salinity. The (are usually found between 30° north and 30° south latitude. The major reef are found in the Caribbean and the Indo-Pacific.

Types of Coral Reefs:

Coral reefs are generally found in one of three forms, fringing reefs. barrier r atolls (Fig.4.24:

Fig.4.24 : Coral reef formation A - A fringing coral reef growing around an oce B - A small barrier reef widely separated from the island; and C- Formation of an atoll enclosing it central lagoon.

1. **Fringing or Shore Reef:** This is a platform of reef skirting the shore a seawds rather abruptly front which there is a steep slope down to the (Fig.4.25). There may not be a lagoon or only a narrow lagoon between and the shore.

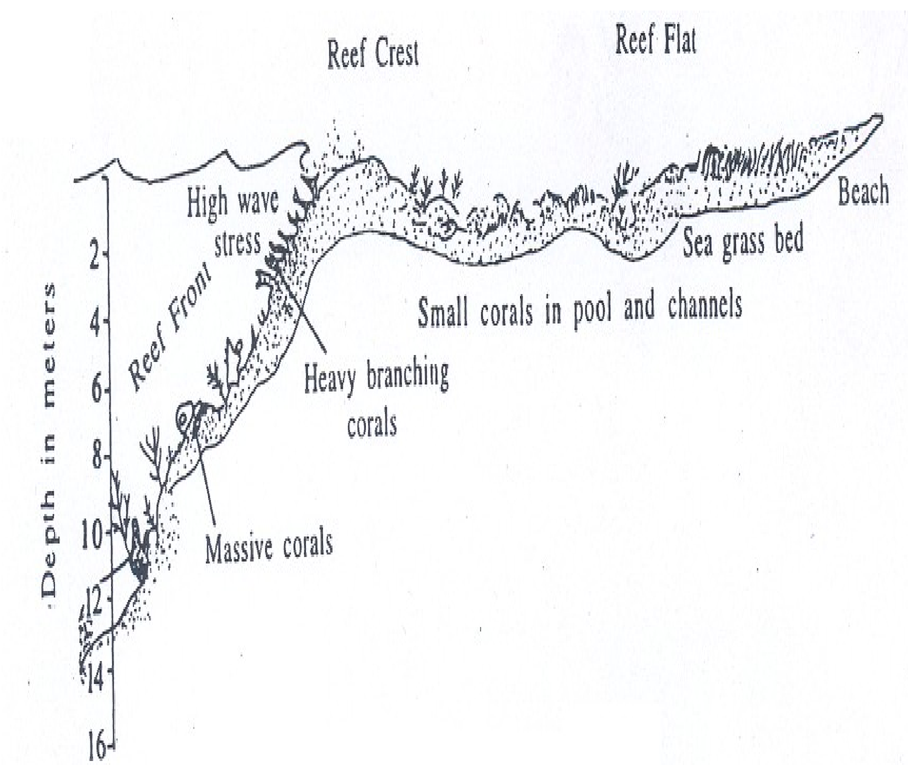


Fig.4.25: A generalised profile of fringing reef.

2. **Barrier Reef:** The barrier reef runs parallel to the shore and resembles a fringing reef except that it is separated from the shore by a channel (Fig 4.26), which is often of great width and depth.

The Great Barrier Reef is over 2000 km in length and 145 km from the shore off the north east coast of Australia. It is actually a complex type of reef.

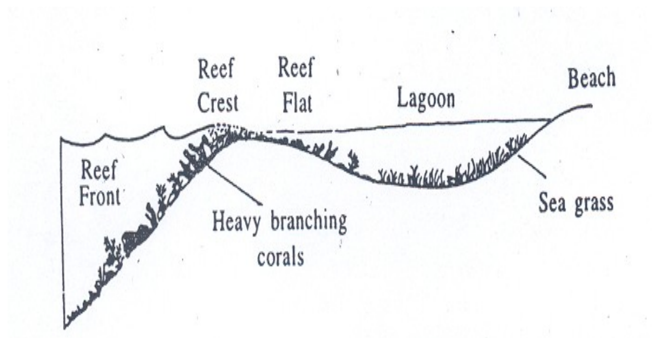


Fig.4.26: Profile of a barrier reef.

3. **Atolls**: Atoll consists of a ring shaped reef, enclosing an open lagoon but not an island (Fig.4.24).

4. **Patch Reefs:** Patch reefs are small irregular reefs that arise from the floor of the lagoons, and may be numerous.In all the first three above cases, that side of the reef which faces the sea is called the reef front.At the top of the reef front, is the reef crest.The reef flat slopes down from the reef crest to the lagoon.The reef flat usually consists of broken corals and growing plants such as coralline algae and other sea grasses.

Reef Formation

Coral reefs can grow outwards, towards the sea, without much difficulty. But its vertical growth is limited by availability of light. With increasing depth, light penetration becomes difficult and intensity of illumination rapidly falls.With that, the number of species of corals also decreases.Most of the living corals are thus limited from surface to a depth of 10-30m or so.

However, most of the modem reefs show a vertical thickness of upto 1000m or more. This has happened gradually either because of rise of sea level due to glacial melting or by subsidence of the substratum or by both. It is well known that during glacial periods, much sea water was locked in ice in the polar and even temperate regions. Much of the land now under the sea was exposed. With rise of temperature and melting of ice, sea level gradually rose, sometimes even up to lcin per year.

Corals grew up to catch up with the rising level of sea water.This continued for thousands of years resulting in vertical growth of coral reefs. Formation of reefs of very great thickness involved subsidence of substratum. Examples are certain barrier reefs such as the Great Barrier Reef and many atolls. Atolls usually occur on top of volcanic mountains of the sea. Gradual subsidence of the volcanic mountains with coral reefs will be compensated by the upward growth of the reefs resulting in reef thickness of 1000litter more. Eniwetok Atoll of the Pacific is known to have coral rock thickness exceeding a depth of 1250m. This atoll, like many others, is the result (subsidence as well as sea level changes.

3.4 Phylum Ctenophora

These are commonly known as Comb jellies, sea walnuts or sea gooseberries, and to about 100 species, all being marine. They derive their name from comb plates for locomotion.

3.4.1 Characteristic Features

1. All are medusoid. No polymorphism.

2. Otherwise radial symmetry has become biradial symmetry because of the pre: of two tentacles.

3. Mesoglea with amoebocytes and smooth muscle fibres.

4. Devoid of nematocysts. Instead, they have adhesive cells (colloblasts or lass cells).

5. Locomotion by means of comb plates, which are comb-like fused ciliary plat, arranged radially in 8 meridional rows (combrows).

6. The subepidermal nerve plexus concentrated beneath comb rows. An aboral organ, which is a statocyst, is present.

7. Gastrovascular cavity consists of mouth, pharynx, stomach, a series of canal: anal pores, carnivorous.

8. Hermaphrodite. Gonads are gastrodermal in origin, and situated on the wall the gastrovascular canals under the comb rows. Mosaic cleavage, accompanied a cydippid larva.

9. All are marine, mostly pelagic and luminescent.

Pleurobrachia is an example (Fig.4.27). Transparent body is 1.5-2 cm diameter. Resembles basically a cnidarian medusa. However, there are eight meridional ban the surface extending from the aboral pole almost upto the oral pole. Each of the made up of comb like transverse plates of long fused cilia, called comb-plates. Beating of the cilia of the comb plates results in locomotion.

The nerve net beneath these plates and the aboral statocyst co-ordinate the activity of these animals. The two 1 solid tentacles can be retracted into the tentacle sheaths.The surface of the tentai carry colloblasts which secrete a sticky substance used for catching tiny animals. Thick mesoglea or collenchyma contain amoeboid cells and muscle fibres. Thougt derived from ectodermal cells, the muscle cells are distinct. They are not part of epithelio-muscular cells.

The mouth opens into the pharynx, which leads into a stomach. The stomach is connected to a system of gastrovascular canals branchin through the mesoglea. The aboral canal from the stomach divides into two tiny a canals near the statocyst leading to the outside through anal pores, through which and material is expelled. The aboral sense organ is a statocyst (Fig.4.27).

The animal hermaphrodite, each gonad made up of two bands: one ovary the other testis they are situated on the lining of the gastrovascular canals under the comb plates Fertilised eggs are shed into the water. Cleavage is, unlike in cnidarians, mosaic (determinate). It results in a cydippid larva with superficial resemblance to the ai into which it directly develops.

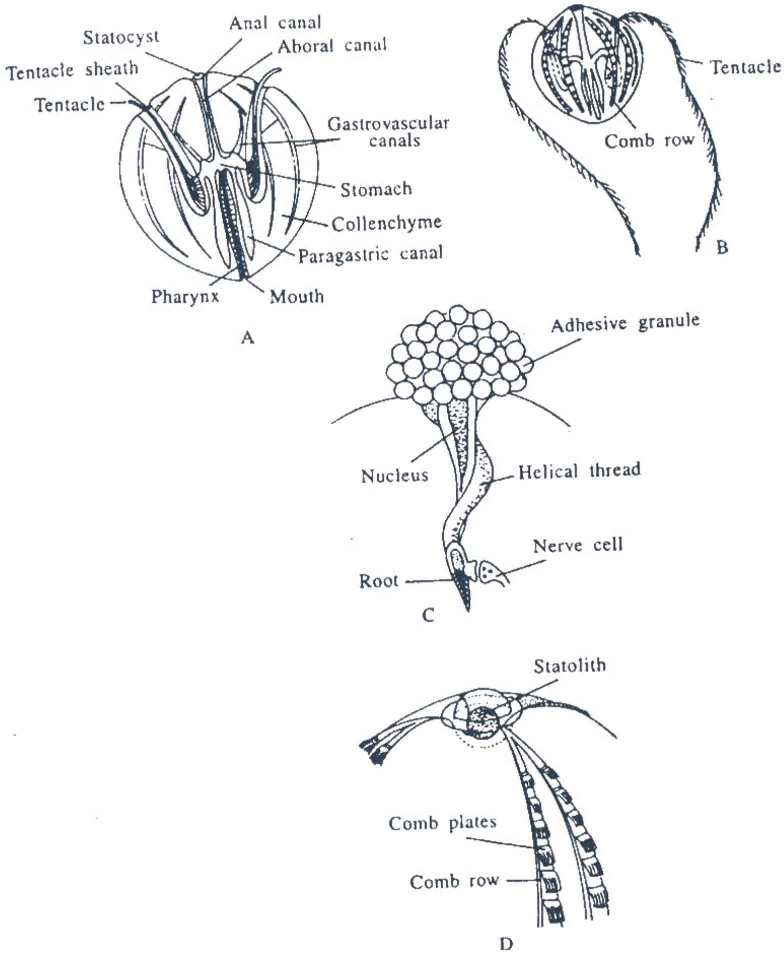


Fig.4.27: -The comb jelly Pleurobrachia, a ctenophore. A, Hemisection. B, External view. C, Colloblast, an adhesive cell characteristic of ctenophores. D, Portion of comb rows showing comb plates, each composed of transverse rows of long fused cilia

3.4.2. Classification

Phylum ctenophora is divided into two classes:

1. **Class Tentaculata. These have two tentacles. Example** Pleurobrachia **(Fig.4.27)** Velamen**. Body is so much laterally flattened that it appears to be a ansparent ribbon.** Ctenoplana **(Fig. 4.28) is flattened along the oro-aboral axis.**

2. **Class Nuda. Without tentacles, with wide mouth and expanded stomodaeum. Somewhat conical; example** Beroe **(Fig.4.29).**

SAQ 2

i) a) Mention two important characters of Cndaria.

b) Mention two important characters of Ctenophora.

c) Name five cell types in Cnidarian epidermal layer.

d) Name the four classes of Phylum Cmdari&

e) Name the two classes of Ctenophora.

ii) Fill in blanks with suitable words:

iii) a) Though living coral, are found only upto a depth of 30m or so, most of the coral reefs of the world show far greater vertical thickness.This is because of gradual rise of the sea level due to ---------------------------- and -------------------------------------

b) Ctenophores show -----------------------symmetry.

4.0 Conclusion

1. In this unit, you have studied the characteristic of the following phyla: porifera, cnideria and ctenophore

2. You now know how to distinguish animals belonging to any one of these phyla from those belonging to another.

3. The porifera are the sponges whose bodies posses a large number of minute spore (remember the "sponges" you use for bathing) these pores are called ostia (sing.ostium).

a) Water current passes into the body cavity through thses pores which actually lead to a system of channels that, after permeating the whole body, open to the exterior by one or more lage exhalent openings called oscula (sing. Osculum)

b) The sponges are covered exteranllly aby an epitherlial layer called pinacoderm which is made up of flattered cells called pinacocytes. Some pinacocytes are modified myocytes arranged around the osculum.

3. Phylum Cnidera consists of aquaticanimls with radial biradial symmetry, but no head. The body consists of two layer (diploblastic). They posses no coelom, or separate exceretory or respiratory system, no distinct musle tissue but an epithelio – muscular system is present

4. Member of the phylum ctenophore are all medusoids and all are marine habitants.

5.0 Summary

You have studied the basic organization or body plan of various animals especially those in the phyla porifera, cnidera and ctenophore. You have also studied various charactersaitcs to distinguish each phylum from one another. You will study the organization of varioud systems significance in greater details in alter units.

6.0 Tutor marked Assignment

1. What are the salient features of Porifera? How are they classified?
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2. What are coral reefs? How are they formed'?
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3. Point out the major differences between cnidaria and platyhelminthes.
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7.0 Further readings

1. Invertebrate zoology by Rupert/ Barnes 6th International Edition 1994

2. Intergrated principles of zoology, by Hickman, Roberts, larson 9th Edition 1995.

Answers to Question
SAQs

1. i) Multcelluar, movement, plant, attached.
   ii) Pinacocytes
   iii) Calcarea
   iv) Sixrayed
   v) Choanocytes.

2. i) a) Diploblastic; presence of nematocysts.

   b) Diploblastic; presence of combplates

   c) Epitheliomuscular cells, interstitial cells, cnidocytes, mucu gland cells, sensory – nerve cells.

   d) Hydrozoa, scyphozoa, cubozoa and Anthozoa.

   e) Tentaculata, Nuda

   ii) a) Glacial melting, subsidence
   b) Biradial

Terminal Question

1. Porifera are lowly organized animals.They are not capable of locomotion and bear large number of small pores (ostia) on the surface. Through these pores water current enters the cavity (spongocoel) and leaves through one or more larger pores, oscula. They have an outer layer of pinacocytes. Collar cells (choanocytes) line the spongocoel. These celluar alyers are not, however, homologeous to germ layers. In these animals, tissues are absent or poorly defined; naturally there are also no organs or organ systems.

Porifera are classified into four classes based mainly on the nature of their skeleton: 1) Calcarea; 2) Hexactinellida; 3) Demospongiare; 4) Sclerospongiae.

2. The coral reefs are built manily of stony corals but amny other organism play consireable role in their formation. Coral reefs are mainly fringing reefs, barriers, reefs or attols. Most reefs are formed gradually either because of rise of sea level due to glacial activity or by subsidence of the substratum or by both.

3.

	Cnidera	**Platyhelminthers.**
Germlayers	Diplobastic, with non-cellular mesoglea	Triplobastic, with cellular parenchyma derived from mesenchyme
Symmetry	Radiat no anteroposterior axis or cephalisation	Bilateral, with anteroposterior axis and cephalisation
Organs	Nil, or poorly developed systems.	Well developed with organ
Cnidcoytes	present	absent
Nervous System	diffuse nerve net	Concentrated in the for brain in the head and cord extending into the body.
Protonephridia or flame cells	absent	present

Unit 5

PHYLUM PLATYHELMINTHES, NEMATODA. ROTIFERA

Table of contents

1.0 Introduction

You have just now studied two phyla of animals (Cnidaria and Ctenophora) which are diploblastic - whose body is made up of only two germ layers - the ectoderm and endoderm. The space in between is made up mostly of a jelly like substance, with very few cells. Now you will proceed to study triploblastic animals which have in addition to ectoderm and endoderm, a third germ layer - mesoderam. The first phylum among these is phylum platyhelminthes.

Animals coming under phylum Platyhelminthes are soft bodied bilaterally symmetrical animals popularly known as flat worms which number more than 15,000 species. The gelatinous mesoglea of the cnidarians is here replaced by a mesodermal, cellular, parenchyma, a type of packing tissue consisting of more cells and fibres than mesoglea. This has laid the foundation for a more complex organization, with more organs and organ systems. These animals range in size from less than a milimater to a few meters as in some tapeworms. They include free – living and parasitic species. Many live on land but some are fresh – water or marine, crawling on weeds and sediment.

Another feature in Platyhelminthes is the evolution of more elaborate and clear `organ systems' for the first time – protonepluidial feeding involving reproductive, nervous, sensory etc. involving better integration of tissues and organs.

The gut of Platyhelminthes has only one opening the mouth.Naturally, most of these animals feed on tissues of other animals though some feed on algae.Most species are parasitic, with organs specialised for adhesion to the host. In gut parasites which are surrounded by partially digested food of host gut, alimentary canal is completely absent. But the surface of the platyhelminthe parasite body is suitably modified for absorption of the surrounding digested food. Reproductive system is extensive in these animals, capable of producing large number of eggs:

2.0 Objectives

At the end of this unit, you should be able to:

- Describe the characteristics features of animals under the phylum Platyhelminthes.
- Give a basic idea of the organization of the animals belonging to different classes in this phylum
- This unit will also feature the pseudocoelomates, namely in the phylum Nematoda and Phylum Rotifera.

3.1 Characterisitc Features

1. Bilaterally symmetrical, with anterior and posterior ends.
2. Body dorsoventrally flattened.
3. Triploblastic - with three germ layers.
4. Acoelomate - no internal body cavity. The space between the organs is filled with a form of connective tissue called parenchyma derived from mesenchyme.

5. Digestive system absent in some; when present, has only the mouth but no anus.

6. Nervous system ladder-like, with simple sense organs.

7. `Excretory system' protonephridial type.

8. No respiratory, circulatory or skeletal systems.

9. Hermaphrodites, with complex reproductive system

10. Eggs show spiral cleavage, which may be highly modified.

11. Developments usually direct in free living forms; in some there is a free-swimming larva (Muller's larva or Gotte's larva). In certain parasites development may be much complicated involving many larval stages in the life cycle.

Bilateral symmetry has evolved for the first time in this group of animals and it has been maintained in all higher groups (Hence all these phyla are called Bilateria). This symmetry and the accompanying cephalisation have evolved side by side in response to progression in one direction - that end of the animal which is in front during locomotion has become the head. Of necessity, sense organs are concentrated at this end.

Flattening of the body is the consequence of these animals having no circulatory system, and the animals' dependence on simple diffusion from body surface for respiration, excretion and other purposes. Another important feature of this group of animals is the appearance of a third cellular layer between epidermis and gastrodermis - the parenchyma - instead of the gelatinous noncellular mesoglea of the coelenterates.

Yet another characteristic of platyhelminthes is the protonephridia with flame cells (Fig.5.1) The flame cell is in fact made up of two cells: a cap cell and- a tubule cell.The cupshaped cap cell has a tuft of flagella arising from the inner face of the cup and extending into its cavity beating like the flickering flame of a candle (hence flame cell).

The cap cell and the tubule cell are fitted into one another by means of their finger like interdigitations. At the interdigitation fenestrations occur. Beatings of the flagella draws fluid into the lumen of the flame cell through the fenestrations and drive the flow further forward through the duct system. During this process, ions and various other molecules may be resorbed.

Many such flame cells unite to form a duct system which may open out through nephridiopores. Though the system is often called excretory, it appears to be mainly osmoregulatory, as the system is reduced br even absent in marine forms. Nitrogenous wastes are actually removed by diffusion through the body surface.

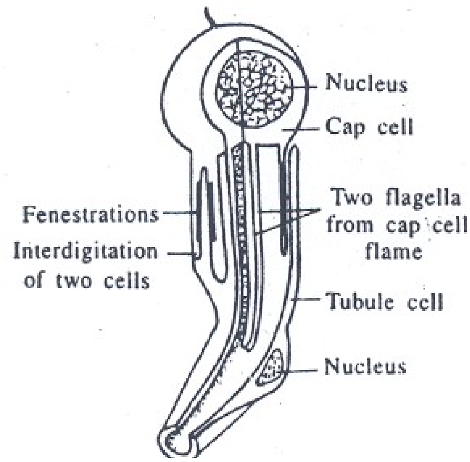


Fig. 5.1: protonephridial system with details of a flame cell.

3.1.2 Classification

Phylum Platyhelminthes is divided into four classes: **Turbellaria,** Monogenea, **Trematoda** and **Cestoda**.

1. **Class Turbellaria. These are mostly free living and aquatic. Some are terrestrial, confined to humid areas. Body of these animals is covered with ciliated epidermal cells containing rhabdoids. Mouth is on the ventral side**.

These animals range from a few millimeter to a few centimeter. They move by means of cilia covering the body. Undulations of the body also help in locomotion of larger forms.In a transverse section (fig. 5.2) you will see an outer covering of ciliated epidermal cells containing rod-like structures called rhabdoids. Cilia may be missing dorsally.If you disturb the animal the rhabdoids are ejected. So they are defensive in function. Rhabdoids may also form a mucus covering around the body. Beneath the epidermis you will see the circular, diagonal and longitudinal muscle fibres.

These fibres are unstriated. You can also see mucus gland cells located in parenchyma. They open to the outside. A loose type of connective tissue, parenchyma-made up of aggregation of irregular cells, packs the space between internal organs.You will also see simple eyes on the head. Nerve tissue is concentrated as ganglia (brain) in the head. The gut may be a solid syncytial mass, a simple sac or a number of lateral diverticula.

Apart from possessing a well-developed reproductive system, the turbellarians have tremendous capacity for asexual reproduction especially by transverse binary fission. They have also extensive capacity for re eneration. Examples are Dugesia (Planaria), Microstonum and Planocera (Figs.5.3, 5.4):

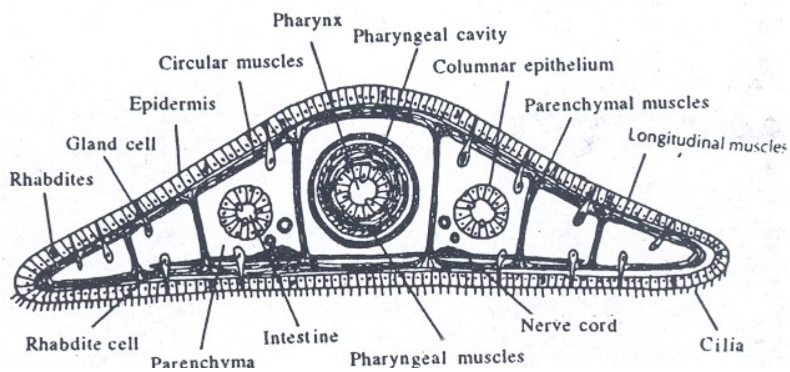


Fig.5.2: Cross section of planarian through pharyngeal region, showing relationships of body structures.

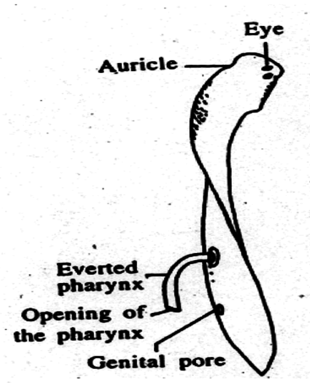


Fig.5.3: Planaria, side view

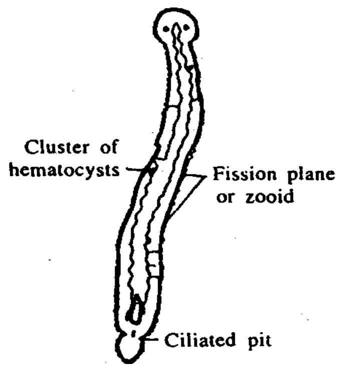


Fig.5.4: Microstomum

2. **Class Monogenea. Body of these animals is covered with a non-ciliated syncythrm the tegument. They are leaf like to cylindrical. They are parasitic, usually on the skin or gills of fish. For this they have posterior attachment organs in the form of hooks, suckers; clamps etc. Their development is direct, with only one host. They have usually a free-swimming ciliated larva**.

These are monogenetic flukes. Important differences from the turbellerians are, that, instead of the ciliated epidermis, these have a non-ciliated, syncitial tegument.You can also note a muscular pharynx for active ingestion of food from the host, into the gut.The gut is branched t, into two. The adult has no sense organs.Examples Gyrodactylus (Fig.5.6), Polystoma (Fig.5.6), a parasite in the urinary bladder of frogs.

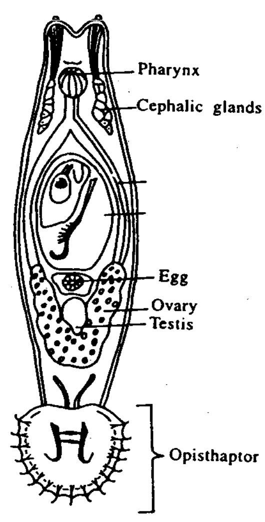


Fig.5.5: Gyrodactylus cylindriformis, ventral view.

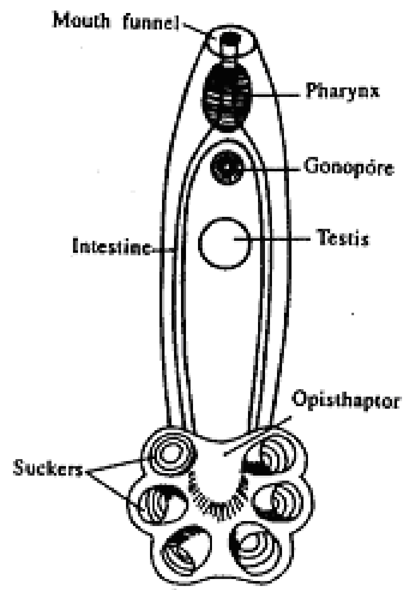


Fig. 5.6: polystoma

3. **Class Trematoda. Body of these animals is also leaf-like to cylindricalcovered with non-ciliated syncitium the tegument. However, they have oral sucker and ventral sucker, but no hooks. Development is indirect. The definitive host (host in which sexual reproduction takes place; it is also known as final host) is a vertebrate. First host or the intermediate host in which asexual reproduction takes place, is a mollusc**

These are the digenetic flukes, endoparastic, many of them causing diseases in humans and domestic animals. A typical example is Fasciola (Fig.5.7). Fasciola hepatica causes liver -rot in sheep and other ruminants.The adult lives in the bile duct of the liver. The eggs are passed along faeces, to the outside on hatching, a ciliated larva, the miracidium, emerges out.

The miracidium penetrates a snail which is the secondary, host. In the snail, the miracidium becomes a sporocyst. Each sporocyst contains germinal masses, which by mitoses gives rise to a number of primary rediae. Each primary redia similarly gives rise to a large number of secondary rediae. The secondary redia similarly gives rise to a number of cercariae.

Thus you can see that each egg can give rise to a large number of progeny.The cercaria encysts on vegetation and is now called metacercaria. The metacercariae along with vegetation are eaten up by the ruminant, in which it encysts (comes out of the cyst) and grows into a young fluke, completing the life cycle.

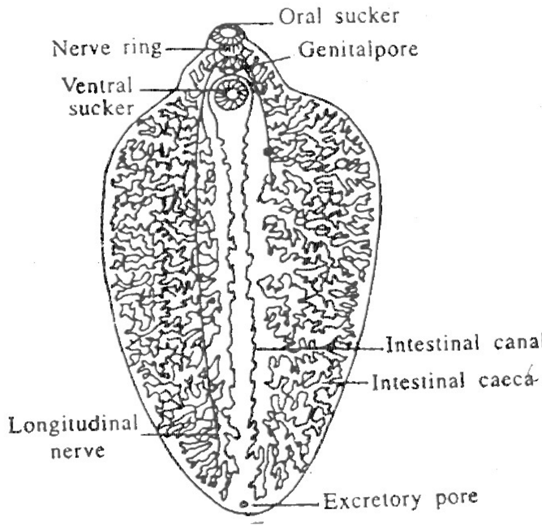


Fig.5.7: Fasciola.

Another example is Schistosoma (Fig.5.8), the blood fluke. The species *S*. mansoni, .S. japonicum and S. haematobium cause schistosomiasis in humans. You will note that schistosomatids are peculiar in that they are gonochoristic (= dioecious i.e., having separate sexes), unlike other species of this phylum. The mature males and females are found in close association with one-another (Fig.5.8). The male has a ventral groove into which is found the slender female.

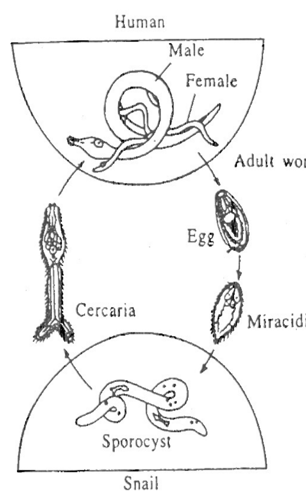


Fig.5.8: Life cycle of Schistosoma mansoni.

4. Class Cestoda.These are the tape worms, parasitic in the digestive various vertebrates. In these animals also, body is covered with not syncytial tegument, but body is tape-like, with an anterior scolex carrying suckers and hooks for attachment to host tissues. Body is also divided into a number of proglottids. You will find that these have no digestive organ Development is indirect, with two or more hosts.

A typical example is **Taenia.** As these are found in the digested food mater host, though these animals have no mouth or gut, food can directly be absorbed through the highly modified tegument (Fig.5.9). The scolex end buds off immature segments or proglottids which gradually mature developing reproductive system; as they pass back new proglottids are added on (you may note that this is opposite to what occurs in annelids in which segments are formed posteriorly, and they pass on anteriorly while maturing). Mature progiottids at the opposite end (gravid proglottids) are more or less, bags of eggs.

The gravid proglottids containing large number of mature egg ultimately shed off. The fully grown adult beef tape worm of the humans, *saginata,* having 700-1000 or more proglottids, may shed 3-10 proglottids daily containing 1,00,000 eggs. The proglottids passed out along with the stools, crawl on vegetation which may be eaten up by grazing cattle. In the gut of the cattle the eggs hatch and a larva with six hooks (oncosphere) emerges out.

The oncosphere penetrates the intestinal wall into blood vessels, reaching through the blood stream, the muscles. Here they encyst forming bladder worms (cysticerci) with invaginated scolex. When infected measly beef is eaten by the human host, wall of their cyst dissolves, the scolex evaginates and it attaches to the intestinal wall, developing new proglottids, thus starting its own life cycle in the human host.

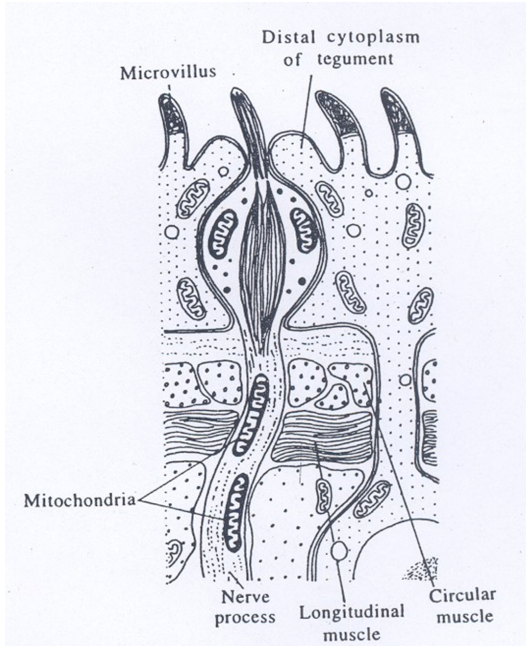


Fig.5.9: Schematic drawing of a longitudinal section through a sensory ending in the tegument of Echinococcus granulosus.

Other examples include the pork tape worm Taenia solium (Fig.5.10) and worm Diphyllohothrium latum.Echinococcus granulosus (Fig.5.11) is the dog tapeworm; the juveniles of this are found in many species of mammals including man. Man, in this case, is an intermediate host. The juvenile stage is a peculiar kind cysticercus known as hydatid cyst (Fig.5.11b). It grows for a long time attaining very large size.The main cyst having a unilocular chamber, may bud off daughter cysts within, each containing thousands of scolices.Each scolex can produce a tape worm when eaten by dog.

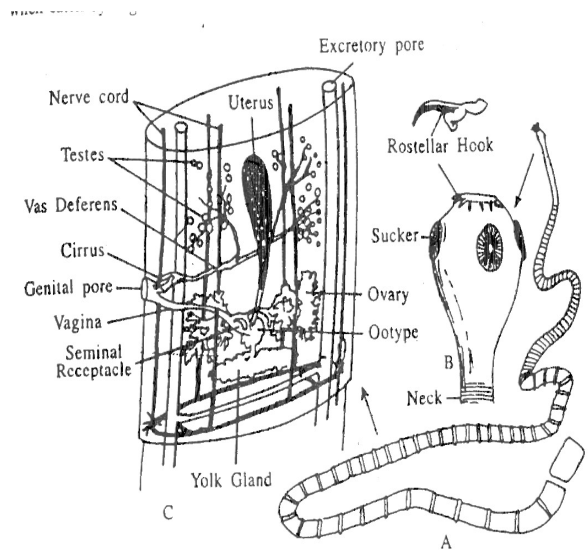


Fig. 5.10: Taenai solium: A- Entire specimen, b – Scolex of the same enlarged; and C – A mature proglottid enlarged.

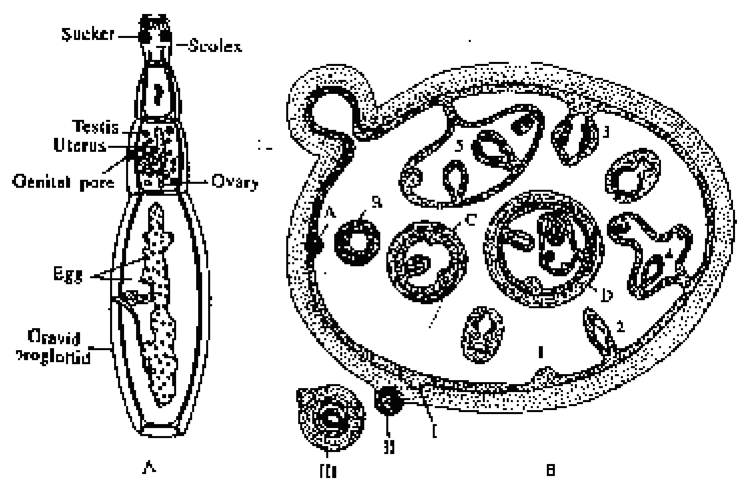


Fig.5.11: Echinococcus granulosus: A - Adult tape worm lives in the intestine of dog or other carnivore,B - Hydatid cyst-1-5 stages in development of scolices from germinative layer, A-D stages in budding of endogenous layer, 1-111 stages in budding of an exogenous daughter cyst.

SAQ I

1) Which of the words given in the bracket is correct? Flame cells in Platyhelminthes are----------------in function (excretory/osmoregulatory).

2) Name three important characters of Platyhelminthes for considering them more advanced than cnidarians.

3) Arrange the character most appropriate to the class of Platyhelminthes. Against it.

	Classes	Characters
a)	Turbelloria	i) Presence of scolex
b)	Monogenea	ii) Presence of oral and ventral suckers, but no hooks
c)	Trematoda	iii) Presence of posterior hooks, suckers, clamps etc.
d)	Cestoda	iv) Ciliated epidermal cells covering the body.

3.2 Pseudocoelomata - phylum nematoda

As we have already seen earlier, the body cavity of Pseudocoelomata is a pseudocoel. It is the original blastocoel of the embryo persisting between the alimentary canal and body wall. It is not lined by a mesodernal peritoneal lining. This lining is a characteristic of the true coelom the body cavity of coelomates. The pseudocoelonmates comprise the following phyla: Gastrotricha. Kinorhyncha, Loricifera. Priapulida. Nematomorpha. Acanthocephala, Entoprocta, Nematoda and Rotifera. These groups are polyphyletic - they have originated from different ancestors. They are heterogenous. We will be studying only two phyla among these: Phylum Nematoda and Phylum Rotifera.

3.2.1 Phylum Nematoda

Phylum Nematoda are popularly known as round worms. A highly successful group animals with about 12,000 species known, but unknown species are expected to far out number these (about 5, (00,000!). They are found in the soil in all types of aquatic environment, in animals and plants as parasites and otherwise. They are also know cause diseases in them. However, there is very little structural diversity among them all being built on the same fundamental plan.

3.2.2 Characteristics features

1. Vermiform body bilaterally symmetrical, but with a tendency for radial synmmetry along longitudinal axis. Cross sectional area circular: no segmentation or appendages.

2. A complex cuticle present.

3. Body has more than two cell-layers: tissues and organs present.

4. Circular muscles absent in the body wall.

5. Body cavity is pseudocoel with body fluid at high pressure.

6. Gut extending from the mouth at the anterior end to anus wltich is subtennina Muscular pharynx.

7. One ventral, one dorsal and two lateral epidermal chords with longitudinal muscles arranged in the four quadrants in between.

8. Longitudinal nerves in the dorsal and ventral epidermal chords. with direct con with muscle cells.

9. Muscles of the body wall are with peculiar features.

10. No circulatory system. No flame cells or nephridia. No cilia or flagella. Excretory tubules in one or a limited number of renette cells.

11. Highly determinate type of cleavage; Development direct.

12. Eutely - Growth involves increase in cell-size rather than cell number.

The cuticle of nematodes is characteristic of the group. It is non-living and many layered, with spiral fibres of one layer crossing those of the others (Fig.5.12).This type of cuticular organisation affords considerable strength to withstand high hydrostatic pressure of the fluid within the body cavity.

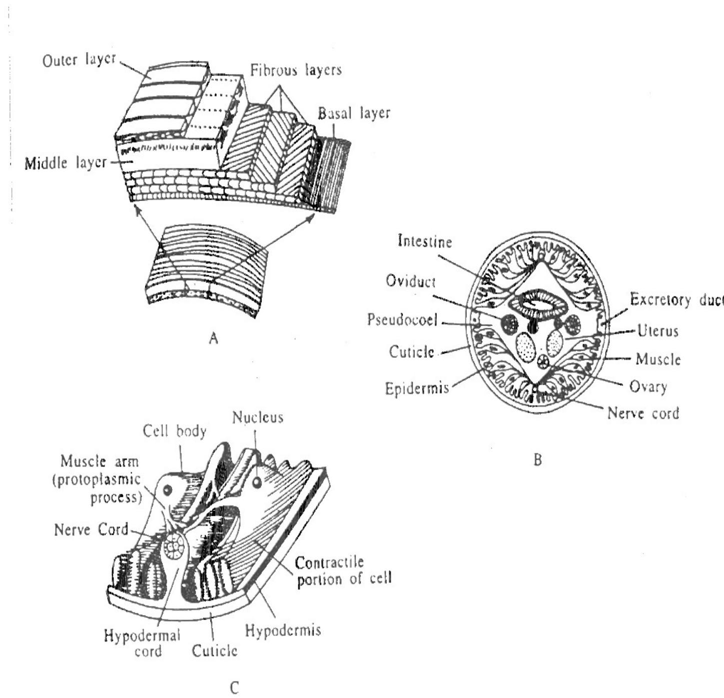


Fig.5.12: A, Structure of the nematode cuticle. The cuticle consists of an outer striated layer, an inner homogeneous layer and a complex of fibrous layers; B & C, Structure of a nematode as illustrated by Ascaris female. B - Cross section. C - Single muscle cell; spindle abuts hypodermis, muscle arm extends to dorsal or ventral nerve.

A cross section of the body wall (Fig.5.12) shows epidermal layer beneath the cuticle. There are four longitudinal strands or chords in the epidermis: one midventral, one mid-dorsal and two lateral. The dorsal and the ventral chords contain the longitudinal nerve trunks: the lateral chords contain the excretory canal. The muscle fibres are peculiar in this phylum.

They form neuromotor units. The contractile elements of these rest on the epidermis (Fig.5.12C) An innervation process proceeds from the muscle cell to the nerve chord. It enables simultaneous contraction of all muscle cells.You may note here that the system of muscle fibres sending process to the nerve fibre is unusual. It is the nerve fibre which usually sends process to the muscle fibres.

The alimentary canal is made up mostly of the non-muscular intestine. The pharynx is, however, muscular functioning to pump food into the gut. Rectum is short leading out through the anus. The body cavity is almost completely filled by the paired reproductive organs (Fig.5.13 Sexes are separate. Fertilization is internal. The eggs, when laid, are either zygotes, or even embryos at early stage of development.They are extremely resistant.

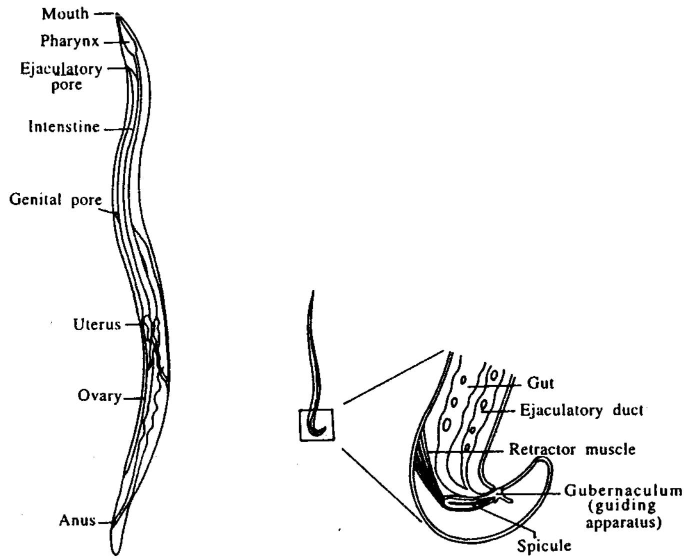


Fig.5.13: Female Ascaris, B - Male Ascaris (Posterior part)

3.2.3 Classifications

Classification of Phylum Nematoda into classes is based on characters which are difficult for non-specialists to distinguish. The Phylum is divided into two classes: I) Class Phasmidia (Secementea), 2) Class Aphasmidia (Adenophorea).

Example

Ascaris lumbricoides is the human intestinal round worm. Ascaris megalocephala is found in the intestine of horses.An Ascaris female may lay about 2, 00,000 eggs per day, which pass out along the stools of the host.The eggs remain alive for years, in the soil. They gain entry into the host alinientarv canal through contaminated food ani there the tiny juveniles come out of the eggs. Then they burrow through the intestinal wall and enter the veins and lymph vessels, from where they are carried to the heart and from there to the lungs.

There they penetrate the alveoli and enter the trachea. If infestation is severe they may cause pneumonia at this stage. When they reach the pharynx they may be swallowed, passing through the stomach and maturing in about two month after ingestion of eggs. In the intestine they feed on intestinal contents and cause various symptoms, including intestinal blockade, if present in large numbers.

The hook worm Ancylostoma duodenale (Fig.5.14) is a parasite of man.The anterior end curves dorsally in the form of a hook. By means of large plates in their mouth, they lacerate the intestinal mucosa of the human host and pump blood into intestine, as a result of which the host becomes anaetuic.Eggs pass out through faeces and juveniles hatch out in the soil. They burrow through the human skin to blood. Reaching lungs, and ultimately intestine, as in Ascaris.

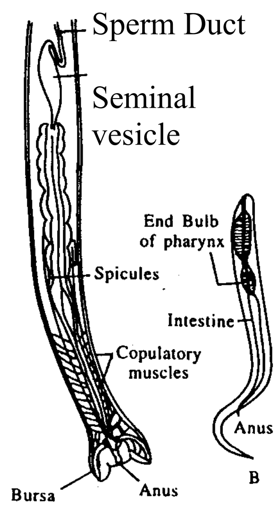


Fig.5.14: A - Posterior end of male Ancylostoma duodenale; B - first stage rhabdiform.

Other examples include the pinworm (Fig.5.15)Enterobius vermicularis, the trichina worm Trichinella spiralis (Fig.5.16) the Whip worm Trichuris trichura (Fig.5.17) the filarial worms Wuchereria bancrolli and Brugia malai living in the lymphatic system causing obstruction and inflammation.The females of the filarial worm release small microfilariae into blood and lymphatic system. These enter the mosquito through blood. In the mosquito they undergo development upto infective stage. Then they escape mosquito and enter another human host through mosquito bite.

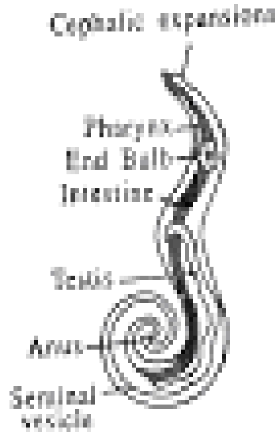


Fig. 5.15: Enterobius

Fig. 5.16: A - Trichinella spiralis the trichina worm, male; B -Female; C, Eyeworm in the cornea.

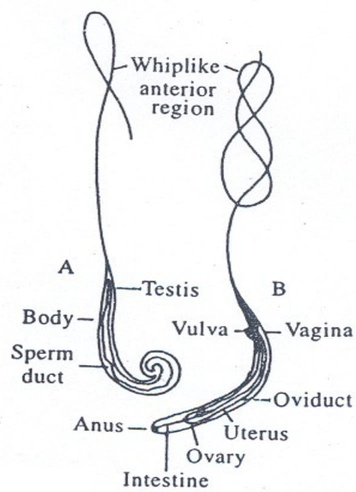


Fig.5.17: Trichiurus trichiura, A- male; B- female.

3.3 Pseudocoelomata - phylum rotifera

These are tiny animals bearing ciliated crown.When the cilia beat, the crown has the appearance of rotating wheel. They mostly range from 100-500 μm, and are cosmopolitan in distribution, though only about 1800 species are known. Most of them are fresh water forms. Some are marine, a few are terrestrial epizoic living on the body of other animals, or even parasitic.

3.3.1 Characteristic Features

1. Body minute, bilaterally symmetrical, more than two cell layers thick, with ti and organs. They are non-segmented.

2. A preoral and a post oral band of cilia in the form of a crown at the anterior part of the body.The crown gives the appearance of rotating wheel when the cilia beat, from which the animal derives its name (Fig.5.18).

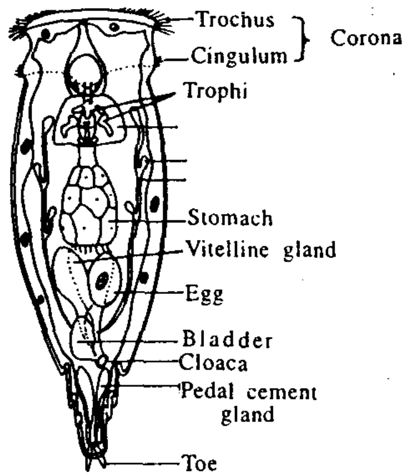


Fig.5.18: General features of rotiferan anatomy: ventral view.

3. Alimentary canal with a -mouth, jaw apparatus, muscular pharynx.The posterior anus, opens into a Cloaca.

4. Epidermis has an intracellular cuticle. This is often thickened to form a lorica.

5. protonephridia present

6. Body cavity pseudocoel.

7. No circulatory or respiratory system.

8. Sexes separate. However, often no males: or when present, mates are rare and dwarf.

9. Development direct, with modified spiral cleavage.

10. Most structures are syncitial, with constant number of nuclei in each species (eutely).

The body is usually enclosed in a sculptured cuplike cuticle called lorica. The open end of lorica carries the corona and the mouth.The corona can be retracted into the cup. The lorica narrows posteriorly to form a foot which is ringed. This gives a segmented appearance to the lorica. The pseudosegments slide into one another telescopically and then the foot can be retracted. At the tip of the foot are a pair of toes which anchor the animal to the substratum.

The animals have a rather simple internal organisation.The mouth parts are, however, complicated (Fig.5.18). The feeding apparatus (mastax) consists of certain hard parts, known as trophi.One of them, the median fulcrum, supports the two rami (singular-ramus). The unci (singular-uncus) and the manubria (Sing-manubrium) hinge on the rami. There are salivary glands and gastric glands associated with the gut.

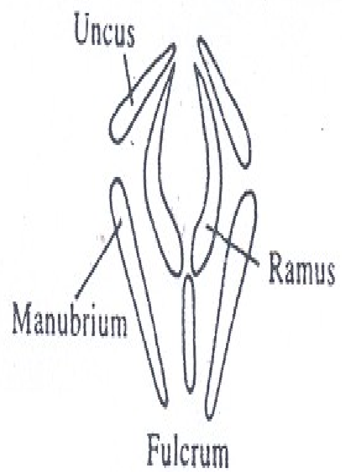


Fig.5.18 The mouth parts of Rotifera.

Tract of the protoneplrridial tubules has several flame cells. The system is osmoregulatory. The tubules empty into a bladder which pulsates and empties in turn into a cloaca. Into the cloaca also empty the intestine and oviducts. Sexes are separate. Males may be smaller or even unknown. Parthenogenesis is common among the group.

3.3.2 Classification

Phylum Rotifera is divided into three classes.

1. **Class Seisonida. Marine, elongated, with vestigial corona. Sexes identical in size and form.Female with a pair of ovaries and no vitellaria. Examples** Seison **(Fig.5.19) epizoic on the gills of the crustacean** ***Nebalia.***

Fig. 5.19: seison

2. **Class Bdelloidea. Swimming or creeping. Retractile interior end. Corona with two trochal discs. Males unknown. Parthenogenetic. Two ovaries and vitellaria. Example :** *Philodina* **(Fig.5.20)**

3. **Class Monogonata. Swimming or sessile. Single ovary and vitellarium. Males smaller, Eggs three types: diploid, haploid and dormant. Example** Asplanchna **(Fig.5.21).**

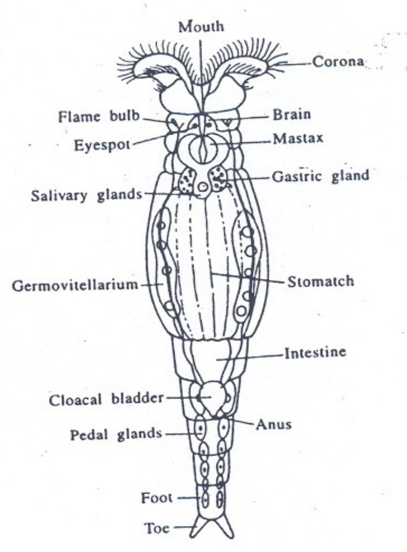


Fig.5.20: Structure of Philodina rotifer.

Fig. 5.21: Asplanchna

SAQ 2

Match the animals given in column A with their characteristic features given in column B.

A	B
a) Nematoda	i) A crown of preoral and pastoral barid of cilia at the anterior end, giving the appearance of a rotating wheel, which the cilia beat.
b) Rotifera	(ii) Complex, non-living many layered cuticle - with spiral fibres of one layer crossing those of the other.

4.0 Conclusion

1. Animals belonging to the phylum platyhelminthes are also called the flatworms, numbering more than 15,00 species.
2. Platyhelminthes exhibit bilateral symmetry and range in size from less than a millimeter to a few meters as in some tapeworms.
3. They include free- living and parasitic species.
4. Many are terrestrial but some are fresh – water or marine spp. Crawling on weeds and sediments.
5. Most feed on tisses of other animals though some feed on algae.
6. Most speices are parasitic, with organs specialized for adhesion, but have no alimentary canal since they live in the gut and absorb their food directly all over their body.

7. Platyhelminthes have exstensive reproductive system and are capble of producing large number of eggs.

8. The pseudocolemata posses a pseudocoel (a false body cavity).

9. The nematodes are popularly known as round worms with about 12, 000 species known.

10. They are found in the soil, in all types of aquatic environment, in animals and plants, as parasites and otherwise.

11. A complex cuticle characteristics covers the body,

12. Examples of Nematodes include Ascaris, Ancylostoma Chodenale and Trichinella Spiralis.

13. The phylum Rotifera are tiny ciliated animals. The body cavity is pseudocel.

14. Most of them are fresh water forms; some are marine, a few terrestrial, epizoic living on the body of other animals or even parasitic.

5.0 Summary

You have just studied the Platyhelminthes (flat worms), the Nematodes (round worms) and the Rotiferans. Some of these are of interest to you because they cause disease in man e.g. Taenia, Which lives in the gut of man and animals causes anaemia and food absorpotion for the host. Fasciola hepatice (the liver fluke) which causes liver – rot in sheep and other ruminants. Trichinella spiralis (the eyeworm) may cause blindness. Ascaris lumbricoides lives in the human intestine causing, amonmg other symptoms, intestinal blockage, if present in large numbers.

6.0 Tutor – Marked Assisgnment

1. List seven (7) characteristices feature of the phylum Platyhelminthes.

2. Name three animals in the phylum Platyhelminthes that are parasitic and the diseases they cause.

3. Discuss the characteristics differences between Platyhelminthes and Nematodes.

7.0 Further Reading

Invertebrate zoology by Rupert/ Barnes 6th International Edition 1994

Intergrated principles of zoology by Hickman, Roberts and Larson 9th Edition 1995.

Answers

SAQ

1. i) Osmoregulatory

   ii) a) Bilateral symmetry accompanied by cephalisation

   b) Tripoblastic nature with celluar parencyma

   c) Presence of amny organ systems

2. iii) a- (iv); b- (iii); c-(ii); d-(i)

   a) (ii) b) (i)

Unit 6

PHYLUM ANNELIDA

Table of contents

1.0 Introduction

In this unit we conmtiue our study of metazons. In this, as well as in the next unit you will learn about coelomate phyla. Coelom could be defined as a cavity lined by an epithelium of cells derived from the embryonic mesoderm. Phylum Annelida which includes segemneted worms will be the first coleomate phylum that you will be studying in this unit. This will be followed by the study of phylum Arthropoda – a successful group of invertebrates with jointed legs. As was done in the previous unit, in this unit also we shall describe the charaters of each phylum, classify the phylum upto classes giving examples and briefly describe the class characters.

2.0 Objectives

After studying this unit you should be able to:

- Enumerate the characters of phyla Annelida, name the classes under the phylum and relate their salient characters.

3.1 Coelomata – Eucoelomata – Phylum Annelida

The animals belonging to Phylum Annelida are true coelomates and they are also called euoelomates. In general, annelids have elongatesd body divided externally into a number of rings which represent a division of the interan; paets into a series of segments or metameres. You will study in little detail about different features of Coelomates in the following subsections.

The Coelom

You have already seen above that the pseudocoel gave animals certain selective advantages. Among other things, this fluid – filled space served as a hydrostatic skeleton increasing the efficieny of burrowing. However, in pseudocoelomates, organs lay loose in the body cavity (fig. 6.1). To circumvent this advantage, coelom evolved within mesoderm.

The result was that the new body cavity, namely the coelom, came to be suspended in the coelom by the mesodermal layer called mesenteries also served as a btter medium for postioning blood vessles to the respective organs. Thus, development of coelom has been a major step in the eveolutiioon of more comple and larger animls. You must keep in mind that all the phyla to be treated below in detail are coelomates.

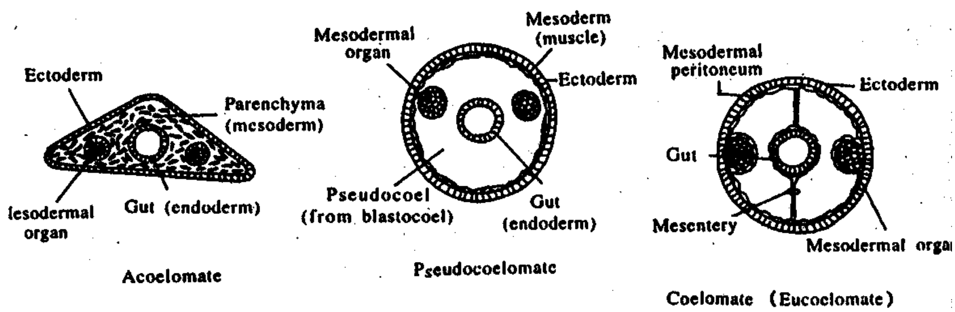


Fig. 6.1: Acoelomate, pseudocoelomate, and eucoelomate body plans

3.1.2 Metamerism (segmentation)

In the early coelomates the coelom was not divided into segements, the entire body cavity was a single space. Hence body movements were nor precise. However, with evolution, coelom became divided into a number of chambers by partitions or septa made up of the mesodermal lining, the peritoneum. This increased the efficiency nad precision of body movements, as individual segements could be moverd more precisely now, with the same mechanism viz, hydrostatic or hydraulic pressure. Also, each segement came to have a repetition of many other organ systems like circulatory, excretory, reproductive and nervous sytems.

Each body segement is thus more or less a repetition of the other and hence redundant; the animal can survive and function normally even if a few segements were lost. This phenomenon of divisions of body into a series of more or less identical segements each containing a section of almost all systems, is known as segmentation or has evolved independently at least twice in the animal as a segement or metamere. Metamerism (Annelida – Arhtropoda) and in deuterostomes (vertebrates).

Phylum Annelida consists of segemented worms. There are about 15,000 species coming under this phylum. They include the earth worms, leeches and polychaetes.

3.1.3 Charactersitc features

1. Body vermiform, bilaterally symmetrical, with metamerism.

2. Triploblastic, with tisues, organs and organ systems; body wall with outer circular and inner longitudinal layers; epithelium secretes an outer transparent, moist cuticle.

3. Chitinous setae present (except in leeaches)

4. Schizocoelic coelom - coelom appearing as a split or cayity within mesoderm.

5. Blood vascular system closed, often with retory pigments; plasma contains amoebocytes.

6. Gut muscular, with mouth and anus.

7. A presegmental prostomium and a post segmental pygidium.

8. Nervous system consists of a supraoesophageal ganglion (cerebral ganglin) circumoesophageal ring and ventral nerve card with segmental ganglia.

9. Different degrees of cephalization is shown

10. Sensory sytem consisting of eyes, photoreceptorcells, statocysts, taste buds and tactile orgasm..

11. Excretory system typically consisting of a pair of nephridia in each segement.

12. Respiration through skin, gills or parapodia.

13. Sexes may be separate, or animals may be hermaphrodites. Cleaveage spiral, with mosaic development. When present, larva is a trochophore. Some animals show asexual reproduction by budding.

Let us now examine the annelid body pattern (fig. 6.2) You will see that the annelid body pattern is basically made up of a prostomium and a segemented body followed by a pygidium respectively from infont backwards. Prostomium and pygigium are not considered segements. Mouth opens on the first segements, and anus opens on the pygidium. Anterior few segements fuse with the prostomium to form head. New segements are added on infront of the pygidium, and the oldest segements are situated anteriorly.

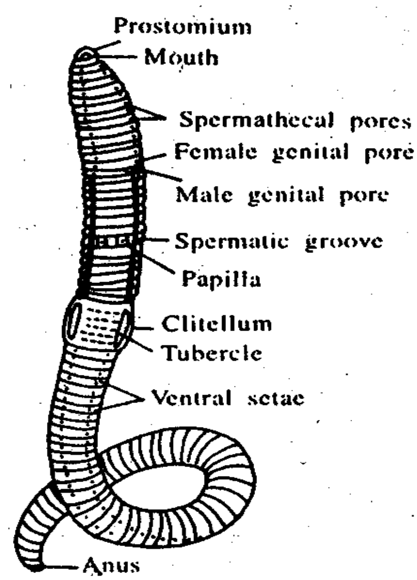


Fig. 6.2: Lumbriucs

The body wall has well developed and strong longitudinal muscles and circular muscles: covering the muscular layer is the epidermal epithdium which secretes a nonchitinous cutilcle. Varying number of chitinous setae are present in the body wall, except in leeches.

The coelom orginates from the embryonic mesodermal cell mass, as a split or cavity on either side, and is hence schizocoetic. Ultimately the coelom becomes lined by a mesodermal layer, the peritoneum. The peritoneal layers on either side meet along the median line forming the mesenteries, which suspend the alimentary canal as well as the longituidinal blood vessels.

Other organs are also suspended by the peritoneal lining. Where the peritoneal linings of the adjacent segments meet, they form the transeverse septa which form partitions between the two segments. The septa are penetrated by alimentary canal and longitudinal blood vesels.

In addition, the excretory organs, the nephridia are typically positioned intersegmentally, one on either side of the median line, on the septa. Their internal openings into the coelom, the nephrostomes are postioned infront of the septum; the body of the nephridium is postioned in the segment behind.typically, each segement has thus got a coelomic chamber, because of the hydrostatic pressure. Contraction of the longitudinal muscles results in broadening of the segment; contraction of the circular muscles results in elongation of the segement.

Thus the effects of contraction and rexalation of the muscles of a segment cen be limited to that segment. In other words, it is localised. A sequential contraction and relaxation cycle results in peristaltic wave. This is effectively used by animals for burrowing, swimming or crawling.

3.1.4 Classification

This phylum is generally divided into three classes, namely Polychaeta, Oligochaeta and Hirudinea.

1. **Class Polychatea. There are mostly marine forms with distinct head, having eyes and tentacles, segments have Lateral projections of the body wall known as parapodia which carry bundles of setae. These animals do not have clitellium. Sexes are sperate (dioecious). They have no distinct or permanent sex organs, but their gonads consist of masses of developing gametes arising as swellings of peritoneum. Eggs usually**

develop into trochophore larva. Many forms reproduce asexually by budding.

Most of the polychaetes are 5 – 10 cm long. They live beneath rocks and in crevices, or burrow in mud. Some build tubes. Other are pelagic. These animals are broadly divided into (1) errant forms on the one hand, which are freely moving, pelagic, active burrowers, crawlers and the tube worms which leave their tubes for various purposes. On the other hand (2) the sedentary forms do not leave their tubes or burrows but may usually expose only their heads outside.

Errant polychaete structure may be considered typical of a generalized polychaete. The prostomium is well developed, with various sense organs like eyes, antennae, palps and the nuchal organs. While prostomium is dorsal and preoral projecting over the mouth. The peristomium which is the first segment, carries ther mouth. The predatory forms have jaws in the mouth.

The peristomium is often fused with one or more subsequent segments forming the head (fig. 6.3). These segments also usually carry sensory structures, but therir parapodium also bears bundles of chitinous setae in the setae in the setal sacs. Neris (fig. 6.3) is a tyupically example. A cross section of its body through one of its middle segments (fig. 6.4) shows well its internal organization.

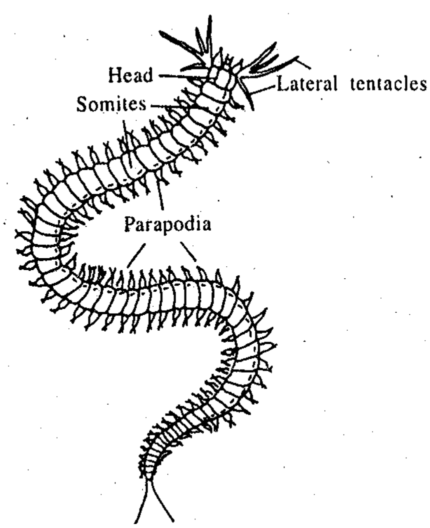


Fig. 6.3: Nereis

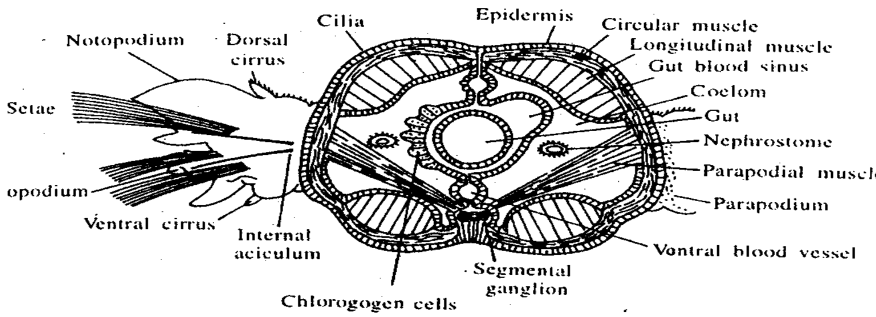


Fig. 6.4: Polychaete organizations shown by cross section of trunk. (Based primarily on Nereis

Amphitrite is an example of a sedevtary polychaete found *intubes* built in mud or sand (Fig. 6.5). It feeds on the tiny particles of food using long extensible tentacles arising from its head projecting out of its burrow. It has also three pairs of branched gills *Sabella* (fig. 6.6.) is another sedentary polychaete. It extends its crown of tentacles (radioles) from the leathery tube which it secretes, reinforced with sand.

The radioles nerve to each food. Chaetopterus (fig. 6.7) is also a sedentary polychaete living in a 'U' shaped parchment like tube. It pumps in water through the tube by means of three forms. They food particles in the stream are entangled by mucus secreted by wing like notopodia of the 12th segment. *Arenicola,* the lug worm (fig. 6.8a) lives in a burrow which is 'L' shaped (fig. 6.8b) it causes water to flow into the burrow by peristaltic movements. It ingests the sand in front of it, laden with filtered and accumulated food particles. It has also gills on certain middle segments.

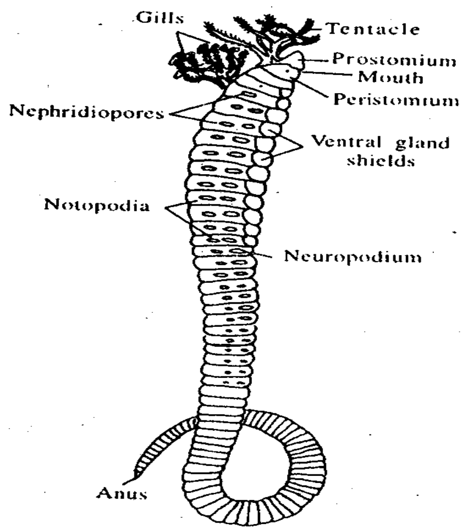
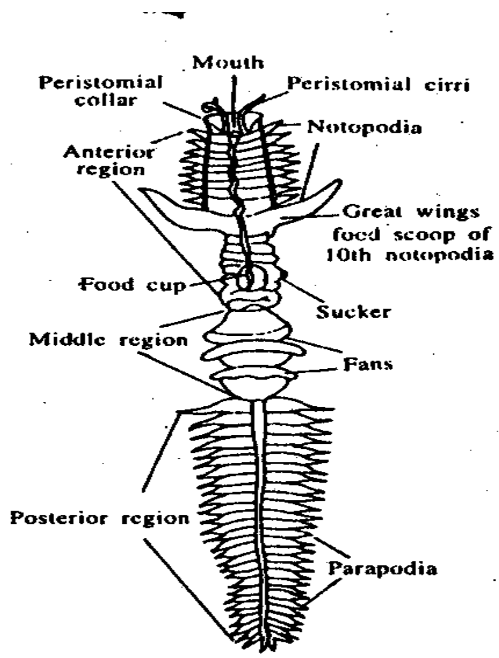


Fig.6.5: Amphitrite

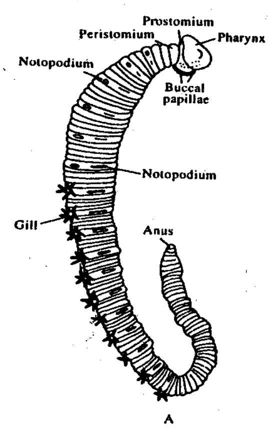
Sabella.



Chaetopterus.

Fig. 6.6: Sabella.

Fig. 6.7: Chaetopterus



Arenicola.

Fig. 6.8a: Arenicola

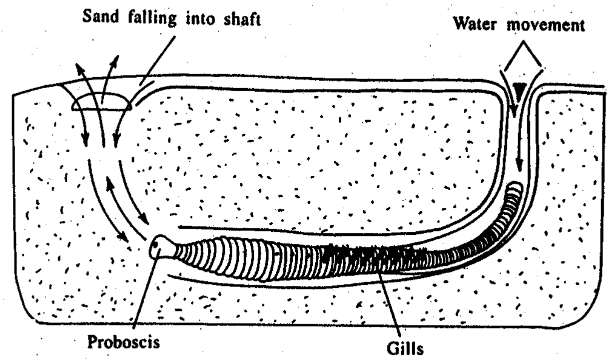


Fig. 6.8b: Arenicola, the lugworm, lives in an L- shaped burrow in intertidal mud flats. It burrows by successive eversion and retractions of its proboscis. By peristaltic movements it keeps water filtering through the sand. The worm then ingests the food – laden sand.

Eunice viridis (fig.6.9) the palolo worm, is an example of eptitoky. It lives in its burrow most of the time in sexually immature (atokous) state. During breeding season certain segments mature sexually and become swollen with gametes. This portion (epitoke) is broken off during the swarming period and swims to the surface, bursting and thereby liberating sperms and eggs into the sea facilitating fertilization. This happens just before sunrise when the sea is crowded with large number of these epitokes. The anterior portion of the worm (atoke) can regenerate the posterior portion.

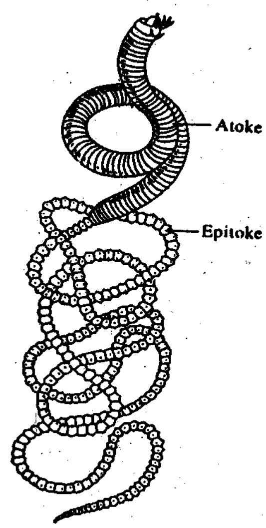


Fig. 6.9: Eunice viridis, the Samoan palolo worm. The posterior segments make up the epitokal region, consisting of segments packed with gametes. Each segment has an eyesoof on the ventral side. Once a year the worms swarm, and the epitokes detach, rise to the surface, and discharge their ripe gametes, leaving the water milkly. By the breeding season, the epitokes are regenerated.

2. **Class Oligoachaeta. Mostly living in soil, or in fresh water, conspicuous body segmentation but no distinct head; body variable number of segements. Number of setae in each metamere fewer. Parapodia absent. Coelom spacious and divided by intersegmental septa; hermaphrodites (monoecious). Reproductive system more complicatred, compact ovaries and testes but fewer in number. Clitellum present. No larva, development direct.**

The earthworms are the most familiar animals in this group, burrowing in soil, enriching it and producing the worm casts. These are fairly larger, usually 12- 30cm long and have 150 – 250 segments or more. They come out of the burrows at night. The other group of oligochaetes is aquatic, mainly fresh water, being very small.

Locomotion in earthworms is by peristaltic movement, the setae being used for anchoring the body. The body plan of the earthworms is remarkably constant. A cross section of the body (fig.6.10) shows a thin but water – proof cuticle over the epidermal layer. Beneath the epidermis there is a circular layer of muscle fibres, followed by large bundles of longitudinal muscles.

Bristle – like setae are inserted in sacs within the body wall. They partly project out of the body wall. Setae can be moved by their own muscles. The coelom surrounding the alimentary canal in lined by outer and inner peritoneal linings. Adjacent segments are partitoned by septa. The endodermal lining of the gut is surrounded by muscle layers of the gut wall.

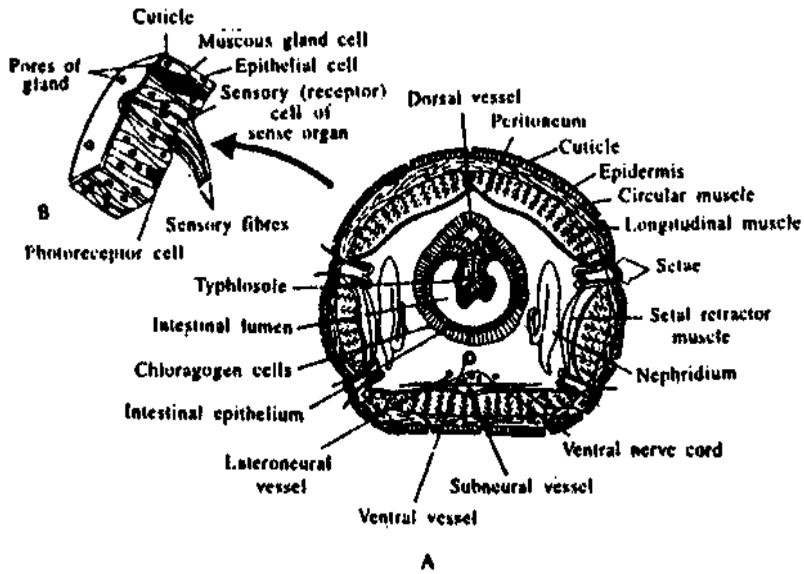


Fig. 6.10: earthworm anatomy: A – Generalised transverse section region posterior to clitellum. B- Portion of epidermis showing sensory, glandular, and epithelail cells.

They feed on decayed organic matter. The muscular pharynx sucks in moistened food. The calciferous glands along the oesophagus regulate calcium ions of the blood by secreting excess calcium into gut. The glands are inregulatory and control the pH of the body fliouds. The oesophagus is followed by a thin walled crop and then a gizzard. The latter grinds the food. The food is digested abd absorbewde in the intenstine. In the intestine an infolding of its wall, the typholosole increases the surfaces area of digestion and absorption. Surrounding the dorsal blood vessel is the tissue. This is derived from the perictoneum and is the site of synthesis of glycogen and fat. It is also excretory in function.

Coelomic fliud as well as blood serve to transport food, waste and respiratory gases. The blood vacualar system is closed, with five main longitudinal blood vessels and a capillary system. The blood has colorless amoeboid corpuscles and haemoglobin dissolved in the plasma. Excretory organs are nephridia. Each typical nephridium has a ciliated funnel or nephrostome in the segement in front of the intersegmented septum and the main part of the nephridium (the body) lies in the segment behind.

A tube leads from the nephrostome piercing the septum into the body of the nephridium where it is thrown into a number of loops, ultimately opening out through a nephridiopore. The nervous system consists of the brain situated above the pharynx and made up of a pair of cerebral ganglia. A pair of cirum – pharyngeal connectives connects the brain with the 1st galgloin of the double ventral nerve cord (subpharyneal ganglion). The cord runs throughout of the length of the animal, worth a ganglion in each segment.

Earthworms are hermaphrodites. However, copulatuion between two worms take place (fig. 6.11b) resulting in exchange of sperm between the two. After copulation a cocoon is secrected around the clitelium.The clitelium is a conspicuous girdle around certain adjacent segments, made up of swollen glands secreting mucus and cocoon material.

Hence, this region is thickened. Usually the clitellum is situated in the anterior half of the body. As the cocoon passes forward, eggs from the oviduct are deposited into the cocoon in which fertilization takes place. The cocoon ultimately leaves the worm and its ends close. Young earthworms hatch out from the eggs. *Lumbricuis* (fig. 6.2), *Pheretima* (fig. 6.11a) and Megascolex are typicall examples of earthworms.

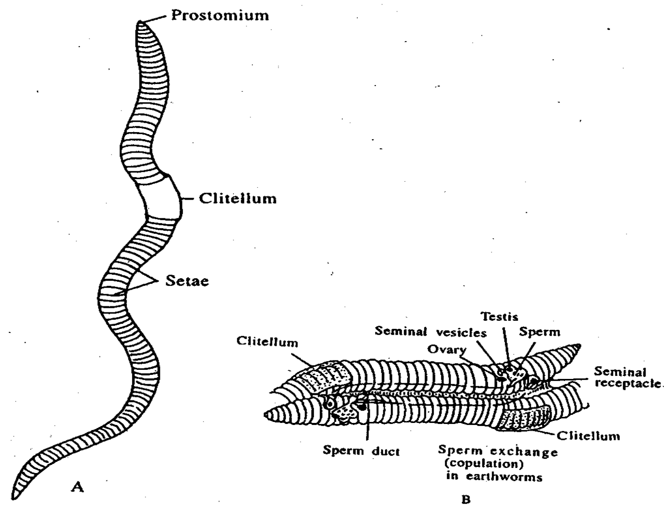


Fig. 6.11a: A pheretima; B, mating and reproduction in earthworms.

Aelosoma (fig. 6.12) is an example of fresh water oligochaete. It is about 1 mm long. Stylaria (Fig. 6.13) has a prostomium extended into a long process. *Dero* (fig. 6. 14) lives in tubes and has 3 - 4 pairs of gills. Tubifex (fig. 6.15) usually has its head buried in mud in ponds and body showing a waving movement. It is reddish in colour. All these are aquatic oligochaetes.

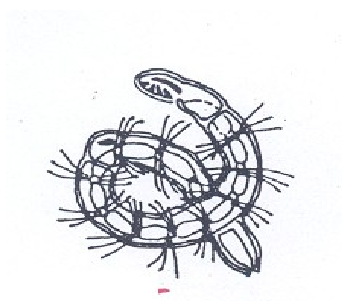


Fig.6. 12: Aeolosoma

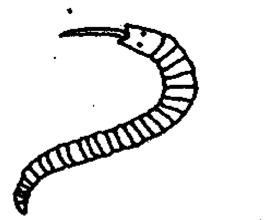


Fig. 6.13: Stylaria

Fig. 6.14: Dero

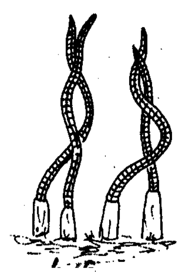
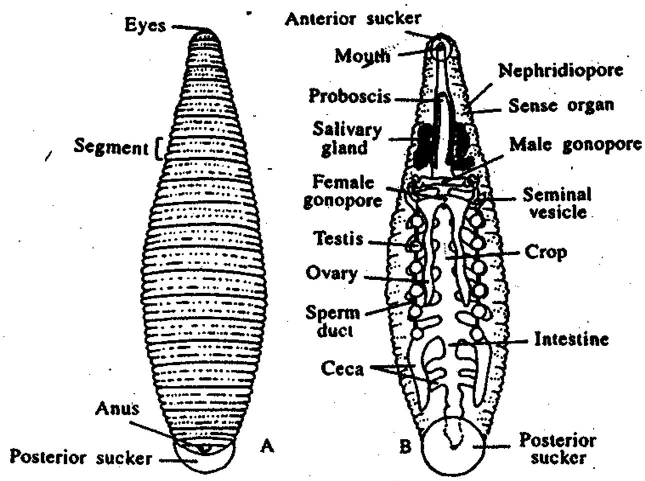


Fig.6. 15: Tubifex

3. **Class Hirudinea. These are leeches. Number of body segments of these animals is fixed; usually there are 34 segments; in some groups there may be only 31 or even 17. Segments have many small annuli. Anterior and posterior sucker present, as also clitellum. No parapodia or setae. Coelom filled with connective tissue and muscles. Hermaphrodites; direct development, may be terrestrial, fresh water or even marine.**

The leeches vary in size frm 2- 6cm in the length (fig. 6.16), and are flattered dorsoventrally. The clitellum, thought present, appears only during breeding season. Their gut is highly specialized for storage of blood. Though they have only 34 segments, because the segments are marked by transverse grooves they appear to have more rings (annuli). With regard to coelom, the septa have disappeared, and the coelom is filled with a connective tiisue (botryoidal tissue). The remining space called lacunae are filled with coelomic fluid (fig. 6. 17)



Structure of a leech, Placobdella, A, External appearance, dorsal view. B, Internal structure, ventral view.

Fig. 6.16: Structure of a leech, placobdella, A, external appearance, dorsal view B, internal streucture, ventral view.

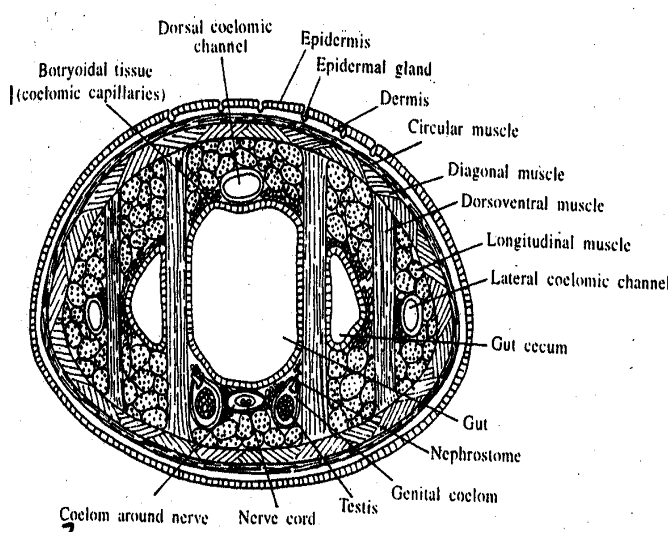


Fig. 6.17: Transverse section through the arhynchobdellid leech, Hirudo. In arhynchobdellid leeches, the blood – vascular system has been completely replaced by the modified coelomic circulatory system.

Locomtiom is by looping movements, by means of the two suckers, or by undiluating, movements in water. Most of them feed on blood and are bloodsuckers of either warm-blooded or cold blooded vcertebrates, and have jaws for cutting tissues. Main excretory organs are nephridia. The brains consist of a ring of gangalia around the pharynx and a double ventral nerve and with a number of gangalia.they are hermaphrodites, but carry out cross fertilizatiion. The cocoon secreted by the clitellum receives the eggs and sperms. It is deposited in the mud.

Examples: Hirudo medicinalis (fig. 6.18), the medicinal leech; Glossiphonia (fig. 6.19), Haemadipsa (fig. 6.20), a blood sucking terrestrial leech: piscicola (fig. 6.21), a fish parasite.

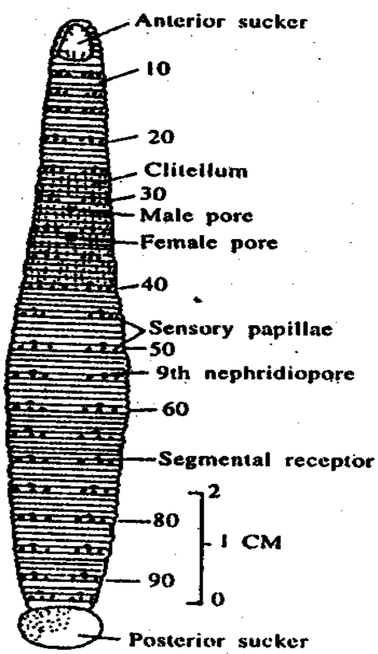


Fig. 6.18: External, ventral surface of the medicinal leech, Hirudo medicinalis

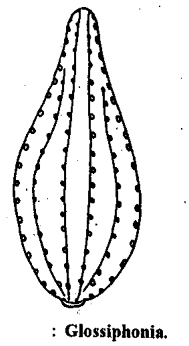


Fig. 6.19: Glossiphonia

Fig. 6.20: Haemadipsa.

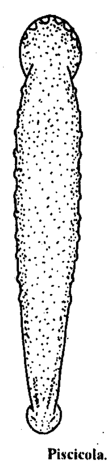


Fig. 6.21: Piscicola

SAQ 1

On the basis of ht egiven characteristics, name the class to which the annelid belongs.

Annelid	parapodia	Clitellum	Suckers	Setae	Class
i)	Absent	present only during breeding season.	two suckers	absent	?
ii)	Present	absent	absent	bundles present	?
ii)	Absent	distinct, more conspicuous during breeding season	absent	a few setae per segment present	?

4.0 Conclusion

1) Annelida contains animals with true coeloms and are called eucoelomates.

2) Bilaterally symmetrical with metamerism they are triploblastic with tisues, organs and organ system.

3) Chitinous setae are present (except in leeches)

4) Their blood circular system is closed, often with retory pigments and the plasma contains amoebocytes.

5) Body segmented.

6) Sexes may be separatd or hermaphroditic.

5.0 Summary

You have, in this unit, learnt abnout the segmented worms in phylum Annelida. These animals are evoulutionarilly linked to insects. These are the first coelomate phylum you will be studying.

6.0 Tutor Marked Assignment

1. Discuss characteristics that distingius between the phyla platyhelminthes and Annelida.

2. Name two uses of Phylum Annelida

7.0 Further Readings

Invertebrate zoology by Rupert/ Barnes 6th International Edition 1994

Intergrated principles of zoology by Hickman, Roberts and Larson 9th Edition 1995.

Answers

SAQ1

i) Hirudinea ii) Polycheata iii) Oligochaeta

Unit 7

ARTHROPODA AND ONYECHOPHORA

Table of contents

1.0 Introduction

In the previous section you have already studied how the coelom evolved and the body of the coelomates got segmented leading to evolution of segmentation or metamerism. The advantage of serial metamerism to animals was also made clear to you. You have also seen how this feature was made use of by annelids to their maxium advantage, enabling them to occupy various niches, primarily aquatic, successfully.

We now begin the study of the largest phylum in the animal kingdom, phylum Arthropoda. This phylum includes more than 1,000,000 species of animals that have been so far described. This number constitutes more than three times the number of all the other species of animals that are known to exist in the biosphere.

Arthropods having inhabited all types of aquatic habitats are the first major group of animals to have invaded successfully the terrestrial environment occupying every possible niche there. Like annelids arthropods are coelomates and segmented, and probably both the phyla arose from a common ancestor.

2.0 Objectives

After studying this unit you should be able to:

1. Discuss the reasons for the success of arthropods

2. With the aid of diagrams describe how insection mouth parts are adapted for their various feeding habits.

3. Briefly describe the characters of phylum onyechopora and point out the affinities of the phylum.

3.1 Characteristics features

1) Body bilaterally symmetrical and metamerically segmented show a tendency to combine or fuse together to form functional units called **tagmata**, like cephalothorax and abdomen: head and truck, or head, thorax and abdomen.

2) Segments carry jointed appendages.

3) Exoskeleton consists of a tough cuticle made up of chitin, protein and lipid, sometimes strengthened with calcium carbonate. The cuticle, secreted by the underlying epidermis, is ushed periodically to permit growth of body.

4) Absence of cilia.

5) Coelom present but highly reduced and obliterated in the adult. The main body cavity is haemocoel, a charactersistics space between organs and tissues, filled with blood.

6) Circulatory systems, open type.

7) Well – developed muscular system with striated muscles attached to the exoskeleton, and visceral organs having smooth muscles.

8) Mouth parts modified from appendages well developed alimentary canal.

9) Respiratory organs are usually tracheae, booklungs or gills.

10) Excretory organs Malpighian tubules, coxal glands, antennal glands or maxillary glands.

11) Nervous system is of the annelidan plan.

12) Sexes are separate; fertilization internal; development often involves metamorphosis.

One of the distinguishing features of arthropods is the presence of a tough, chitinous exoskeleton called cutile which covers the entire body surface. It is a product of give flexibility. The cuticle between two segements and at joints remains extremely thin and flexible and is called articular membrane (fig. 7.2). The cuticle in each segment form a dorsal plate the **tergum,** a ventral plate **sternum** and the lateral structure the **pleura** (sl. Pleuron) (fig.7.2).

In all other parts there is some degree of fusion of segments to form functional groups called tagmata (sl. Tagma). Such a fusion of segments has resulted in body parts like: the head and trunk; or head, thorax and abdomen; or cephalothorax and abdomen. The infolding of the cuticle has resulted in endoskeletal structure called apodemes (fig. 7.3). Muscles are attached to these apodmes.

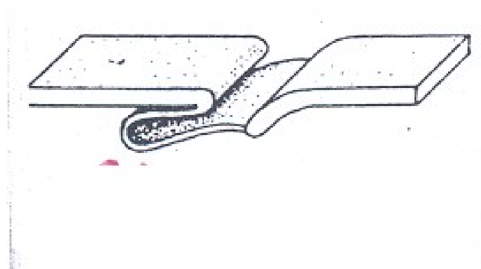


Fig. 7.1: Articular membrance between two segments

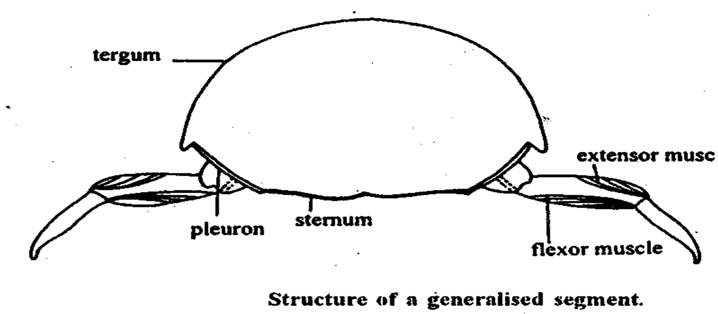


Fig 7.2: Structure of a generalized segment.

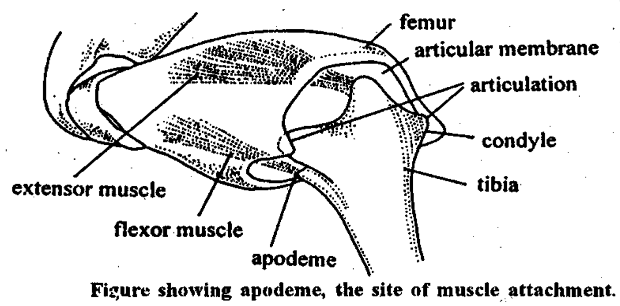


Fig. 7.3: Figure showing apodeme, the site of muscle attachement

The integument in arthropods has an epidermal layer that rests on a basement membrane. The epidermis secretes the cuticle as we stated above. The cuticle is essentially a chitin- protein complex. The colour of arthropods in general is due to the deposition of brown, yellow, orange and red melanin pigments within the cuticle. Physical colurs are produced by the fine sculpturing of the cuticle that provides elevations and depressions which diffract light and give the appearance of colours.

Though when laid down, cuticle is flexible, as a result of a complex chemical process known as taning or sclerotisation, it soon becomes hard. Once this happens it is not possible for the body to grow any further. So the animal sheds the cuticle periodically to enable growth of the animal. This shedding of the old cuticle is known as **moulting or ecdysis**. Ecdysis is hormonally controlled. During moulting, aport of the old cuticle is resorbed amd made use of for building up the new cuticle (fig.7.4).

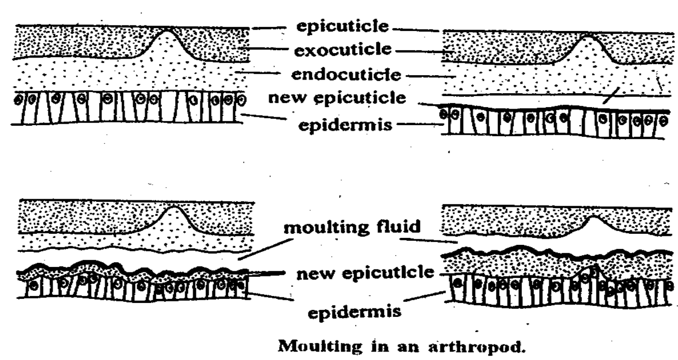


Fig.7.4: Moulting in an arthropod

(a) Fully formed cuticle; (b) Separation of epidermis and secretion of moulting fliud and new cuticle; (c) Digestion of

old endocuticle and secretion of new proccuticle;(d) Newly formed cuticle and old cuticle before it is shed.

Coleom has undergone drastic reduction in arthropods as compared to annelids. The coleom is often represented by a cavity in certain excretory organs or around gonads. The major body space in arthropods is not coelom but haemocoel. The haemocoel is a blood filled space between various structures, and is characteristic of arthropods. The blood vascular system in arthropods is composed of a tubular heart, a dorsal aorta and the blood – filled cavity, the haemocoel (fig. 7.5). The tubular heart enclosed in a pericardium is contractile and is the centre of blood propulsion. There are no blood capillaries and system is open type. The blood plasma contains haemocyanin as the repiratory pirment, and in a few species the pigment is haemoglobin.

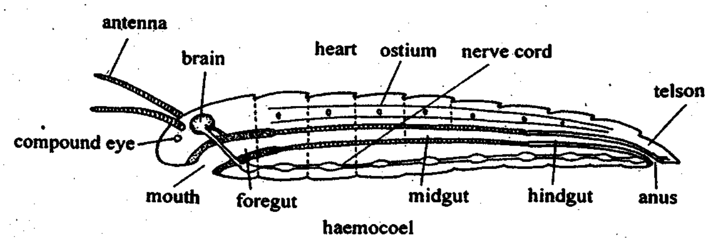


Fig. 7.5: Strcutre of a generalized arthropod

Excretion is carried out by structures called **Malpighian tubules** generally found in terrestrial arthropods as blind tubular elongations of the gut, and lie freely in the haemocoel. The aquatic forms have generally paired coxal glands, **antennary glands** or **maxillary glands** which are homologous to the metameric nephridia of annelids (fig. 7.6).

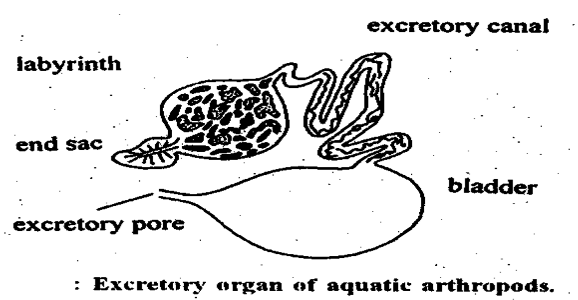


Fig.7.6: Excretory organ of aquatic arthropods.

Arthropod digestive tract is generally divided into three parts the foregut or **stomadaeum**, the **midgut** or **mesenteron** and the **hindgut** or **proctodaeum** (fig. 7.7). The stomadaeum and proctodaeum are ectodermal in orgin and are lined with thin chitinous layer. Mesenteron is endodermal in orgin. Salivary glands hepatopancreas and hepatic

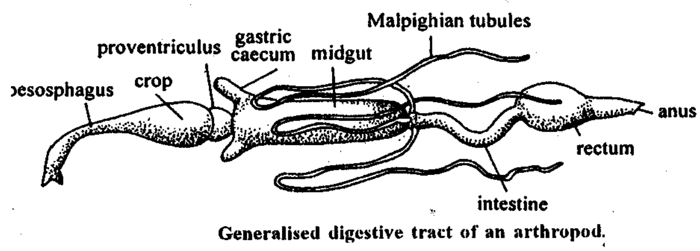


Fig. 7.7: Generalised digestive tract of an arthropod.

There nervous system of arthropods is built on the annelidan plan (fig.7.8). There is a brain dorsally connected to suboesgohageal ganglion by circumoesophaageal connectives. The double ventral nerve cord bears segmented ganglia which may be fused variously in different groups. Arthropods have a variety of sense organs. The sensory receptors of arthropods basically comprise various types of sensilla.

The sensilla vary from hairs bristles, setae etc. (fig. 7.9) with sensory neurons plus a number of cells that produce the cuticular housing apparatus. Insects and crustaceans havecompund eyes formed of a number of many long, cylindrical units called ommatidia (sl. Ommatidium) possessing all the elements fro light refraction and reception (fig. 7.10).

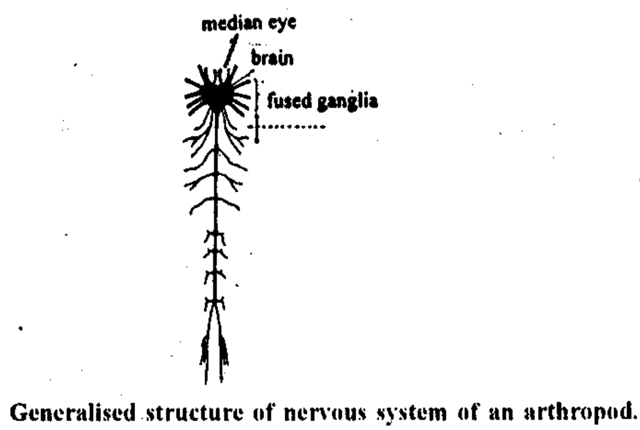
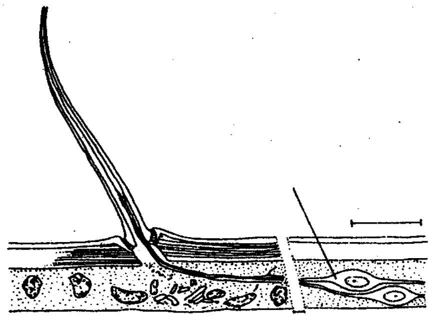


Fig. 7.8: Generalized structure of nervous system of an arthropod.



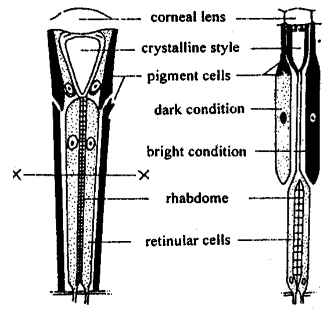


Fig. 7.9: A chemo senspry hair of an arthropod.
Fig. 7.10: Insect Ommatidium

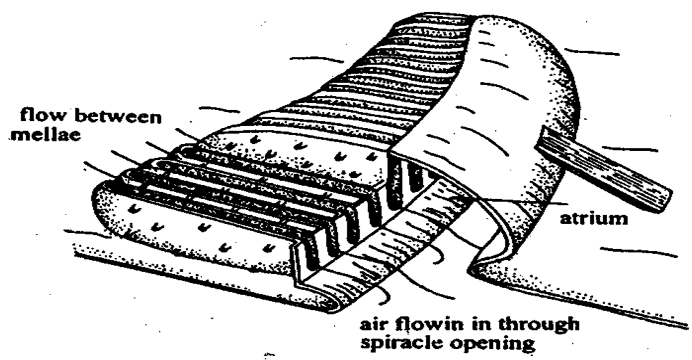


Fig. 7.11: Book lung of an arachnid. (Diagrammatic)

Generally arthropods are dioecious. Sperm transfer by copulation is common and the appendages are modified for such a purpose. Fertilization is internal in all terrestrial arthropods as well as in some aquatic forms but in certain aquatic forms external; fertilisation is not uncommon. Arthropods have centrolecithal eggs with rich york. Cleavage is superficial. Development may include one or more larval stafges. Viviparity is observed in some groups of arthropods.

Arthropods include crustaceans, common examples being prawns, lobsters and crabs: arachnids including scorpions, spiders, ticks and mites: myriapods comprising mainly centipedes and millipedes; and insects such as grasshoppers, bugs, beetles, moths and butterflies, houseflies, mosquitoes, ants, bees and wasps.

We have outlined above some of the general characters of the Phylum Arthropods. Arthropods have evolved along four main lines. Each of these lines is treated as a subphylum. (See the chart). Of the four subphyla, subphylum **Trilobitomorpha** consists of only extinct forms with no living representative today. Subphylum **Chelicerata** contains mostly terrestial arthropods such as scorpions, spiders and ticks and mites and the aquatic **horseshoe crabs**. Subphylum **Crustacea** comprise mostly aquatic arthropods, such as copepods, barnacles, shrimps, lobsters and crabs. Subphylum **Uniramia** includes mostly terrestrial forms, the centipedes, millipedes and insects. Although the phylum had its orgin in the sea, uniramians and several of the chelicerates appear to have evolved on land.

Before youy proceed with your study of the subphyla answer the following SAQ.

SAQ1

i).Fill in the blanks with appropriate words

1. Phylum Athropoda includes nearly-------------------------- species of animals.
2. The term "Athropoda" means --
3. The different segmented appendages of various arthropods are said to be -------------------------------------- organs.
4. The branched appendages of Crustaceans are known as ------------------- organs whereas th unbranched ones of centipedes, millipedes and insects are --
5. The dorsal chitinous plate of each segment in arthropods is------------------ the ventral plate is -------------------and the lateral structures are -------------
6. The cavity enclosing the gonads and the end sacs of the excretory organs in Crustaceans is the ---
7. --------------------------- and ------------------------------ are the excretory organs of arthropods.
8. The component unit of a compound eye is called ---------------------------
9. The four subphyla of phylum Athropods are 1)----------------------2)------------ 3)------------------------------- & 4)--
10. List any five distinctive characters of phylum Athropods.

1) ---------------------------
2) ---------------------------
3) ---------------------------
4) ---------------------------
5) ---------------------------

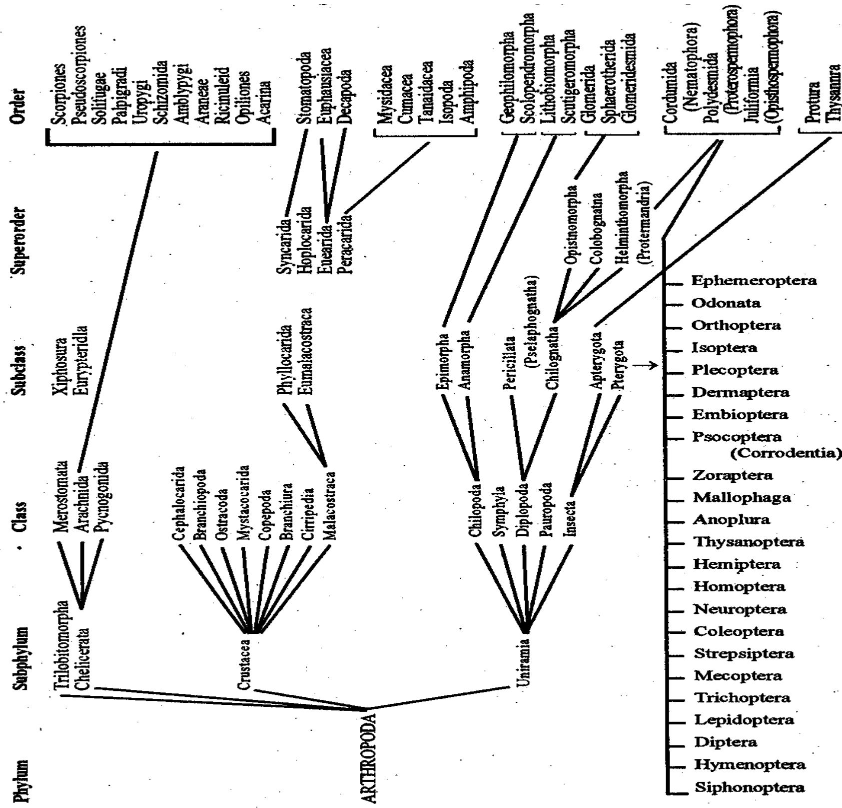


Fig. 7.12 Chart showing the classification of Phylum Arthropoda

3.1.1 Subphylum Trilobitomorpha

Subphylum Trilobitomorpha includes the trilobites (fig. 7.13). All species are extinct and the fossils indicate that they were all marine forms belonging to palae ozoic era. They are the most primitive of all arthropods. Body was divided into three lobes by means of two furrows longitudinally; distinct head, thorax and abdomen were present. Appendages biramous. It appears that trilobites had a variety of habits; they included burrowing, epibenthic, crawling, planktonic and swimming forms.

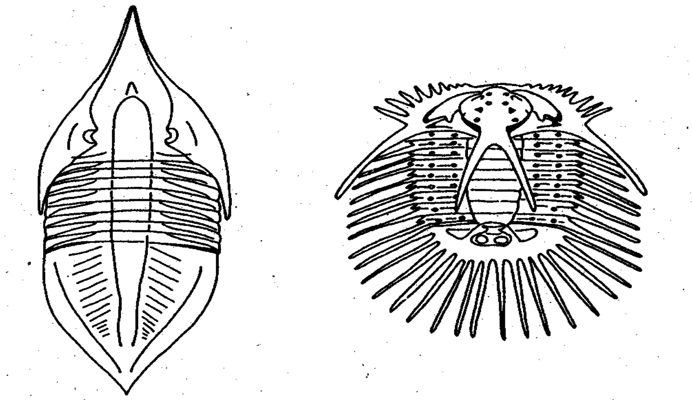


Fig. 7.13: Extinct trilobites (a) Megalaspis sp. – burrowing form (b) Radiaspis sp. – planktonci form.

3.1.2 Subphylum Chelicerata

Chelicerata body is divided into two parts an anterior **cephalothorax** or prosoma and a posterior **abdomen** or **opisthosoma.** Antennae are absent. The first pair of appendages are known as **Chelicerae** which are food capturing structures. The second pair of appendages are the **pedipalpi** performing a varerity of functions in different groups. Following pedipalpi, the cephalothoracic region has four [pairs of walking legs.

Subphylum chelicerata includes three classes: Merostomata, Arachnida and Pycnogonida.

Class 1 Merostomata: Aquatic chelicertates in which five or six pairs of abdominal appendages are modified into gills for resipratiioon. At the end of the body there is a spike like telson.

The group includes two subclasses: (1) Xiphosura, the horseshore crabs and (2) **Eurypterida** which is extinct now.

Subclass 1 Xiphosura: Xiphosurans are known to exist from Cambrian period. Most species have become extinct. Only four species are knoiwn to exist from Cambrian period. The most common genus of horseshoe crab is Limulus, (fig. 7.14). This lives in shallow water with soft bottom. They reach a length of 60cm and are dark brown in colour. The cephalothorax is covered by means of a shield – like or horseshoe shaped convex exosketeal plate called carapace that facilitates the organism to push through sand.

The carapace also forms a cover to protect the ventral appendages. The head bears a pair of compound eyes and a pair of simple median eyes. The prosoma bears a pair of chelicerae and five pairs of walking legs. The abdomen or opistohosoma is unsegmented aid bears six pairs of appendages. The first pair of appendages are fused to form a genital operculum bearing two genital pores. The other five pairs are modified as gills. Each gill has about 150 leaflike folds or lamellae arranged like the leaves of abook. So these appendages are sometimes called **book gills**.

Horseshoe crabs are omnivorous. They have well developed digestive and circulatory systems. Excretion is by four pairs of coxal glands which open to the exterior at the base of last pair of walking legs by a common excretory pore. The brain is formed by the fusion of several ganglia including the ganglia of first seven segments. Abdomen has five ganglia. Sexes are separate.

Female *Limulus* lays 2000 to 3000 eggs. Cleaveage is total and development includes a **trilobite** larval stage (fig. 7.15). This larva resembles the tributes. Sexual maturity is reached after 3 years or more and life span is around 19 years. Since xiphosurans have lived on earth for over 200 million years without having undergone much change, they are an **evolutionary relic** and sometimes considered **living fosil.**

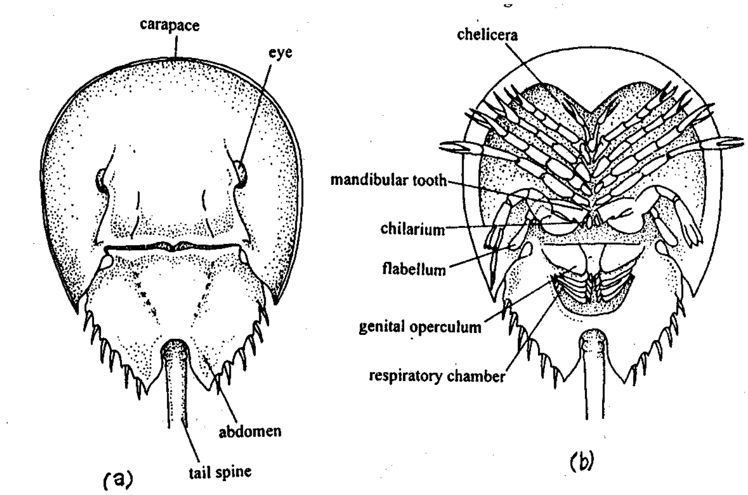
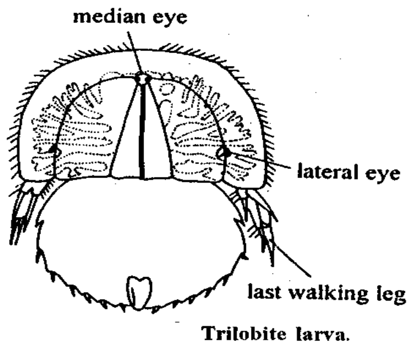


Fig. 7.14: Limulus (a) dorsal view (b) ventral view.

Subclass 2 Eurypterida: Eurypterida are a group of gland, extinct merostomes. They were aquatic forms and existed from Ordovician to permain period. A species of the genus *pterygotus* was about three meters long. The body plan of eurypterids was similair to xiphosurans. They also resembled the scorpions. However, their cephalothorax was smaller. Abdomen was made up of separate segments, with a seven segmented preabdomen (mesosoma) with appendages. Besides the marine environment, they also appear to have inhabited brackish water, freshwater and terrestrial environement. It is also suggested that eurypterids could have been the ancestors of arachnids: e.g. Eurypterus (fig.7.16)



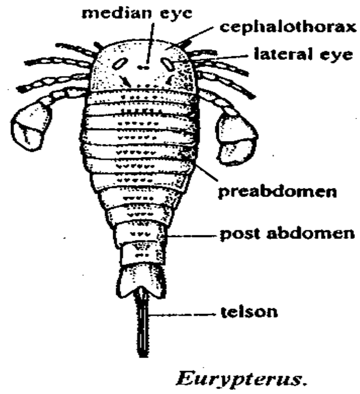


Fig. 7.15: Trilobite larva   Fig. 7.16: Eurypterus

Class 3 Arachnida: Body divided into cephalothorax and abdomen. Cephalothorax with four pairs of legs; abdomen segmented, with or without appendages. Respiratory organs are either, tracheae, or book lungs. Excretory organs are Malpighian tubules or coxal glands. Brain bilobed connected to ventral ganglionic mass forming a ring. Eyes simple. Mainly oviparous; no metamorphosis.

Arachnids, the largest of all the chelicerate classes, include some of the common and familiar but diverse form, like spiders, ticks, mites, scorpions, pseudoscorpions, Whipscorpions, harvestmen (daddy longlegs) etc. Arachnids are one of the oldest classes of arthropods, the fossil forms dating back to Silurian period. Most living arachnids are terrestrial. As a result,the epicuticle has become waxy reducing water loss, the book gills became modified into booklungs for use in air and the appendages became better adapted for terrestrial locomotion.

The body of arachnids, (fig. 7.17) shows three district regions; the **prosoma** which is unsegmented and covered by a carapace; the **mesosoma** or preabdomen and the **metasoma** or postabdomen.except in scorpions, in other arachnids the two divisions of the abdomen are not conspicuous and the segments are fused. The appendages are usually confined to prosoma and consist of a pair of chelicerae, a pair of pedipalpi and four pairs of walking legs. There are no antennae and mandibles.

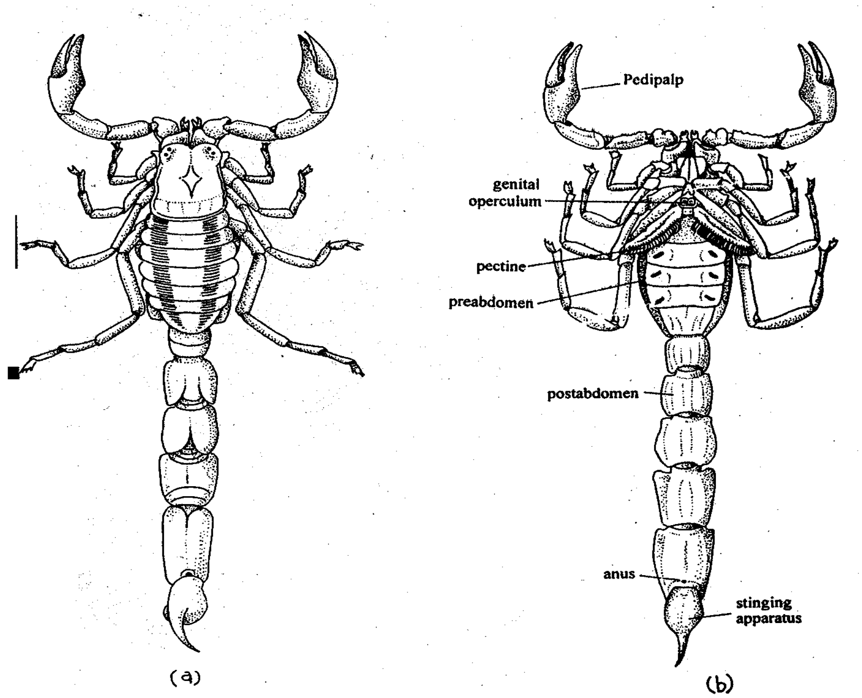
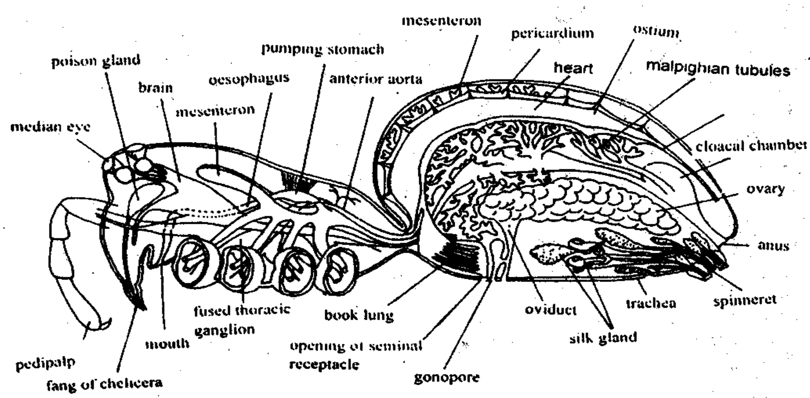


Fig. 7.17: Scorpions (a) dorsal view (b) ventral view.

Arachnids are generally carnviorus and partial digestion of food takes places ourtside the body of the animals. The small arthropods captured as prey are killed by pedipalpi and chelicerae. The enzymes from the midgut are poured over the prey held by the chelicerae. The partially digested liquid food is taken in through the mouth, by means of the strong sucking pharynx. Trhe midgut is a specialized structure with a central tube and lateral diverticula (fig. 7.18). The diverticula located both in prosoma and abdomen become filled with partially digested food and further digestion occurs here. The midgut contiues into the posterior part of the abdomen as rectum where it opens outside by anus.



Internal organisation of a spider.

Fig. 7.18: Internal organizations of a spider.

The nervous system (fig. 7.19) is higly concentrated. The brain is composed of protocerebrum and tritocerebrum and in many orders most or all the thoracic and abdominal ganglia have moved forward and fused with suboesophgeal ganglion.

Thus often the nervous system appears in the form of a ring around oesophagus. The sense organs include sensory hairs eyes and slit sense organs. The sensory hairs are chemoreceptors or olfactory in function. The slit sense organs which occur singly or in groups respond to changes in the tension of exoskeleton, load stress in locomotion grtavity, and to airborne vibrations. The slit organs occurring in groups are called **lyriform organs**. Scorpions have a pair of peculiar comblike sense organd called pectines (fig. 7.17). These are located ventrally behind the gental plates and attached to the second abdominal segment. Some mites have special type of sensory organs known as **pseudostigmatic** organ for monitoring air currents.

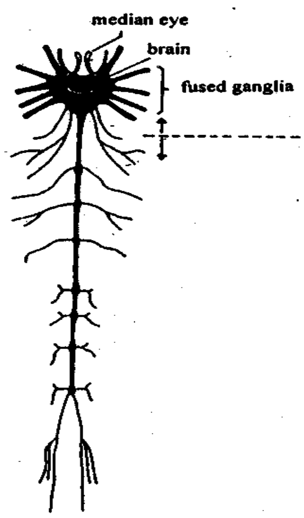


Fig.7.19: Nervous systems of Scorpion.

Arachinds possess booklungs (fig. 7.11) or trachea of both as respiratory organs. Book lungs are considered to be modified book gills and resemble them in structure. However, they occur as pockets of ventral abdominal wall. One of these walls is folded into lamellae in which blood circulates; outside these lamellae there is circulation of air, enabling respiration.

The heart is located in the anterior half of the abdomen. In scorpions there are seven pairs of ostia each corresponding to a segment. But in other arachnid orders, varying degress or reduction in number of osita are found. Excretion is carried out by means of coxal glands (fig.7.6) and Malpighian tubules. Coxal glands are derived from coelomic sacs. Their ducts open on the coxae of the leg. Malpighian tubules their legs in their reproductive tract and give birth to live, developed young ones. Thus viviparity is common among arachnids.

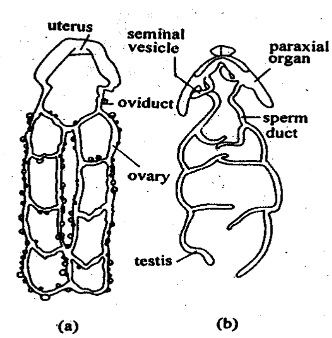


Fig.7. 20: Reproductive system of Scorpoins (a) male (b) female.

Of particular interest, is the **silk glands** and the associated **spinnerets** of many spiders. The spinnerets or the spinning organs (fig.7.21) are modified appendages and are located on the abdomen ventrally, in front the anus. They bear a number of **spigots,** which are the openings of the silk glands. The silk glands themselves are large with a reservoir and duct opening on the spinneret.The silk plays a very important role in life of spiders. The web is used to catch the prey; many spider use silk thread as a drag line or a safety line as used by mountain climbers; silken nets may be used as their retreats; their eggs are usually wrapped in silken cocoons.

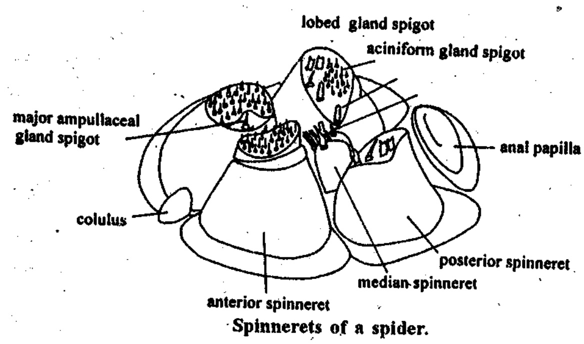


Fig.7.21: Spinnerets of a spider

Examples

Order 1 Scorpions: includes scorpions e.g. Buthus, Palamnaeus (fig. 7.22) *Androctonus, Centruroides, and Heterometrus*. Their abdomen ends in a stinging apparatus.

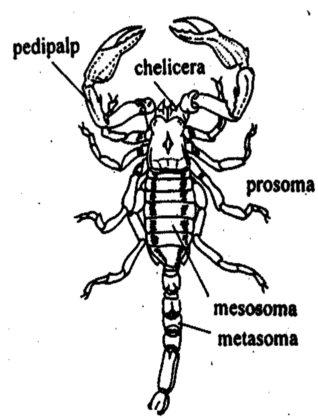
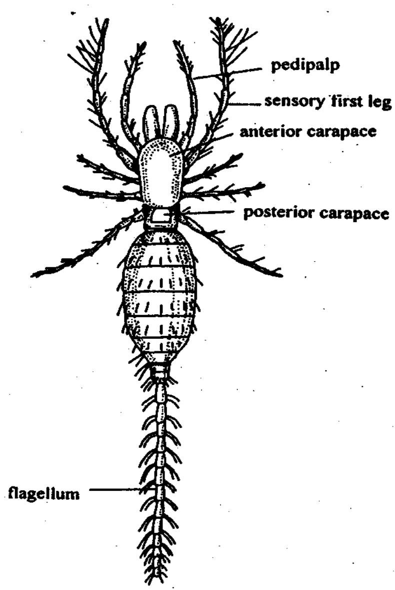


Fig. 7.22: Palamnaeus

Order 2 palpigradi: These are the palpigrades; e.g. Eukoenenia (fig. 7.23).



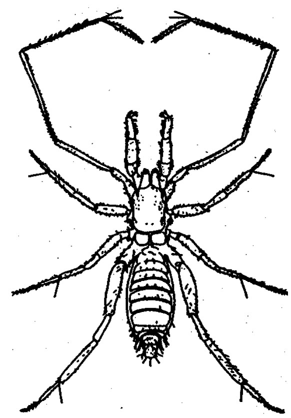


Fig. 7.23: Eukoenenia **Fig. 7.24: Schizomus**

Order 3 Schizomus: These include tailless whip scorpions; e.g. Schizomus (fig. 7.24)

Order 4 Uropygi: These are the whipscorpions, e.g Thelyphous (fig. 7.25)

Order 5 Araneae: These comprise spider, e.g. Latrodectus, balck widow spider (fig. 7.26); Synema, a crab spider.

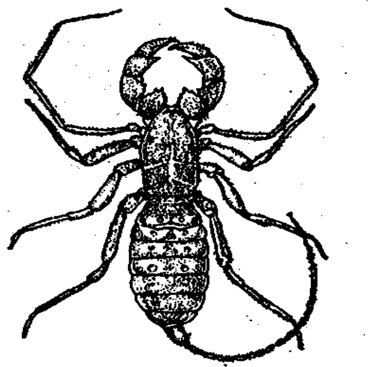


Fig.7.25: Whip scorpion

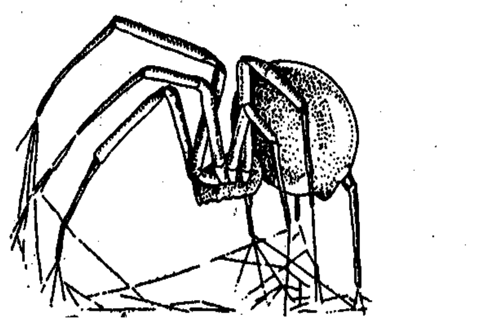


Fig. 7.26: Black widow spider

Order 6 Amblypgi: These are found beneath logs, bark, stones, leaves etc. eg. Tarantula, Charinus (fig. 7.27)

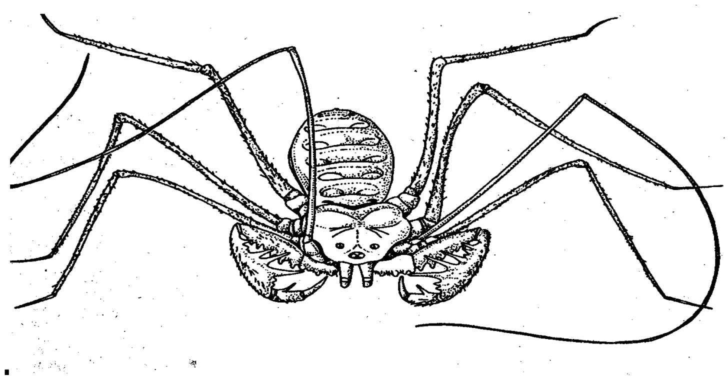


Fig. 7.27: Charinus

Order 7 Ricinulei: These are known as tick spiders (fig. 7.28) mostly confined to Africa and America; eg. Cryptocellus, Ricinoides.

Order 8 Pseudoscorpions: Includes Pseudoscorpions found beneath barks, stones etc. eg. Chelifer (fig.7.29)

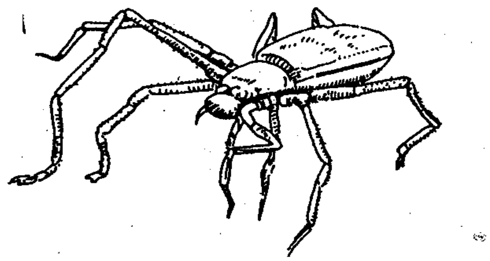


Fig. 7.28: Ricinuleid

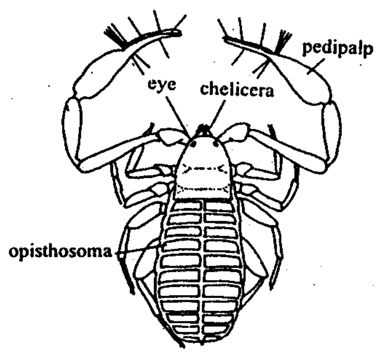


Fig. 7.29: Chelifer

Order 9 Solifugae: Commonly called sum spiders or wind scorpions. They live under stones and crevies and many are burrowing forms; measure a maximum of 7cm; eg. Galeodes (Fig. 7.30).

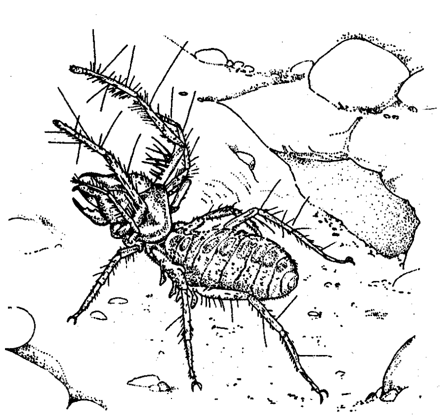


Fig.7.30: Galeodes

Order 10 Opiliones or Phalangida: Opiliones or Phalangids commonly known as harvestman or daddy long legs inhabit humid place both in temperate and tropical regions. Phalanigids are found to live in forest floor, tree trunks, fallen logs and humus. They usually measure about 5 to 10mm in length. The legs of opiliones are long and slender and exceed body length several times. eg. Leiobunum (fig. 7.31)

Order 11 The Acarina: The Acarina are a group of very diverse assemblage of arachnids known as ticks and mites (fig. 7.32 and 7.33). Many species are ectoparasites on humans, dosmetic animals and crops. They can also cause damage to man;s possessions as well as to food . Free living mites have varied habitats as they live on moss, plants, fallen leaves, humans, soil, rotten wood and detritus. They are also aquatic inhabiting both freshwater and sea.

Nearly, 30,000 species have been described thus far but many more unidentified species still exist. They generally measure 0.25 to 0.75mm. Ticks are slightly larger, some species may reach upto 3cm in length. The small size has enabled them to inhabit many microhabitats such as the trachea of insects, wings of beetles, quill feather of birds and hair mammals. The head region carrying the mouth parts is called **capitulum** or **gnathosoma** (fig. 7.34). A structure called buccal cone is attached to the anterior region opf the body like a socket that can be extended or retracted.

The chelicerae and pedipalpi are attached to the **buccal cone.** Ticks remain attached to hosts and attack all groups of terrestrial vertebrates including man. Amercian rocky mountains spotted fever – tularemia. Texas cattle fever, relapsing fever, and lyme disease are some of the human diseases cause by ticks. A species of mite Sarcoptes scabiei causes scabies or seven year itch by tunneling into epidermis.

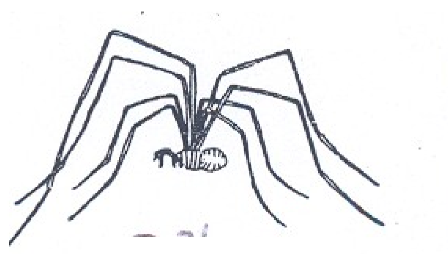


Fig. 7.31: Leiobunum

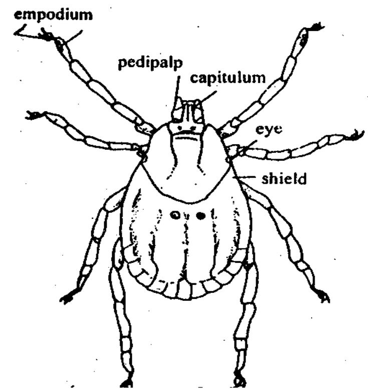


fig. 7.32: A tick.

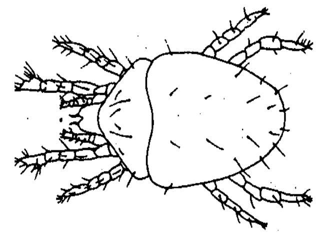


Fig.7.33: A mite

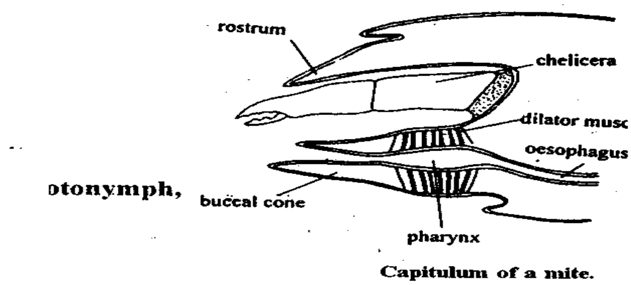


Fig.7.34: Capitulum of a mite

Class 3 pycnogonida: measures usually 3 – 4 mm; body chiefly made up of cephalothorax, abdomen being very small; generally four pairs of walking legs; long proboscis with a mouth; simple eyes, four in number; no excretory or respiratory organs.

These are commonly known as sea spiders (fig. 7.35) occur in all the seas. The narrow body is formed of a number of distinct segments. Prosoma (cephalothrax) is the promienent region of the body and opisthosoma (abdomen) is much reduced. The head or cephalon bears four simple eyes mounted on the dorsal surface on a tubercle and a cylindrical proboscis. It also bears a pair of comparatively small chelicerae and palps each.

The trunk is formed of four cylindrical segments, of which the first one is fused with the head. From each of the four segments, a pair of lateral processes project out to which the long walking legs are articulated. The legs are eight segmented and are usually much longer than the body. The abdomen appears as a short conical process.

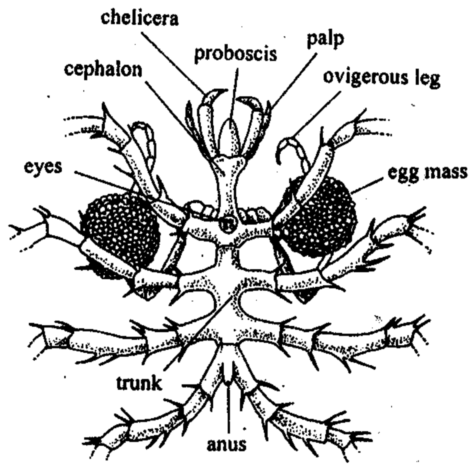


Fig.7.35: A sea spider

Pycnogonids are mostly carnivorous and feed on soft colenterates, bryozoans, polychaets and sponges. Most parastic forms live on molluscs. The pharynx acts as a pump and also macerates food by means of the bristles located there (fig. 7.36). From the extensive interstine (midgut) caeca extend into appendages. The circulatory system consists of a heart dorsal vessel and the haemocoel. Special; respiratory or exceretory organs are absent and gas exchange is by body surface. Nervous system resembles that of other chelicerates.

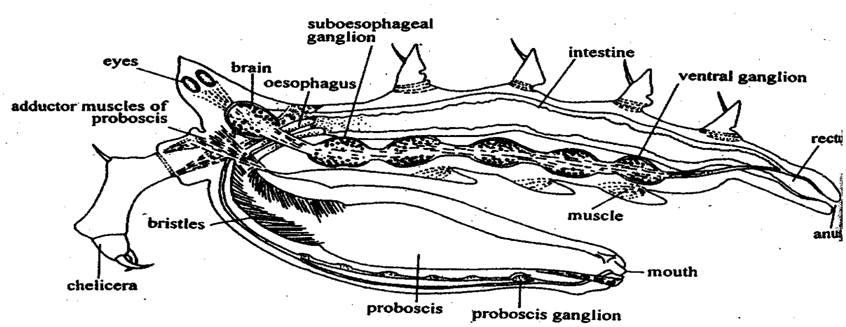


Fig. 7.36: Sagittal section of a sea spider showing internal organizations

Pycnogonids sexes are separate. Gential openings ar multiple,located on the ventral side of the coxae of second and fouth pair legs in males and of all legs in females. The gonads are located in the trunk, but lateral branches extend into the legs. The eggs release by the females are collected in ovigerous sacs of the males. A larval stage known as **protonymphon** (fig. 7. 37) which may reamin in the ovigorous legs of the male or may develop among the hybrids and corals. A sequence of moults and development lead to the transformation of larvae into adult.

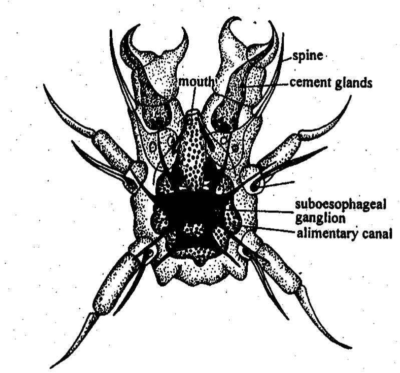


Fig. 7.37: protonymphon larva of a sea spider.

The systematic position of Pycnogonids is not clear. The structure of nervous system, nature of sense organs and presence of chelicerae – all find for them a place among chelicerates. But the presence of multiple gonopores, ovigerous legs, and segmented trunk distinguish them from chelicerates. It could not be said with certainly whether Pycnogonids are related to arachnids or not.

SAQ2

1. Choose the coorect word from the alternatives given.

1. Trilobites are extinct group of primitive/ advances arthrodpods.
2. One of the characteristic features of chelicerates is presence/ absence of antennae.
3. The second pair of appendages of chelicerates is known as chelicerae/ pedipalpi
4. Class Merostoma consists of terrestrial/ aquatic chelicerates.
5. Class Xiphosura/ Arachinda are regareded as living fossils.

6. Spiders, ticks, mites and scorpions are included under the calss Eurypeterida/ Arachnida.

7. In scorpions the post – abdominal region is known as mesosoma/ metasoma.

8. Spinning organs or spinnerets are characteristics of Araneae/ Acarina.

9. Order solifugae/ Acarina includes mites.

11. Fill in the blanks with suitable words.

1. The three classes of the subphylum chelicerata are --- and ---

2. Horse – shoe crabs are included under the subclass-------------------

3. Xiphosurans are called ---------------------------------- because they undergone much change and have remained an evolutinaory relic.

4. The slit organs of arachnids that occur in groups are called---------

5. The special comb – like sense organs of scorpions are --------------

6. ------------------------as the arachnids that are popularly known as dadsdy long legs or harvestman.

7. Many members of Acarina are -----------------on humans, dosmetic animals and crops.

8. Some of the diseases caused to humans by ticks are ---------------- ---------------------- --------------------- and --------------------------

9. ----------------------- Organ is the sense organ in mites that are useful in detecting air currents.

10. Sea spiders belong to the class---

3.1.2 Subphylum Crustacea

Crustacea are mostly aquatic arthropods with gills for respiration. Cephalothorax has usually a carapace; appendages biramous but modified for various functions. Head has apir of antennules, a pair of antennae, a pair of mandibles and two pairs of maxillae. Development with a nauplius stage, but this way be absent in higher forms.

Crustacea includes arthropods most of which have an aquatic existence. The group abounds in species diversity and biomass. It includes crabs, shrimps, lobsters, cxrayfish, woodlice etc. Although largely aquatic there are some semiterrestrial and terrestrial species. Their success on land is not significiant.

Let us briefly took into the structural pecualiarities of crustaceans. The body of crustaceans is divided into three regions, head, thorax and abdomen (fig. 7.28). The head and throaic segments may be fused to form the **cephalothorax.** The thorax and abdomen may together form a trunk in some forms. The thoracic segments are covered by a dorsal shield known as carapace. The carapace is aposteriroly directed fold of the body wall of the head and fused with varying number of segments behind it. Carapace may overhang the sides of the body to some extent or in some cases it may enclose the entire body.

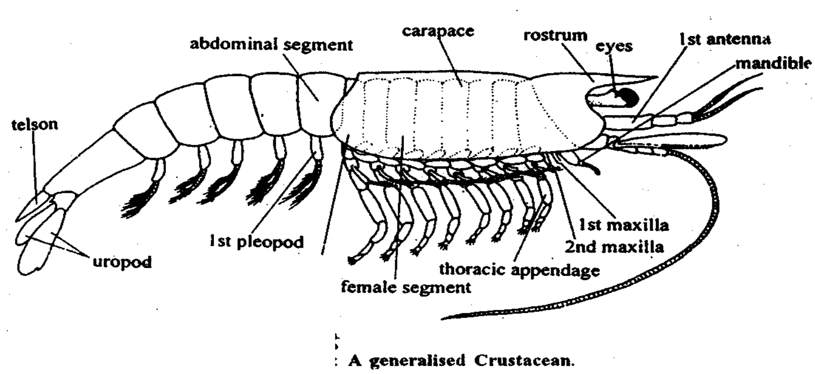


Fig. 7.38: A generalized Crustacean

The head has five pairs of appendages, corresponding to its segments. The first two appendages (fig. 7.29) are **antennules (first pair of antennae) and antennae** (second pair of antennae). Thus crustanceans are the only arthropods with two apairs of antennae.

These are followed by apair of **mandibles** - short and heavy structure with apposing and grinding surface and two pairs of accessory feeding appendages the **first pair of maxillae** and the **second pair of maxillae.**

All these appendages as well as those present on the thorax and on the abdomen, are **biramous**. In each biramous appendages, there is a large **protopodite** composed of two pieces – **a coax** and **a basis**. Attached to the basis is an inner branch called **endopodite** and an outer branch, the **exopodite,** each of which is made of one or several segments. The different appendages are modified to do different functions such as food handling, crawing, walking, swimming, prehension, sperm transfer and egg broding (fig. 7. 30). The number of segments in crustaceans vary; most has 16 – 20 segments.

Malacostraca, the most advanced class of Crustacea which includes lobsters, prawns, shrimps, crabs etc. have in addition to head, a thorax of eight segments and an abdomen of six segments. In addition, the hed carries a non – segmented **rostrum** and the posterior has a non – segmented **telson.** The telson the last abdominal segments and its **uropods** together form the tail fin. Smaller Crustaceans in general are capable of swimming. Large forms have taken to benthic zones and the appendages are modified for crawing and burrowing mode of life.

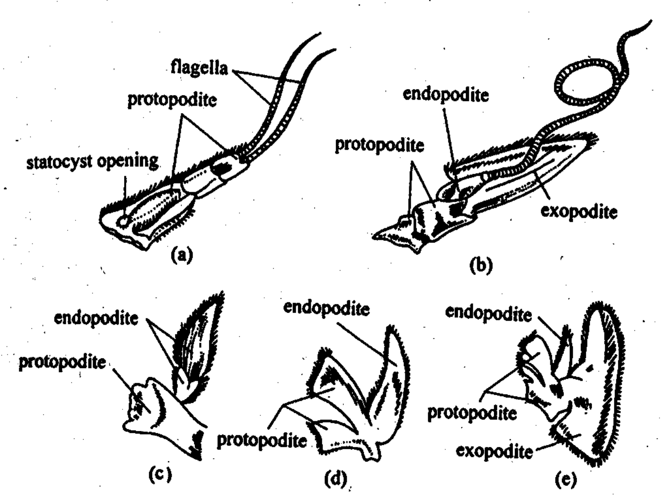


Fig. 7.39: Cephalic appendages of prawn

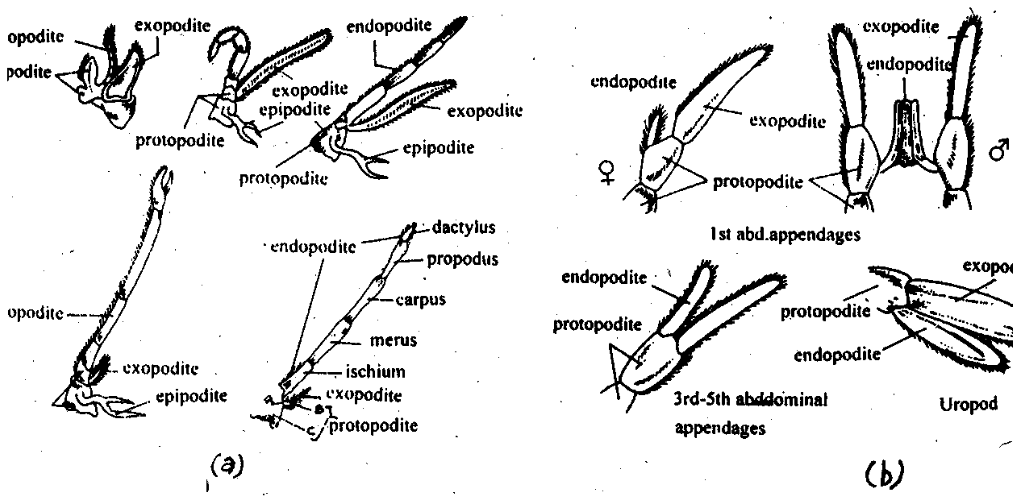


Fig. 7.40: Thoraic and abdominal appendages of prawn.

The cuticle of Crustaceans usually contain calcium salts. Tanned proteins and pigments may also be present. Most Crustaceans are also capable of changing their colour to suit environment. This is by concentration or dispersal of various pigments contained in certain cells known as **chromatophores**, which are subepidermal. Many Crustaceans are predators, many are also adapted for filter feeding of tiny organism constituting planktons and detritus.

Generally a few of the trunk appendages are modified for this purpose and these are the **maxillepedes**. Mouth is ventral in position and the disgestive tract is a straight tube. **Hepatopancreas**, the spongy digestive glands, arise as a diverticulum of the midgut. Circulatory system is open and typically arthropodan although the heart varies called **amoebocytes** which are involved in phagocytosis and blood clotting. The gills are the respiratory organs. They are uassly associated with segmental appendages. The ventilating currents produced by the beating of the appendaged are helpful in the exchange of gases.

The excretory organs are similar to the coxal glands of chelicerates and consist of an end sac, an excretory canal and a short exist duct (fig. 7.3). Depending on their postion, the excretory organs are called **antennal or maxillary glands.** Nervous system is characterized by varying degrees of concentrations and fusion of ganglia. Sense organs of crustaceans include simple and compound eyes, starcysts, sensory hairs. Compound eyes are highly developed.

Most crustaceans are dioecious. Certain appendages are modified for clasping the female during copulation and for sperm transfer. Some crustaceans also produce spermatophores. Many crustaceans have non- flagellated spermatozoa. Many crustaceans brood their eggs, for which there may be brood chamber at various parts of the body or other mechaisnms. There are amny larval stages larval stages in crustaceans; **nauplis, metanuplius, protozoea, zoea, mysis** and **megalopa** are some of them (fig. 7.31). Primitive crustaceans have fewer larval stages; more advanced forms have several larval stages.

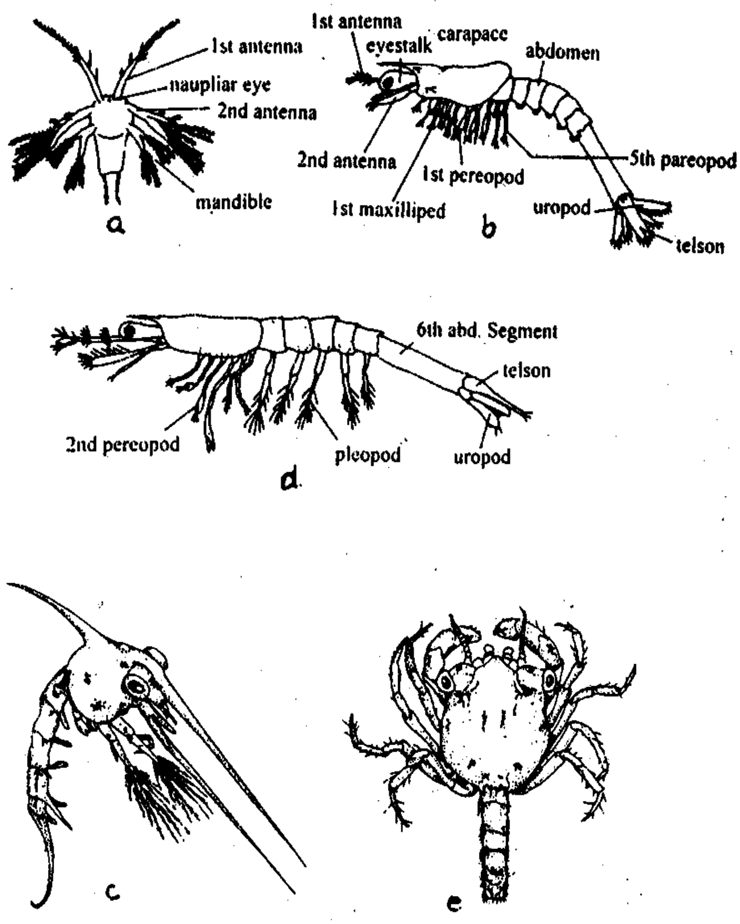


Fig.7. 31: some larval stages of crustaceans

(a) Nauplius **(b) Protozoea**

(c) Zoea **(d) Mysis**

(e) Megalopa

Crustacea include such a diversity of organisms that it is very diffuclt to give a concise account of its classification with any amount of justice to the subject, at the same time avaoiding confusion to the student. We here stick to our paln of classifying the group only upto classes, but attemopt has been made up to give example of representatives from various mnajor orders. The crustacea are accommodated into six major classes. These are:

(1) Branchiopoda
(2) Ostracoda
(3) Copepoda
(4) Branchiura
(5) Cirripedia
(6) Malacostraca

Class 1 Branchiopoda: These are small fresh water crustaceans. The trunk appendages are flattened and leaf like and are useful for locomotion as well as respiration hence the name Branchiopoda. The first antennae and second maxillae are much reduced. The anal segments bears a pair of large terminal processes called cercopods eg. Triops, the tadpole shrimp (fig. 7.32) *Branchinecta*, the fairly shrimp (fig. 7.33), *Daphnia*, waterfleas (fig. 7. 34), Artemia the brine shrimp (fig. 7.35) that lives in salt lakes and ponds.

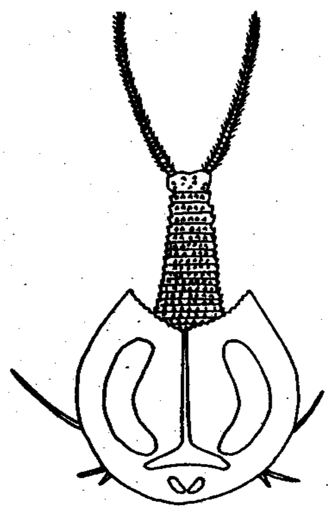


Fig.7.32: Triops

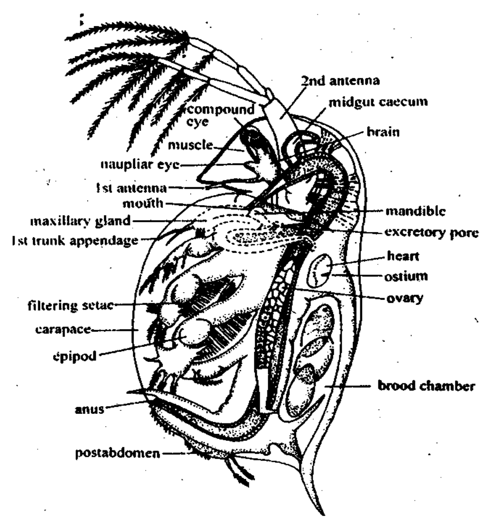


Fig.7.34:Daphnia

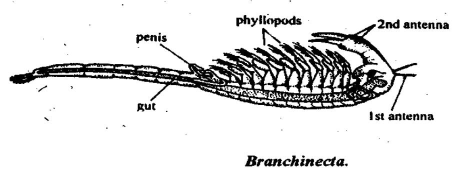


Fig. 7.33: Branchinecta,

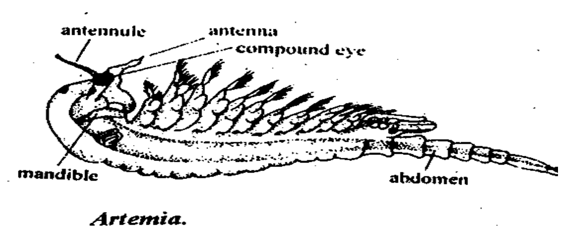


Fig. 7.35: Artemia.

Class 2 Ostracoda: Commonly called mussel or seed – shrimps, ostracods include both fresh water and marine forms. The small crustaceans, measuring a few mm have their body covered in a carapace formed by two elliptical values. The head is the dominant part of the body, with well developed appendages. The trunk is much reduced and segmented. Only two pairs of appendages are found. Single median eye is common among all ostracods and a few have sessile compound eyes. Some of the fresh water forms are parthenogenetic, eg. *Cypricercus, Gigantocypris, Cypris, Ponticypris Candona* (fig. 7.37)

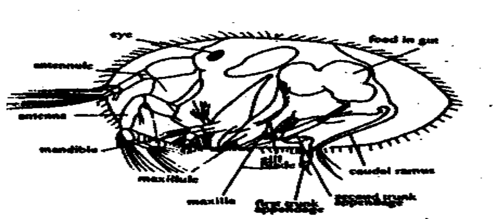


Fig. 7.36: Cypricercus

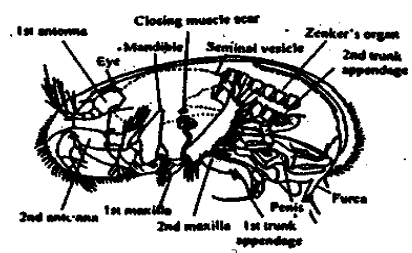


Fig. 7.37: Candoma

Class 3 Copepoda: Copepoda is a large class of small (1 -5mm) crustaceans occupying both marine and freshwater environments. Copepoda form the most abundant and conspicuous members of planktonic collection. Many are parastic. Most copepods are briglty coloured and some of the species are also bioluminescent. The body is cylindrical and tapering antero – posteriorly. The trunk is divided into thorax and abdomen.

The first and sometimes the second thoracic segment is fused with the head. A median eye is present. The first apir of antennae are large and uniramous. The first pair of thoracic appendaged are maxillepeds used for feeding. Abdomen has five segments and lacks appendages. Last abdominal segment has a pair of caudal rami. Planktonic copepods are either saprophytic feeders, or they may feed on phytoplankton or detritus. Some are carnivores.

Nauplius larval stage seen. e.g. Calanus, (Fig. 7.38) Diaptomus, Monstrilla, Haemocera (fig. 7.39) – both parasitic on polychaetes; salmincola and penella (fig. 7.40) – adults parasitic on freshwater and marine fish invertebrates. Cyclops (fig. 7.41) and Daropygus. Ergasitus (fig.7.42) Chondracanthus are parasitic copepods living in marine fish and invertebrates.

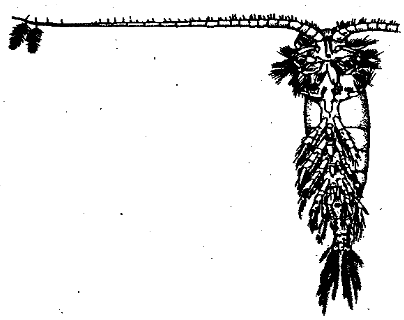


Fig. 7.42: Calanus

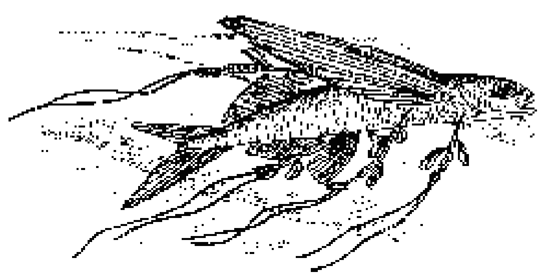


Fig. 7.39: Penella attached in flying fish

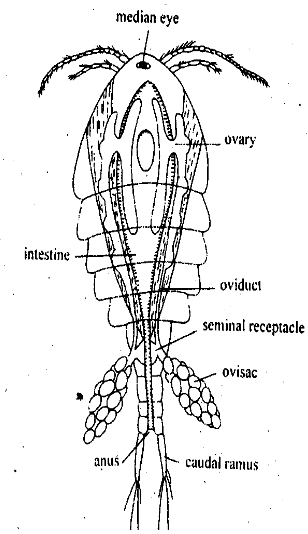


Fig. 7.41: Cyclops

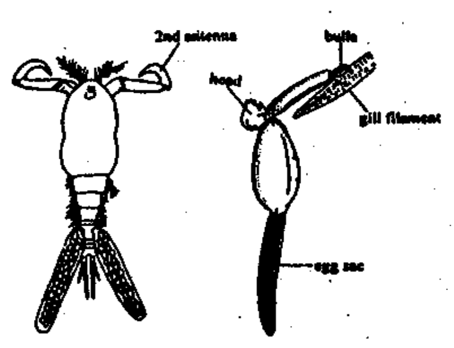


Fig. 7.41: Ergasilius

Class 4 Branchiura: Branchiura includes only around 130 species of ectoparasitic crustaceans living mostly on the integument and gill cavities of fresh water and marine fish feeding on the muscus and blood of their hosts. A pair of sessile compound eyes and a large shield like carapace that covers both the head and thorax are the distinguishing features of brachiran morphology. Abdomen is small, unsegmented and formed of two lobes. Both the pairs of antennae are much reduced.

The first pair of antennae are provided with a large calw to enable organisms to attch itself to the host. First pair of maxillae are also modified into large suckers aiding in the attachement to the host. There are no no maxillilps or they are vestigal. Mouth parsts are adapted are well developed; they enable the branchiurans to swim in water and switch from one host to the other. Eggs are deposited at the bottom of the waters. The larvae that emerge are also parasitic e.g *Argulus* (fig. 7.43) *Porocephalus.*

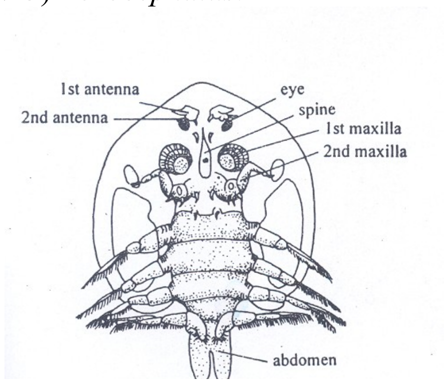


Fig. 7.47: Argulus

Class 5 Cirripedia: These crustaceans are exclusively marine and include the barnacles. Most species are free living attached to rock, shell, coral, timber and other objects. Some are parasites. Free living forms are either stalked or sessile. The stalked froms (goose barnacles) measure a few mm to 75cm in length. Sessile forms are a few centimenters long. Stalked forms have a muscular. Flexible stalk or **peduncle** which is attached to the substratum as its lower end and ahs the major parts of thebody, the **capitulum**, at the other end.

The peduncle is the preoral end of the animal and bears the vestiges of the larval first antennae and the cement glands. The secretion of the cement gland is adhesive in nature. The capitulum includes the entire body except the preoral parts. The body is covered by a carapace or the **mantle**. The mantle is covered by five plates (fig. 7.42); a posterior dorsal plate **carina,** a pair of **terga** and a pair of **scuta.** Sessile barnacles are attached to the substratum by a membranous or calcareous basis.

The forms the precoral region of the animal and contains cement glands. The animal is surrounded by a wall of plates and within this wall the animal is covered by an operculum formed by movable terga and scuta.

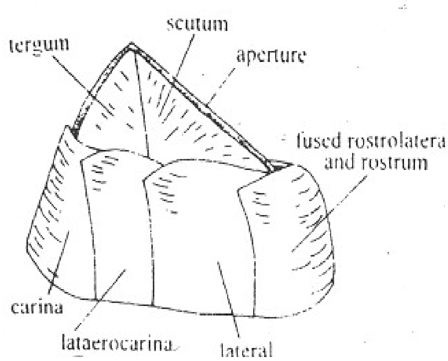
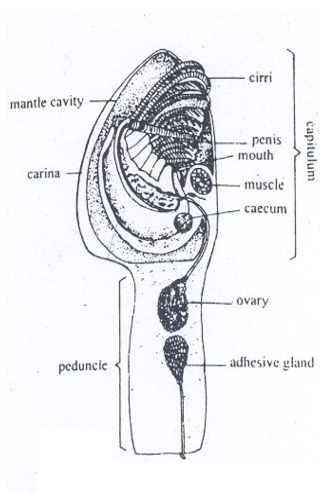


Fig. 7.44: Balanus – a sessile barnacle

Inside the shell, the soft body is held flexed at 90^0 to the point of attachement of the head and the thoracic appendages (cirri) are directed upward. The body is made up mostly of the head and thorax. There is no external evidence of segmentation. First pair of antennae are much reduced and the second pair are absent in adults. Six pairs of long biramous thoracic appensdaged called **cirri** are present (hence the name Cirripedia) (fig. 7.45). The cirri many long setae on them and are useful in suspension feeding.



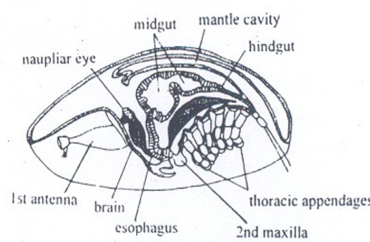


Fig. 7.44: Lepas – stalked barnacle – showing internal organisation

fig. 7.46: Cyris larva

Sexes may be separate or the animals may be hermaphrodites. Sperm transfer is direct. There are six nauplius instars before the emergence of non- feeding cypris larva (fig.7.46). The cypris larva settles onto a susbtratum and metamorphoses into an adult eg. Ascothorax, (fig. 7.47) Dendrog faster – parasitic on invertebrates. Trypetesa, Berndtia – bore into calcareous substratum such as shells or corals. Lepas (fig. 7.48), Scalpellum, Verruca are all freeliving barnacles or commensal.

Sacculina (fig.7.49), peltogasterella belong to the other Rhizocephala; they are parasitic in tunicates. Appendages and digestive system are absent. From the peduncle absorptive processes are given out to obtain nourishment from the hosts.

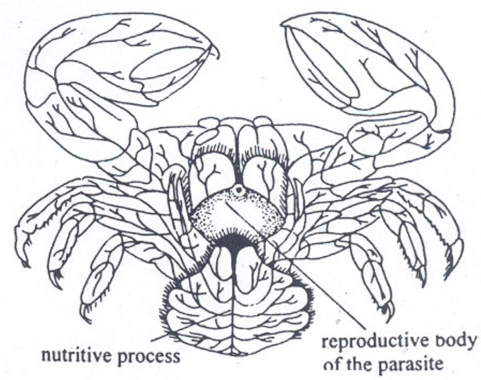


Fig. 7.47: Sacculina

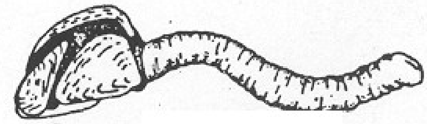


Fig.7.48: Lepas

Class 6 Malacostraca: Malacostraca includes most of the larger forms such as crabs, lobsters, shrimps etc. and constitute the majority of crustacean species. The cephalic region is formed by the dusion of five segments; the trunk region consists of five thoracic and six abdominal segments. Additionally, a postabdominal telson forms part of the tail fin. A carapace covering the thorax may or may not be present. The thoracic appendages called **paraeopods** or walking legs have well developed endopodites used for crawling and prehension. The thoracic legs have gills, usually modified epipodites.

In many malacostracans, first apair of thoracic appendages are modified into maxillepeds used for feeding. The first five pairs of abdominal appendaged called pleopods are the swimming legs. Besides swimming, they may also be used for burrowing, carrying eggs in females and often for gas exchange. In males the first pair of abdominal appebdagesare modified as copulatory organs.

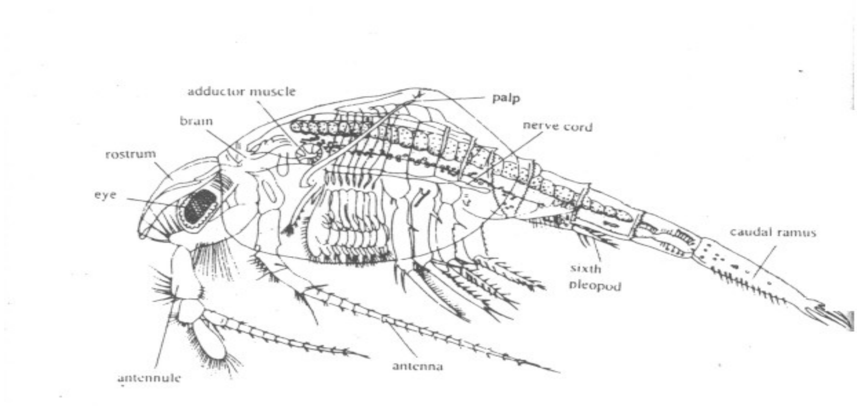


Fig. 7.49: Nebalia

Malacostraca generally have a foegut modified as a two chambered stomach with triturating teeth and comblike filtering setae. The female gonopores are located on the six thoracic segment and the male gonopore on the eight. The life cycle of malacostracans include many larval stages but the nauplius stage is usally passed in the egg. Nebalis (fig. 7.49) in many respects differs from most other malacostracans, and is included with a few other similair species, under subclass phyllocarida (order Leptos traca).

It has eight abdominal segments. The group is supposed to be the most primitive of the present day malacostracans. First thoracic segment fused with head. Anaspides (fig. 7.51); freshwater forms; Euphausia (fig.7.51); one of the krills that is pelagic in marine waters. Biramous thoracic appendages; the anterior ones are not modifies into maxillipeds. Gills not tightly enclosed in a carapace.

Fig. 7.50: Anaspides

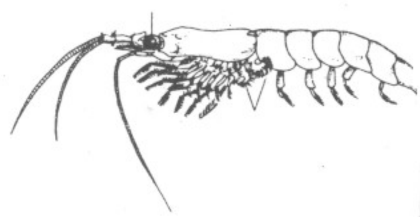


Fig. 7.51: Euphausia

In the order Decapoda the first threeepiars of thoracic appendages are modifiedf as food capturing devices, the maxillipeds. Gills are tightly enclosed in carapace. This includes freshwater, brackish water and marine forms commonly know as:
Shrimps: e.g. Penaeus (fig. 7.52) and palaemontes, macrobrachium

(Fig. 7.53, (fig 7.54)
Crayfish; e.g. Astacus.
Lobster; e.g. Homoraus, palinurus;
Hermit cayfish; e.g Clibanarius;
Mole crabs; e.g. Hippa, (fig. 7.55) Albunea; and
Crabs; e.g. Portunus, Potamon, Uca, Ocypode
Other malacostracan examples are;

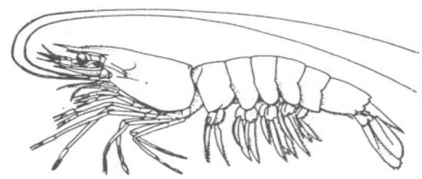


Fig.7.52: Penaeus

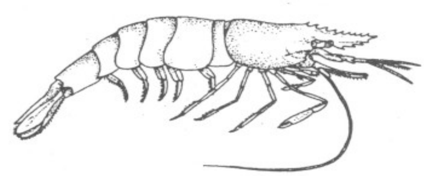


Fig. 7.53: Palaemontes

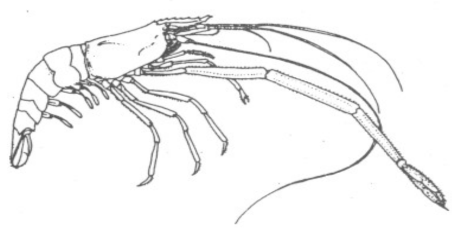


Fig.7.54: Macrobrachium

Mysis, Diastylis, (fig. 7.56); *Armadillidium* and Ligia (fig. 7.57) are dorsoventrally flattened and terrestrial, known as wood lice, belonging to order isopoda; *Tanais, Leptochelia.*

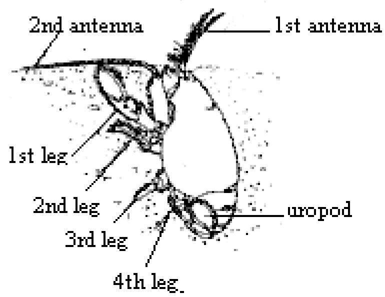


Fig. 7.55: Hippa

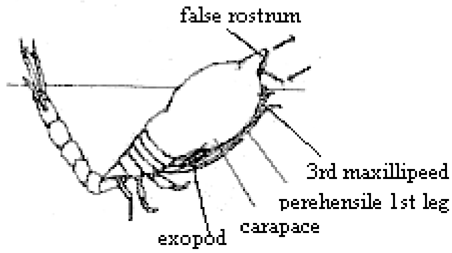


Fig 7.56 : Diastylis

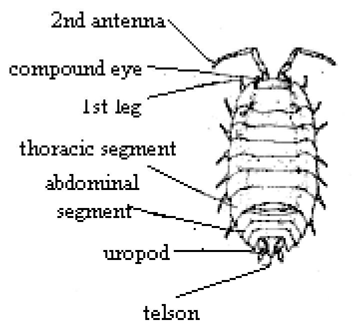


Fig. 7.57: Ligia

SAQ3

1. Indicate whether the following are true or false.

1. In most crustaceans there is fusion of head and thorax to form cephalothorax. T/F

2. There are six pairs of appendages in the head of crustaceans corresponding to six segments. T/F

3. Protopodit, exopodite and endopodite are three divisions of the appendages of crustaceans.T/F

4. In crustaceans maxillipeds are the trunk appendages modified for filter feeding. T/F

5. Trachea are the respiratory structures of crustaceans T/F

6. The excretory organs of crustaceans are called antennary or maxillary glands dependinmg on their postion.T/F

7. Most crustaceans are hermaphrodites.T/F

8. Crustaceans mosatly undergo direct development into adults, without passing through larval stages.T/F

9. Malacostracans account for over 60% of asll the crustaceans. T/F

10. Crabs, molecrabs and horseshoe crabs are all the members of the subphylum crustacean. T/F

11. Match the items in A with those in B

A.Branchiopoda	(i) Mussel shrimps
B.Ostracoda	(ii) Barnacles
C.Copepoda	(iii) Argulus
D.Branchiura	(iv) Losters
E.Cirripedia	(v) Water fleas
F.Malacostraca	(vi) Cyclops

3.1.3 Subphylum Uniramia

Uniramia, the largest subphylum of phylum Arthropoda includes myriapods and insects. Because of the unbranched nature of the appendages of its members, the subphylum is designed uniramia, as against those of crustaceans and primitive chelicerates that are branched and hence biramous. The uniramians have mandibles which are non – jointed, unbranched appendages without any palps; there have only a single pair of antennae which correspond to the second cephalic segments (second anbtennae). Uniramians having taken to terrestrial mode of life, have developed trachea as gas exchange organs, hence the subphylum is also known as **Tracheata.**

Malpighian tubules are the excretory organs. Uniramia includes over a million species of arthropods, of which nearly a million species are insects. About 10,500 species belong to four other classes **Chilopoda, Diplopoda, pauropoda** and **Symplyla.** These latter four groups are collectively known as myriapodous athropods. Let us now studsy briefly the calss characters of each class of uniramia.

Class 1 Chilopoda: Chilopoda comprise the centipedes (fig. 7.58). The class contains some 2500 specoes that have been described so far.

They inhabit both tropical and temperate regions of the world, living in soil and humus, beneath stones, barks and logs.

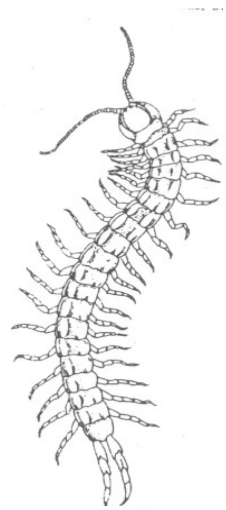


Fig. 7.58: A centipede

They have somewhat flattened body and generally measure from 3 -20cm in length and are red, brown, green, blue, yellow or in combination of these colours. Pair of **antennae,** a pair of **mandibles** and two pairs of **maxillae** are the appendages of the head.covering these is a large pair of maxillipeds (forcipules or the poision claws) which are the appendages of first pair trunk segments. Each forcipule ends in a terminal pointed fang through which the duct of the poision gland opens.

Following the first trunk segment there may be 15 or more trunk segments each having a pair of legs and the last pairs of legs has sensory or defensive function. Appendages are usaully absent in the last two trunk segments. These animals are generally adapted for running.

For this purpose the legs are long and are of same length. The centipedes are predators and feed mostly on other arthropods. Prey is paralysed with forcipules. Some forms, partial digestion of the food may occur before ingestion. The digestive system (fig. 7.59) is a straight tube and the salivary glands open into the buccal region. Gas exchange is carried out by the tracheal system and usually there is one pair of spiracles per segment. The spiracles cannot be closed. Amny of the chilopods have a single pair of Malpighian tubules.

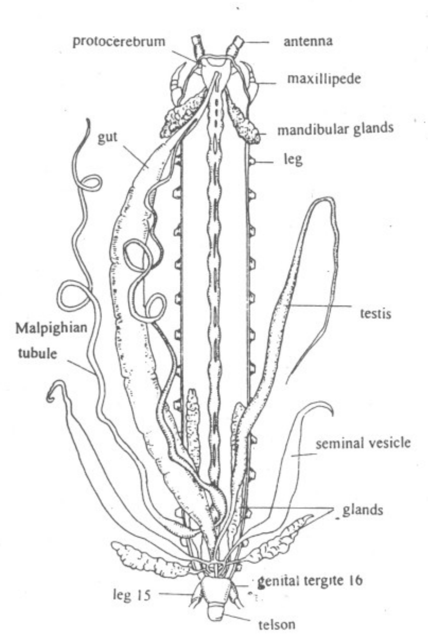


Fig. 7.59: Internal structure of a centipede.

The nervous system is typical arthropodan. Eyes are absent in many; but in some form a few to many oceli may be present. Many chilopods have a sense organs called **organ of Tomosvary** of uncertain function located in the head at the base of antennae. It may detect vibrations. The ovary is an unpaired, tubular structure lying above the gut and oviduct opens to the exterior by an aperture located on the ventral surface of the posterior legless ventral segement.

The testes are paired and the common genital segment. The genital segments of both sexes carries small appendages called gonopods. Sperm transfer is indirect, via spermatophores. Centipeds exhibit courtship behaviour. The young hatching out of the egg, may have full complement of segments (epimorphic development), or in some species the young may have only a limited number of segments (**anamorphic development**); the rest they acquire later.

Examples:
Geophilus, Strigamia; Scolopendra, Theatops, Lithobius; Scutigera (fig.). Young ones do not possess the full complement of segments on hatching. Adults have 15 pairs of legs.

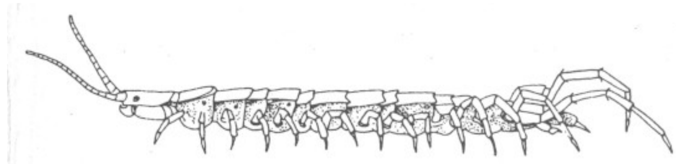


Fig.7. 60: Lithobius

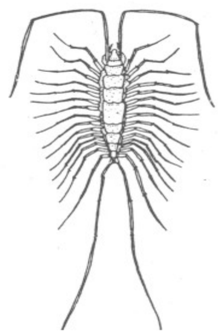


Fig. 7.61: Scutigera

Class 2 Diplopoda: Diplopoda comprise the millipedes which are anoctural and live beneath leaves, stones, bark and logs as well as in soil an in caves. As the name indicates, these have large number of legs. They are mostly cydrindical and are abundant in the tropics. They vary in size from 2mm as in *polyxenus* to nearly 30cm as in Spirostreptus. The distinguishing feature of diplopods is the presence of **diplosegments** (fig.7.62), formed by the fusion of two originally separate segments.

Each diplosegment bears two pairs of ventral ganglia two pairs of legs, two pairs of ostia in the heart and two pairs of spiracles. The head bears a pair of large chitinous mandibles and a fused pair of maxillae called **gnhathocilarium** (fig 7.61). The second pair of maxillae are absent. The first segment following head is legelss and is called the collum. The collum is not a diplosegment. The second, third and fourth segments carry only one pair of legs. In some millipedes the last five segments may also be legless. The trunk ends in a telson at the base of which the anus opens. The exoskeleton of most the millipedes is impregnated with calcium carbonate.

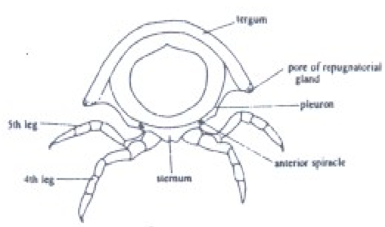


Fig. 7.61: A diplosegment

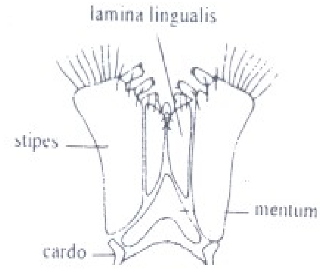


Fig.7.62: Gnhathocilarium

Millipedes are generally herbivorous feeding on decomposing vegetation. The food moistened by salivary secretions is scraped by mandibles. Some millipedes feed on plant juices. A few are carnovrous predating on insects, earthworms and centipedes. Respiration is by tracheal sytem. Each diplosegments has two pairs of spiracles in the stermum. There is a tubular heart that ends blindly posteriorly but contiues anterioly as an aorta. Excretion is by a pair of Malpighian tubules. Eyes are generally absent but sone forms of have oceli which vary 2 to 80 in number. The tectlic hjairs and conical projections present in antennae serve as chemorecptors. As in centipeded organ of Tomosvary is present in millipeds also.

A pair of long, fused tubular ovaries are present. The two oviducts open separqtely into a pounch like strium locates in the thirs segment known as gential segment. Testes appear as paired structures with transverse connections. In malkes the pserm ducts open at the base of the second apir of legs. Millipedes also fabricate spermatophores for sperm transfer. As in centipeds there is courtship behaviour prior to mating. Most millipedes reproduce parthenogentically. Development is anamorphic. The eggs which hatch after several weeks produce young ones with only three pairs of legs and seven segments. Additionally legs and segments are added with each moult.

Examples:

Ployxenus (fig. 7.61), *Lophoproctus*, minute with soft integument. The integumewnt has scale like, setae, 13 to 17 pairs of legs are present. No gonopods. Distribution is worldwide; Glomeridesmus, Sphaerotherium (fig. 7.6), and the pill millipede; *Glomeris* (fig. 7.64) are the forms with arched tergal plates; last two apirs of legs modified for clasping; Polyzonium, (fig.7.62): Narceus, Rhinocrius, Spirostreptus. (Fig.7.65) Orthoporus; Julus, Blanilus, Chordeuma (fig. 7.66) have one or two pairs of legs located on the seventh segment are modified as gonopods for sperm transfer; polydesmus, Oxidus, flat back, with lateral tergal keels; gonopods present; Cleidogono Choredeuma.

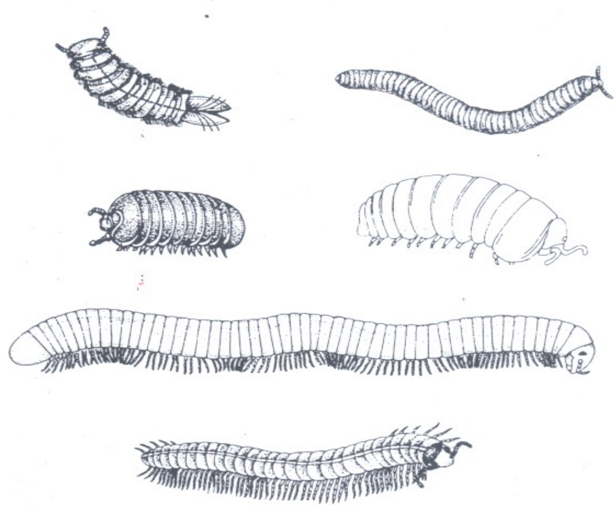


Fig. 7.63: Polyxenus **Fig. 7.64: Polyzonium**
Fig.7.65: Sphaeraotherium **Fig. 7.66: Glomeris**
Fig. 7.67: Spirostreptus. **Fig. 7.68: Chordeuma**

Class 3 Pauropoda: A small group of uniramains, there are 500 speices of pauropods described so far. The minute organisms measuring about 1.5mm in length live in leaf mold or in soil. The body is eleventh segements are legless. The tergal plates are very large. Overlapping adjacent segments. The collu, pf pauropods is inconspicuous dorsally but expanded ventrally. The head bears on each side a sense organs comparable to the organ of Tomosvary.

The antennae are biramous. One branch ends in a single flagellum and the other in two flagella and a club shaped sensory structure.pauropods mostly feed on decomposing plant tissue. Heart and trachea are usually absent owing to the small size of the organism. The third trunk segment is the gential segment. Sperm transfer is indirect and via spermattophores. Devrlpoemnt is anamorphic. Examples: Pauropus (fig. 7.69) *Allopauropus.*

Fig. 7.69: Pauropus

Class 4 Symphyla: Symphyla is yet another small myriapodous group that includes around 160 described species. These are also soil living forms and live in leaf molds as well. They measure around 1 to 8mm in length and have a trunk made of 13 segments but 15 – 22 tergal plates. Only 12 segments bear a pair of legs each and the 13th segment bears a pair of cerci or spinnerets. The 13th segement also bears a pair of sensory hairs called **trichobothria.** These animals can run through humus. The trunk terminates in a tiny telson. Mouth parts include a pair of mandibles, two apirs of maxullae of which the second pair of maxillae is fused to form labium.

A pair of spiracles opens, on each side of the head and the trachea arising from them supply only the first three segments. Eyes are absent but a pair of Tomosvary's organs are present. Symphylans exhibit peculiar copulatory behaviour. The males deposit 150 to 450 spermatophores which are swaalowed by the female. There are stored in special buccal pouches. Then she releases the eggs through a single gonopore located on the ventral surface of the fouth segment. The eggs are attached to the substratum and the sperms are smeared over the eggs by the female to fertilize them. Development is anamorphic. Pathenogensis is also common in symphylans eg. Scutigeralla (fig. 7.68).

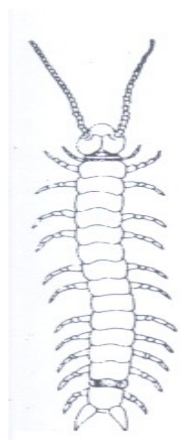


Fig. 7.70: Scutigeralla

SAQ 4

Write brief answers to the following questions:

1. Why is the name Uniramia given to centipedes, millipedes and insects?

2. Name the five classes included under the symphyla Uniramia?

3. Name the cephalic appendages of chilopods.

4. What is a diplosegments**?**

5. a. The fused pair of maxillae of millipedes is called------------------
   b. The legless first trunk segment of millipedes is--------------------

6. What is the peculiarity of the antennae of pauropods?

7. What is the sperm transfer mechanism in symphylans?

Class 5 Insecta: Class insecta contins nearly a million described species. There are more species of insects that all the other species of animals combined. The most important characteristics features of insects are the division of body into three tagmata namely, head, thorax and abdomen; presence of three pairs of legs and two apirs of wings on the thoracic region of the body, though some insects may have no wings.

Insects have conquered the terrerstrail environment so completely that they occupy every possible niche. They have also invaded the aquatic habitats though there are only a few marine species. Insects affect then ecology and human life in a number of ways. They have been both friends and foes of man.evolution of flight, an impermeable cuticle and tracheal respirartin are some of the factors that have contributed to their success on land.

The head of insects is a composite structure. It bears a pair of antennae and a pair of compound eyes. There are also usually three ocelli. Three pairs of appendages constitute the mouth parts. They are a pair of **mandibles** and two pairs of **maxillae,** of which the second apir of maxillae are fused to form the labium. The mandibles are covered in front by an upper lip or **labium**. Into the anterior region of buccal cavity projects a median lobe like process the epipharynx. This arises from the base of the labium.

The head is followed by a three segmented thorax – prothorax, **mesothorax** and **metathorax** (fig. 7.69). The tergum of the thoracic segments of insects is known as **notum**. The two pairs of wings articulate with meso and metathorax. While some primitive insects do not have wings (apterygotes), some higher forms have lost their wings secondarily. A pair of legs articulate with each of the three thoracic segments. Each leg is a jointed structre formed by **coxa, trochanster, femur, tibia, and tarsus**. The legs of different insects are variously modified to suit various functions like walking, food clothing etc. the abdomen is composed of 9 to 11 segments. Abdomen bears a pair of sensory structure called anal cerei on the 11^{th} segment. An intromittent organ in males for the transfer of spermatozoa and an ovipositor in females for the deposition of eggs are also present in the genital segments of insects.

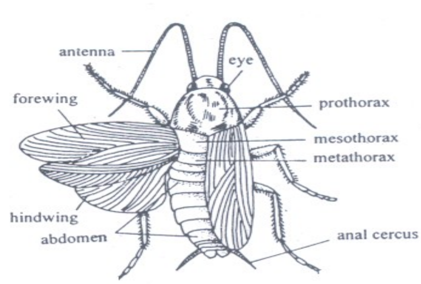


Fig. 7.70: Cockroach external organsiation

Mouthparts:
Insects have adapted themselves to a variety of food habits. Consequently their mouth parts, the porgans of feeding, are also variously modified.

These can be broadly divided into two types: (1) Mouth parts adapted for bitting and chewing solid fof. These are considered more primitive (2) those adapted for sucking upliqiud food. These are derived from the former, by elongation of certain components and loss of certain other.

1. **Bitting and chewing type**: These are found in many insects like the primitive apterygotes, crickets, grassphoppers, cockroaches etc. they consist of an unpaires labrum or upper lip in front of the mouth; a pair of mandibles and a pair of maxillae along the sides, and a labium forming the lower lip (fig. 7.70) hypopharynx behind the mouth.

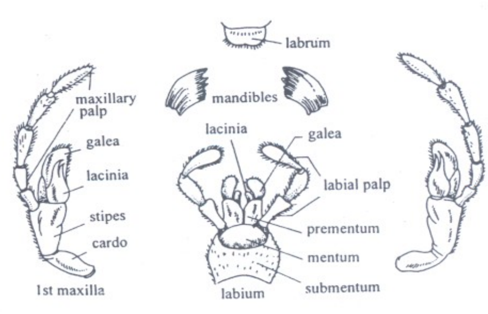


Fig. 7.71: Mouth parts of cockroach.

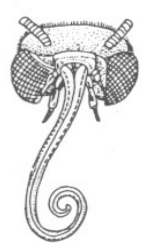
The mandibles ar strongly sclerotised, poften differentiated into a bitting incisor region and a chewing molar region. They are provided with string muscles and are articulated with the cranium.

The maxillae are made up of many aprts. The proximal part has a bascal cardo, and a flat distsl stipes carries two lobes; an outer galea; the stipes also has an outer, jointed palp. The palp is ensory by means of which the insect checks the quality of food. by means of lacinea and galea, food is scraped into mouth they are also used for cleaning.

The labium is comparable in structure to the maxillae, but fused along the median line. It has a basal postemetum which is constituted by a proximal submentum and a distal mentum.
Metum carries a prementum in front. The prementum has four lobes in front two glasses medially and two paraglossae laterally. Glossae, together with paralossae are known as ligula. Prementum also carries a pair of jointed palps laterally. The hypopharynx is a lobe behind the mouth; the duct of the salivary glands opens at its base.

2. **Sucking type**: In moths and butterflies, the mouth parts are adapted for sucking nectar from flowers (fig.). Here, the two galea forma along tube (proboscis) for sucking food. The proboscis is kept coiled when the insect is not feeding.

   In bees (fig. 7.72) the galea and labial palps form a tube around the long fused glossae. Labrum and mandiubles are retained in the chewing condition, to handle pollen and wax.



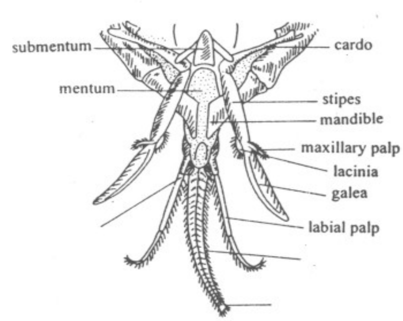


Fig.7.72: Mouth parts of a butterfly
Fig. 7.73: Mouth parts of a honeybee

Piercing mouth parts are found in insects such as plant bugs and aphids which suck plant juice, as well as in blood sucking insects like mosquites. In these insects, the mouth parts are elongated to form a long beak in different ways. In bugs (fig.) the mandibles and maxillae form opposing styles. These lie in the labium which forms a groove covering them. The paired stylets form separate salivary and food canals. In mosquitoes (fig. 7.73) however, labrum and the labrum together form the food canal, whereas the saluivary canal runs through the hypopharynx.

In the biting flies the sharp mandibles produce a wound; the blood coming out is collected by a sponge like labrium, and carried to the mouth by means of a tube formed of hypopharynx and aprt of the labrum (**epipharynx**). In house flies (fig.) sponge - like labium serves the purpose, mandibles being reduced. Closely associated with salivary pump for injecting saliva are also present.

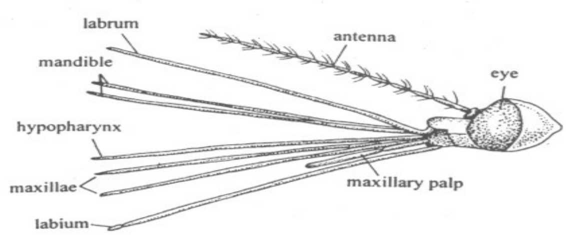


Fig.7. 74: Mouth parts of a mosquito

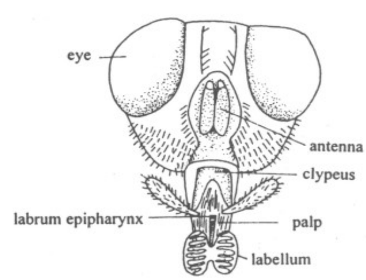


Fig. 7.75: Mouth parts of a house fly

The alimentary canal (fig. 7.75) of insects has three regions, the **foregut**, the **midgut** and the **hindgut**. The foregut and hgiondgut are lined with cuticle and the midgut with a **peritrophic membrane**. The foregut consists of a **pharynx, oesophagus, crop** and **proventriculus** or **gizzard**. Many insects possess a pair of salivary glands as digestive glands. The midgut, variously named as venticulus or mesenteron is a tubular structure and is the main site of enzme secretion and digestion. At the junction of foregut and midgut, fingerlike projections called gastric cacea or heptalic caeca are present. The hingut shows three divisions, **ileum, colon** and **rectum**.

The body cavity of the insects is a blood filled space for **haemocoel.** Structure called **fatbody** are present in haemocoel. Fatbody is the site of storage in insects and is comparable to liver of vertebrates in its functioning.

The circulatory sytem consists of a tubular heart that is enclosed in a pericardium (fig. 7.76) the tubular heart extends through the first nine abdominal segments. Anteriorly the heart continues as aorta. The blood contains a variety of haemocytes. It plays very little role in gas exchange. Gas exchange is carried out by a well developed **tracheal** system (fig. 7.77). Eight to ten pairs of spiracles are generally located on the lateral surface in the plural memberane.

The spiracle leads into a trachea which branches sand finally end in minutr tubules the **tracheoles** (fig. 7.74). Exchange of gases occurs by diffusion. Aquatic insects which utilize dissolved oxygen I water have structures called gills (eg. larvae pf dragonflies and of mayflies) Aquatic insects which depend on the atmosphere air for their oxygen needs, trap air in the form of bubbles or film held against the body surface by special unwettable hydrofuge hairs.

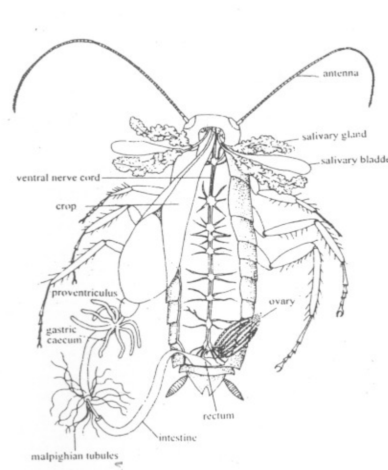


Fig. 7.76: Visera of a cockroach

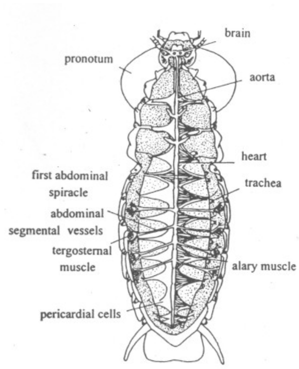


Fig. 7.77: Cirulatory system of cockroach.

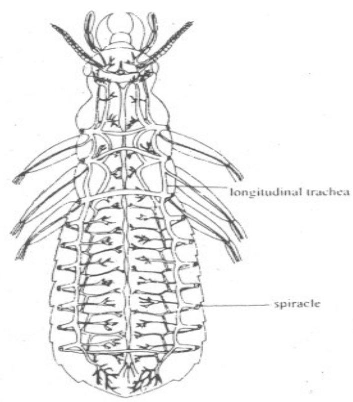


Fig. 7.78: Tracheal system of cockroach

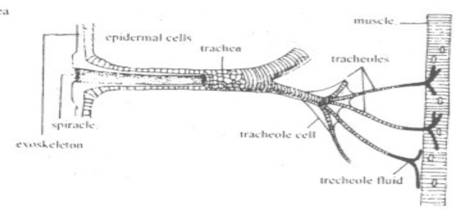


Fig. 7.79: Trachcolex and their ending in tissues

In most insects excretion is carried out by Malpighian tubules. The Mapighian tubules are attached to the junction of midgut and their distal ends lies freely in the haeamocoel. The tubules vary in number from two to 250.

Insects possess typically arthropodan nervous sytem. Brain, subocohageal ganglia, double ventral nerve cord and segmental ganglia are the components of nervous systems. In some insects the fusion of ganglia has taken place more commonly in the abdomen. Corpora cardiaca and corpora allata located ventral to the brain and prothoracic glands are the endodrine glands in insects that regulate the growth metamorphosis and reproduction.

Most insects have well developed compound eyes. In addition, various types of sensila also occur all over the body, and in large numbers at particular palces froming peculiar organs discharging various functions. **Tympanic organs** for examples are found in grasshoppers, cicadas and crickets.

In females the reproductive system consists of a pair of ovaries (fig. 7.79a). Each ovary is formed of tubular structure called ovaries, and paired oviducts which unite to form a common oviduct. The common oviduct opens ventrally in the 7th, 8th, or 9th segment. **Spermathecae** or **seminal receptacles** which are the sperm storage structure and various accessory reproductive glands are also present. The male reproductive system consists of a pair of testes, a pair of lateral ducts and a median duct that opens through a ventral penis called aedegus located in nthe 8th segment (fig., 7.79b).

Sperm transfer may be dirct of as spermatophores. Devlpoment may occur without metamorphosis as in silver fish, or incomplete metamorphosis as in bugs where the young ones resemble the adults excepty for the developwemtn of wings and reproductive organs. Complete metamorphosis (fig. 7.80) occur in many as in butterflies, beetles and houseflies. Ion these insects the larva does not resemble the aduly and developes into a nonfeeding quiescent pupa before becoming as adult.

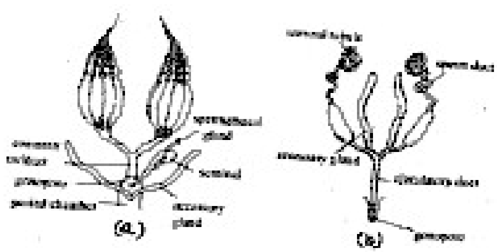


Fig. 7.80: Reproductive sytem of an insect (a) female (b) male

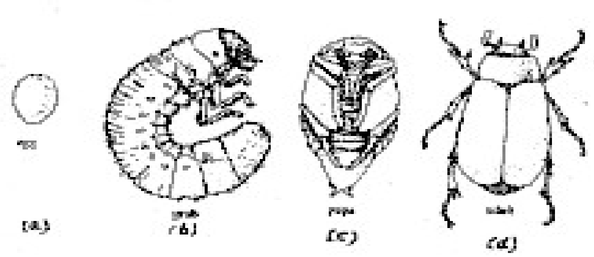


Fig. 7.81: Complete metamorphosis in a beetle (a) egg (b) gruel (c) Pupa (d) adult.

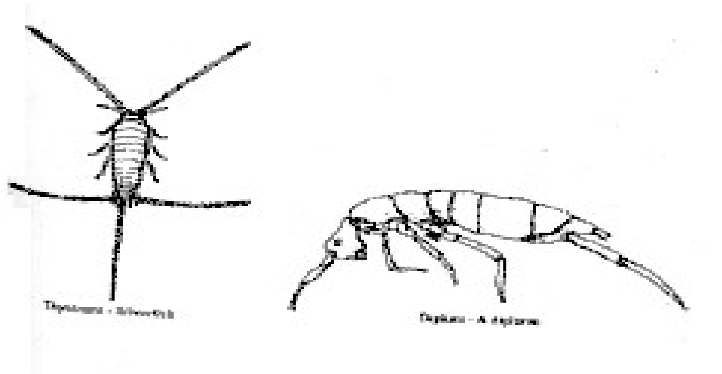
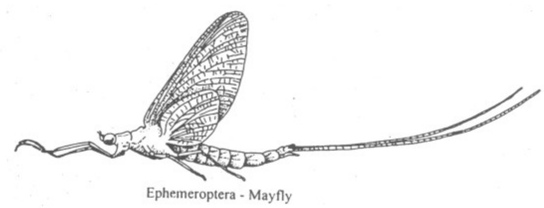
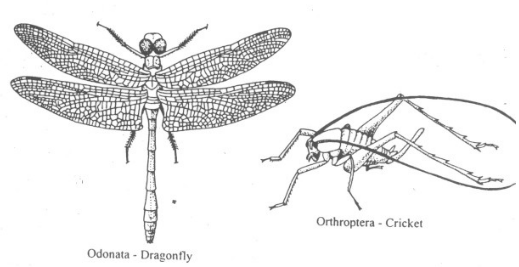


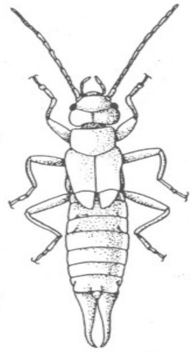
Fig. 7.82: Example of insects.



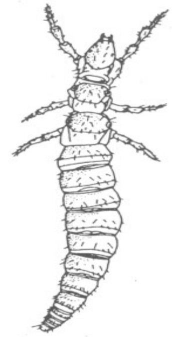
Ehenmeroptera – Mayfly



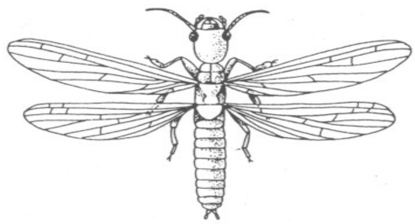
Ododnata – Dragonfly **Orthroptera – Cricket**



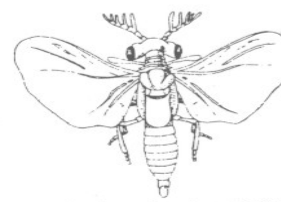
Dermaptera - Earwig



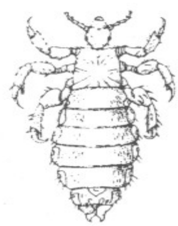
Protura - A proturan



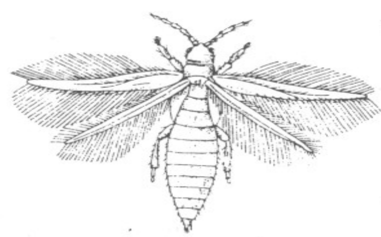
Isoptera - Termite



Strepsiptera - Twisted wing parasite

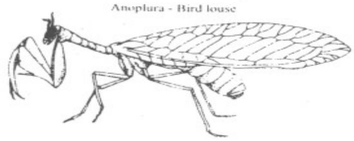


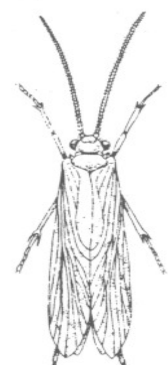
Mallophaga - Head louse



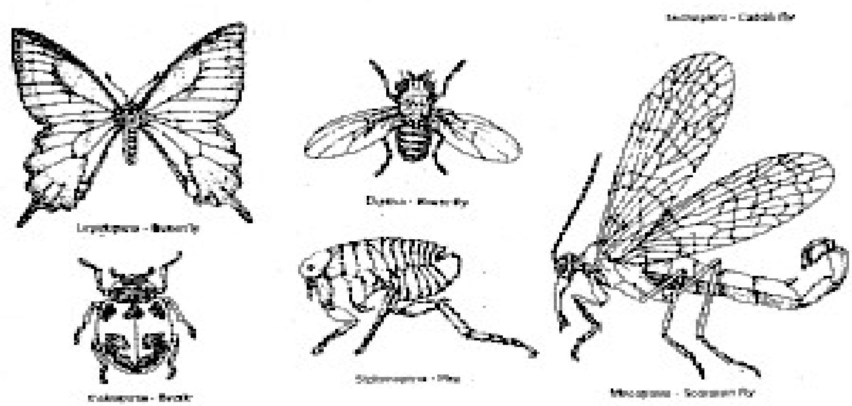
Anoplura - Bird louse

Hom. ptera - Tree hopper





Trichoptera - Caddis fly



Example of insects (Contd.)

SAQ 5

1. State whether the following are true or false

1. Class insecta is the largest calss in the animal kingdom. T/F
2. The presence of three pairs of legs, main digestive system and the presence of mouth are the reasons for the sucesss of insects in terrestrial environment. T/F

3. The body of insects ius made up of three tagamta.T/F

4. The two pairs of insect wings articulated with pro and mesothorax T/F

5. The mouth parts of all adult insects are indentical in structure despite the differences n their food habits. T/F

6. Haemocoel is the site of intermediary metabolism in insects. T/F

7. The exchange of gases in the trachyeal sytel of insects occurs by diffusion.T/F

8. All aquatic insetcs depend on dissolved oxygen in water for their respiratory needs.T/F

9. The secretion of prothoracic glands regulate metamorphosis in insects. T/F

11. Match the insects listed in A to their respective orders listed in B.

A	B
1. Silver fish	a. Lepidoptera
2. Grasshopper	b. Colecoptera

3. Plant bug	c. Hymenoptera
4. Dragonfly	d. Ephemeroptera
5. Mayfly	e. Thysanura
6. Housefly	f. Hemiptera
7. Beetle	g. Odonata
8. Moth	h. Orthroptera
9. Wasp	i. Isoptera
10. Termites	j. Diptera.

3.2 Phylumm Onychophora

3.2.1 Charactersitics Features

1. Free living terrestrial
2. Body is bilaterally symmetrical, elongated, cydrindrical, vermiform, with tissues and organs.
3. Body wall has thin flexible, chitinous cuticle over epidermis, layers of circular, oblique and longiotitudianl smooth muscles beneath.
4. 14 - 43 pairs of short, unjointed, fleshy legs which are hollow invaginations of body wall with terminal pad and terminal claws.
5. Gut straight, complete, with a pair of claw – like mandible; foregut and hindgut lined with cuticle; no digestive diverticula.
6. Body cavity is a well developed haemocoel
7. Open circualroty sytem with tubulart heart but no othjer blood vessels; paired ostia present.
8. Serial pairs of excretory organs; anteriorly they form salivary glands and posteriorly gonadoducts.
9. Respiration through tracheae which are simple and tubular but appear in bundles, openings out through large number of small spiracles scattered all over the body.
10. Nervous system consists of a brain and ladder - like ventral nerve cord widely separates. Sense organs consists of a pair of antennae amd simple eyes.

11. Sexes are separate; gonads paired; produce spermatophore. Fertilization internal; developement direct.

Onychophora are a small group of invertebrates closely related to arthropods. They have not changed much in their structure since cambrain period. The most common genus is peripatus (fig. 7.82). The group shows discontinous distribution and are mostly confirmed to tropical; regions of the world, found between stones, logs and leaves or along the banks of streams.

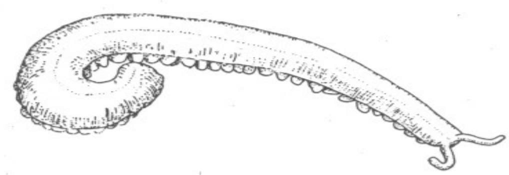


Fig.7. 84: Peripatus

The cylindrical body ranges from 1.5cm to 125cm in lerngth. The anterior end has pair of large annulated antennae and a ventral mouth (fig. 7.83). A pair of mandibles and a pair of conical papillae constitute the mouth parts. The number of legs vary from 14 to 43 pairs. These legs are the only external indications of metasmerism. The legs appear are non – jointed protuberancles from the body ending in a pair of claws. The body surface is covered with large and small tubercles encircling the trunk as well as the legs. The tubercles are covered with scales.

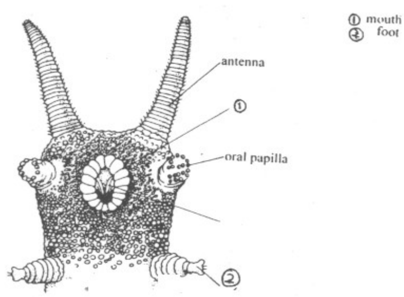


Fig. 7.85: Anterior end of an onychophoran

The body is covered by an exosketelon, the cuticle. The compostion of cuticle is very similar to that of arthropods. But there here it is thin, flexible, permeable and untanned (not sclerotised). Beaneth the cuticle there is a layer of epidermis and circular, diagonal and longitutudinal layers of smooth muscle fibres (fig. 7.84). thus the body wall is similar to those of annelids; and the coleom is reduced to gonadoal cavities and nephridia. As haemocoel is present as in arthropods.

Onychophorans are predators snd feed on small snails, insects and worms. A pair of slime glands (fig. 7.85) open at the end of the oral papillae. They produce slime which is squirted out to a distance of even upto 15cm. the slime hardens and engulfs the prey. The mouth leads into a chitin – lined foregut comprised of pharynx and oesophagus and this is followed by a large, straight intestine (fig. 7.86). The rectum opens through anus located at the posterior end of the body.

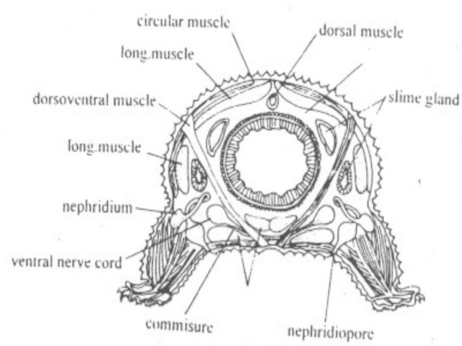


Fig.7.86: A cross section of the bodywall of an onychophoran

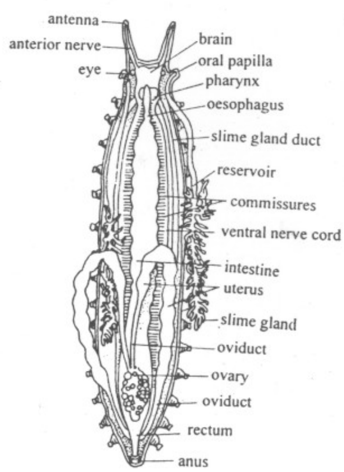


Fig. 7.86: Viscera of an Onychophoran

Circulatory system is open type. It consists of a tubular heart. Paired lateral ostia, pericardial sinus and haemocoel. The blood is colourless and contains phagocytic amoebocytes. Excretion is by paired nephridia which are serially repeated. The nephridiopore is located at the base of each leg. Respiration is by tracheal system and spiracles appear as minute openings located in large numbers all over the surface of the body between the lands and tubercles.

Nervous system has a bilobed brain and a ladder like nerve cord with a number of commissures. Antennae and the simple eves are the sensory structures of Onychophora. Sexes are separate. Some species transfer sperms as spermatophores. Onychophorans are oviparous or viviparous or ovoviviparous.

3.2.2 Affinities

Onychophorans possess both annelidan and arthropodan characters. Arthropodan characters include reduced coelom, chitionuous cuticle. Moulting Possession of appendages modified for feeding, tubular heart and haemocoel for circulation. The annelidan characters are suggested by the structure of the body wall, nephridia, and thin and flexible cuticle and non jointed appendages. Also onychophorans resemble annelids in the embryonic development. Onychophorans were once thought to be a missing link between Annelida and Arthropoda. It is now believed that onychophorans probably shared a common ancestor with arthropods.

4.0 Conclusion

In this unit you have learnt

- Pseudocoelomates, the fluid filled space served as a hydrostatic skeleton increasing the efficiency of burrowing and the organs lay loose in the body cavity. To overcome this disadvantage the coelom came to be lined by mesodermal layer i.e., peritoneal layer.

  Consequently the various organs also came to lie suspended in the coelom by mesodermal layer called mesenteries. This modification enabled the body wall to become more muscular with better developed longitudinal and circular muscles. With evolution, coelom became divided into number of chambers by partitions or septa made of the mesodermal lining. Each segment came to have a repetition of many other organ systems like circulatory, excretory, reproductive and nervous systems. Each segment of the body is known as a segment or metamere. The phylum comprises three classes namely Polychaeta, Oligochaeta, and Hirudinea.

- Phylum Arthopoda with over a million species is the largest phylum of Kingdom Animalia. The phylum includes four subphyla Trilobitomorpha, Crustacea, Chelicerata and Uniramia. Trilobitomorpha is an extinct group. Chelicerata includes three classes, Xiphosura (horse shoe crabs), Arachnida (scorpions, spiders, pseudoscotpions, phalangids etc.) and Pycnogonida (sea spiders). Subphylum Crustacea includes six classes. Class Branchiopoda (shrimps and water fleas), Class Ostraeoda (mussel shrimps), Class Copepoda (Cyclops), Class Branchiun (ectoparasites such as Argulus), Class Cirripedia (barnacles) and the largest class among crustaceans - Malacostraca (prawns, lobsters and crabs). And subphylum Uniramia includes five classes: Chilopoda (centipedes), Diplopoda (millipedes). Pauropoda (Pauropus), Symphyla (Scutigeralla) and the largest class of Animalia - Insecta which comprises of nearly a million species (cockroaches, grasshoppers, bugs, antlions- moths, butterflies, housefly, ants, bees wasps, beetles etc-).

- The appendages of head of arthropods are the food capturing devices and the postcephalic appendages are locomotory in function. The digestive sysicilt shores regional specialisation with foregut generally serciug as a storage and mastigatorv organ: the midgut is the region of digestion and absorption: and the hindgut is the region for processing and expelling the undigested waste materials. Respiration is ___by gills or book gills in aquatic forms and by trachea or book lungs in terrestrial forms.

- Excretion is carried out by coxal glands that are structurally homologous to metanephridia of annelids. Terrestrial arthropods have evolved structures called Malpighian tubules for the removal of nitrogenous waste materials. Circulation in arthropods is open type, and the body cavity filled with the body fluid: the liaemolymph, is called the haemocoel. Nervous system consists of a bilobed brain, segmental ganglia and a double ventral nerve cord. In many arthropods there is a fusion of segmental ganglia. A variety of sense organs to cam out tire functions of photoreception, chemoreception and mechanoreception are present in arthropods. Sexes are separate. Sperm transfer is either direct or via spernatophores. Fertilisation is internal. Developniem is through metamorphosis and includes more than one larval stage.

- Phylum Onychophora possesses characters that are both atmelidan and arthropodan. The embryonic development of onychophorans resembles those of annelids. Once believed to be the connecting link between Amielida and Arthropoda, phylum Onychophora probably shared a common ancestor with arthropods.

5.0 Summary

You have just leant about the largest phylum of kingdom Animalia, comprising over a million species. They are so many and so much around us to be ignored. From the household cockroaches, bedbugs, moths houseflies, ants, the field grasshopper, bees, spider, butterflies, tse – tse flies, wasps, beetles, beetles centipedes etc we would be ignoring them as our own peril. They are of economic importance to us in that they produce products like honey (e.g. bees), are agents of pollination in plants (e.g. butterfly) are pests to agricultural products (e.g. locusts) and are vectors for disease (e.g. tse tse fly, mosquito, and cockroach).

The onychophorans present an interesting study in that they serve as evolutionary links between Annelida and Arthropoda. It is very interesting how these phyla have survival over the ages.

6.0 Tutor Marked Assignment

I. Enumerate some major differences between Nematoda and Annelida.

2. List the characters of phylum Arthropoda.

3. a) Briefly describe the characters of subclass Xiphosura.
   b) Why is Xiphosura considered an evolutionary relic?

4. Write short notes on the following, with suitable diagrams.
   a) Book lungs of Arachnida   b) Pectines of scorpions
   c) Coxal glands of Arachnida.

5. Write descriptive notes on:
   a) Class copepoda   b) barnacles

6. Briefly describe the organisation of Malacostraca, Give a few examples of decapod malacostracans

7. What are the classes included under Uniramia '? Give examples of a few genera under each class.

8. What is a diplosegment? List the characters of class Diplopoda.

9. Insects have dominated the terrestrial environment. What are the reasons for the success of the insects in the terrestrial environment'?

10. Name the orders to which the following insects belong: a) silverfish b) grasshopper c) plant bug d) dragon fly e) antlion f) head louse g) moth i) housefly j) wasp k) beetle

7.0 Further Reading

1. Invertebrate Zoology by Rupert/ Barnes. 6th international Editions 1994

2. Integrated principles of Zoology by Hickman, Roberts and Larson. 9th Edition. 1995

Answers

SAQ I

l.
1. A million 2. Jointed legs 3. Homologus
4. Biramous, uniramous 5. Tergum, sternum, pleuron
6. Coelom 7. Coxal glands and malpighian tubules
8. Omnnatidia 9. Trilobitomorpha, Crustacea, Chelicerata. Uniramia.

11.
1. Segments fuse to form functional units called tagmata.
2. Segments carry jointed appendages.
3. Cilia are absent
4. Coelom is reduced and confined to the cavity enclosed by excretory organs and gonads.
5. Development often involves metamorphosis.

SAQ 2

1. 1. Primitive 2. Absence 3. Pedipalpi 4. Aquatic 5. Xiphosura
6. Arachnida 7. Metasoma 8. Araneae 9. Acarina

11.
1. Merosiomata, Arachnida, Pycnogonida. 2. Xiphosura
3. Living fossils 4, 1yriforrn organs 5. Pectines
6. Phalangids 7. Ectoparasitic
8. Tularemia, relapsing fever and Iyrne disease
9. Pseudostigmatic organ 10. Pycnogonida

SAQ 3

1. I. T 2.F 3.T 4.T 5.F 6.T 7.F S. F 9.T 10.F 11. A-v; B-i, C-vi:

SAQ 4

l. The appendages of millipedes, centipedes and insects are all unbranched, hence the name Uniran»a.

2. Chilopoda, Diplopoda, Pauropoda, Syntphyla and Insecta

3. A pair of antetnral. A pair of mandibles and two pairs of maxillae

4. A diplosegment is the segment of diplopods formed by the fusion of two originally separate segments.

5. (a) gnathochilarium (b) collum

6. The antennae of paurpods are biramous.

7. The males of Syraphyla deposit 150-450 spermatophores which are swallowed by the female. They are stored in buccal pouches. The sperm are subsequently smeared over the eggs once they are deposited.

SAQ5

1 I. T 2. F 3. T
11 1. e 2. 11 3. f
4. F 5. F 6. T
4. g 5. d 6. j
7. T 8. F 9. T

7. b 8. a 9. c 10. i

Answers to Terminal Questions.

1.	**Nematoda**	**Annelida**
Cuticle	Complex	Simple
Body cavity	pseudocoel	Coelom

Metamerisnn	absent	present
Muscles	Body wall with special type of muscle cells-neuromotor units. No circular muscles.	Well developed circular and longitudinal muscles for the body wall and alimentary canal
Cephelisation	Poor	Well developed
Blood vascular System	Nil	Well developed
Nervous system	Poorly developed	Well developed
Excretory system	Poorly developed	Well developed

2. Refer to section 6.2

3. Refer to class 3: Arachnida under subphylum Chelicerata (6.2.2)

4. a) and b) Refer to subclass Xiphosura under subsection 6.2.2

5. Refer to class 3: Copepoda and class 5: Cirripedia under subsection 6.2.3.

6. Refer to class 6: Malacostraca under subphylum Crustacea (6.2.3)

7. Class Chilopoda, class Diplopoda, class Pauropoda, class Symphyla and class Insecta.

   Chilopoda: *Scolopendra, Lithobius and Scutigera.*

   Diplopoda*: Spirostreptuç, Sphaerotherium Glomeris*

   Pauropoda*: Pauropus, Allopauropus*

   Symphyla*: Scutigerella*

   Insecta*: Periplanata, Musca. Apis*

8. *A* diplosegment, found in class Diplopoda, is formed by the fusion of two originally separate segments. Each-diplosegment bears two pairs of ventral ganglia, two pairs of legs, two pairs of ostia in the heart and two pairs of spiracles. For the characters of class Diplopoda refer under subsection 6.2.4.

9. Refer under class Insecta of subsection 6.2.4.

10 a) Thysanura b) Orthoptera c) Hemiptera d) Odonata
e) Neuroptera f) Anopleura g) Lepidoptera h) Diplera
i) Hymenoptera j) Coleoptera

Unit 8

PHYLUM MOLLUSCA

Table of contents

1.0 Introduction

In this unit we continue our study of coelomate invertebrates. You have learnt that coelom could be defined as a cavity lined by an epithelium of cells derived from the embryonic mesoderm. Phylum Molluscs which includes soft bodied animals with a shell is the first phylum that you will be studying in this unit.

This will be followed by the study of a group of spiny skinned, exclusively marine living animals, the echinoderms. Towards the end of the unit you will study the names of certain phyla, the minor phyla, each of which comprise of a limited number of species and whose systematic position is not very clear. As was done in the previous unit, in this unit also we shall describe the characters of each phylum, classify the phylum up to classes giving examples and briefly describe the organisation of the group.

2.0 Objectives

After studying this unit you should be able to:

1. Relate the general characters of phylum Molluscs and have a clear understanding of the major classes it comprises,

2. Briefly relate their structural organisation and mention the important characters of various classes included under the phylum mollusca.

3.1 Phylum Mollusca

Phylum Molluscs is one of the largest phyla among the invertebrates and includes over 50,000 living species and about 35,000 fossil species. They comprise **snails, clams** and **squids** etc. The rich fossil record of the phylum is due to the presence of a mineralised shell in many species. Although the majority of molluscs are aquatic, occupying both fresh and marine waters, some species live on land as well. We shall first study the general characters of the phylum and then study each class briefly.

3.2 Characteristic Features

1. Bilaterally symmetrical.

2. Generally there is a distinct head and a muscular foot; the dorsal body wall forms the mantle folds which enclose the mantle cavity.

3. Often there are gills and lungs for respiration, formed by modified mantle.

4. A hard, calcareous shell secreted by mantle, protecting the soft body, is common.
5. Coelom is limited to spaces around the heart (pericardial cavity), in the gonads and in the kidneys.

6. Circulatory system is open type in most forms, with heart, blood vessels and sinuses.

7. Excretory organs are metanephridia, the sac-like kidneys, opening proximally into the pericardium and distally into the mantle cavity.

8. Nervous system consists of well-developed ganglia (cerebral, pedal, pleural and visceral) most of them concentrated into a ring with connectives and commissures.

9. Digestive system is complex, with characteristic rasping organ, the radula; anus emptying into the mantle cavity.

10. Spiral cleavage, usually with indirect development, accompanied by first a trochophore larva and sometimes with a second veliger larva.

Molluscs generally measure several centimeters in length. Though molluscs appear to be a heterogeneous assemblage of animals, they have a basic body plan. This can be understood from the study of the generalised body plan of a hypothetical ancestral mollusc (Fig.8.l).

The ventral surface of the body is flat and muscular and forms the locomotory organ. The foot. The head is close to it, at one end. The dorsal side of the body is more or less ovoid in share and contains the internal organs. The visceral mass. **The visceral mass** is covered by an epidermis, the **mantle** or **pallium**. The mantle encloses a cavity. The mantle cavity. The mantle secretes the overlying protective shell and the edges of the mantle are most active in secreting the shell.

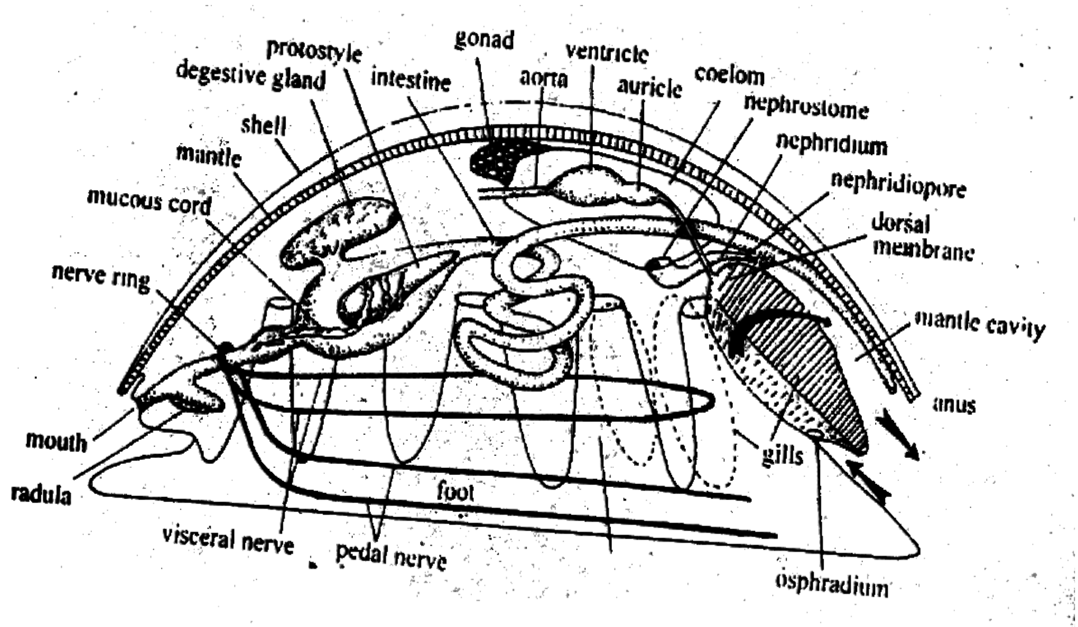


Fig. 8.1 Organisation of a generalised mollusc.

The shell has three layers (Fig. 8.2):

(1) The outer, homy layer made up of conchiolin. a modified protein. This layer is called periostracum. It is protective to the underlying layers and is secreted by the fold of the mantle edge only.

(2) The middle prismatic layer is made up of prisms of calcium carbonate
dorsally packed, in a matrix of protein. This layer is also secreted by the glandular margin of the mantle.

(3) The innermost is the nacreous layer. This is calcareous material, and is layered down by the mantle surface continuously. This is the iridescent mother-of-pearl of many molluscs. Pearl is formed between mantle and shell in response to trapped foreign particles when they get covered with nacreous layer.

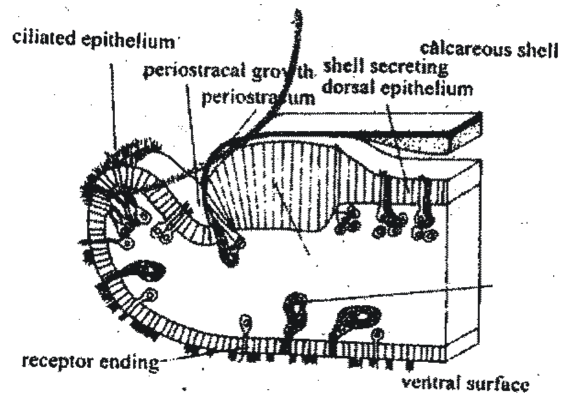
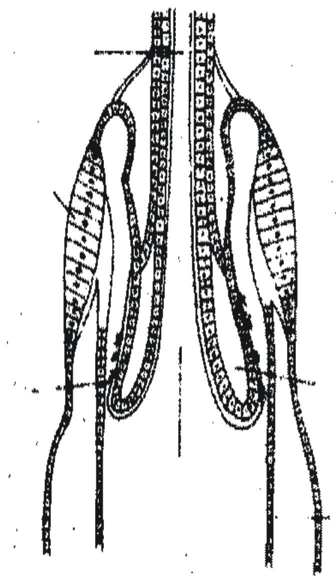


Fig. 8.2: A section through the mantle edge of a gastroped shell.

In molluscs, the respiratory structures are usually gills or ctenidia (Sing. Ctenidium) (Fig 8 .1). The ctenidia are located one on each side of the mantle cavity. Each gill consists of along, flattened axis projecting from the anterior wall of the mantle cavity (Fig.8.3). The axis contains the muscles, nerves and blood vessels. Triangular gill filaments are attached to the sides of the broad surface of the axis as in. a comb.

When the filaments are found on only one side of the axis the ctenidium in known as **monopectinate;** when they are found on both sides, it is **bipectinate.** Water enters the lower part of the mantle cavity from the posterior end, travels upwards, flows back posteriorly to leave the cavity. Cilia are located on the gills in the lateral, frontal and abfrontal regions (Fig. 8.4).



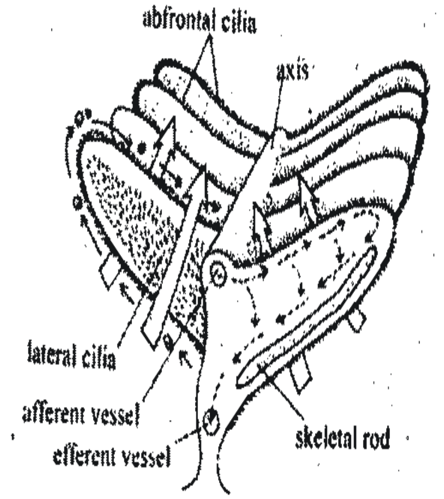


Fig 8.3: Frontal section through a gill. **Fig.8.4: Transverse section through a gill.**

The axis harbours two blood vessels: an **afferent** vessel that carries blood to the gills and an **efferent** vessel that collects blood from the gills. The flow of the blood is from the afferent vessel through the gill filaments to the efferent vessel. The blood thus runs countercurrent to the water flowing from frontal to the abfrontal margin maximising the oxygen uptake by the blood.

Many molluscs are herbivores, feeding on algae and plants. The mouth leads into a cuticle-lined **buccal cavity.** On the floor of the buccal cavity, there is a structure called **odontophore**. Odontophore is an elongated muscular and cartilagenous structure that bears a membranous belt called **radula** (Fig.8.5). The radula which lies in a radular sac has transverse rows of teeth.
The radula and the odontophore together do the function of scraping and collecting the food.

Due to the repeated scraping activity there is loss of radular teeth whicch are continuously secreted at the posterior end of the radula. At least one pair of salivary glands open into the buccal cavity of molluscs. The buccal cavity leads into oesophagus followed by stomach (Fig.8.1). The anterior region of the stomach is lined with clintin e.ecept for a short, ciliated and ridged region called the sorting region. The hepatopancreas constitute the digestive glands: their ducts open into stomach.

The stomach is followed by a long, coiled intestine. The posterior region of intestine functions as a rectum concentrating the faecal pellets. The faecal materials expelled through the anus located at the posterior margin of the mantle cavity are swept away by the exhalent water current (Fig. 8.1).

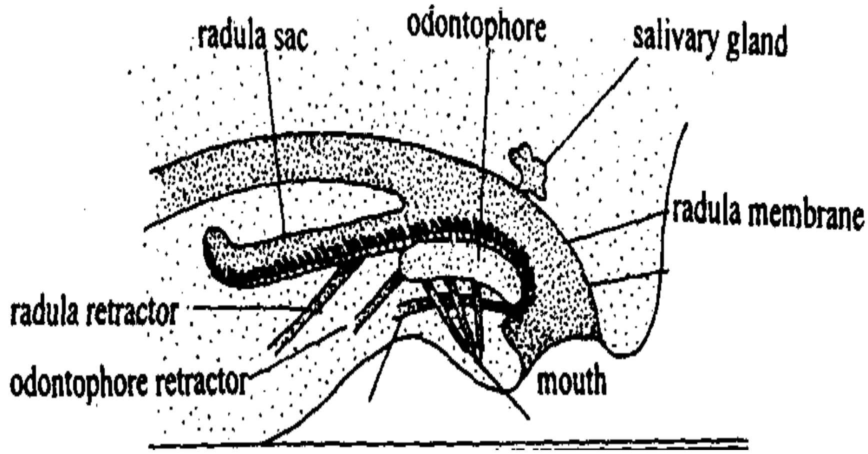


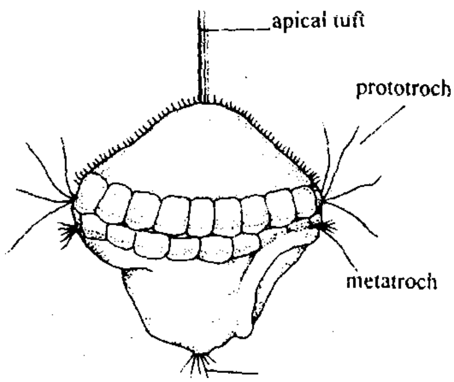
Fig.8.5: The inner view of molluscan radular apparatus.

The coelomic cavity is highly reduced and is confined mainly to the pericardium surrounding the heart dorsally and a portion of the intestine ventrally. The heart of molluscs is three chambered with an unpaired anterior ventricle and a pair of posterior auricles (Fig.8.2). From the ventricle an aorta arises and it branches, supplying blood to the blood sinuses. From these sinuses blood returns to the heart via the excretory organs and gills. In cephalopods (squids and octopuses) the blood is enclosed in vessels, and the sinuses are absent. The blood contains the respiratory pigment haemocyanin, and amoebocytes.

Excretion in molluscs is carried out by one or two nephridia or kidneys. Each kidney is a **metanephric tubule** with the **nephrostome** opening into the coelom at one end and the **nephridiopore** opening into the mantle cavity at the other end. In many molluscs the nephridium is a blind sac. The urine is discharged through the nephridiopore into the mantle cavity (fig. 8.3).

The nervous system of molluscs consists of a nerve ring around the oesophagus from which two pairs of nerve cords.extend posteriorly (Fig. 8. 4). of these two pairs, one pair, the pedal nerve cords innervate the foot and its muscles. The other pair, the visceral pair innervates the mantle cavity and visceral organs. Transverse connections occur between each pair of nerve cords. The sense organs of molluscs include **tentacles**, a pair of eyes, balancing organs-the statocysts and the chemoreceptors the **ospharadia** (Fig. 8. 5).

Molluscs may be hermaphrodites or the sexes may be separate. The mature gametes may be released into water in which case fertilisation will be external, In forms where fertilisation is internal, sperm transfer may occur directly or the sperm will be packaged into structures called spermatophores and. transferred. Cleavage is spiral and a free swimming trochophore larva (Fig.8.6) develops from the gastrula. The trochophore in many molluscs transforms into another larval stage the veliger larva (Fig.8.7) in which the foot, shell and other structures begin to appear. Veliger larva metamorphoses in to an adult.



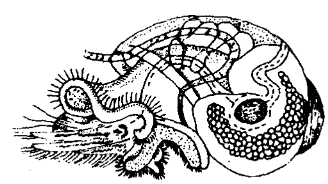


Fig.8.6: Trochophore larva of gastropod. **Fig. 8.7: Veliger larva**

SAQ 1

Fill in the blanks with suitable words.

a) The molluscs comprise the following major groups, commonly known as and ___________ ____________________ ______________

b) The rich fossil record of molluscs is due to the presence of ___________ _________________ _________________ in many organisms.

c) The ovoid dorsal side of the body of molluscs that contains the I nternal organs is called ____________ ___________________

d) Is an epidermal covering over the visceral mass?

e) The gills of molluscs are known as__________ _________ ________

3.3 Classfication Of Mollusca

Thus far we described some of the salient features of the phylum Mollusca. Phylum Mollusca includes seven classes. They are:

Class Monoplacophora
Class Polyplacophora
Class Aplacophora
Class Gastropoda
Class Bivalvia
Class Scaphopoda
Class Cephalopoda

Of these seven classes, class Monoplacophora is a primitive group of molluscs. The first living specimen of class Monoplacophora was discovered as late as 1952. This is the genus Neopilina that was dredged out from pacific coast of Costa Rica. We shall now study these classes in detail.

3.3.1 Class Monoplacophora

Bilaterally symmetrical, with broad flat foot and single shell, mantle cavity has five to six pairs of gills; six pairs of nephridia of which two function as gonoducts; radula present; sexes separate. Extant species are included in three genera. These are found at great depths in the sea. Also many fossil forms belonging to Cambrian and Devonian times are known. The monoplacophorans can he regarded as the ancestors of all molluscs.

Monoplacophorans have following salient characters:

- The shell varies in shape from a flat shield to short cone; length of the animals ranges from 3 mm to 3 cm (Fig.8.8).

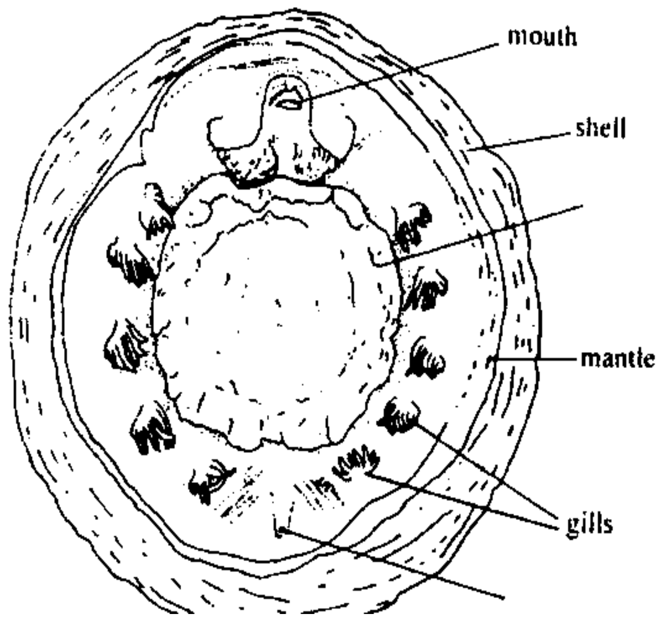


Fig.9.8: Monoplacophoran Neopilina (ventral view)

- The foot is broad and flat
- The mouth lies in front of the foot and the anus opens posteriorly in the mantle cavity. There is a preoral fold in front of the month extending laterally as a larger ciliated palp like structure. Another fold projects behind the mouth on either side as postoral tentacles.
- The mantle cavity has 5 or 6 pairs of monopectinate gills.
- Sexes pairs of kidneys are present.
- Heart has two pairs of auricles and a pair of ventricles (Fig.8.9) and is surrounded by paired pericardial coelom.
- The buccal cavity has a radula and a subradular organ. The stomach has a crystalline style. There is a long and coiled intestine.
- Nervous system is typical with a pair of cerebral ganglia, circumoral nerve ring, a pair of visceral nerves and a pair of pedal nerves.

- Sixes are separate. Two pairs of gonads are located in the middle of the body. Fertilisation is external. Example: *Neopilina.*

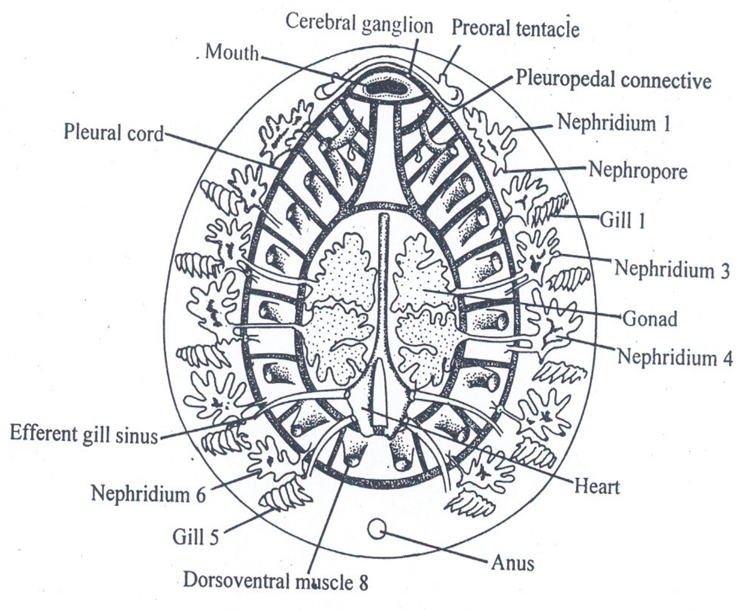


Fig. 8.9: Internal Anatomy of Neopilina.

3.3.2 Class Polyplacophora

Bilaterally symmetrical elongated, dorsoventrally flattened; head reduced, with radula, shell consists of eight dorsal plates, foot flat and broad; multiple gills along sides of the body; sexes separate. Trochophore larva in life cycle; no veliger larva.

Class Polyplacophora include chitons (Fig.8.10): They live attached to rocks. The body is dorsoventrally flattened and is covered by eight overlapping shell plates: hence the name Polyplacophora. Their important general characters are as follows:

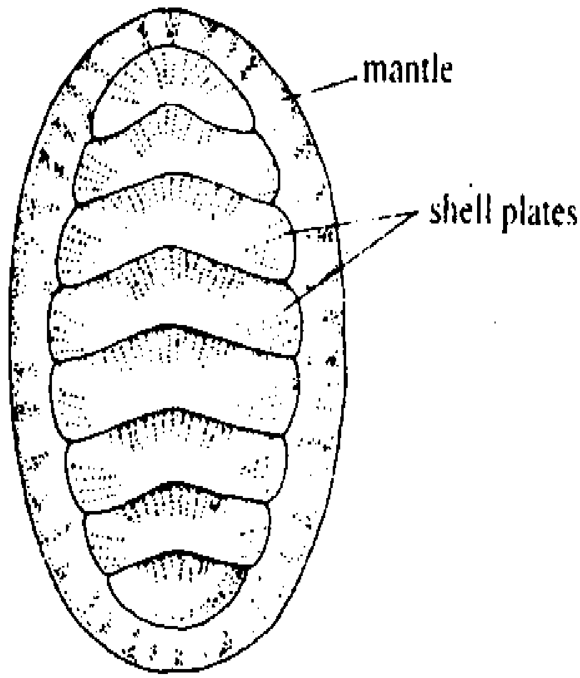


Fig.8.10: Chiton.

- They range usually from 3 to 12 cm in length and occupy intertidal zones.

- They have eight shell plates covered by the mantle. The mantle is thick and stiff at forming a periphery, girdle, where it may bear scales, bristles or spicules or may be smooth.

- The broad and flat foot occupies almost the entire ventral surface of the animal and is used for adhesion to the hard substratum. The eight shell plates are transversely divided and articulated with each other. Such an arrangement besides aiding in locomotion helps the animal to roll up into a ball as a defense mechanism when disturbed. There are no eyes or well developed sense organs on the head.

- Chitons feed on algae and other attached organisms. The mouth leads into a chitinised buccal cavity that bears a long radula. The buccal cavity leads into stomach through an oesophagus. Pharyngeal glands open into the oesophagus (Fig. 8.11). The stomach is followed by intestine which loops and continues as posterior intestine where faecal pellets are formed. The anus is located at the midline behind the posterior margin of the foot.

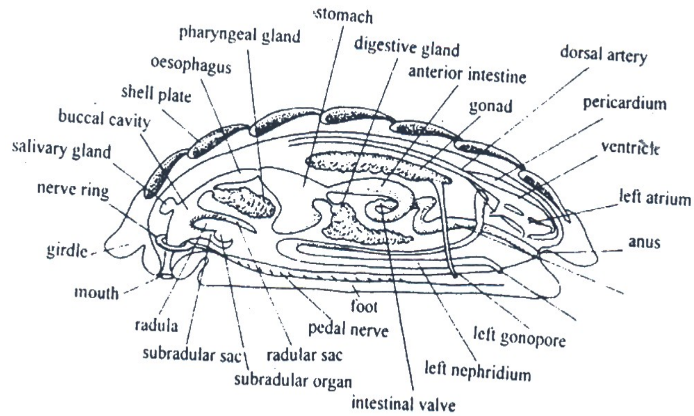


Fig.8.11: Internal Anatomy of chiton.

- The gills are arranged in linear series. The number and size of the gills vary.

- The heart is located beneath the last two shell plates, enclosed in a pericardial cavity. It has a pair of auricles and a single ventricle. The nephrostomes of the large U shaped kidneys open into the pericardial cavity. The nephridiopore opens into the pallial groove.

- The nervous system is typically molluscan (Fig. 8.12). However, ganglia are lacking or poorly developed. From the circumoesophageal nerve ring, the pedal nerves and palliovisceral nerve arise. The sense. organs include subradular organs, girdle hairs and mantle structures known as esthetes of unknown sensory function.

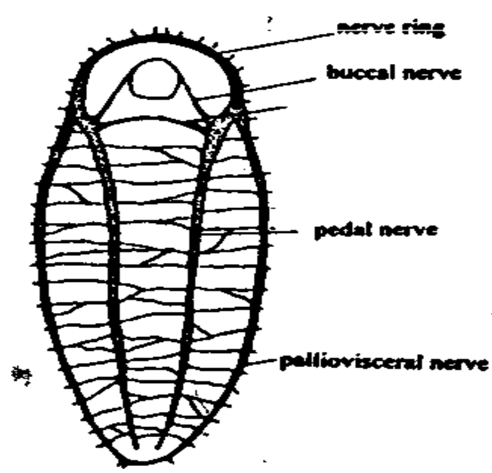


Fig.8. 12: Nervous System of Chiton.

- Most chitons are dioecious. The median gonad is located anterior to pericardial cavity beneath the middle shell plates. The gonoducts open separately to outside by gonopores located in the mantle groove. Gametes are shed into the sea and fertilisation is external in water or in the mantle cavity of females.

- Development includes a tree swimming larval stage.

3.3.3 Class Aplacophora

Worm-like, no shell, head or excretory organs; mantle with chitinous cuticle or scales or spicules; mantle cavity posterior.

Aplacophorans are a group of small worm like molluscs devoid of any shell, (Fig. 8.13) called solenogasters. They occupy ocean depths, although some shallow water species are also known. Their biology is poorly understood. You will very briefly study their salient features.

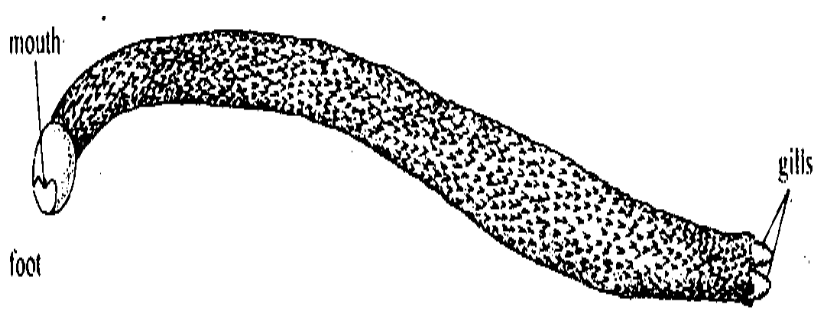


Fig.8.13: An Aplacophoran.

- They are less than 5 cm in length with a poorly developed head and a cuticlecovered integument in which calcareous scales or spicules are embedded. The upward rolling of mantle margins provide worm like appearance to creeping species. The foot is much reduced in burrowing forms. The posterior end of the body has a chamber, the mantle cavity, into which anus opens. In some forms the gills are located inside the mantle cavity. There is no shell.

- Burrowing forms feed on small organisms and deposited materials, and the creeping species feed on cnidarians. A radula may or may not be present.

- Most forms are hermaphrodites and the gonoducts open into -the mantle cavity. The eggs may develop directly into adult or pass through a trochophore larval stage.

Thus far you have studied three classes of primitive molluscs - Monoplacophora, organisms with a single shell plate: Polyplacophora, organisms with many shell plates and Aplacophora, organisms with no shell plate. Before we proceed with the other classes, you may attempt the following SAQ.

SAQ 2

Match the following classes given in Section A with their characters in Section B.

i) Aplacophora	a) Presence of esthetes.
	b) Heart with 2 pairs of auricles and a pair of ventricles.
ii) Monoplacophora	
	c) Body covered by a cuticle lined integument embedded with calcareous. Scales or spicules.
iii) Polyplacophora	
	d) Presence of 8 shell plates that articulate with each other.
	e) Worm like organism devoid of any sh-ell plate.
	f) 5 to 6 pairs of monopectinate gills.
	g) Presence of broad and flat foot used for adhering to hard rocks and shells.
	h) Presence of single flattened shell.
	i) Radula may or may not be present.

3.3.4 Class Gastropoda

Body asymmetrical, shows torsion or its effects; shell coiled in most, well developed head with radula; large flat foot; gills one or two or with pulmonary cavity (lung); mostly with single auricle and single kidney. Nervous system with cerebral, pedal, pleural and visceral ganglia; usually with trochophore and veliger larvae.

Gastropods, the largest class of molluscs, show extensive adaptive radiation, having adapted to life for bottom as well as spelagic and littoral existence in sea. They have also invaded fresh water and many have successfully conquered land as well. In this subsection you will study the organisation of their body.

Gastropods differ from the other groups you have studied so far in four major ways.

1. There is the development of a distinct head;

2. Body shows dorsoventral elongation;

3. Plate like shell is converted into a spiral asymmetrical shell that serves as a protective retreat for the animal;

4. The visceral mass undergoes a 90 to 180 degree twist with respect to head and foot, a phenomenon known as **torsion.**

Of the four major changes in the organisation of gastropoda torsion is the most distinctive one. You should remember that torsion is not the coiling of the shell, but it is the twisting of the body (see Box 6.1). In this process most of the body behind the head including visceral mass, mantle and mantle cavity are twisted 180 degrees in the anticlockwise direction and when viewed dorsally the gills, mantle cavity, anus and nephridiopores come to be located at the anterior part of the body behind the head. Torsion also results in the looping of the digestive tract and twisting of the nervous system into a figure 8. Only the head and foot remain untorted. The shell is usually a conospiral.

Box 8.1

Torsion is the most distinctive character of gastropods and in no other group of molluscs this phenomenon occurs. You will have to recall here the basic body plan of the bilaterally symmetrical, hypothetical ancestral mollusc with a simple hump like conical visceral mass and a close fitting shell of shallow cone above and a flat foot below for creeping. Further it had a mouth in front and a mantle cavity behind with gills, and into which opened the anus and the nephridiopores. During evolution of gastropods, visceral mass lengthened dorsoventrally. Simultaneously they underwent a phenomenon known as torsion which is quite distinct from coiling (see below). During this process of torsion, the posterior end of the body turned 180 degrees in a counterclockwise direction (looking from dorsally) carrying with it the mantle cavity along with the organs it held. This also affected the visceral mass and the organs it contained. The mantle cavity along with its various organs, earlier situated behind came now to occupy in front, above the mouth (Fig. 8.14). The gill and kidney originally on the right side came to occupy the left side. The intestine was thrown into a `U' turn loop and the anus came to open in front above the head. The anterior portion of the nervous system constituting the ring was not affected by torsion; only the posterior portion got involved in this process. Thus the two visceral nerve cords connecting the pleural ganglion and the visceral ganglion of the corresponding side got twisted into a figure of 8 (Fig.8.15).

During this process, the-original right parietal ganglion came to occupy then side and higher up the visceral mass, and hence it also came to be referred to as supraparietal ganglion, the original left one now occupying the right side being referred to as the infraparietal ganglion. What necessitated this torsion during evolution is not exactly known. But this gave rise to fouling of water in the mantle cavity because of the discharge of faecal matter and excretory products near the gills. Torsion actually takes place in the larval stage of gastropods, and is due to the asymmetrical or uneven growth of the right and left retractor muscles that connect the shell with the foot.

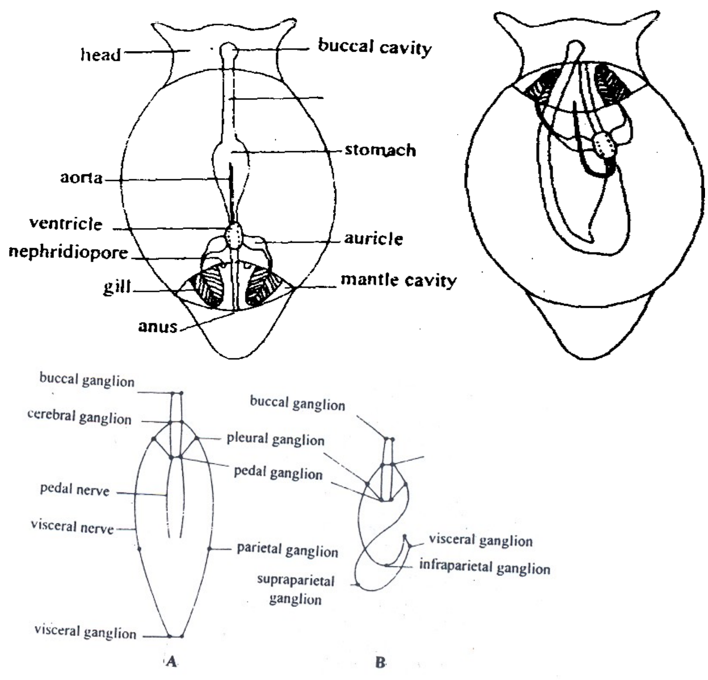
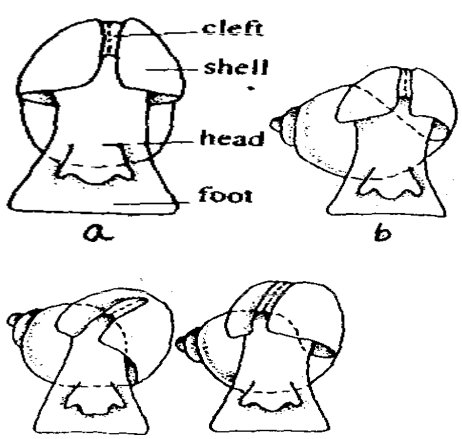


Fig.8.15: A: pre torsion nervous system.
B.Post torsion nervous system.

The condition described above is seen in the primitive gastropods (subclass Prosobranchia) to which most gastropods belong. In pulmonates which include the land snails, the gills have disappeared and the mantle cavity is modified into a pulmonary chamber or lung. In subclass Opisthobranchia a reverse process known as detorsion has taken place and they have once again become bilaterally symmetrical secondarily. In them the shell and mantle cavity are either reduced or absent. Examples are the sea hares and nudibranches.

Quite apart from torsion of the visceral mass described above, gastropods have also undergone coiling. The primitive gastropods had a bilaterally symmetrical planospiral coiling of the shell, all whorls lying in the same plane. As this type of shell is not compact, the conospiral type evolved (Fig. 8.16). In this type, the succeeding whorl is at the side of the preceding whorl, but around the same central axis. This type of coiling in its turn created problems in balancing the conospiral, too much weight being on one side of the body. This was solved by shifting the shell upward and posteriorly, with shell axis positioned oblique to the foot axis. This new position of the_ shell and the body limited the mantle cavity mostly to the left side of the body, almost the whole visceral mass pressing against the mantle cavity on the right side of the body. This has resulted' in atropy or disappearance of the gill, kidney and auricle on the right side of the body. This has also enabled the animal, to get over the problem of fouling. Water now enters the left side of the mantle cavity, bathes the gill there, receives the faeces from the anus and excretory products from the nephridiopore situated on the right side of the mantle cavity and leaves from the right side of the mantle cavity.



c. d.

Fig. 8.16: Evolution of the asymmetrical gastropod shell
(a) Ancestral planospiral shell
(b)Apex of the shell is- drawn out producing a more compact shell

(c) Position of the shell over the body is shifted producing a more equal distribution of weight
(d) Final position of the shell over the body as seen in most living gastropods.

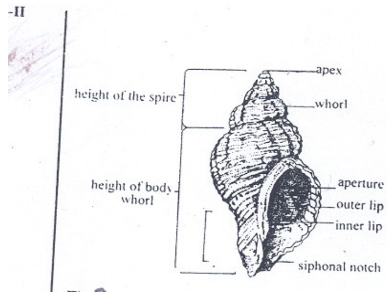
Box 8.2

Most gastropods possess a shell. Gastropod shell is a "portable retreat' for the animal. These shells vary very much in their size and shape and this is not surprising considering the number and diversity of the species in the class. They range from microscopic size to about 60 cm in length as in the giant marine snail Pleuroploca gigantea. Many of them are of exquisite beauty. They present varying hues, shapes and surface sculptures of ridges, grooves, ribs, tubercles, spines etc.

The typical gastropod shell is asymmetrical, conical spiral (Fig. 8.17) around an axis called columella (Fig. 8.18). It has evolved from the primitive planospiral shell as a result of torsion (Fig.8.19). The spiral turns are thrown as whorls. The whorls are limited by sutures, an are generally in contact with one another. The succeeding larger whorls partially cover the preceeding smaller whorls. The remaining smaller whorls together constitute the spire. The spire has a pointed apex.

However, as in vermitids, the whorls may stand apart resembling the tube of a worm. Tenagodus is an example. The body whorl has a large opening, the aperture, through which the foot and the head come out. When distributed the entire foot and head can be retracted into the body whorl and in many species the aperture can be closed tightly by means of an independent lid like piece of shell called operculum on the foot as in the turban shell Turbo (Fig.8.20). The body whorl and the aperture may often be drawn out into a spout in front forming a siphonal canal that contains the siphon as in Cowries (Fig.8.21). Some like the olive shell also show a similar but smaller posterior canal.

If you hold the shell in your hand in front of you, the aperture above and apex turned away from you, usually the aperture will be on the right hand side. Then the shell is described a right handed spiral and is called dextral. Rarely you may come across a sinstral shell with a left handed spiral, in which case the aperture will be on the left hand side. The coiling i.e., whether dextral or sinitral, has genetic basis.



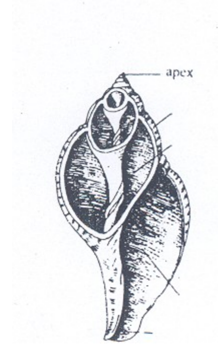
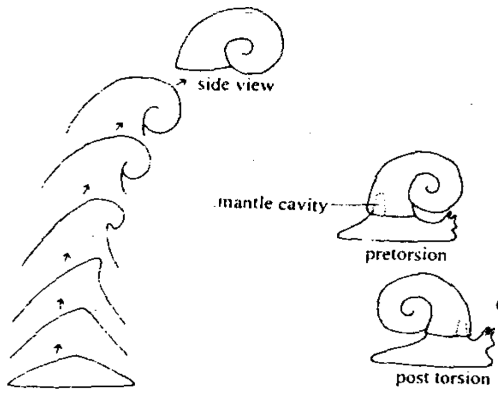


Fig.8.17: A typical conospiral Shell of a gastropod

Fig. 8.18: A Longitudinal section through shell



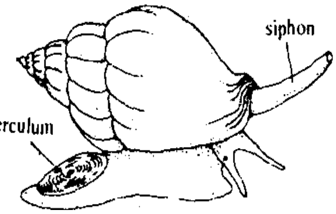
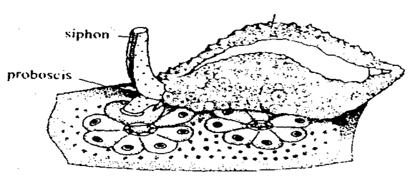


Fig. 8.19 : Planospiral shell
(a) before torsion
(b) after torsion

fig. 8.20 shell with operculum

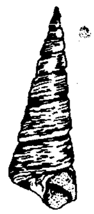


tentacle

Fig.8.21: The Cowrie
(Feeding as a tunicate)

Some of the conspicuous variants from the typical shape described above include the long and slender tower shell of Turitella (Fig. 8.22) with large number of whorls on the one hand, and the short broad smooth shell of Laom (Fig.8.23) with the large body whorl and the tin). Spire. On the other. The spire is not even visible in the shell of Cydindrella (Fig.8.24). The limpets (Fig.8.25) also have a broadly conical shell, with a broad aperture but apparently no spire.

The cowries also have a broadly conical shell, with a broad aperture but apparently no spire. In the cowries the aperture has become slit-like and the successive whorls enclose the previous whorls. Shell may become internal and even undergo reduction and ultimately disappear in the adult, as in nudibranches.



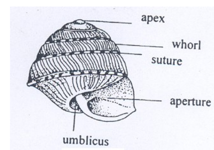


Fig.8.22 : Turirefa **fig. 8.23:Laoma**

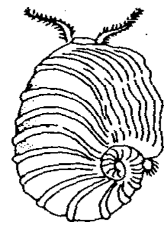


fig.8.24 Cylinderalla **fig. 25 Fissurella**

The shell basically consists of an outer periostracum and a varying number of inner calcareous layers. But there is quite a lot of qualitative and quantitative variations in the composition of the shell. The periostracurn may be worn off, or may be even completely absent when the shell is covered by the mantle. Tire number and composition of inner layers also vary: basically they are made up of largely calcium carbonate, but may be either calcite or aragonite, differing from one another in crystalline properties. Calcium carbonate may also occur in an amorphous form.

The colouration of the shell is due to pigments such as pyrroles, melanins, porphyrins etc; They are supposed to be derived by the molluscs from their diet or are metabolic products and are secreted into the shell as a method of disposal from the body. Chromoproteins occur in higher gastropods.

Typically the gastropod foot is a flat creeping sole adapted for locomotion on a variety of substrata. The sole of the foot is ciliated and the gland cells located in tire foot secrete mucus over which the animals moves.

The snails are propelled by a wave of muscular contraction that sweeps along the foot. In burrowing forms the foot acts like a plough and anchor. Limpets, abalones and slipper snails are adapted for clinging to rocks and shells. In pteropods (sea-butterflies), a group of pelagic gastropods the foot is modified into effective fin like swimming organ (Fig.8.26).

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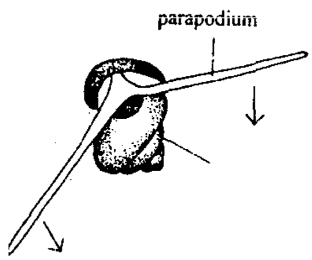


Fig.8.26: Sea-buttertly.

Gills (ctenidia) of gastropods could be either monopectinate or bipectinate. Most gastropods have only one ctenidium. The land snails among gastropods have their. Mantle highly vascularised and converted into a lung for purposes of gas exchange.

Gastropods exhibit a variety of feeding habits. There are herbivores carnivores Scavengers, deposit feeders, suspension feeders and parasites. Due to torsion the stomach has been rotated 180 degrees and as a result the oesophagus joins stomach posteriorly and the intestine leaves the stomach anteriorly (Fig.8.27). Many suspension and deposit feeders have a structure called crystalline style that s cretes the enzyme amylase. You will learn more about crystalline style during our study of bivalve molluscs.

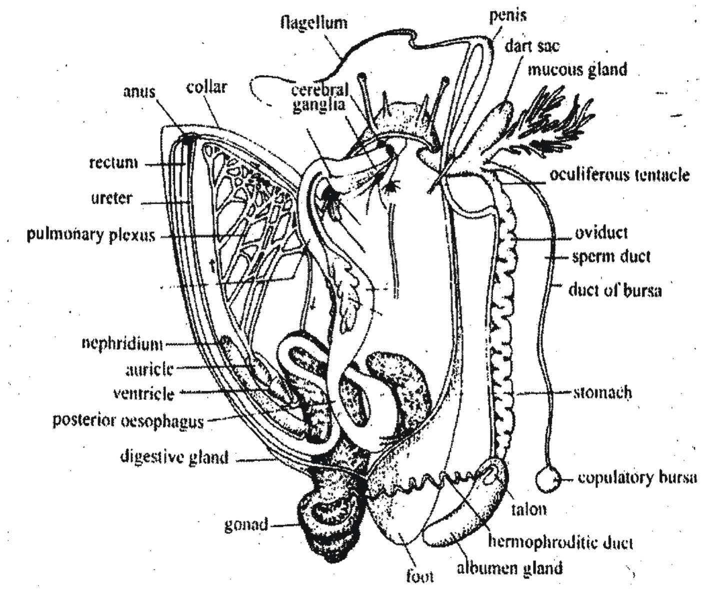


Fig. 8.27: Viscera of a land snail.

The heart is located anteriorly in the visceral mass. In most gastropods the right auricle is reduced or even absent. From the ventricle an anterior and a posterior aorta arises. The anterior aorta supplies blood to head and foot and the posterior aorta to visceral mass. In the foot and head region blood is collected into a sinus. Blood also passes into kidneys before entering into respiratory structures (Fig.8.28).

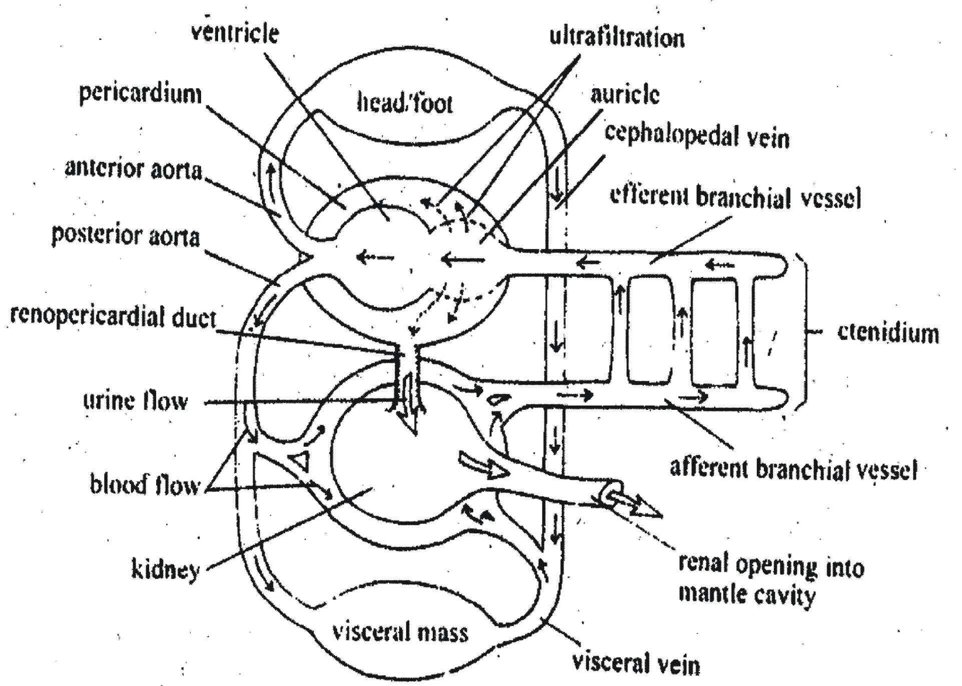


Fig.8.28: Blood circulation in a gastropod.

The nervous system consists of a pair of cerebral ganglia located over the oesophagus. Eyes, tentacles statocysts and buccal cavity are the structures innervated by cerebral ganglion. Other ganglia include pleural, pedal; buccal, parietal and visceral, innervating the respective organs; their connectives and commissures are shown in the fig.8.l5.

Gastropods may be hermaphrodites or dioecious and possess unpaired gonad. Fertilization is mostly internal. Fertilised eggs may sometimes be enclosed in egg capsules in large or small numbers. Veliger larva may be present, or the larval stage may be spent in egg capsule, animals emerging as young ones.

Examples

Haliotis (Fig.8.29), Fisseurella, Patella, Trochus, Nerita: all are primitive forms: Pila, Crepidula. Strornbus: (Fig. 8.30): Murex (Fig. 8.3). Mucella; These are all examples of subclass Prosobranchia. They show torsion, and have gills.

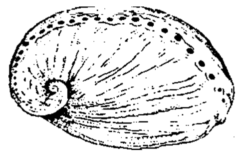


Fig. 8.29: Haliotis

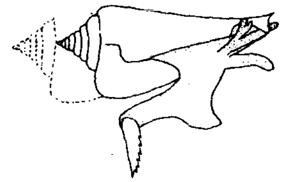


fig. 8.30: Strombus

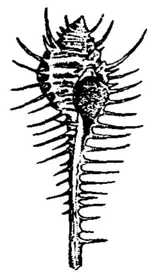


Fig.8. 31: Mures

Subclass **Opisthobranchiata** includes those gastropods which have undergone detorsion. Many species have reduced shell or no shell at all and a reduced mantle cavity. Detorsion has restored bilateral symmetry secondarily in many forms. Examples include: Acteon, Hydatina (Fig.8.32); Odostomia is an ectoparasitic opisthobranch, the buccal cavity has a stylet instead of a radula for piercing into host organs to draw food: Aplysia (Fig.8.33) a large opisthobranch commonly known as sea-hare, exhibits bilateral symmetry in its external morphology. The shell is very much reduced and is hidden in the mantle. Both gill and mantle cavity are present.

The foot of the animal is provided with extensions called lateral parapodia. Pleurobranchus (Fig.8.34); Clio, Cavolina (Fig.8.35): Provided with shell; but the foot has large extensions called parapodia. Hence called pteropods and popularly known as sea butterflies; Pneumoderma, Chopsis (Fig. 8.36) pteropods without shell, these organism lack a mantle cavity. Structures called parapodal fins help in locomotion; commonly called sea-slugs which lack both mantle cavity and shell. The body has attained a bilateral symmerty secondarily. Doris (Fig.8.37) and has secondary gills around anus.

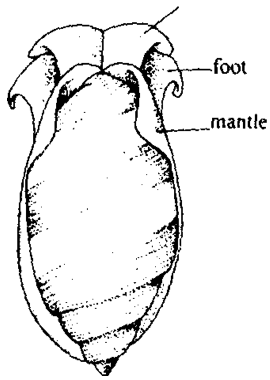


Fig. 8.32: Hydatina

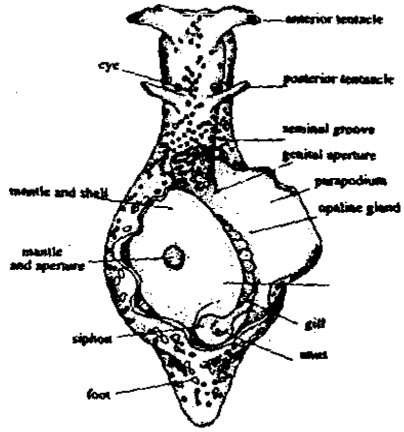


Fig.8.35: Cavolina.

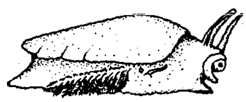


Fig. 8.34: Pleurobranchus

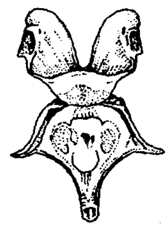


Fig. 8.35 Cavolina

Subclass Pulmonata are gastropods with one auricle and one nephridium, and includes many terrestrial forms. To suit the terrestrial mode of life the mantle cavity is vascularised for purposes of gas exchange in air or secondarily in water.

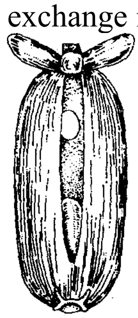


Fig.8.36: Chopsis.

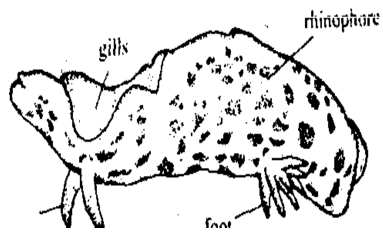


Fig.8.37: Doris.

Examples are: Onchidium (Fig.8.38): slugs. Unlike the other pulmonates where anus opens laterally, anus is located posteriorly, Lywnaeal, Planorbis (Fig.8.39) are fresh water forms; The eyes are borne on a pair of cephalic tentacles; Giant African snail Achatina, Helix, Limax are terrestrial pulmonates with 2 pairs of cephalic tentacles. The eyes are home at the tip of the upper tentacles.

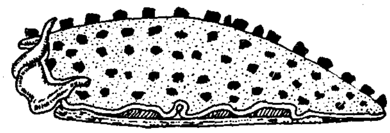


Fig.8.38: Onchidium.

3.3.5 Class Bivalvia

Body within a bilobed mantle enclosed in a two-valved shell; head reduced; mouth with labial palps but no radula; foot wedge-shaped; plate-like gills; sexes separate; trochophore and veliger larvae.

Class Bivalvia is also known as **Pelecypoda** or **Lamellibranchia**. It includes clams, oysters and muscles. The body of these molluscs is laterally compressed and the shell is formed of two valves hinged dorsally. The shell covers the body completely. The foot of the animal is also laterally compressed. Bivalves have the most spacious mantle cavity among the molluscs. The large gills that are enclosed in the mantle cavity function as organs of gas exchange and food gathering apparatus producing ciliary currents helping in filter feeding. Bivalves do not have a distinct head or radula. Most of the bivalves burrow in the bottom of fresh water bodies or sea and the body is suitably modified for such a habitat. But there are other forms which have taken to other modes of life as well.

Box 8.3

The shell of bivalves consists of two more or less similar oval valves (Figs.8.40). Each valve has a dorsal protuberance called umbo. This is the oldest portion of the shell, and the lines around it indicate growth of the shell. The two valves are kept closed by a pair of adductor muscles. The valves are also attached and articulated dorsally by a hinge ligament, an elastic protein band serving to open the valves when the adductor muscles relax. There are ridges and grooves on the shell to tightly lock them in position.

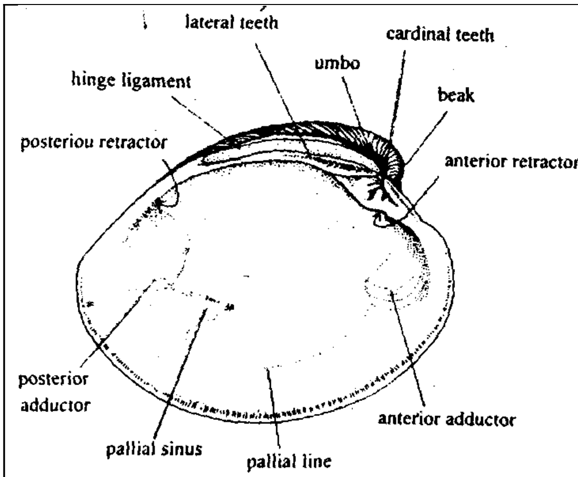


Fig.8.40: Inner surface of the left valve of a bivalve.

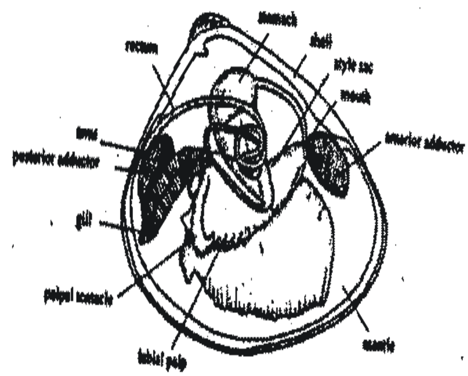
The structure of the bivalve shell as well as its composition is basically molluscan as described previously, with layers of periostracum and calcium carbonate. Calcareous layers are made up of aragonite and calcite, in the form of prisms and sheets called nacre in a matrix of organic matter. The shells vary very much in shape, colour and surface patterns. In size they vary from 1 mm to over I m.

Pearls of quality and commercial value are deposits of concentric layers of nacre around foreign objects such as sand grains or parasites. The pearl oysters Pinctada margaritifera and Pinctada mertorsi produce best quality natural pearls. Oysters can be artificially induced to produce pearls.

Bivalves range in size from 2 mm in length to giant forms such as Tridacna which measures over a meter in length. The line of the mamle attachment to the inner surface of the shell is called pallial line.

Bivalves have adapted themselves to filter feeding method. Generally water enters the mantle cavity posteriorly and ventrally through incurrent siphon and leaves the mantle cavity posteriorly and dorsally through excurrent siphon. Primitive bivalves possess a pair of postero-lateral bipectinate gills (Fig, 8.4.1), In these forms the margins of the mouth elongate forming structures called tentacles. Each tentacle is associated with a large fold composed of two flaps called labial palp. In higher bivalves the gills act as filters and the gill cilia produce a current which transport the food particles trapped in mucus to the buccal palps and mouth.

The stomach of lamellibranchs (Fig.8.41a) contains a structure called crystalline style, a compact and often a long gelatinous rod that secretes enzymes like amylase and lipase'. The heart is three chambered and is folded around the rectum, and pericardial cavity surrounds the heart. The pericardial cavity thus encloses both the heart and a section of the posterior part of the digestivtract. Gills also function as organs of gas.



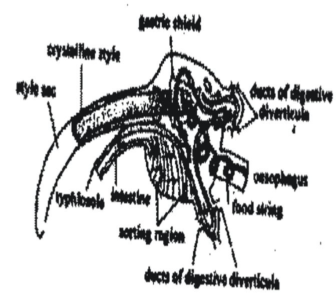


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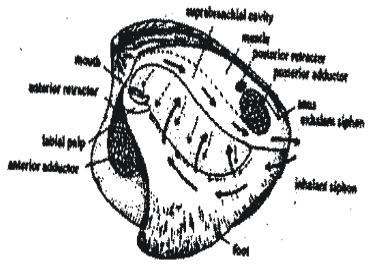
fig.8.41: Internal organisation of a bivalve. Fig.8.41a:Crystalline style.

Exchange (Fig.8.42). Paired nephridia or kidneys are the excretory organs. These are located beneath the pericardial cavity and above the gills. The nervous system is bilaterally symmetrical consisting of three pairs of ganglia connected by commissures and connetives (Fig. 8.43). Statocysts, ocelii and osphradium are the sense organs in bivalves. Sexes are separate in most bivalves but a few hermaphrodite species are also known. Development includes **trochophore** and **veliger larval stages** (Fig.8.44). Some clams have glochidium as the larval stage (Fig.8.45).



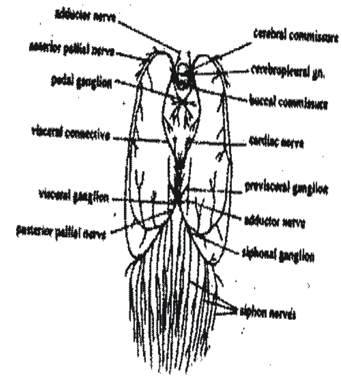


Fig.8.42: Route of entry and exit of water for gas exchange.

Fig. 8.43: Nervous system of a bivalve

Examples: *Nucula:* the shell valves are equal and carry a row of teeth along the hinge. Arca, the arks (Fig. 8.46), *Mytilus* (Fig.8.47), *Pinna, Pteria* (Fig.8.48) pen shells and winged oysters. *Pecten* (Fig.8.49) (scallop) *Spondylus* (thorny oyster), Ostrea (oyster) *Placuma* (window pane clam) *Lima Union Lamellidens* (Fig.8.50), the fresh water forms; So1en (Fig.8.51), Entovplva, burrowing forms with thin shells and well developed siphons; *mya (clam),* Teredo, Bankia (wood boring forms), Pholas (rock boring) (Fig.8.52).

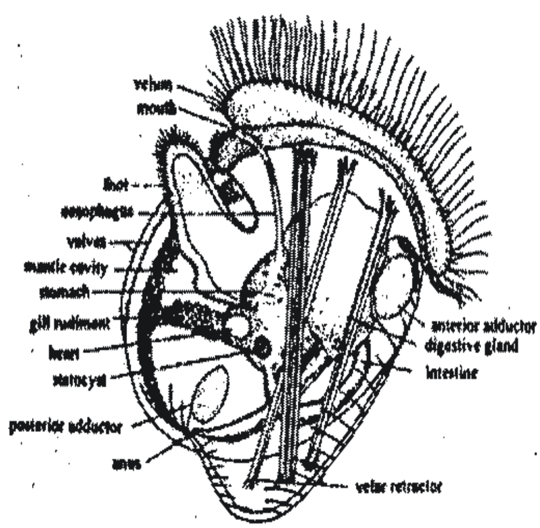


Fig 8. 44: Veliger

fig. 8. 45: Glochidium

Fig. 8.46: Acra

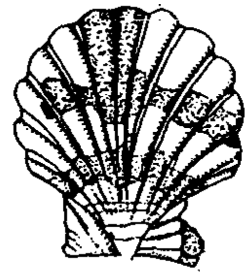


fig. 8.47: Mytitlus

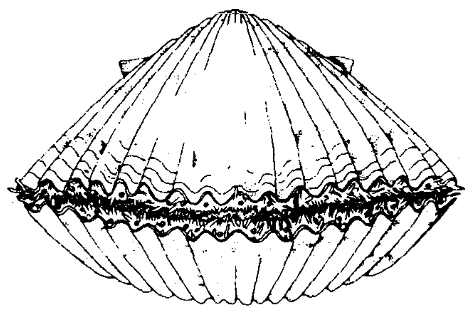


Fig. 8.49: Pecten

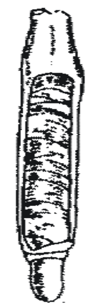


fig.8.51: Solen

3.3.6. Class Scaphopoda

Body within a single tusk-shaped shell open at either ends; foot conical; mouth has radula and tentacles; no head; no gills; sexes separate; trochophore larva.

Class Scaphopoda includes marine burrowing forms commonly known as tusk shells or tooth shells, .due to the resemblance of the shell to the tusk of the elephant (Fig 6.53a). The size of the shells usually ranges on an average from 3 to 6 cm. The shells are mostly white or yellowish. Both ends of the tube are open.

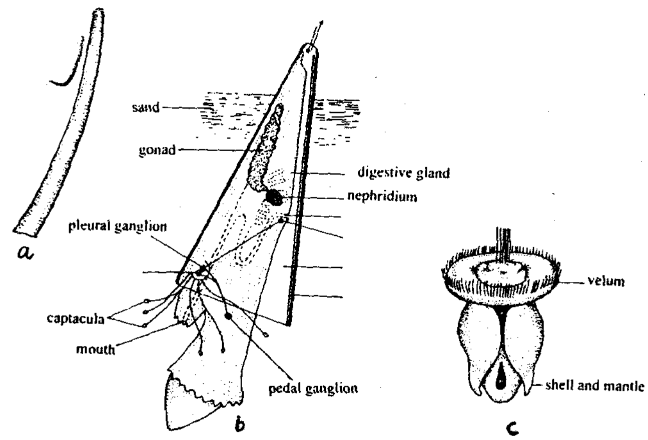


Fig.8.53a: Shell of Dentalium.
Fig.8.53b: Organisation of Dentalium.
Fig.8.53c: Veliger larva.

The body of scaphopods is elongated and the head and foot project from anterior larger aperture of the shell (Fig.8.53b). The mantle forms a tube covering the viscera. Scaphopods have a large mantle cavity extending the entire length of ventral surface.
The gills are absent and the mantle surface functions as a respiratory structure. Unique thread like tentacles captacula with ciliated knob at their tips aid in food capturing. Heart is absent and circulatory system consists of only blood sinuses.

Typical molluscan nervous system consisting of cerebral, pedal, pleural and visceral ganglia is present. Eyes, sensory tentacles and ospharidia are absent. A pair of nephridia serves as excretory organs. Sexes are separate. Development includes a free swimming trochophore and bilaterally symmetrical veliger larva (Fig. 8.53c) e.g. *Dentalium Cadulus.*

3.3.7 Class Cephalopoda

Shell reduced or absent except in Nautilus**; head well developed with well developed eyes; head bears tentacles; foot modified into siphon; well developed, brain with fused ganglia; sexes separate; development direct.**

Cephalopods are the most active and highly organised of all molluscs, adapted for pelagic, free swimming life. The group includes cuttlefishes (Fig.8.54a), squids, octopods (Fig.8.54b) and *Nautilus* (Fig.8.54c). The body is lengthened in the dorsoventral axis and this has in effect became the antero-posterior axis. The mantle cavity is now ventral. The head projects into a circle of large prehensile tentacles or arms at the anterior region. These tentacles are homologous to the anterior portion of the foot.

On an average cephalopods range in length from 6 to 70 cm; giant forms over 15 in (Archeteuthis) are also known. Locomotion in most cephalopods is by swimming. Swimming is achieved by Jet propulsion of the body by rapidly expelling water from the mantle cavity through a ventral tubular structure, the funnel, which is a modified portion of the foot, the external shell is now seen only in four living species of genus Nautilus from Indo-Western Pacific Sea and the other genera completely lack a shell. Cephalopods use gas filled shells to maintain buoyancy in water.

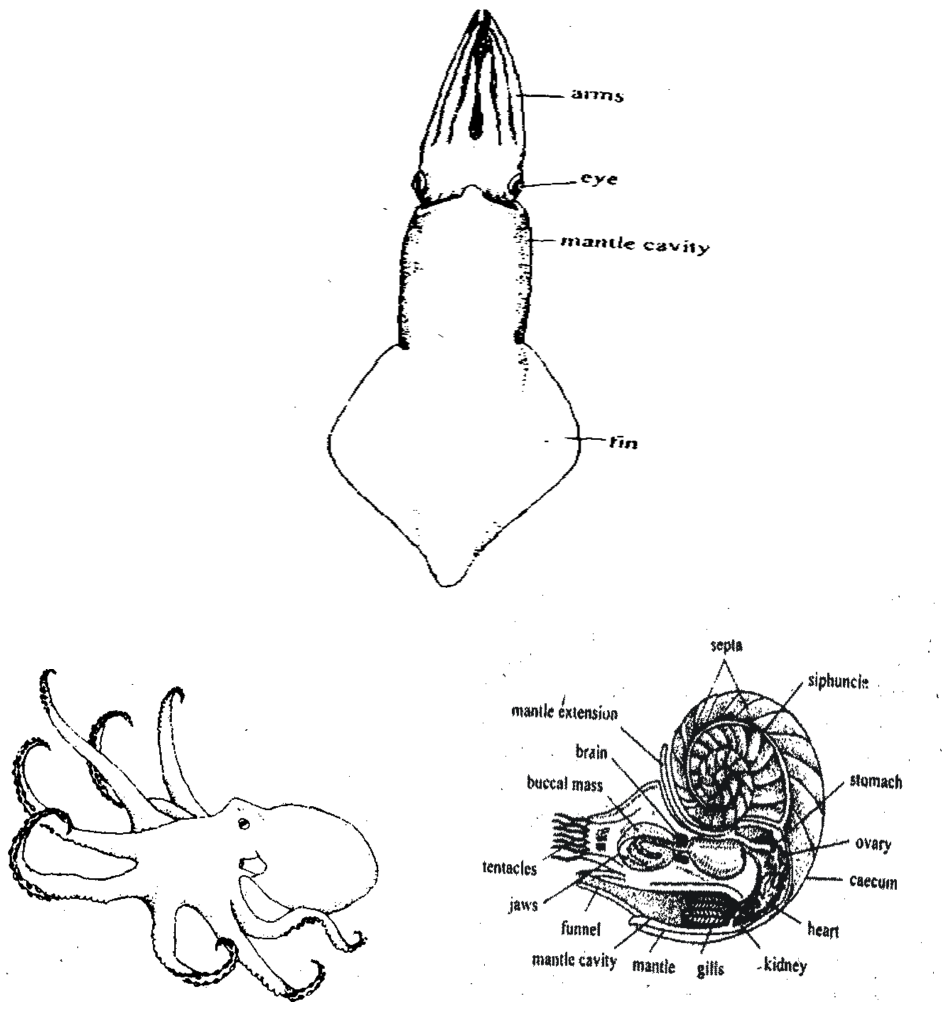


Fig.8.54: Some Cephalopods.

a: Cuttlefish Sepia
b: Octopus c: Nautilus

Box.4

The shell of Nautilus is a planospiral (Fig.8.54c). The inner whorls are covered by the last two whorls. The shell is divided by transverse septa, and the animal occupies only the last chamber. The septa is perforated at the centre through which a siphuncle passes. The Siphuncle secretes gas into the chambers. This makes the shell buoyant. The shell has an outer pearly white smooth layer made up of prisms of calcium carbonate embedded in an organic matrix. There is also an inner nacreous layer.

In the cuttle fish Spirula (Fig.8.55) the internal shell is coiled. In the Sepia and loligo, the shell is reduced to a "pen" (Fig8.56),

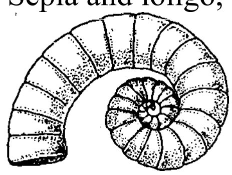


Fig.8.55:Shells of spirula

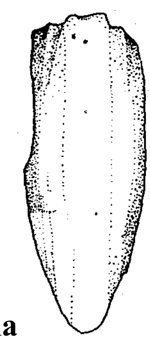


Fig 8.56:shell of sepia

Cephalopods are carnivorous and capture their prey by tentacles or arms.- Squids and cuttle fish have ten arms of which one pair is long, called tentacles. Octopods have eight arms. The inner surface of each arm contains adhesive discs that function as powerful suckers. The suckers are stalked in Octopus. The buccal cavity has a radula and a pair of powerful beak-like jaws.

There are two pairs of salivary glands emptying into the buccal cavity (Fig.8.57). The digestive glands include a diffuse "pancreas" and a solid "liver". Anus is located near the funnel and the excretory wastes are carried away along with exhalent water jet. Respiration is by gills. The circulating water in the mantle cavity is the source of oxygen for the gills.

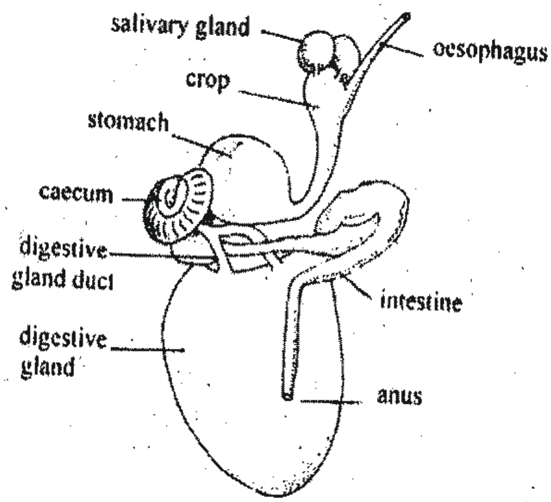
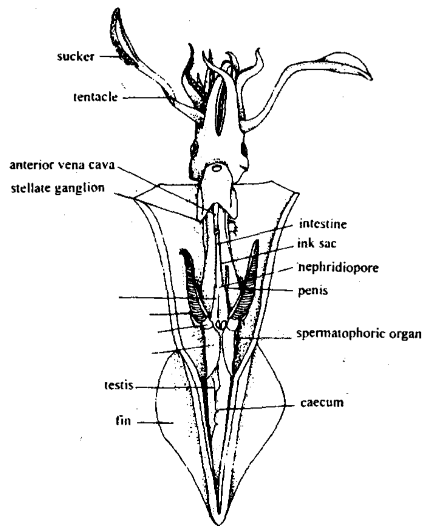


Fig.8.57: Digestive System of Octopus.

Nephridia are the excretory organs (Fig.8.58). Circulatory system in Cephalopods is closed. It consists of extensive system of vessels and capillaries lined by endothelium, closely resembling those of vertebrates. Heart is a three chambered structure with two auricles and a ventricle (Fig.8.59). Besides there is a pair of branchial hearts that pump blood through the gills. Blood contains the pigment haemocyanin for transporting oxygen to the tissues from the gills. Nervous system is also well developed with a higher degree of cephalisation.

The brain is perhaps the best developed among invertebrates. It is formed by the fusion of all ganglia that are typical of molluscs. Besides, there are **brachial gangalia** providing nerves to the arms; on each side, the mantle wall has a **stellate ganglion** that innervates the mantle musculature. Sense organs include well developed eyes strikingly similar to those of fishes, statocysts and osphradia. The coloumtion of the body is due to pigment cells or chromatophores present in die integument.

The animals can rapidly change their colour, which is an effective means of communication. Except in *Nautilus* in other cephalopods there is a large ink sac (Fig.8.50) that secretes brown or black fluid or ink made of melanin pigments. The ink sac opens into the rectum. When the organism is distributed the ink is released into the surrounding water. This cloud of ink is used as a decoy confusing the intruders and predators and the animal makes good its escape.



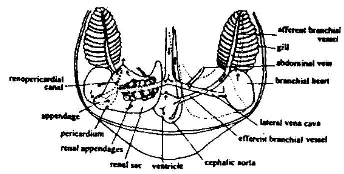


Fig.8.58: Internal anatomy of squid.

Fig.8.59: Excretory and Circulatory systems of Octopus.

Sexes are separate. The males fabricate elaborate spermatophores for sperm transfer. One of the arms of the adult male is modified into an intromittent organ called hectocotylus.

Cephalopoda includes three subclasses: Ammonoidea, Nautiloidea and Coleoidea. Subclass Ammonoidea is extinct and Nautiloidea contains only one living genus Nautilus while the rest are extinct. Nautils have coiled extedmal shell and many slender suckerless tentacles. Gills and nephridia occur in two pairs. Bulks of the cephalopods belong to subclass Coleoidea.

Subclass Coleoidea: Includes both living and extinct forms. Internal shell is present in some forms. In others shell may be reduced or absent. The arms are provided with suckers. Pair of gills and nephridia are present. First recorded in Missisipian period; includes five orders.

Sepia, Spirulo: Cottle fishes: Eight arms and two tentacles. Shell provided with septa. Greatly reduced internal shell. In some forms shell is absent; Architeuthis, Loligo and squids. The shell appears as a flattened blade, the pen. Elongated body with 8 arms and two small filaments. The eight arms are united with a web. Octopus: octopuses are with fins and without gills. All forms have a globular body and eight arms.

SAQ 3

1. Answer the following questions briefly.

(i) Name four major differences between the Gastropoda on the one hand, and Aplacophora, Monoplacophora and Polyplacophora on the other.

(ii) What is meant by torsion'?

(iii) What is the composition of molluscan shell?

(iv) Name the respiratory organ of pulmonates.

(v) Name the three subclasses of class Gastropoda.

2. State whether the following statements are true or false:

(A) Class Bivalvia includes snails, slugs, limpets and abalones. T/F

(B) Bivalves have the smallest mantle cavity among molluscs. T/F

(C) The inner surface of shells of bivalves have a lustrous appearance.T/F

(D) Bivalves have adapted for filter feeding methods. T/F

(E) The crystalline style of bivalves produces digestive enzymes. T/F

(F) The crystalline style is a long gelatinous rod.T/F

G) The gills of bivalves play a key role in filter feeding mechanism. T/F

(h) The blood of cephalopods contains haemocyanin. T/F

(1) Cephalopods have one of the best developed nervous systems among invertebrates. T/F

(J) Development in bivalves includes trochophore and veliger larvae. T/f

3. Fill in the blanks with suitable words.

(A) Tusk shells belong to the class ___________

(B). _________________are the tentacles of scaphopods provided with a ciliated knob at their tips.

(C) _________________Is the only living genus under the subclass Nautiloidea.

(D) Some Cephalopods have ________filled shells to maintain their in water.

(E) In cephalopods a pair of______________ hearts pumps the blood through the gills.

(F) The blood vessels and capillaries in cephalopods are lined by______________ as in vertebrates.

(G) The mantle is innervated by ________________ ganglia.

(H) Male cephalopods fabricate elaborate_____________________ for sperm transfer.

4.0 Conclusion

In this unit you have learnt

- Phylum Mollusa is a large phylum of soft bodied animals and includes over 50.000 living species. The bilaterally symmetrical animals are usually provided with an outer calcareous shell that offers protection to them. A ventral muscular foot aids in locomotion. Dorsally, the body of the animal, known as visceral mass is covered by a body wall, the mantle that encloses a space.

  The mantle cavity. Gills or ctenidia located in the mantle cavity are the respiratory structures. Many molluscs are herbivores feeding on algae and other plants. Food collecting organs. The odontophore and radula are located in the buccal cavity. Coelom is confined to a place enclosed, by the pericardium dorsally and a portion of the intestine ventrally. Circulatory system consists of a three chambered heart, blood vessels and blood sinuses. Excretion is by nephridia or kidneys.

  Nervous system consists of brain, pleural. pedal and visceral ganglia and the associated commissures and connectives. Molluscs may be hermaphrodites or dioceous. Fertilisation may be external or internal. In organisms with internal fertilisation sperm transfer may be direct or via spermatophores. Development may include one or two larval stages, the trochophore and the veliger larvae.

- Phylum Mollusca includes seven classes of these Class Monoplacophora includes most primitive molluscs. Class Polyplacophori includes chitons that have a dorsoventrally flattened body covered by eight overlapping plates. Class Aplacophora comprises of shell less molluscs, the solenogasters. The remaining four classes are Gastropoda Bivalvia Scaphopoda and Cephalopods, Gastropods. The members of the largest class of Mollusca occupy marine, fresh water and terrestrial environment.

  They include snails and slugs. The snails possess a conospiral shell and the visceral mass has undergone a 90 to 180° twist - the torsion. The foot, a flat, creeping sole is the typical locomotioy organ. The class Bivalvia, as the name suggests comprises of molluscs that have a shell formed of two valves and the body is laterally flattened. And the caphalopods, with the exception of Nautilus have no external shell. Cephalopods can be regarded as highly advanced of all the invertebrates because of the presence of a well developed nervous system as well as the circulator system.

5.0 Summary

Next to the arthropods the mollusks have the most named species in the animal kingdom. The name molluscum (L - mollusus, soft) indicates one of their distinctive charcterisrcs. The group ranges in form from fairly simple organisms to some of the most complex invertebrates and in size from almost microscopic to a length of 50 feet – the largesrt of all in vertebrates.

Two structural features of the mollusks that set them aside from all other animals are the ventral muscular foot and the fleshly mantle.

A group as large as the mollusks would naturally affect man in some way. As food, oysters and clam are popular everwhere, and you must have eaten snails at one time or the other. Also certain species of snails are intermidate mosts for some stages of parasite, e.g. schistosoma species.

6.0 Tutor Marked Assignment

1. List the diagnostic characters of phylum Molluscs.

2. Briefly write about the organisation of chitons.

3. What is torsion? Briefly discuss the process of torsion in gastropods.

4. Write brief notes on:
   a) Shell in Bivalvia
   b) Crystalline style

7.0 Further Readings

1. Invertebrate zoology by Rupert/ Barnes 6th International Edition 1994

2. Integrated principles of zoology by Hickman, Riberts and Larson. 9th Edition 1995

3. Hickman, C.P.1970 intergrated princplesd of zoology C.V. Mesby. Company St Loius

ANSWERS

SAQ I

a) Snails, clams and squids
b) Mineralised shell
c) Visceral mass
d) Mantle -
e) Ctenidia

SAQ 2

(i) c,e,i. (ii) a, b, f, h (iii) d, g

SAQ 3

I (1) (1) Development of distinct head
(2)Dorsoventral elongation of the body
(3) Gastropods exhibit torsion
(4) Conversion of plate like shell into a spiral asymmetrical shell.

(2) Torsion of the twisting of the visceral mass 180° with respect to head and foot. The anticlockwise twist behind the head results in the positioning of the gills, mantle cavity, anus, and nephridiopore at the anterior part of the body behind the head when viewed dorsally,

(3) Molluscan shell has three layers, the outer homy layer made of conchiolin, a modified protein. The middle layer is prismatic layer made up of prisms of calcium carbonate packed in a matrix of protein. And the inner nacreous layer is the calcareous layer.

(4) The large gills that are located in the spacious mantle cavity are the respiratory organs in bivalves.

(5) Prosobranchia, Opisthobranchia, Pulmonata.

Il A-F: C-T; D-T; E-T; F-T; G-T; H-T; 1-T; J-T.

III A. Scaphopoda H. captacula C. Nautilus D. gas, buoyancy E. branchial F. endothelium G. Stellate H. spermatophores

Answers to

I. Refer to section 6.2

2. Refer to section 6.2.2

3. Refer to section 6.2.4

4. (a) Refer to section 6.2.5

(b) Crystalline style is a structure found in the stomach of lamellibranchs. It is a compact and long, gelatinous rod that secretes enzymes amylase and lipase.

Unit 9

PHYLUM ECHINODERMATA

Table of contents

1.0 Introduction

Now you will begin the study of echinoderms. The phylum includes some 6000 species, all marine animals and comprises sea stars, sea urchins, sea lilies and sea cucumbers. Majority of echinoderms are bottom dwellers and measure several centimeters in diameter.

A remarkable feature of the group is the pentamerous radial symmetry. This means that their body can be divided into five equal parts arrarmged around a central axis. But die radial symmetry of adult echinodemts is secondary. The larvae of eclimoderms are bilaterally symmetrical. During metamorphosis the bilateral symmetry of the larvae is replaced by radial symmetry in adults. Also, echinoderms have no relationship with other radially symmetrical invertebrates. Yet another characteristic of echinoderms is the presence of internal skeleton formed of calcareous ossicles. The ossicles may articulate with one another or they may be sutured together. Spines of tubercles project out front the surface of the body that gives the animal a warty or spiny appearance and hence the name of the phylum Echinodernmata meaning spiny skinned animals.

A third characteristic feature of echinoderms is the presence of a unique system, the water vascular system. This system formed by coelomic canals and certain surface appendages, besides functioning as food gathering and gas transport system. Also aids in locomotion of the animals. Echinoderms possess an extensive coelom that forums perivisceral cavity as well as the cavity of water vascular system. The coelom is of enterocoelous type. The coelomic fluid contains amoebocytes.

The blood vascular svstem of echinoderms is much reduced and does not play any significant role in circulation. Structures known as dermal branchiae and tube feet of water vascular system are the respiratory organs. The classes Holothuroidea have a structure called respiratory tree, that aids in gas exchange. In another class, Ophiuroidea, Bursa plays a role in respiration. Echinoderms can lose their body parts by autotomy and have the power of regeneration as well. Phylum Echinodemmata includes five classes. They are:

1. Class Asteroidea
2. Class Ophiuroidea
3. Class Echinoidea
4. Class Holothuroidea
5. Class Crinidea

You will study the characters of the class Asteroidea in detail and the characters of other classes briefly.

2.0 Objectives

After studying this unit you should be able to:

1. Know the different classes under the phylum Echinoidermata

2. Point out the characteristic features of the phylum

3. Briefly relate their structural orgasnisation

4. And mention the important characters of various classes included under the phylum Echinodermata.

3.1 The Characteristic Features of Phylum Echinodermata are:

1. Echinodermata is deuterostomous phylum. Adults mostly with pentamerous symmetry; all are marine.

2. Body not metamerically segmented; rounded, cylinderical or star shaped, without head.

3. No brain. Few specialised sense organs. Central nervous system in the form of circumneural ring and radial nerves.

4. Digestive system complete

5. Coelom enterocoelic and extensive. Forms perivisceral cavity and the cavity of the unique water vascular system.

6. Blood vascular system (haemal system) very much reduced and surrounded by perihaemal sinuses (extensions of coelom).

7. Exoskeleton made up of abnormal calcareous ossicles with spines in most organisms; or calcareous spicules in the dermis of some. Pedicillariae present in some.
8. Locomotion mainly by tube feet; in some by spines or by movement of arms.
9. Respiration by dermal branchiae, tube feet, respiratory tree or bursae.

10. No olfactory organs.

11. Sexes usually separate; gonads large simple gonoducts. Fertilization external.

12. Indeterminate type of development; radial cleavage; free swimming, bilaterally symmetrical larval stages usually present during'development.

13. Autotomy and regeneration extensive.

3.2 Class Asteroidea

Star shaped; arms not sharply demarcated from central disc; ambulacral grooves open; tube feet on oral side and with suckers. Arms and madreporife on the aboral side; pediceltaria are present.

The class includes sea stars or starfishes (Fig.9.1). The sea stars are variously coloured free living animals common along the rocky shores. They ate found on the sea bottom crawling over the rocks or corals or living in sand and mud.

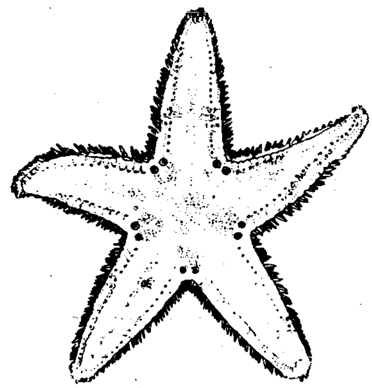


Fig 9.1: Aboral view of seastar.

The body has a central disc from which five arms project out giving the animal pentamerous radial symmetry. They range from 12 to 24 cm on an average. The arms are not very distinct from the central disc; rather they imperceptibly grade into the central disc.The mouth is located at the centre of the disc on its under surface, which is hence called **oral surface** (Fig.9.2): From the mouth a furrow called ambulacral groove extends into each arm radially.

The groove harbours two or four rows of small tubular projections called **tube feet or podia.** The groove may be kept partly closed by movable spines that are located on its margins. Each arm bears at its tip one or more tentatcle like sensory tube feet and a red pigment spot. The upper surface of the animal is called **aboral surface** (fig. 9.2) and it bears anus at the centre. A large button like structure the **madreporite** is also present on the aboral surface on one side of the central disc between two of the arms.

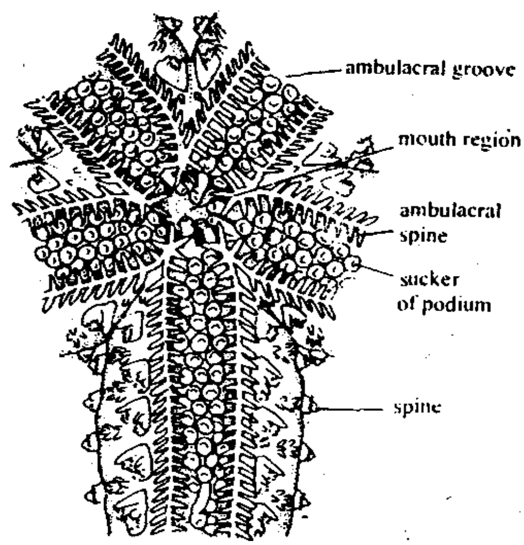
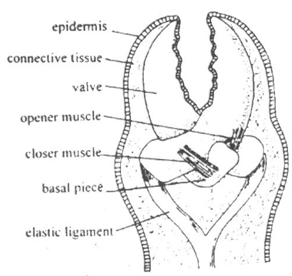


Fig.9.2: Central disc and part of one arm of oral surface of starfish Asterias.

The body wall consists of an outer epidermis formed of monociliated epithelial cells, mucous gland cells and sensory cells. Below the epidermal layer is a thick dermis formed of connective tissue that houses hard skeletal pieces called ossicles. The ossicles are variously shaped as rods, crosses or plates and are arranged as a lattice or network bound together by connective tissue. Ossicles are made up of magnesium rich calcite.

The dermis is followed by muscles that aid in the bending of the arms. The coelom is lined by a ciliated peritoneal membrane. Some seastars have on their body surface specialised jaw like or pincer like appendages, the pedicellaria (Fig.9.2) meant for the protection of the animal from small animals and larvae that try to settle on the sea stars. The pedicellariae may be stalked or sessile.



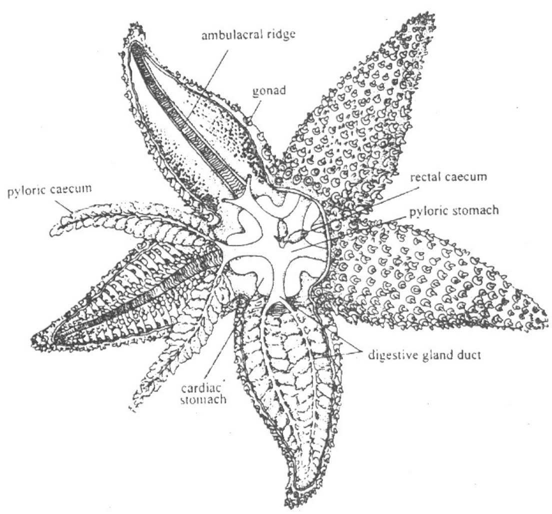


Fig. 9.3: Aboral surface of starfish showing the internal anatomy

Fig. 9.4: A pincer like pedicellaria of starfish

3.2.1 Water Vascular System

Echinoderms have a unique system that consists of canals and appendages of body wall called water vascular system (Fig.10.5) This system is a coelomic derivative: it is lined with ciliated epithelium and filled with fluid. In asteroids the water vascular system is well developed and is mainly locomotor and food gathering in function. It also serves in respiration and excretion.

The water vascular system communicates with the exterior by the button shaped madreporite located on the aboral surface. The madreporite has a number of pores on it. The pores open into a **stone**

canal that runs front the aboral side to the oral side and join the **ring canal** that surrounds the mouth. From the ring canal arises radial canals to each arm just beneath the annbulacral groove.

The radial canal gives rise to a large number of **lateral canals** on either side along its entire length. Each lateral canal has a bulb like **ampulla** and tube foot or podium. The ampulla is a small muscular sac which bulges into the perivisceral coelom. The ampulla is connected with the tubefoot or podium. The podium is located in the ambulacral groove and is a short, tubular, external projection of the body wall and its tip is flattened to form a sucker.

The water vascular system is filled with a fluid similar in composition to sea water and the fluiddigestive gland duct contains coelomocytes and proteins. Arising from the ring canal and at the interradial position are **polian vesicles** which are elongated muscular sacs and paired pouches called **Tiedmann's bodies.**

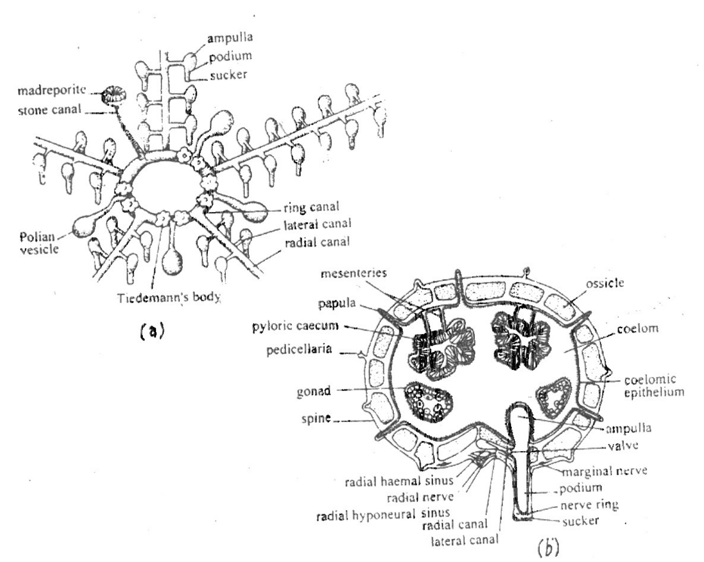


Fig. 9.5: a. water vascular system of starfish b. cross section through an arm of starfish

3.2.2. Digestive System

Most asteroids are scavengers or carnivores and feed on snails, bivalves, polychaets, and other echinoderms, fish, sponges, sea anemones and polyps of hydroids and corals. Some feed on plankton and detritus. The digestive system of sea stars extends between the oral end and aboral disc of the animal. The mouth lies at the centre of a muscular peristomial membrane.

The mouth is followed by a short oesophagus that in turn opens into a large stomach. The stomach occupies most of the interior of the disc and is divided by a horizontal constriction into a large oval cardiac stomach and a smaller, flattened **pyloric stomach** (Fig.9.6). The walls of gastric stomach are pouched. In each arm a pair of digestive glands or pyloric caeca are present and their ducts open into pyloric stomach.

The pyloric stomach leads into a short tubular intestine on the aboral side. The intestine opens to the outside through a minute anus at the centre of the aboral surface of the disc. A number of small outpocketngs called rectal ceaca arise from the intestine.

3.2.3 Circulation, Respiration and Excretion

Asteroids depend on the circulation of coeloimic fluid for the transport of gases and some nutrients. The blood vascular system called haemal system in echinoderms is not very well developed in asteroids. The channels lack a lining. However, these channels are surrounded by extensions of coelom called perihaemal sinuses.

There are four coelomic circulatory systems in asteroids (Fig.9.6)

1) The **perivisceral coelom** and the fluid that circulates in it. supplies the viscera

2) The **water vascular** system that supplies the muscles of the tube feet that aids in locomotion

3) **Hyponeural sinus system** that supplies the nervous system

4) **Genital coelom** that supplies the genital organs.

Echinoderms live exclusively in sea water with which their body fluid is isotonic. The nitrogenous excretory wastes are removed through the thin areas of body surface, such as tube feet and papulae by diffusion. Besides, coelomocytes also play a role in removing the metabolic wastes from the coelom.

Gas exchange in asteroids is achieved by papulae (dermal branchiae), soft projections of coelomic cavity standing out through the spaces between ossicles. Tube feet are also principal respiratory organs.

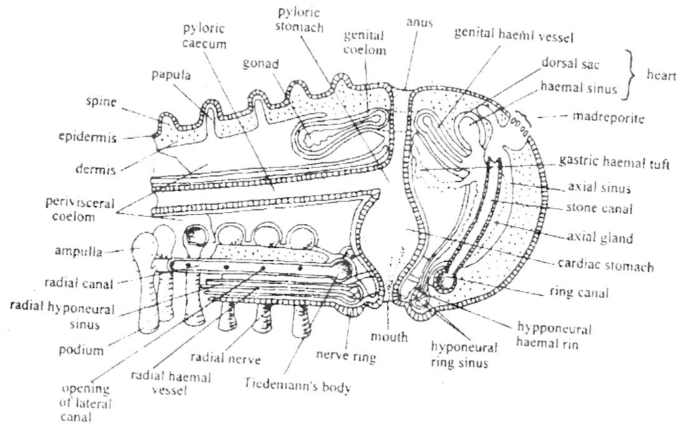


fig.9.6: Diagram showing blood vascular and coelomic system in a Starfish.

3.2.4 Nervous System

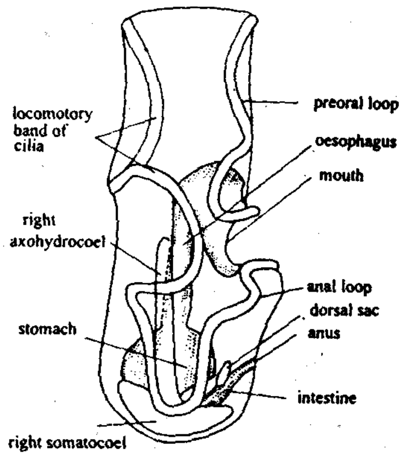
The nervous system of steroids is not ganglionated and is closely associated with epidermis. It consists mainly of a circumoral nerve ring surrounding the mouth. From this nerve ring radial nerves extend into each arm. The radial nerve supplies branches to the podia and ampullae and is continuous with the subepidermal nerve net. Sense organs in asteroids are the eye spots found at the tip of the arm.

The epidermis has also sensory cells that probably function as photoreceptors, chemoreceptors and mechanoreceptors. The epidermal sensory cells are more prevalent on the suckers of tube feet. tentacle like sensory tube feet and along the margins of the ambulacral groove.

3.2.5 Reproductive System

Sexes are separate in most asteroids. There arc ten gonads, two in each arm. They appear tuft-like or as cluster of grapes. Mature gonads occupy almost the entire arrn. The gonopore is located between the bases of die arms. In the majority of seastars the sperms and eggs are shed into sea water and fertilisation is external.

A single female may shed as many as 2.5 million eggs. Development includes a larval stage - the bipinnaria lava (fig.9.7) The free swinmming larva is provided with ciliam bands and arms that function in both locomotion and feeding. The bipinnaria larva then transforms into another larva. The brachiolaria larva (Fig.9.8) with the appearance of additional arms at the anterior end. The branchiolaria then metamorphoses into all adult.



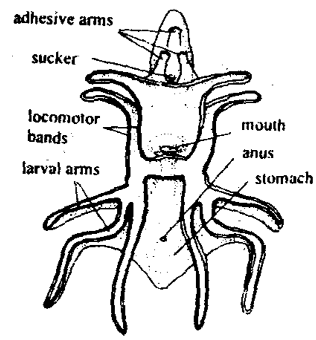


Fig.9.7: Bipinnaria larva. **Fig.9.8: Brachinolaria larva**

Now you have studied in detail the organisation of asteroids. Since the members of the other classes of the arm basically similar in organisation to those of asteroids in the next section we will be highlighting only the salient features of other classes, and the differences they exhibit from asteroids. But before you begin the study of other classes of echinoderms, answer the following SAQs.

SAQ 4

Fill in the blanks with suitable words.

a) Adult echinoderms exhibit __________symmetry and the larvae show _____________ symmetry.

b) The endoskeleton of most echinoderms is formed of______________

c) In echinoderms the system of coelomic canals and tube feet is called _____________________system.

d) The respiratory structures of echinoderms are________and_______

e) The pincer like structures that are found on the surface of the body of asteroids meant for protection are called ___________________

f) The larvel stages of asteroids are _____________ and ___________

3.3 Class Ophiuroidea

Body star shaped but arms sharply demarcated from the central disc; anmbulacral grooves covered by ossicles; tube feet have no suckers; no pedicellaria; no arms.

Class Ophiuroidea includes brittle stars (Fig.9.9), the largest class of echinoderms in terms of number of species. They inhabit benthic zones of sea. Ophiuroids feed on a variety of objects either browsing or by filter feeding.

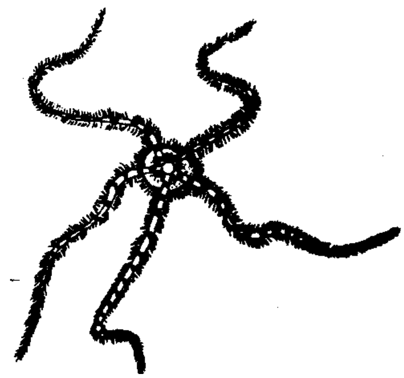


Fig. 9.9.: Brittle star

Although the brittle stars like asteroids have five radial arms, the arms are slender and sharply demarcated from the central disc. Pedicellariae are absent in brittle stars. The ambulacral grooves are covered with ossicles. The tube feet lack suckers, and hence they are helpful in feeding but have no role in locomoton. Unlike in asteroids, in ophiuroids madreporite is located on one of the oral shield ossicles.

The tube feet also lack ampullae. Each arm of the animal has a column of articulated ossicles. These ossicles are covered by plates and connected by muscles usually called vertebral ossicles. Locomotion is brought about by the movement of arms. The mouth is surrounded by movable plates, the jaws. The integument of the animal is leathery and harbours dermal plates and spines. The visceral mass is confined to the central disc.

There is a sac-like stomach and no intestine. Anus is absent. The undigested food is discarded through mouth. Nervous and haemral systems are similar to those of asteroids. The central disc harbours five pairs of sac like structures called bursae (sl. bursa), found only in ophiuroids among the echinoderms. The bursae open towards oral surface by genital slits at the base of arms. Gas exchange occurs in these bursae when water flows in and out of them.

The gonads, small in size, located on the coelomic wall of the bursae, discharge the gametes in the bursa from where they find their way to the water through the genital slits. Sexes are usually separate. Fertilisation is external. Development includes a larval stage **ophiopluteus** (Fig.9.10). Asexual reproduction is observed in the form of regeneration eg. *Ophiura, Ophioderma.*

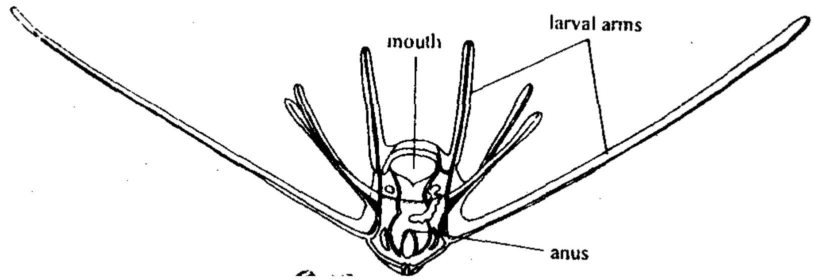


Fig. 9.10: Ophioplutous larva

3.4. Class Echinoidea

Globular or disc shaped, without arms. Skeleton compact made up of dermal ossicles closely fitted with one another. Spines movable; ambulacral grooves closed; tube feet having suckers; pedicellariae present.

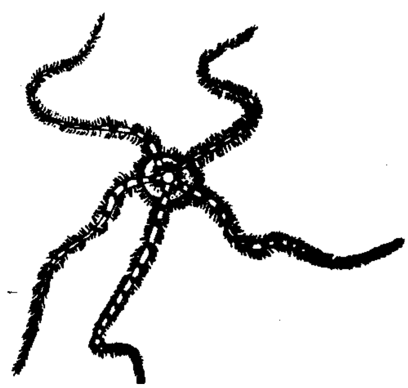


Fig.9.9 Brittle star

Class Echinoidea includes sea urchins (Fig.9.11) sand dollars (Fig.9.12) and heart urchins. Echinoids have a compact body that is enclosed in an endoskeletal test or shell. The test is made up of dermal ossicles which are closely sutured with each other forming a compact structure. The plates bear stiff movable spines. The five pairs of ambulacral rows have pores and are homologous to the five arms of star fishes. Through the pores the long tube feet are protruded. Echinoids also have pedicellariae which help the animals to keep the body clean and to capture small organisms.

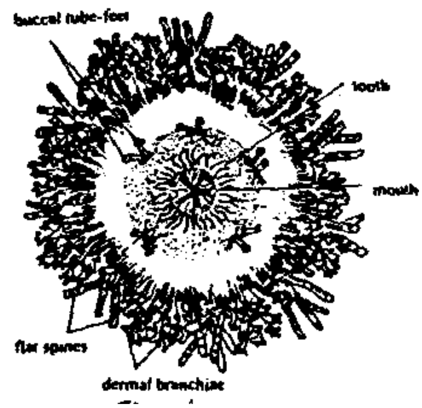


Fig.9.11: Sea urchin

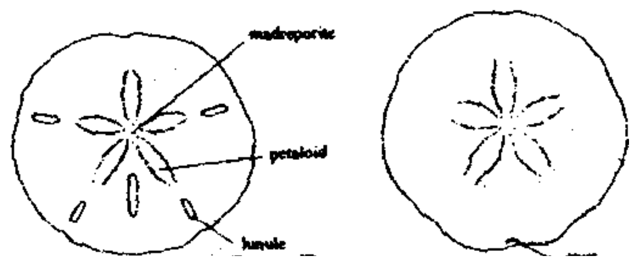
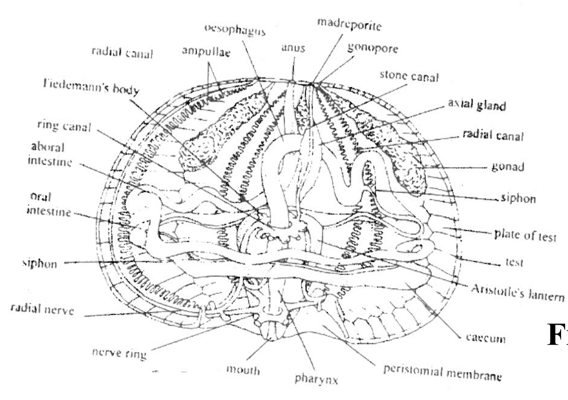


Fig. 9.12: Sans dollar

The mouth of sea urchins lies at the centre of five converging teeth. The teeth are part of a complex chewing organ called Aristotle's lantern (Fig.9.3). Sea urchins feed algae and other organic materials. Inside the test there is a coiled digestive system in which the oesophagus is directly connected to the intestine by a ciliated siphon enabling water to bypass the stomach (Fig. 9.13a). Thus the animal can concentrate the food for digestion in the intestine. The anus is located at the aboral surface.



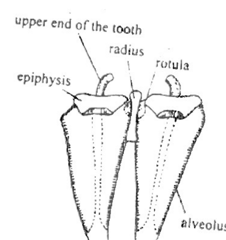


Fig.9.13: Aristotle's lantern.

Fig.9.13a: Internal anatomy of a sea urchin.

Circulatory and the nervous systems are similar to those of asteroids. The ambulacral grooves are closed and the radial canals of the water vascular system are located on the ambulacral radii just beneath the test.

The tube feet are provided with ampullae which lie inside the test and respiration is carried out by podia. In echinoids sexes are separate. Gametes are shed into water and the fertilisation is external. Some individuals may brood the young ones in the depression between the spines. Development includes a larval stage, the echinopluteus larva (Fig.9.14). The larva leads a planktonic life for several months before metamorphosing into an adult. Common general are Arbacia, Strongylocentrous (sea urchins); dendraster (sand dollar).

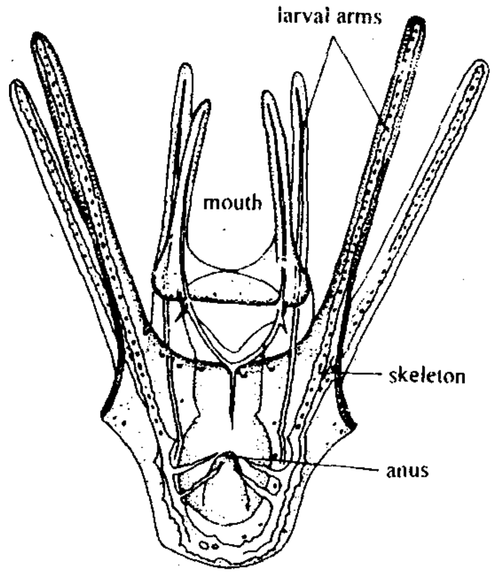


Fig.9.14: Echinopluteus larva

3.5 Class Holothuroidea

Body cucumber-like; no arms; no spines; no pedicellariae; ossciles minute and embedded in muscular wall; anus present; tube feet with suckers; ambulacral grooves closed; modified tube feet in the form of circumoral tentacles present; madreporite internal.

Holothuroida are commonly known as sea cucumbers because of their resemblence to cucumber (Fig.9.15). They differ from the rest of the echinoderms in many respects. Holothurians have greatly elongated oral-aboral axis.

The ossicles (Fig.9.16) are highly reduced and are embedded in a muscular, thick and leathery body wall as a result of which the animals are soft-bodied. They either burrow or crawl on the sea-bottom or are found beneath rocks. As they usually lie on one side, the locomotory tube feet may be present only on that side of the body limited to the three ambulacra. This side is called the sole.

In some species however the tube feet may be distributed in five ambulacral areas or all over the body. There are between ten to thirty retractile oral tentacles that are modified tube feet. Sea cucumbers are sluggish animals. Suspended food particles are entangled in the mucus secreted by the oral tentâcles. The tentacles are, then stuffed on by one through the mouth into the pharynx and the food particles are sucked off.

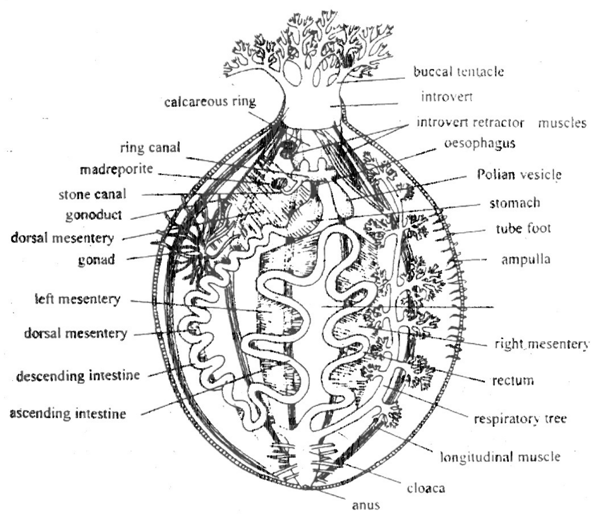


Fig. 9.15: Internal Organisation of a sea cucumber.

A spacious, fluid filled coelomic cavity is' present in holothurians. The digetsive syste consists of oesophagus, stomach and intestine. The intestine opens to the exterior by a cloaca (Fig.9.15).

There is a unique respiratory tree (Fig.9.16) in the coelomic cavity. It is composed of two long highly branched tubes. It opens into the cloaca. The cloacal muscles pump water into cloaca for purpose of gas exchange. Gas exchange is also carried out by skin and tube feet. The respiratory tree also has a role in excretion. The haemal or circulatory system as well as the water vascular system are present. The madreporite is peculiar in that it lies in the coelom.

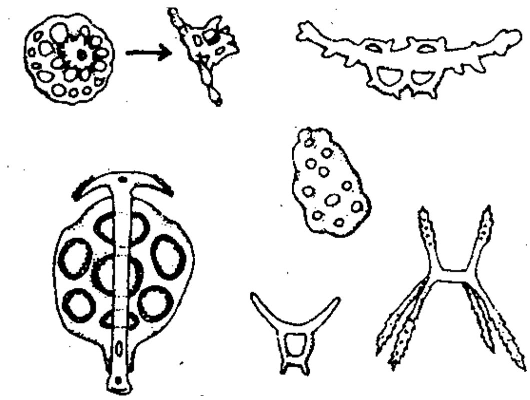


Fig.9.16: ossicles of sea cucmber

Sexes are generally separate. Holothurians have an unpaired gonad that appears as one or two clusters of tubules.

Gametes are shed into water and fertilisation is external. A free swimming larva called auricularia (Fig.9.17) emerges from the fertilised egg and metamorphoses into adult. Sea cucumbers can self-mutilate their body as a form of self-defense. When disturbed they may cast out a part of their viscera by rupturing their body wall. It may also evert the contents through the anus. The lost parts are then regenerated, eg. Cucurmaria, *Leptosynapta, Synapta.*

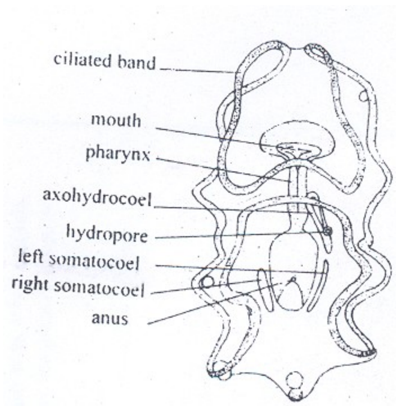


Fig. 9.17: Auricularia larva.

3.6 Class Crinoidea

Five arms but branching at base; they carry pinnules. Oral surface has ciliated ambulacral grooves with tube feet resembling tentacles. No spines, no madreporite, no pedicellaria.

Class Crinoidea includes sea lilies (Fig. 9.18) and feather stars. They constitute the most primitive of living echinoderms. More fossil forms are known than the living ones. The living crinoids range in length from 15-30 cm. Sea lilies have flower shaped body at the top of an attached stalk.'rhe feather stars are free living and have long, many branched arms, although the adults remain in the same spot for very long periods.

Also the feather stars which remain sesile or stalked during metamorphosis, detach, themselves from the stalk to become free living. Many crinoids live at great depth but some of the feather stars occupy shallow waters.

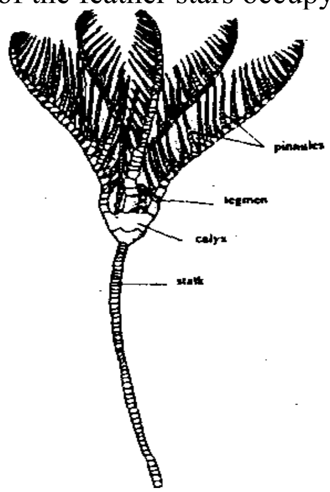


Fig.9. 18: A sea lily

The body disc of crinoids called calyx is covered by a leathery skin, the tegmen. Tegmen contains calcareous plates. There are five flexible arms which branch off to give rise to more arms. Each arm carries many lateral pinnules that are arranged like barbs on a deather. The calyx and arms together are called the crown. In forms that are attached, there is a long stalk present on the aboral side of the body. The stalk itself is formed of many jointed plates and may bear cirri. In crinoids madreporite. Spines and pedicellariae are absent.

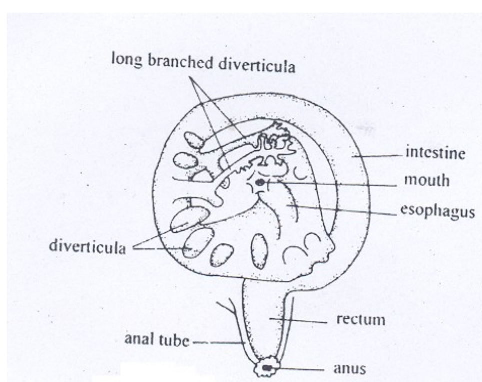


Fig. 9.19: Digestive of a sea lily

The mouth leads into a short oesophagus followed by the long intestine (Fig. 9.19).The intestine bears diverticila and runs aboral1y for distance before taking a complete turn to open through anus located on a raised cone. Crinoids feed on small organisms that are caught in the ambulacral groove with the help of tube feet and mucous nets.

The ciliated ambulacral grooves transport the food to the mouth. The water vascular system is built on typical echinoderm plan although the madreporite is absent. The nervous system has an oral nerve ring front which a radial nerve enters each arm. Sense organs are scanty and primitive. In crinoids sexes are separate.

The gonads appear as masses of cells in the genital cavity. The sperm and ova escape by rupturing the wall. Fertilisation is external. Development includes a free swimming larval stage **Doliolaria** that later on attaches itself to a substratum before metamorphosis into adult e.g. *Antedon Heterometra.*

SAQ2

1. State whether the following statements are true/or false.

1. Brittle stars are pelagic. T/F
2. Bursae in ophiuroids are respiratory in function. T/F
3. In brittle stars tube feet aid in locomotion. T/F
4. Echinoid shell is compact. forced by close suturing

   of dermal plates. T/F
5. Aristotle's lantent is a complex chewing organ of sea. T/F
6. Holothurians closely resemble other echinoderms both morphologicalk and physiologically. T/F
7. The respiratory tree of holothurians is respiraton and excretory in function. T/F
8. Sea lilies and feather stars are most advanced echinoderms. T/F
9. Crinoids do not have madreporite. T/F

2. Match the itenis given in A with those gien in B

A	B
1. Holothuroidea	a) Doliolaria
2. Crinoidea	b) Bipinnaria
3. Asteroidea	c) Echinopluteus
4. Echinoidea	d) Ophiopluteus
5. Ophiuroidea	e) Auricularia

3.7 Other Phyla

You have now studied all the major invertebrate phyla. In addition to these, there are a few other phyla of animals in invertebrates. Each of them contains a very limited number of species of animals only. Information on most of these phyla is very often far from sufficient and hence it is difficult to understand their affinities with other animals with any degree of certainity. So assigning them proper position in the animal kingdom has been very difficult.

It is not possible here to treat these phyla in detail as it is beyond the scope of this course. So instead, given below is the list of these phyla. The approximate number of species in each phylum is given in parenthesis. Their broad position in the animal kingdom is also indicated against them. You will get a brief idea of these phyla from this account.

Name of the phylum	**Number of species**	**Position**	
Placozoa	I	Parazoa	
Mesozoa	50	Protostomia	Acoelomata
Nemertina (Nenrertea)	650	-do-	-do-
Gnathosiomulida	80	-do-	-do-
Gastrotricha	400	-do-	Pseudocoelomata
Kinorhyncha	100	-do-	-do
Nematophora	230	-do-	-do
Acanthocephala	500	-do-	-do-
Entoprocta	60	-do-	-do

Loricifera	(most recently described)	-do-	Schizocoelomous coelomates
Priapulida#	9	-do-	-do-
Sipunculida (Sipuncula)	300	-do-	-do
Echiura	100	-do-	-do
Pogonophora	80	-do-	-do-
Tardigrada	400	-do-	-do
Pentastomida	90	-do-	-do
Phoronida (lophophorate)	10	-do-	-do
Ectoprocia (lophophorate)	50	-do-	-do
Branchiopoda (lophophorate)	280	-do-	-do-
ChactognattaI	50	Deuterostomia	Enterocoelous
Hemichordata	80	-do-	do-

4.0 Conclusion

Echinoderms are the largest deuterostontous group and are exclusively marine in habitat. The adults have a radial symmetry, although the larvae are bilaterally symmetrical. They live in benthic zones in the sea and are particle feeders, browsers, scavengers and predators. Echinoderms generally have five amts around a central disc.

Head and specialised sense organs absent. The side in which the mouth is present is the oral surface and generally anus opens on the aboral surface. They have dermal ossicles as endoskeleton, respiratory papulae and open ambulacral areas. Structures called pedicellaria may be present as organs of protection.

The water vascular system, unique to echnoderms, derived from some of the coelomic cavities does varied functions such as food gathering, locomotion, respiration and circulation. Hemal or circulatory system of undefined function is seen in echinoderms. Sexes are separate and reproductive systems are simple. Development invariably includes a larval stage. Includes five clases: Asteroidea, Ophiuroidea, Echinoidea, Holotlhyroidea and Crinoidea.

5.0 Summary

Because of the spiny nature of their structure echinoderms have a limited use as food for other animals. However, their eggs may serve as food. And the sea cucumber (trepang) is used by the Chinese for soup. Where echinoderms are common along seashores, they have been used for fertilizer.

Sea stars feed mainly on mollusks, crustaceans and other invertebrats, but their chief damage is to clams and oyster are commercially cultivated by man for foods and ornamentals (perls).

A single star may eat as many as a doxzen oysters or clams in a day. To rid shellfish beds of these pests, rope nests in which the sea stars become entangled are sometimes dragged over oyster beds, and the collectied sea stars destroyed. A more effective method is to distribute lime over areas where they abound; lime causes their delicate epidermal membranes to disintegrate thereby effecting the death of the sea stars.

The eggs of echinoderms are widely used in biologic investiagations. Because they are usually very abundant. Artificial pathenogenisis was first discovered in sea urchin eggs when it was found that by changing the chemical without the presence of sperms.

Echinoderms have no parasitic species as far as is known.

6.0 Tutor Marked Assignment

1. What are the characteristics of echinoderms that are unique to them and not found in other phyla?

----

2. Describe the water vascular system of a seastar?

3. List the various classes of phylum Echinodermata giving one example for each class
----

7.0 References and Further Reading

1. Hickman, C.P.1970 Intergrated princplesd of zoology C.V. Mesby. Company St Loius

2. Rupert and Barnesd 1994 invertebrates Zoology 6th international Edition.

3. Hickman, C.P. Ribert and Larson 1995. Intrgrated principles of zoology. 9th Editon C. V. Mesby st Loius.

Answers
To SAQs

SAQ 1

a) Radial, bilateral

b) Dermal ossicles

c) Water vascular

d) Tube feet, dermal branchiae

e) Pedicellariae

f) Bipinnaria, brachiolaria

SAQ 2

I 1-F; 2-F; 3-T; 4-T; 5-T; G-F; 7-T; 8-F; 9-T

II 1-e; 2-a; 3-b; 4-c; 5-d.

Unit 17

ADAPTIVE RADIATIONS

Table of contents

1.0 Introduction

All Living organisms are products of evolution. In simple words evolution may be defined as `descent with change'. Here change is the basic factor. Evolution may be in the nature of the environment or in the form and function of the organism. The nature of the environment has a strong bearing on the form and function of the organism. Organisms always tend to establish harmony with their environment. This process, called adaptation, enables the organism to face the vagaries of the everchanging environment. Adaptation actually sums up the whole result of evolution.

You might have noticed that when organisms belonging to different groups come to occupy similar environment, they develop striking similarities in structure and.behaviour, giving a false impression of closer relationship. For example, fishes and whales which belong actually to different classes (Pisces and Mammalia, respectively) are found in similar habitat i.e., they are both aquatic.
They look so alike that for a layman both are `fishes'. This condition where organisms belonging to different groups adapt themselves to the same environment and look and act alike, is *called adaptive convergence.*

On the other hand, there are situations where organisms belonging to the same or closely related groups may occupy different environments due to which they develop varied adaptations. It gives rise to diverse evolutionary lines. You know that house- lizard, snake, tortoise and crocodile belong to the same class, Reptilia. But they look so different from each other that one may be tempted to place them in separate classes.

This situation in which animals' belonging to same or closely related groups occupy different habitats and acquire different functional adaptations, is called *adaptive divergence or adaptive radiation*. In this unit you will study how adaptive radiations have evolved in. different non-chordate groups.

2.0 Objectives

After studying this unit you should be able to:

- Distinguish between solitary and colonial forms of animals and explain the needs for the evolution of true colonies in lower non-chordate groups,
- Differentiate between adaptive convergence and adaptive divergence or adaptive radiation and identify the different ways in which adaptive radiations have occurred in Annelida, Arthropoda and Mollusca,
- Describe the structure of insect wing and explain the mechanism of flight in insects,
- Describe the meaning, process and significance of migration in insects.

3.1 Solitary and Colonial Forms

Animals may lead their lives either as individuals or in groups. When they exist as individuals, they are called solitary, but if they live in organised colonies, we name then colonial. Colonies are a form of intraspecific association in which the interests of an individual are subordinate to those of the whole group. In true colonies the individuals are organically connected together by living matter or through material secreted by them. The degree and extent of closeness among individuals in a colony may vary considerably.

True colonies are found only in primitive groups with simple organisation, such as protozoans and coelenterates. In sponges it is difficult to ascertain whether the branched animal is an individual or a colony. Colonial forms mostly reproduce asexually. Actually the colony results due to the failure of the individuals to separate. Each individual in a colony is called a zooid.

3.1.1 Colonial Forms Among Protozoans

Many well known colonial forms occur among protozoans. Simplest colony formation is seen in **Choanoflagellates,** which have a collar around the base of the *flagellum* (hence the name). There are a few zooids in a colony as for example, in Codosiga (Fig. 17.1a). Each zooid leads an independent life though remaining attached to a common stalk.

The volvocales form more complex colonies. For example, Gonium forms plate like colonies of 4-16 individuals; Pandorina forms spherical colony of 16 individuals; Euddrina is a spherical colony of 32 zooids arranged on the surface, Pleodorina has 128 zooids.

An advanced form of colony is seen in *Volvox,* which is a plant-like mastigophore, or phytoflagellate. In this colony thousands of individuals remain embedded (Fig.17.1b) on the surface of a spherical jelly-like substance secreted by the zooids. Here also each zooid leads an independent existence except for a co-ordinated flagellar movement which helps in swimming. There is also connection among zooids by protoplasmic threads. (Fig.17.1).

It is of interest to know that these colonies always swim with a particular side forward i.e. they possess polarity, an attribute of fundamental importance for colonial existence. In *Volvox* and *Pleodorina* some sort of division of labour is also noticed. The anterior zooids do not reproduce while those elsewhere are reproductive some of which become

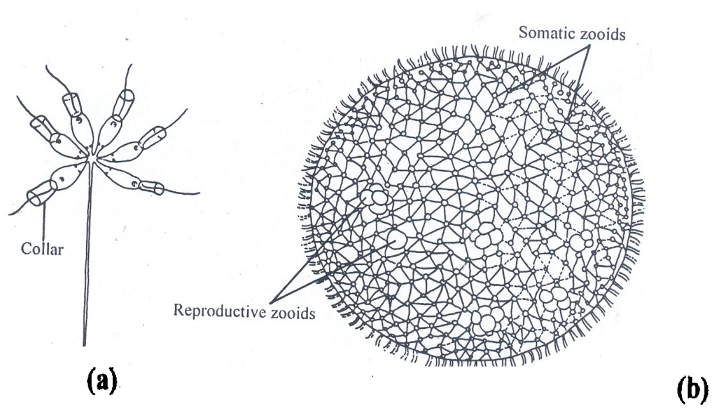


Fig. 17.1: a) Choanotlagellates: the simplest protozoan colony codosiga b) Volvox: an advanced colony.

Many ciliates like Epistylis and Zoothamnium also form colonies. Each of these colonies has bell-shaped zooids united by their stalks (Fig. 17.2 a and b) to a common stem. In Epistylis all zooids are alike while Zoothamnium shows polymorphism in zooid structure.

There are four types of zooids in the colony (Fig.17.2 b) a single terminal macrozooid which transforms into macro- conjugant; median axillary microzooids that can become migratory ciliospores; terminal branch microzooids which can form microconjugants and vegetative microzooids that can transform either into ciliospores or microconjugants.

Now let us examine the advantages of the colonial life in protozoans. Most of the protozoan colonies are autotrophic i.e. they obtain their food in a plant-like manner by photosynthesis. Therefore no apparent nutritive advantage is provided by the colonial way of existence. Then what are the benefits? We can observe following advantages:

1. Association of individuals in a jelly-like ground substance, especially when interconnected by protoplasmic strands, facilitates transmission of nutrients.

2. Combined flagellar activity of many zooids gives locomotory advantage.

3. Most of the colonies being spherical, minimum surface area for a given volume of sphere is exposed to the surrounding water, due to which the resistance offered by water is least.

4. In colonies of ciliates the group association provides protection and more efficient exploitation of food-supplies.

Before we pass on to colonial life in metazoans, let us see what you have learnt so far.

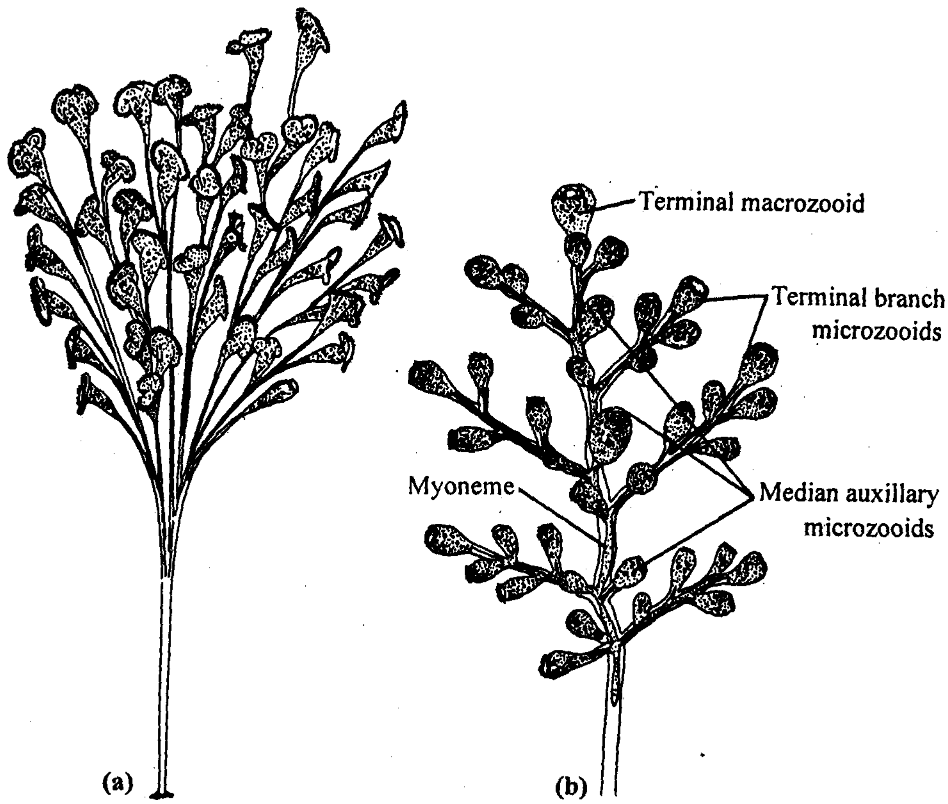


Fig.17.2) **a) Epistylis: Colony having similâr zooids,**
b) Zoothamaium: a polymorphic protozoan colony.

SAQ 1

1. Fill in the blanks using the correct word given in parenthesis below: (environment, different, alike, adaptive convergence, adaptive divergence)

1) The condition where organisms belonging to widely different phylogenetic groups adapt themselves to the same................................ and look and act alike is called..

2) When animals belonging to phylogenetically closely related groups occupy different habitats and acquire different adaptive modification, it is called ---

2. Indicate whether the following statements are true (T) or false (F):

a) In. true colonies zooids are not organically connected with each other.

b) True colonies are found only in organisms with comparatively simple organisation.

c) Colonies in Carchesium show polymorphism.

d) Colonial life provides nutritive advantage in all colonial forms.

3.1.2 Colonial Forms in Metazoans

Among metazoans, true colonial forms are met with in coelenterates, though the term `colony' is often used in relation to sponges and insects also. In sponges the `colony' is arbitrarily defined on the basis of the number of oscula. One osculum-one-individual is the rule.

However, this definition is more a matter of convenience. In insects the word `colony' is employed to denote the complex socitieties that are formed by them, as in the case of honey bees, ants, termites etc. But these social groups do not strictly fall within the definition of the term colony.

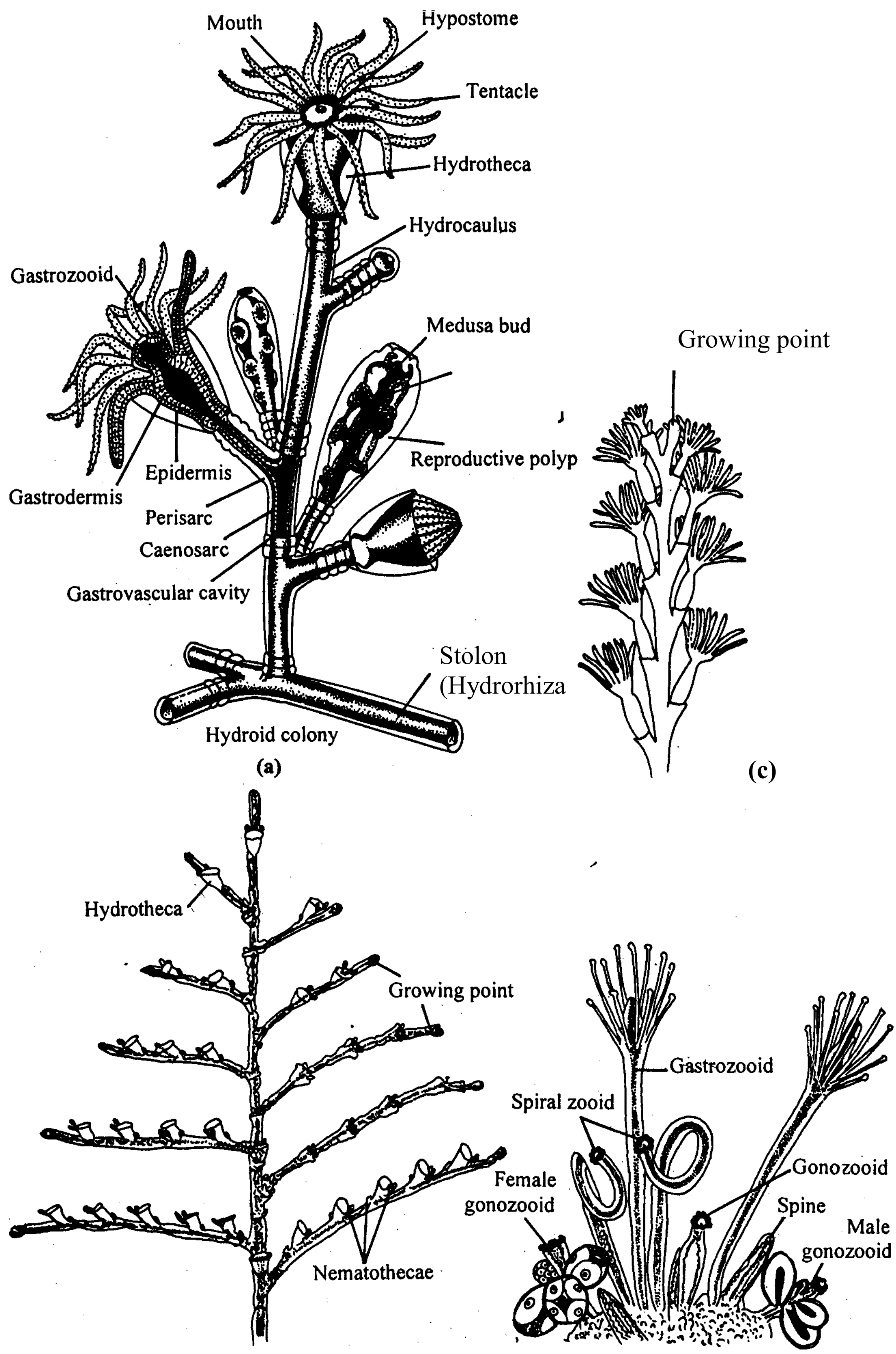

Mouth
Hypostome
Tentacle
Hydrotheca
Hydrocaulus
Gastrozooid
Medusa bud
Reproductive polyp
Epidermis
Gastrodermis
Perisarc
Caenosarc
Gastrovascular cavity
Stolon
(Hydrorhiza
Hydroid colony
(a)
Growing point
(c)
Hydrotheca
Growing point
Nematothecae
(b)
Gastrozooid
Spiral zooid
Female
gonozooid
Gonozooid
Spine
Male
gonozooid
(d)

Fig: 17.3: a) Obelia, the hydroid colony (monopodial colony).

(b) Plumularia colony showing monopodial growth.

(c) Sympodial growth of Halectum colony.

(d) Hydractinia colony where polyps grow directly from the mat of stolons.

Colenterate Colonies

Members of the class Hydrozoa and Anthozoa form true colonies. Zooids with well-defined individuality are present in a colony, the shape and pattern of which varies from species to species. Floating colonies are formed by siphonophores. In the case of sedentary hydrozoan colonies, the colonies are attached to the substratum by living thread-like horizontal stolon or hydrorhiza (Fig.17.3a). From the stolon arise vertical branching stems called hydrocauli. Each hydrocaulus gives off lateral branches, which in their own turn bear branches of the third order. Zooids are borne on these branches (Fig. 17.3a).

The branches and zooids in a colony are connected by a living coenosarc, over which a non-living horny perisarc is present. The coelenteron continues throughout. A zooid is cylindrical or umbrella-shaped, diploblastic structure with a body cavity or coelenteron opening to the exterior by a mouth situated on hypostome.

A circlet of tentacles is usually present around the hypostome. In some cases the perisarc forms a cup like or capsule-like covering, variously named hydrotheca or gonotheca, around the zooids. The zooids covered with theca are called thecate; those without a thecal covering are naked ones or athecate.

The growth of the hydrocaulus is of two types viz. monopodial and sympodial (Fig.17.3b and 17.3c). In the former the main axis maintains a single line of growth i.e., each branch ends in a permanent terminal zooid which is oldest of that branch. Below the base of this terminal zooid is the zone of growth. This zone lengthens the branch.

The growth zone may also give rise to lateral buds, which may elongate in their turn. In the sympodial growth the primary polyp does not continue to elongate. But it produces lateral polyp. This also stops growth, but produces lateral buds again. Here the terminal polyp is the youngest: The main axis is formed by the combined hydrocauli of many polyps (eg. Halecium). In some forms like Hydractinia (Fig17.3d.) zooids Arise directly from the stolon in an irregular fashion.

Polymorphism is another characteristic feature of coelenterate colony. The zooids exist in many forms and show division of labour. Usually some zooids are concerned with feeding; these are called gastrozooids. The blastozooids or gonozooids undertake reproduction, budding off medusae which are another type of zooids, while dactylozooids are meant for protection.

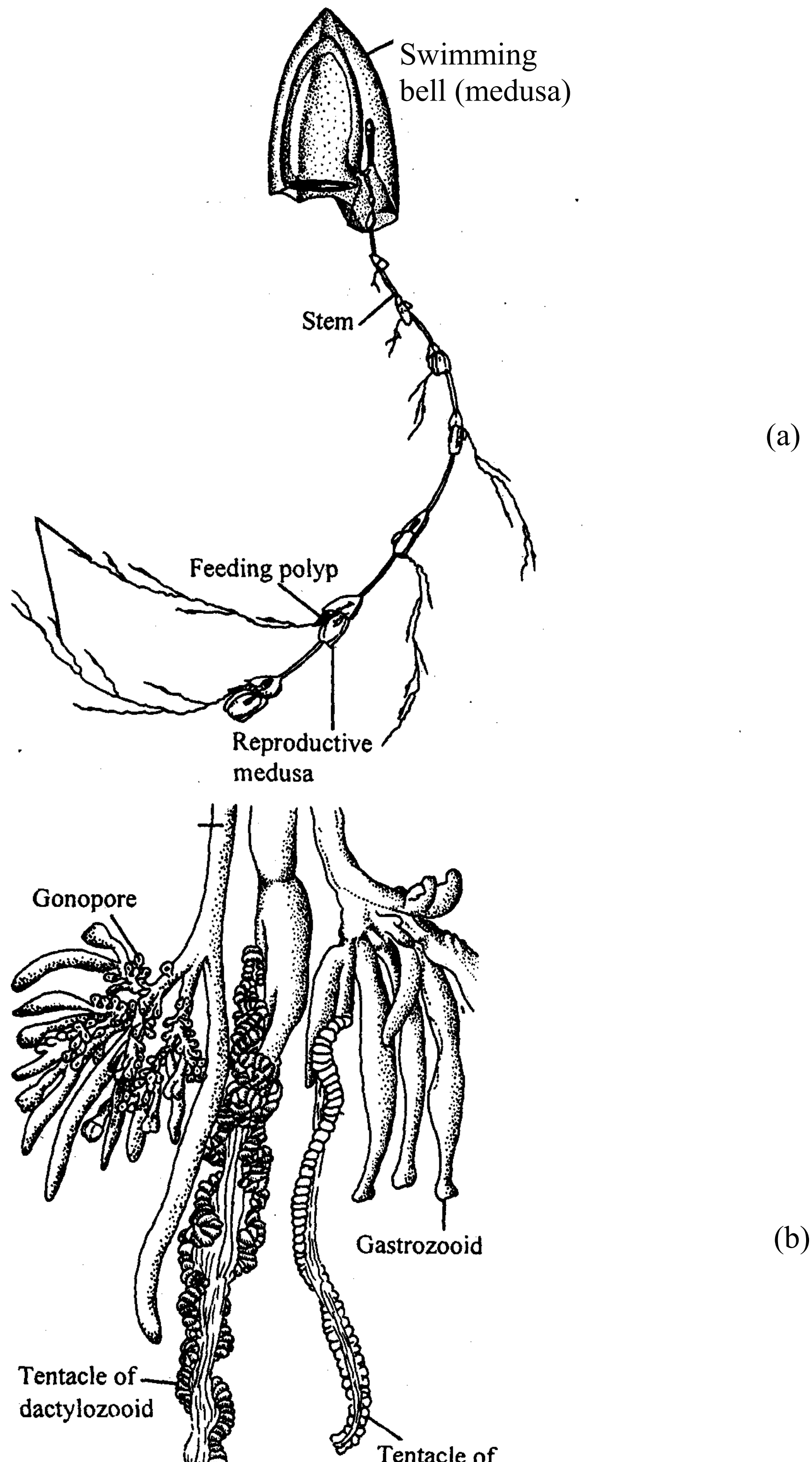


Fig.17.4 **a: A typical submergent siphonophore Muggiaea;**
b) Part of another siphonophore Physalia colony showing the zoid polymorphism.

The saucer-shaped zooids called medusae produce gametes and reproduce sexually. You may recall here the siphonophores and other hydrozoan colonies which you have already studied in previous unit. Siphonophora shows extreme case of polymorphism, for example, *Muggiaea and Physalia* (Fig.17.4).

The group includes pelagic zooids. The colony comprises gastrozooids, dactylozooids and gonozooids. The medusae remain attached to the parents and modify to form **gonophores** (reproductive zooids), nectophores (locomotory zooids) and gas- filled pneumatophores (floating zooids).

In one of the previous units dealing with coelenterates you have studied in detail, corals and coral reefs. You may recall that section here. The Hydrocorallina (the hydrocorals; eg. *Stylaster, Millepora*) (Fig.17.5) are colonial, polypoid, hydroid corals which may attain considerable size contributing to coral formation. Their skeleton is calcareous, internal and epidermal. Though not accompanied by polymorphism, many anthozoans are also Colonial, eg. Palythoa.

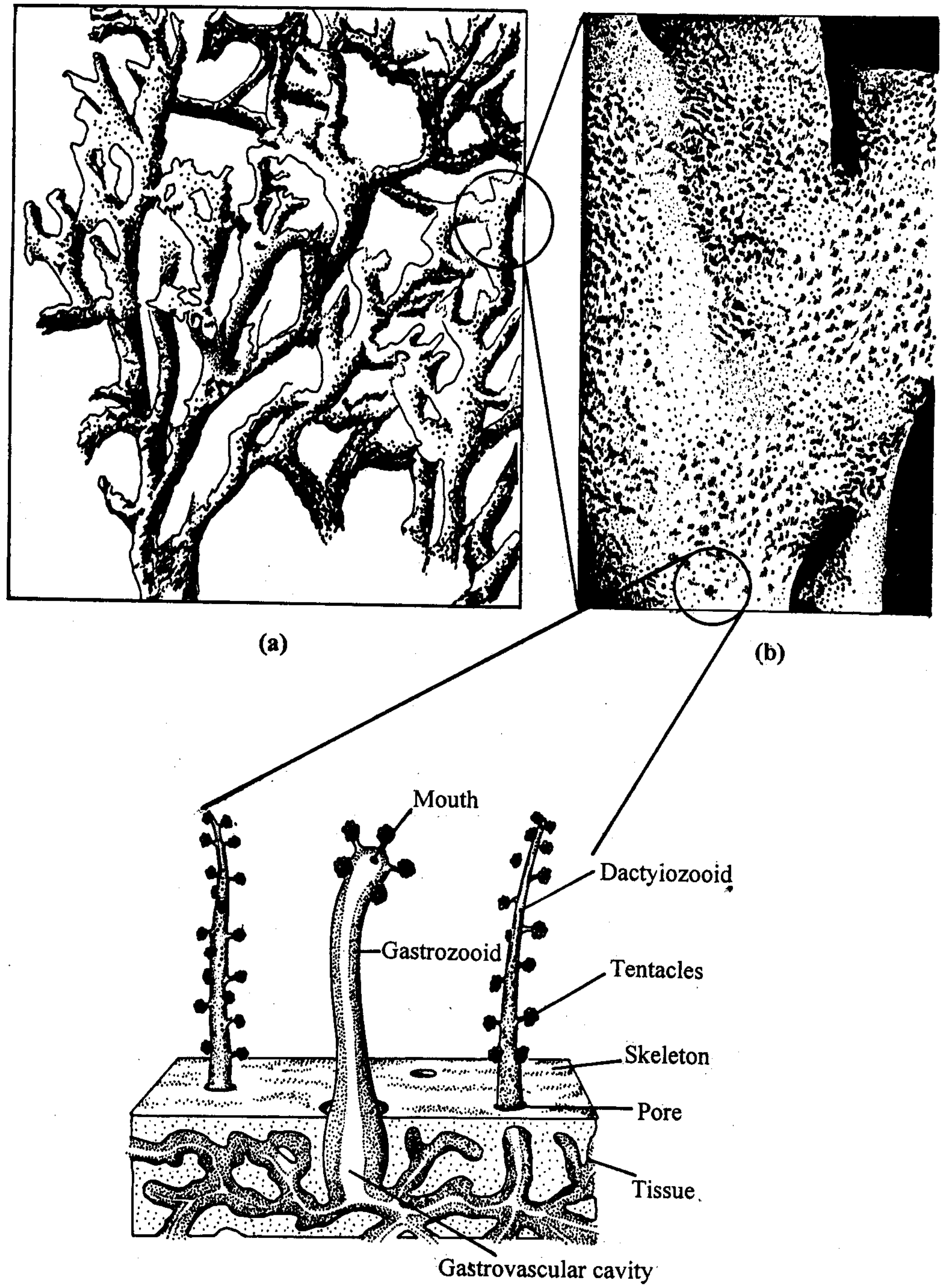


Fig. 17.5: Hydrocoral Millepora;
a) The colony,
b) Part of the colony magnified showing the pores,
c) Polyps of Millepora emerging from the pores in the skeleton.

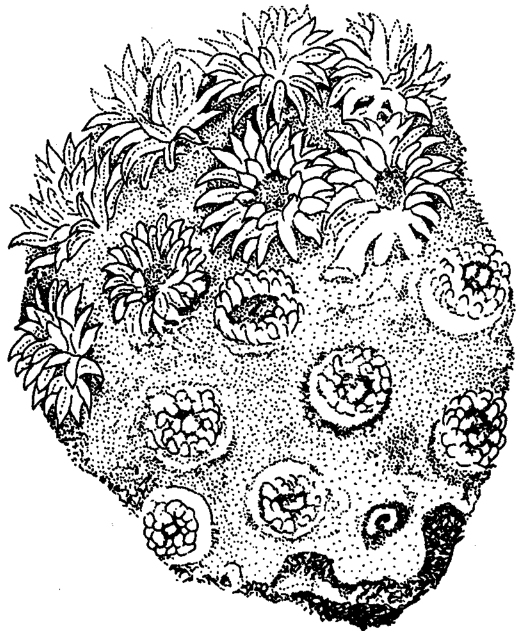


Fig. 17.6: Part of the coral colony showing contracted and expanded polyps.

Many true corals, though not all, are also colonial. Conspicuous among the colonial anthozoans are in fact many coral formers. The colony-forming scleractinian corals or stony corals, also known as hexacorals and madreporerial corals (Fig. 17.6), include Astrangia, Montastrea and the brain coral. Here the polyps are interconnected by horizontal connections.

The skeleton is epidermal and external (Fig. 17.7). There are solitary corals also among them, like Fungia (Fig. 17.8). The colony-forming octocorals (alcyonarians) among anthozoans include the common sea pens, sea rods, sea pansies, sea fans, whip coral, pipe corals etc. (Fig. 17.9).The ameobocytes secrete their skeleton which supports the colony. The skeleton of these octocorals is therefore internal and is part of the tissue.

From this account you will see that corals have developed from different groups of coelenterates. This is convergence in their adaptation.

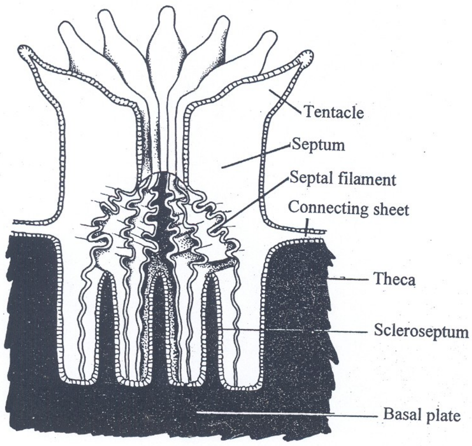


Fig.17.7: Vertical secrtion of the coral poly in its theca

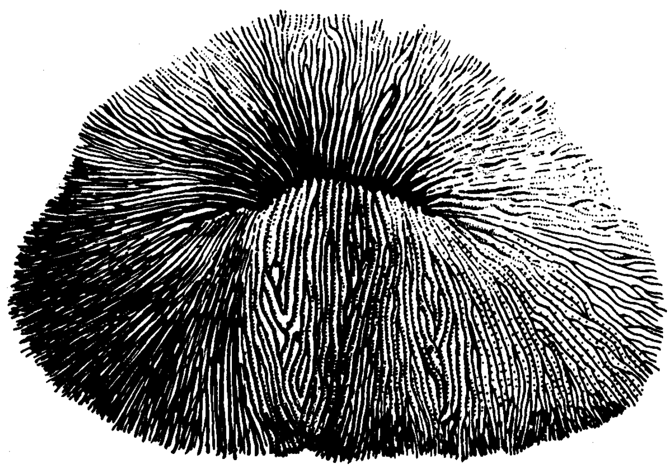
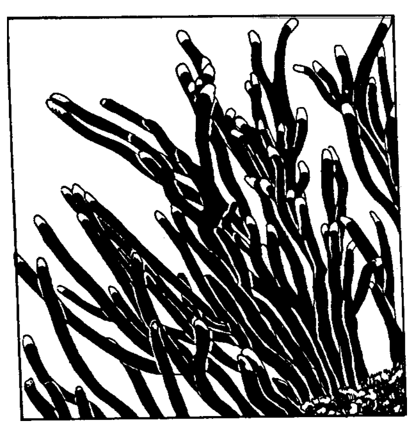


Fig.17.8: Fungia



a

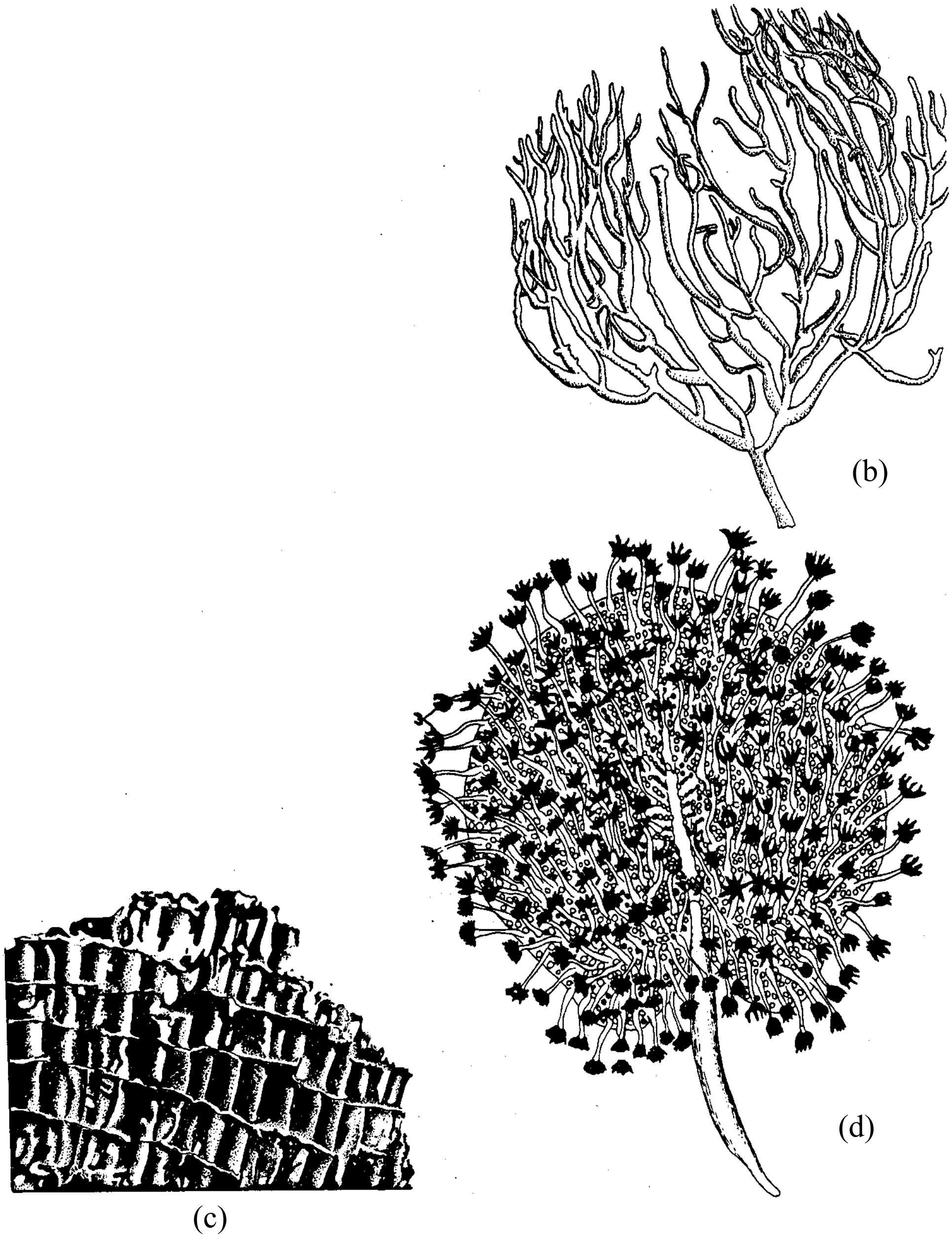


Fig. 17.9 a) Sea rods; b) Sea fan; c) Organ-pipe coral; d) Sea pansy.

Thus the benefit of colonial life is also clear: competition for survival among.individuals is replaced by co-operation. This provides distinct nutritive, protective and reproductive advantages to them.

SAQ 2 i)

1. Match the words in list A with those in list B.

List A	List B
1) Dactylozooid	a.Feeding
2) Gastrozooid	b.Floating
3) Pneumatophore	c.Protection
4) Medusa	d.Sexual Reproduction

2. Fill in the blanks in the following statements on the basis of what you have studied in subsection 14.2.2.

The growth of the hydrocaulus is of two types viz., ... or .... In the former each branch ends in an oldest terminal zooid, below the base of which is the zone of growth that lengthens the branch and gives rise to buds.

3.2 Adaptive Radiations

In the beginning of this unit, you have studied that when the animals belonging to the same or closely related groups adapt for different modes of life, they are said to show adaptive divergence or adaptive radiation. This concept was known to early zoologists like Lamarck and Darwin. Lamarck called it embranchment and Darwin called it divergence. The idea was, however, concretized in the form of a law by Osborn, the law of adaptive radiation.

Though Osborn postulated the law of adaptive radiation on the basis of his studies on mammals, it applies equally well to other animal groups, whether non-chordates or chordates. There is always a brief period in the history of all animal groups when the rate of evolution is very rapid. It results in the emergence of many new major lines of evolution or adaptation. Further evolution of each of these lines is comparatively slow. This process of breaking up of the parent stock into diverse lines which continue their own evolution is adative radiation.

Two fundamental needs of the organisms are mainly responsible for adaptive radiation. These are need for food and need for safety. A major factor in the animal evolution has been their habit of food gathering. Two basic ways of this habit may be recognised. There were animals which would just wait for the food to come their way. Secondly, some animals would actively seek the food and go after it. The former acquired sedentary habits and radial symmetry.

Radial symmetry would allow the fixed animals access to food in all directions. These animals evolved a special feeding device called filter-feeding. On the contrary, a typical food- seeker has to resort to movement for food gathering. They would go after the food. This gave rise to antero-posterior polarity, cephalisation, and bilateral symmetry. The anterior end may have developed into a distinct head, the seat of mouth-parts, sense organs and brain. (See earlier unit).

The second major factor in animal evolution has been the need for safety from the hostile abiotic and biotic components of the environment. All this has also led to exploitation of new habitats and acquisition of appropriate adaptations to suit the new surroundings. These modifications may have been in the habits, morphology and physiology of the animals. The evolutionary history of various lines or animal groups show that functional adaptations in different groups are different. Therefore you will find different lines of adaptive radiations in different groups of animals.

3.2.1 Adaptive Radiation in Annelida

Phylum Annelida includes three classes; **Polychaeta, Oligochaeta** and **Hirudinea**. Of these, the Polychaeta do not have clitellum; the Oligochaeta and Hirudinaria are **clitellate.** Now you should recollect the classification and characters of Annelida which you have studied in Unit 4, Block 1 of this course. The early annelids are supposed to have been marine worms burrowing in the bottom, in sand and mud on the shore.

Polychaetes comprise the marine species which continued their life the sea diversifying into various niches there; Oligochaeta include the line which led to the fresh water forms and to the earth worms; Hirudinea includes the leeches which arose from some fresh water oligochaetes.

Adaptive Radiation in Polychaeta

Having evolved from some small, annelid worm-like creatures adapted for burrowing and crawling life in oceans, the group divergedinto two main branches on the basis of their food habits; a group of active food seekers and another line of sedentary animals. The former actively sought after the food either scavenging or preying upon it whereas, the latter gave rise mainly to burrowing or tubicolous forms. In this section we will discuss the polychaete groups adapted to various modes of locomotion, habitation and nutrition.

Errant Polychaetes:

Worms such as nereids or hesionids are rapid crawling worms that crawl beneath stones and shells in rock and coral crevices and among algae and sessile animals. In these worms the head is well developed having one to, four pairs of eyes, upto five antennae and a pair of palps (Fig. 17.10).

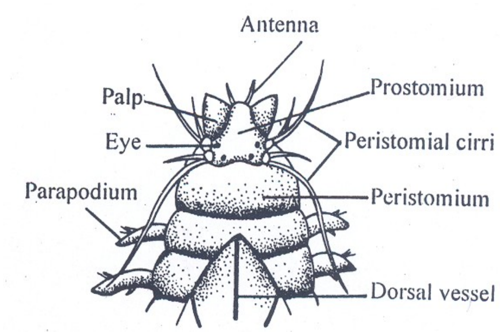


Fig. 17.10: The head region of the polychaete Nereis.

These worms have large parapodia that help in crawling. Many of these polychaetes are carnivores and feed on small vertebrates including other polychaetes. Food habits like scavenging, algae eating and detritus feeding have also evolved in some of these polychaetes. The pharynx of the errant polychaetes is muscular and eversible and possess teeth or jaws which vary in number in different families (Fig. 17.11).

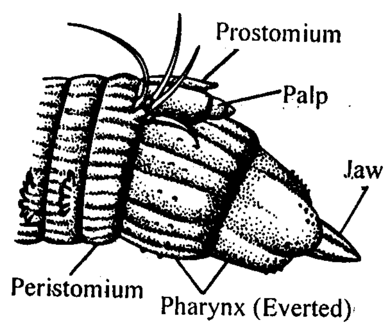


Fig. 17.11: The head of the polychaete Nereis with everted pharynx (lateral view) the jaw is open when pharynx is everted and closed when pharynx is retracted.

Pelagic Polychaetes:

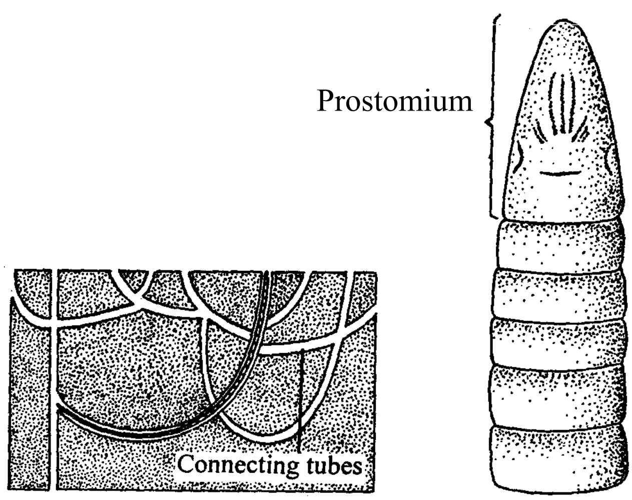
Certain families of polychaetes are adapted to life in oceans and thus are pelagic or planktonic. In these worms head is well developed and parapodia are large that are used as paddles to aid in swimming. Like other planktonic animals these polychaetes are pale or transparent. These worms are generally carnivores, e.g. Rhynchonerella angelina (Fig. 17.12), *Tomopteris* renata.

Gallery Dwellers:

These polychaetes are adapted to live in burrows made of sand or mud. The gallery dwellers make extensive burrow system or galleries that open to the surface at many points (Fig. 17.13a). These burrows are lined by the mucus secreted by the worms that prevent the collapsing of burrows. The prostomium of these worms can be a simple lobe or of conical shape and lack the eyes and other sensory organs (Fig. 17.13 b).

(a) (b)

Fig. 17.12: Pelagic polychaete Rhynchonerella angelina (a) and its parapodium (b).



(a) (b)

Fig.17. l3 a) Burrow system of a gallery dweller worm Glycera alba showing the worm lying in wait for the prey.

b) Anterior end of the gallery dweller Drilonereis showing the conical prostomium that lacks eyes and sensory appendage's.

The worms usually move in the burrows by peristaltic movements, and the parapodia are reduced and help to anchor the segements by gripping the walls of the burrow. The septa and circular muscles are well developed. However, some of the gallery dwellers may crawl with the help of parapodia. They may be carnivorous or non- selective deposit feeders and consume the substratum through which the burrows are made.

Glycera, is the best studied gallery dwelling polychaete and is also used as fishing bait. These worms lie in wait in the gallery system and when the prey moves across the surface creating pressure waves, the worm moves to a nearby opening. Blood worms have a long proboscis that is shot out with explosive force to seize the prey (Fig.17. 14).

Sedentary Burrowers:

Certain polychaefes make simple burrows that have only one or two openings to the outside (Fig.17.15b). These worms move about very little when they move, they also go by peristaltic contractions only. Parapodium is reduced to hook like setae that help in gripping the burrow wall. The prostomium is devoid of most of the sensory structures.

However, special feeding appendages may be present. Some of the sedentary borrowers are nonselective deposit feeders while others are selective' deposit feeders. L-ug worms (Arenicola) (Fig.17.15a) nonselective deposit feeders, live in L- shaped burrows and ingest the sand at the bottom with, an eversible pharynx. At fixed intervals the worm comes out of its burrow and defecates at the surface as a casting. After this the worm resumes feeding and ventilating. Ventilation occurs because peristaltic contractions bring in the water current.

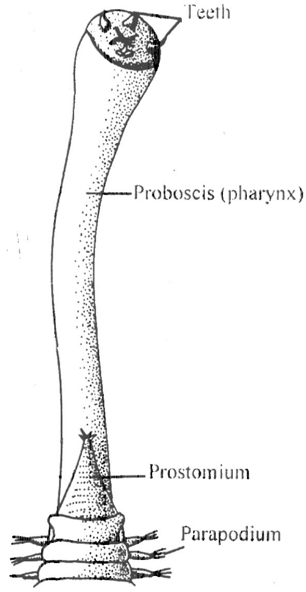
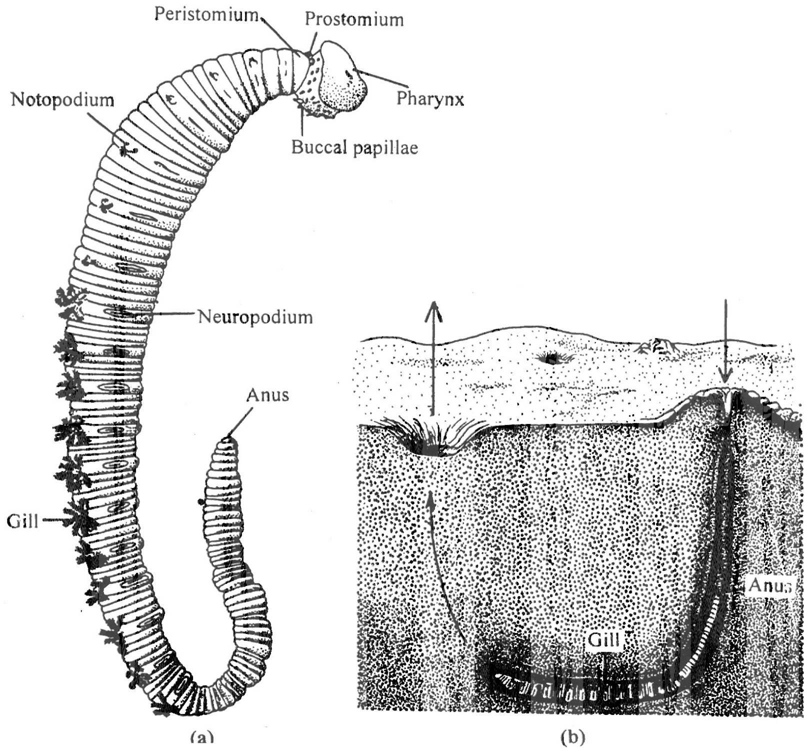


Fig. 17.14: Anterior end of Glycera showing the everted pharynx.



(a)

Fig. 17.15: The L ug worm (Arenicola) with its pharynx everted (a). Worm in the burrow (b)

In selective deposit feeders there is no eversible pharynx. Instead they have special head structures that pick up the organic matter from the surrounding sand grains. For example Amphitrite has a great mass of long tentacles that spread over the surface from the opening of the burrow (Fig.17.16). The detritus material adheres to the mucus on the tentacles and is then passed on to the mouth in a ciliated tentacular gutter with the help of tentacular contraction.

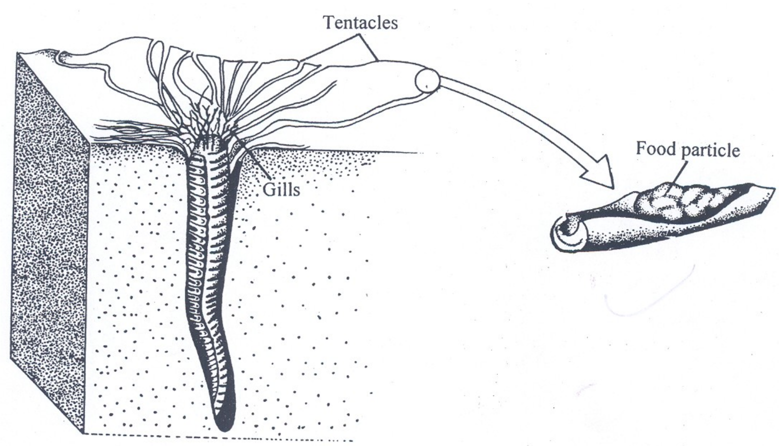


Fig. 17.16 Amphitrite in its burrow with outstretched tentacles on the surface. Also shown is. The food particles trapped in the tentacles that are rolled up to form a ciliary gutter.

Tube-Dwelling Polychaetes:

Tube dwelling is more widespread habit among the polychaetes as compared to other animal groups. The worms can make the tubes in the sand or in firm and exposed substrates such as algae, rock, coral or shell. The tube may be completely made up of hardened material secreted by the worm or composed of foreign material cemented together. Thus, a tube will remain intact when dug out of the sand.

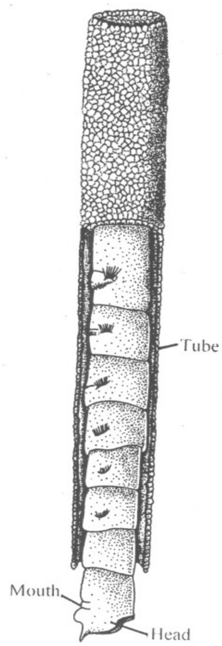


Fig.17. 17: Bamboo worm that lives upside down in the tube.

Tube dweller (tubicolous) polychaetes show structural diversity that is correlated with their different modes of feeding. Majority of the tube-dwellers are sedentary and move about within the tube lazily with the help of peristaltic contractions. They lack sensory structures, although feeding appendages may be present. Parapodia are reduced to ridges with hooked setae for gripping. Infact these adaptations are similar to those for sedentary burrowers as these two habitations are similar to some extent. Some families contain both burrow dwelling and tubicolous species.

The nonselective deposit feeders like bamboo worms (Clymenella, Axiothella) live in sand grain tube by keeping their head down and ingest the substratum at the bottom of the tube with the help of eversible pharynx (Fig. 17.17). Periodically the worm comes back to the surface and defecates.

Filter feeding is another mode of nutrition that has evolved in several families of sedentary and tube dwelling polychaetes. One kind of filter feeding is seen in fan worms or feather duster worms, where the prostomium palps have developed to form a funnel - shaped or spiral crown consisting of pinnate processes called radioles, for example in Sahella (Fig.17.18). During feeding the particles are first trapped in the mucus of the radioles surface and then passed on to the mouth with the help of cilia. When the worm pulls back its anterior end into the free end of the tube, the radioles are rolled and closed up together.

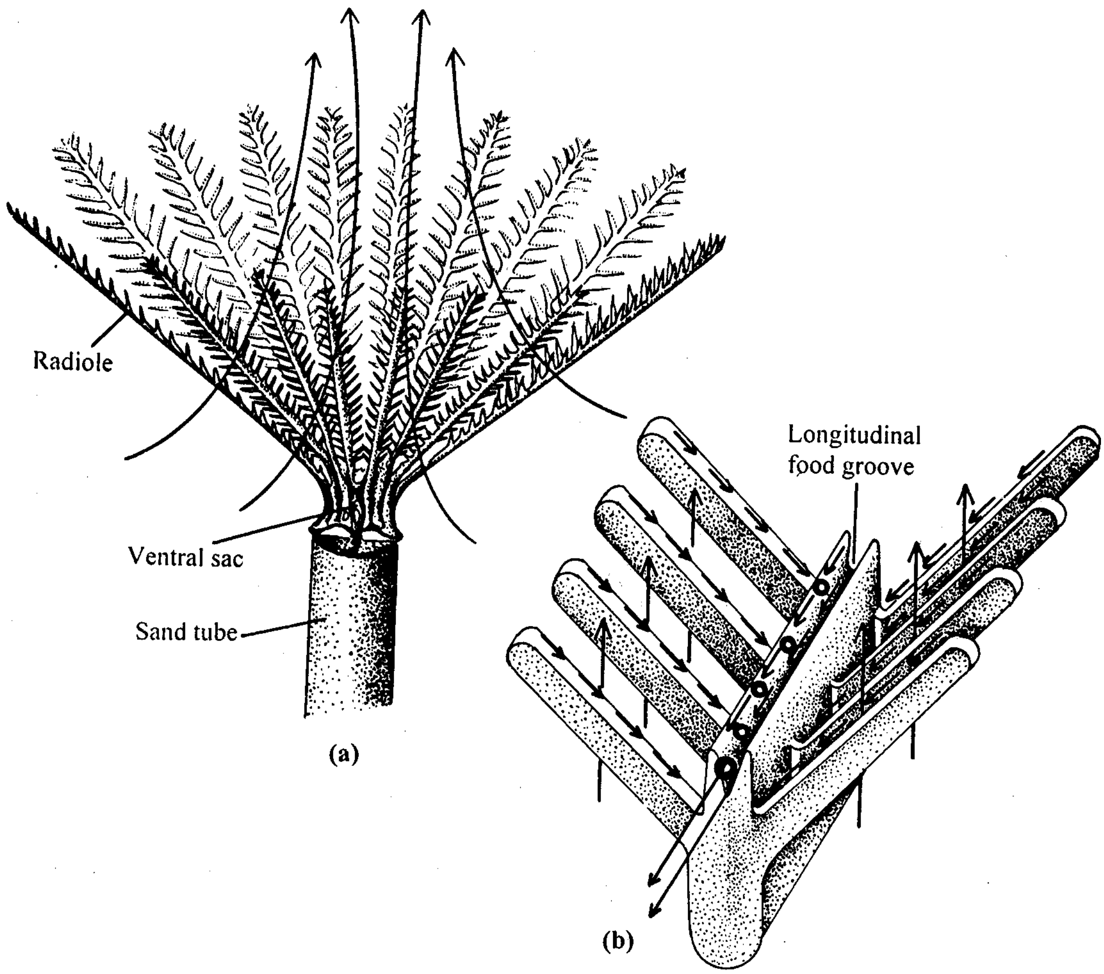


Fig. 14.18: Filter feeding in fanworm Sabetta
(a) Water current passing through radioles.
(b) Water current and ciliary tract over a part of radiole.

Chaetopterus exhibits another mode of filter feeding. It feeds by filtering water through a mucus bag. These worms live in U- shaped tube made by secreted parchment like material (Fig.17.18). In the middle of the body of the worm there are three piston like or `fan' like parapodia that drive water through the tube. Pair of long winglike anterior notopodia secretes a film of mucus that is rolled up into bag like shape with the help of cilia.

The water current driven in the tube passes through these mucus films. Periodically the mucus secretion is stopped and the mucus bag containing trapped food is rolled up into a ball which is passed along the ciliated groove to the mouth.

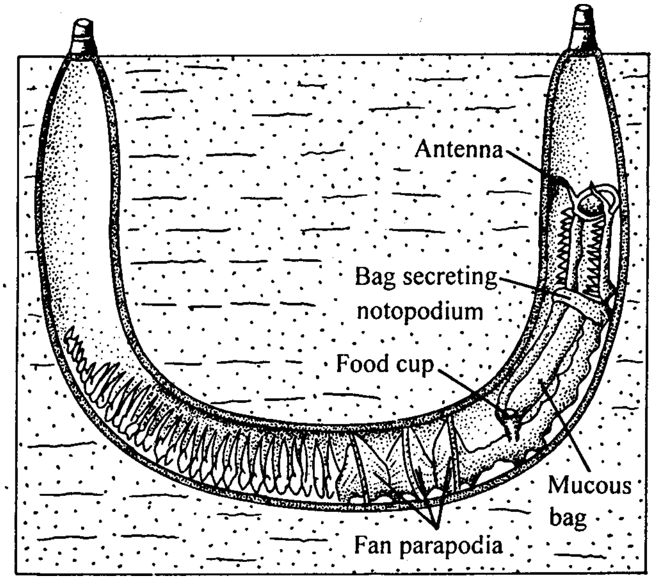


Fig. 17.19: Chaetopterus in its tube (lateral view).

Till now you have studied about the adaptations in annelida. Try the following SAQ before we proceed further.

SAQ 3

1) Mark (√) the correct alternatives in the following statements

- Law of adaptive radiation was postulated by Lamarck/0sborn.
- Adaptive divergence was called `embranchment' by Darwin/Lamarck
- Worms with well developed head having eyes, antennae and a pair of palp are gallery dweller polychaetes/errant polychaetes.
- Large parapodia in polychaetes that are used as paddles are adaptations to life in oceanslsand and mud.

SAQ 4

1. State whether the following statements are true (T) or false (F).

- Sedentary burrower Polychactes are essentially carnivores.
- Filter-feeding is mostly found in sedentary tube-dwelling polychaeta.
- Polychaets are mainly fresh water animals.

- Sedentary and tube-dwelling polychaetes mostly lack well-developed sensory organs.

11. Name the two fundamental needs responsible for adaptive radiation.

    a) .... _ ....

    b).......................................

Adaptive Radiation in Clitellate Aniielida

Polychaeta, being aquatic, lay their eggs in water and most of them develop through a trochophore larval stage. Aquatic environment offers many advantages: animals require less energy expenditure for supporting their body weight, water acts as a cushioned envelope providing protection from jerks and strains, temperature gradient in water is least and it provides an ideal medium for egg-laying and development.

These advantages are available to marine as well as fresh-water forms. However, fresh water habitats have one big drawback. These are not permanent like marine habitats. They may dry up during some part 'of the year. Therefore the fresh water forms and terrestrial ones face a two fold problem to different extent. One, they are denied the benefits of permanent and continuous access to the aquatic medium and secondly, they are exposed to the risk of desiccation. This problem has been solved by clitellate annelids successfully. Let us examine how.

The clitellum-bearing Annelida, the Oligochaeta and Hirudinea, mostly inhabit fresh water and terrestrial habitats. They have no larval stage and the development is direct. Glandular cells of some of their body segments become active during breeding season and form a conspicuous belt-like clitellum (Fig. 17.20) which produces a cocoon. Eggs are laid and develop within these cocoons. The clitellum may be permanent'(as in earthworms) or temporary (as. in leeches). These annelids are hermaphrodites, though reciprocal copulation in earthworms is well known. The clitellates are devoid of antennae, palpi or parapodia.

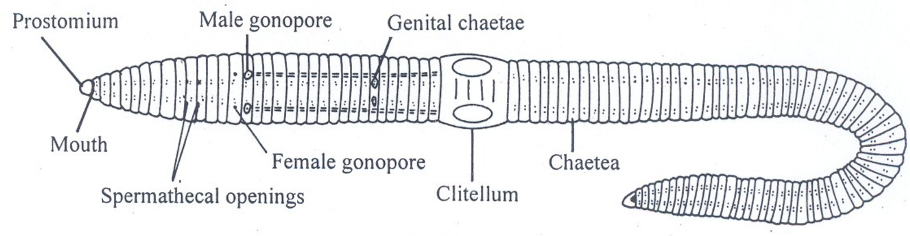


Fig. 17. 20: Earthworm showing clitellum

Oligochaeta appear to have evolved directly from the marine annelids, independently of polycheates. Some species of tubulificids and enchytraeids especially from littoral and intertidal zones and estuaries have been reported from marine waters.

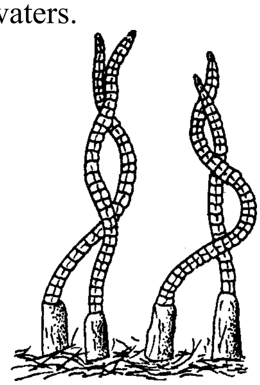


Fig. 17.21: Tubifex that lives head down in long tubes. The posterior end waves about in water to facilitate gas exchange.

Aeolosoma

Fig.17.22 (a) Aeolosoma- the cilia around the mouth sweep in the food particles.

(b) Stylariaprostomium drawn out into long snout.

Tubifex (Fig.17.21) and Limnodrilus are reported to thrive well in sewage-polluted waters. Tubifex which lives in stagnant water in mud, builds tubes. It projects posterior part of its body from the tube and waves it about in water facilitating gas exchange. Some like Aeolosoma and Stylaria (Fig.17.22 fresh water forms. Aulophorus constructs tubes in mud and debris.

Aquatic forms like Dero (Fig.17.23) Aulophorus have finger like gills at the posterior end. Branchiura and Branchiodrilus have filamentous gills on the body. Aquatic forms are generally small; but they have longer setae. Some like enchytraeids are transitional between aquatic and terrestrial habitat, and live in marshes. These include lumbricids, megascolecids and moniligastrids. Earthworms are burrowing animals and are known to increase land fertility.

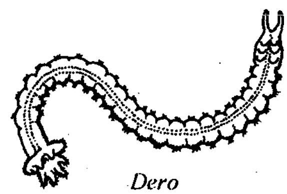


Fig. 17.23: Dero has ciliated anal gills.

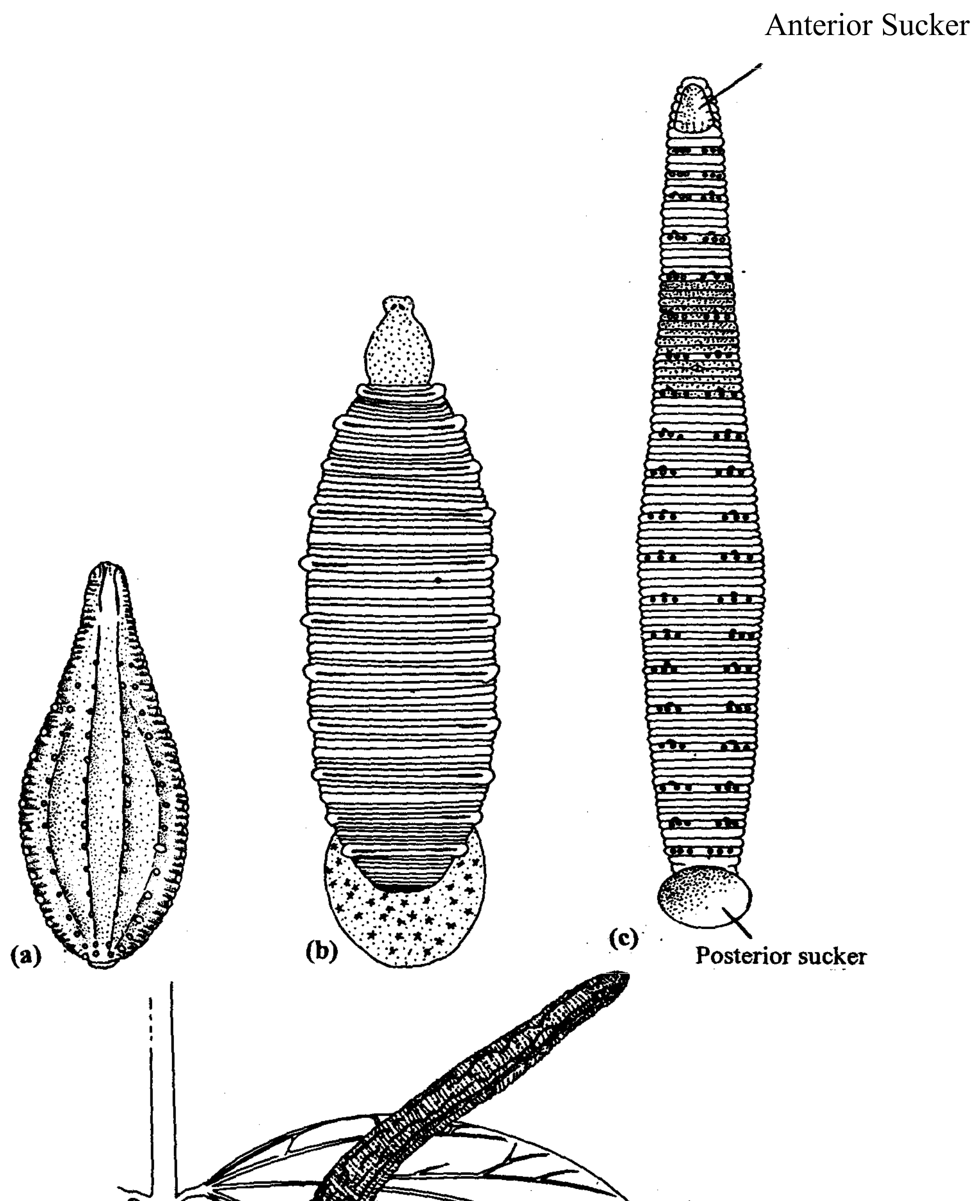


Fig. 17.24: a) Glossphoniid leech Glossiphonia conplanata; b) piscieolid leech Cystobranchus, c) hirudinid leech Hirudo medicinalis; d) haemadipsid leech Haemadipsa.

Hirudinea includes leeches. Many of the leeches are ectoparasites of vertebrates [glossiphoniids, piscicolids, hirudinids, haemadipsids (Fig.17.24)] The parasitic adaptations of the leeches are Presence of sucking pharynx and a post-anal sucker, provision for the secretion of mucus layer over the body by the skin glands to prevent dehydration, secretion of an anticoagulant hirudin to facilitate feeding on blood, and provision of food storage in the spacious crop.

One full meal by a leech may last it for about four months. Leeches and oligochaetes have a common ancestry. Leeches are mostly fresh water animals. However, some have become adapted to terrestrial life (Haemadipsa). Some have also become secondarily adapted to marine habitat.

SAQ 5

I) Indicate whether the following statements are correct or not.

a) All members of the phylum Annelida develop through a larval stage called trochophore.

b) Clitellum is a well developed permanant structure in earthworms.

c) The skin of leeches contains gland cells which secrete a mucus layer over the body which prevents desiccation.

d) Turifex is very comfortable in ponds polluted with sewage.

3.2.2 Adaptive Radiation in Arthropoda

Biologically Arthropoda is the most successful group in terms of numerical strength, adaptive diversity and extent of territorial distribution. They are supposed to be polyphyletic in origin, with number of (three or four) independent lines of evolution. There is also a tendency among them for reduction of number of segments by fusion or loss.

Arthropoda, literally meaning **joint- footed** (Gr. arthros =joint; podos = foot), is represented by horse-shoe crabs (Subclass Xiphosura), prawn, lobsters, crabs (Subphylum Crustacea), spiders and scorpions (class Arachnida), centipedes (class Chilopoda), millipedes (class Diplopoda) and insects (Class Insecta). Formerly Peripatus (Onychophora) also used to be included in this phylum. Arthropods have certainly evolved from marine Annelida by acquiring an armour of chitin over the body and paired appendages on almost all body segments.

The armour not only provided support and protection to the animal but also prevented entry of excess water and salts in the body in aquatic forms and desiccation in terrestrial ones. But it interfered with smooth gas exchange through the body surface and hampered growth. The adaptive radiation in Arthropoda is mainly related to the evolution of suitable respiratory mechanism, appropriate limb modifications and flight.

Respiration

The annelids respire by the general body surface or by gills. In Arthropoda while gills are retained by aquatic forms, terrestrial members of the group have evolved book-lungs (scorpions) and tracheae (centipedes, milipedes and insects). Xiphosura and Crustacea are almost exclusively aquatic. They evolved in water and remained there.

There are also some water-dwelling arthropods, which had actually invaded land and acquired terrestrial adaptations. They re-entered aquatic medium and made it a second home. This includes many adult insects (water-bugs, water-beetles, etc), which respire by tracheae while living in water. Thus, aquatic respiration in Arthropoda may be by gills (usually called branchial respiration) or by tracheae (tracheal respiration).

Aquatic Respiration by Gills

In Xiphosura, Crustacea and many larval insects respiration takes place by gills. A trill is a vascular outgrowth of the bodywall. It remains bathed in water and gaseous exchange occurs on its surface. In Limulus (Xiphosura) five pairs of book-gills are present on the ventral surface (Fig. 17.25). These are flat, lamellate abdominal appendages. Each gill supports about 150 gill lamellae arranged in a manner which gives it an appearance of the leaves of a book, hence the name.

In Crustacea the gills or branchiae are arranged as lateral extensions along the central axis. Gills may be of three types: Phyllobranchs are simple, leaf-like lobes set on either side of a main axis (Fig. 17.26a), Triochobranchs have filaments arranged around a central axis (Fig. 17.26 b) and dendrobranchs are modified phyllobranchs with each lateral lobe being subdivided (Fig.17.26 c). Gills have a supply of haemocoelomic channels. A continuous supply of water is maintained in the gill chamber. This ensures proper gas exchange.

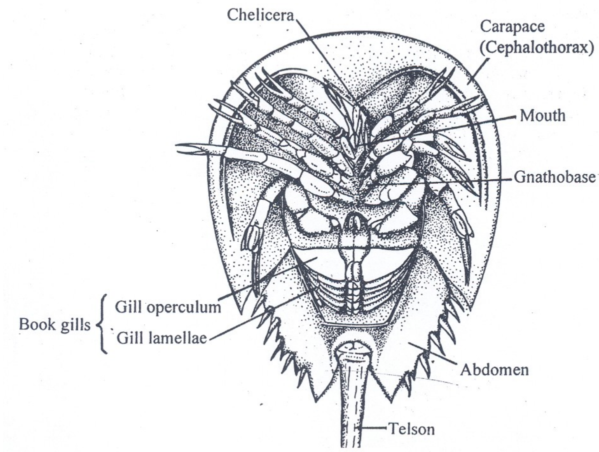
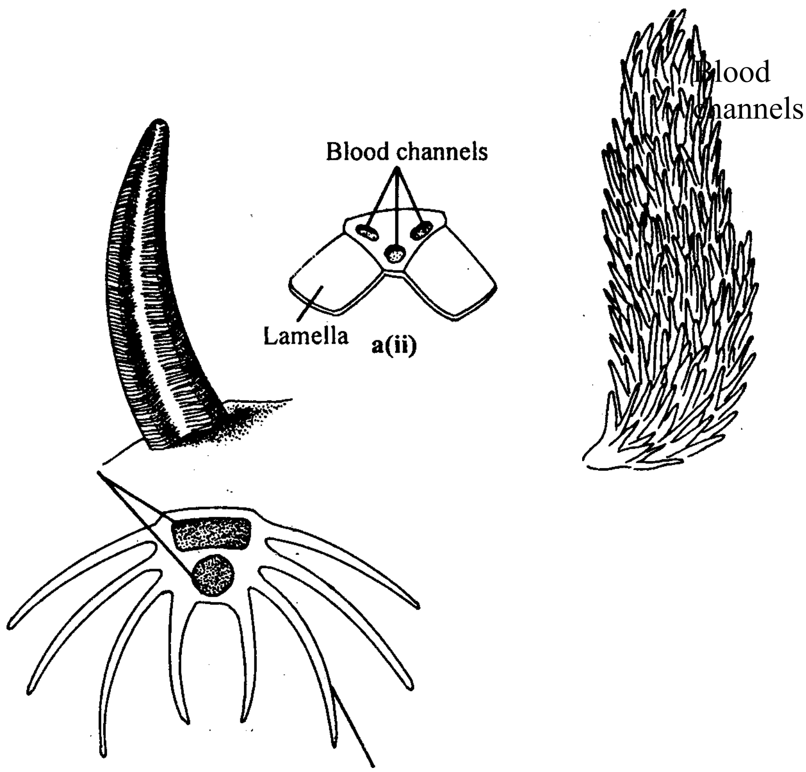


Fig. 17.25: Ventral view of horseshoe crab Limiulus polyphemus.



(a) b (i) B(ii) Filament

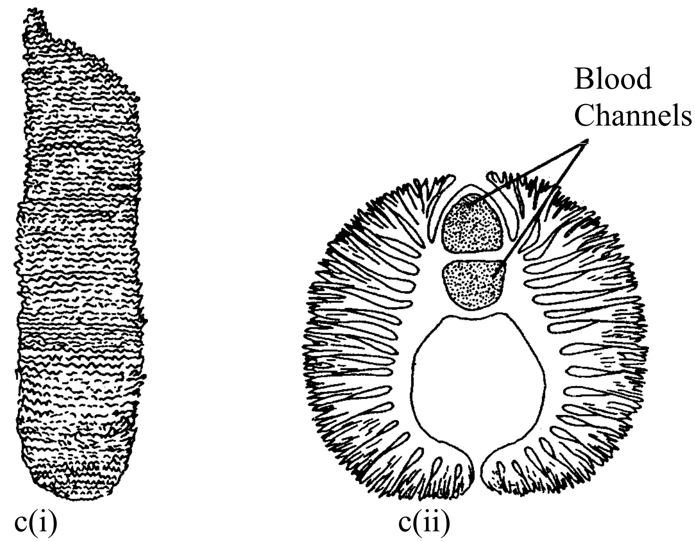


Fig. 17.26: Gill types in crustaceans.
a) Phyllobranch,
b) Triochobranch,
c) Dendrobranch,
(i) Lateral view
(ii) Transverse view.

Aquatic Respiration in Insects

Two modes of aquatic respiration in insects are recognised. In one, the insects obtain oxygen dissolved in water. This may be affected either through the general body surface or by means of different types of gills. **Tracheal gills** of the aquatic larvae of mayfly, stonefly and caddisfly are the lateral outgrowths of the bodywall and contain tracheal branches.

Rectal gills are present in the rectum of Odonata larvae. The stonefly larvae (Fig. 17.27) possess **tracheal gills** on various regions of the body and anal gills on each side of the anus. The **blood-gills** of some dipteran larvae are blood-filled out-growths of the bodywall. The blood of **Chironomus** larvae is red due to haemoglobin, giving the name blood-worm to the larvae.

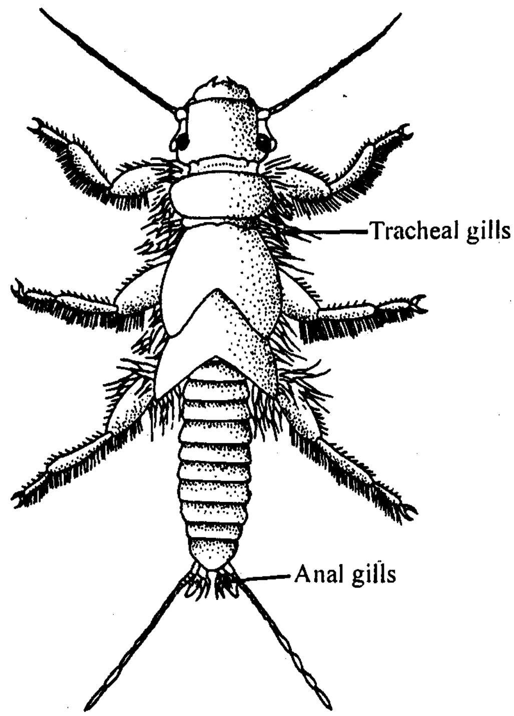


Fig. 17.27: Stonefly larva showing tracheal and anal gills.

There are some insects which live in water but still breathe air. They have devised modifications to obtain supply of fresh air at periodic intervals. We will discuss more about these forms when we deal with respiration in terrestrial insects.

Respiration in Terrestrial Arthropoda

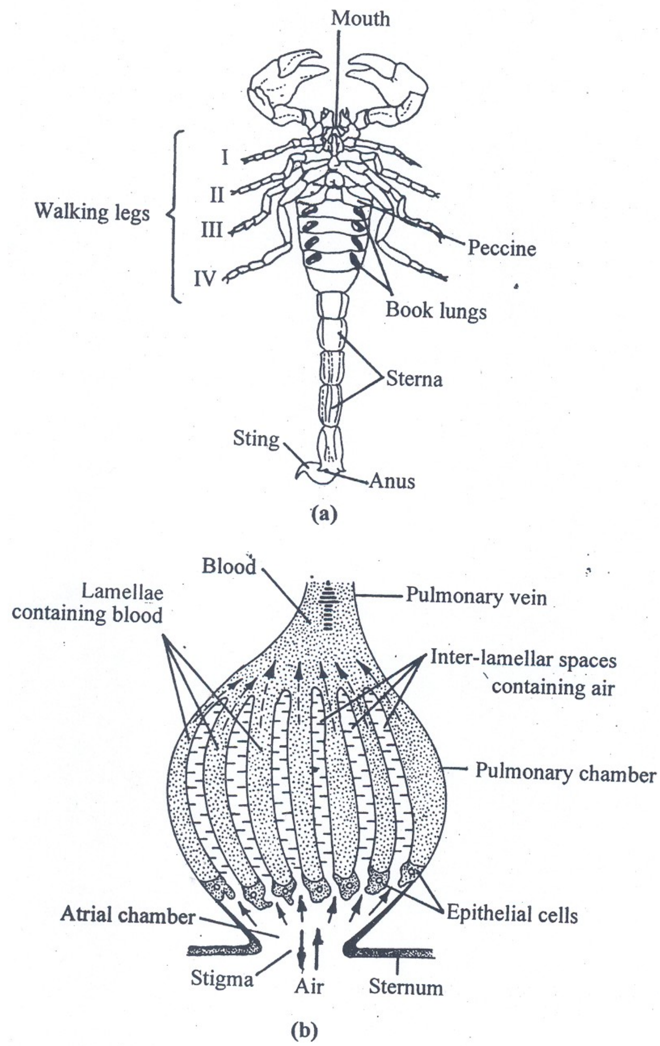
In land-dwelling Arthropods respiration is effected either by book-lungs (Arachnids) or by tracheae (Myriapoda and Insecta). The book-lungs seem to have been modified from the book-gills of the ancestral arachnids, the Merostomata. Scorpions possess four pairs of book-lungs, one inside each mesosomatic segments 3-6 (Fig.17.28a). A book-lung has a ventral atrial chamber and a dorsal pulmonary chamber (Fig. 17.28b).

The former opens to the exterior, by stigma (plural-stigmata) and the latter contains about 150 vertically placed lamellae giving the whole structure an appearance of the leaves of a book that explains the nomenclature. In spiders the respiratory organs may be either primary book-lungs or some modified structures such as tube- trachea and sieve-trachea.

Respiration by Tracheae

In most animals, except small and simple integument-breathers, oxygen is supplied to the different body parts through blood stream. Blood and air come in'contact either in the gills or in the lungs: However, the land arthropods like Myriapoda and Insects evolved an entirely unique system for oxygen transport in the body.

In their case a series of pores, called spiracles are present on either side of the thorax and abdomen. These pores lead into a network of branching tubules, the tracheae (Fig. 11.29), which ramify throughout the body. Finer branches of tracheae called tracheoles reach out almost every cell. Air enters the trachea via spiracles and directly reaches the tissues. Thus, blood does not carry respiratory gases in them.



(a)

Fig. 17:28: Ventral surface of scorpion showing spiracle of book-lungs (a). Vertical section of a book lung (b).

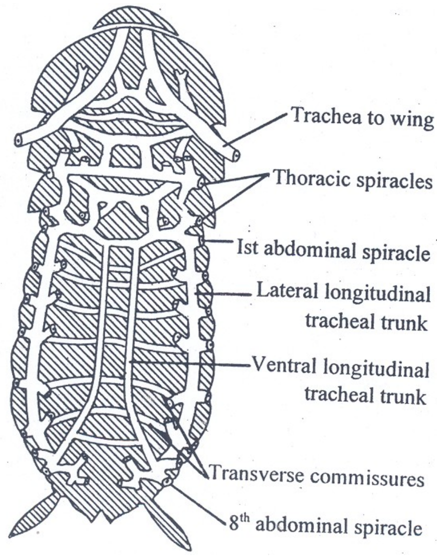


Fig. 17:29: Tracheal system in insects (Dorsal view).

While talking about respiration in aquatic insects it was mentioned that some insects live in water but breathe air. Let us now see how they do that. The tracheal system in such airbreathers is little altered and the spiracles are open. But these insects acquire various modifications to renew the supply of fresh air.

The Odonata and mosquito larvae periodically come to the water surface to take in fresh one. In many water-bugs and water beetles there are tufts of water-proof (hydrofuge) hairs on different parts of the body. The air trapped among these hairs is used for breathing. In the water-beetle Dytiscus the air is enclosed between body and the forewings (elytra). The adults of water-bug Nepa or the larvae of Eristalis (Diptera) possess a long respiratory siphon (Fig.17.30), which remains in contact with the air.

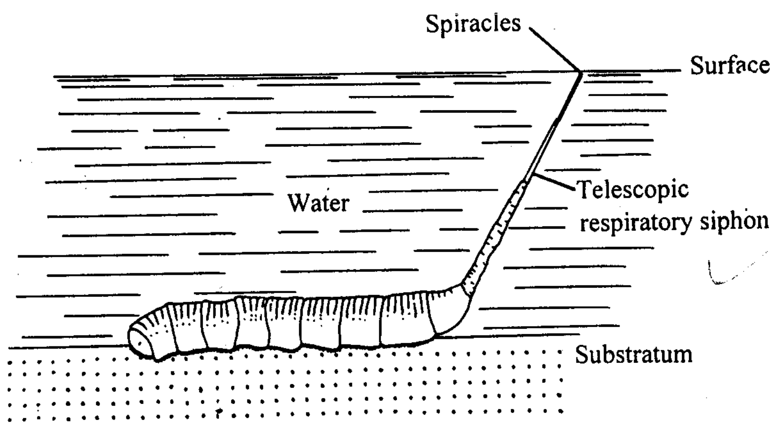


Fig. 17.30: Respiratory siphon in Eristalis larva.

SAQ 6

i) On the basis of what you have read in subsection 3.3.2 supply the missing words in the following sentences.

- In scorpions the respiratory organs are ...., of which there are ....:........................ pairs.
- Respiratory organs of Limulus'are.......................................
- In Crustacea three types of gills are found. These are ....:.......:..........,.......................................and....................... ....
- Rectal gills are present in the aquatic larvae of ....
- The adults of the water-bug, ... has a long respiratory siphon.

Modifications of Limbs

You may recall here what you have already studied under "Animal Diversity" on arthropod appendages. The appendages in Arthropoda have undergone three major functional modifications:

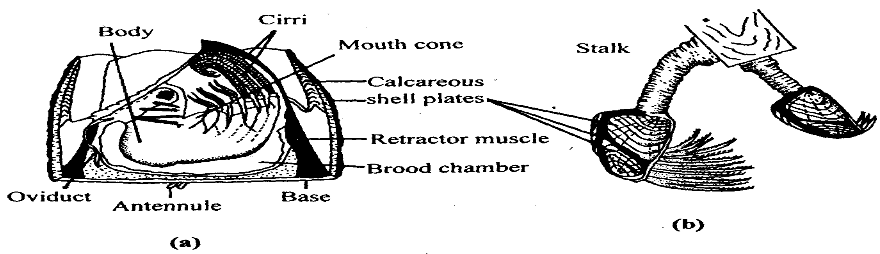
- As sense organs,
- As mouth parts, and
- As locomotor organs.

Out of these, maximum adaptive divergence is shown by the locomotor organs and mouth parts. Locomotor organs are modified in most of the arthropod groups. On the whole, primitive groups have more appendages. The locomotor appendages tend to become reduced in number as they become specialised and modified for various functions.

This increases their maneuverability as well as speed. Two distinct lines of adaptations are recognised: aquatic and terrestrial. On the contrary, mouth parts-show highest adaptive divergence only in insects, the details of which you have already studied in Unit 4, Block 1 of this course. Therefore, we will presently discuss the modifications of locomotor appendages only.

Locomotion in Aquatic Arthropoda

The aquatic arthropods are mostly adapted for crawling or walking on the substratum and, for swimming. The horse-shoe crab Limulus is a coastal dweller. Its locomotion is effected by walking on sand or mud bottoms. For this it has five pairs of walking legs. The fifth pair of walking legs is specially modified for removing the mud while burrowing. The distal lamellae of this pair spread and can push against the floor to prevent sinking in the loose mud.



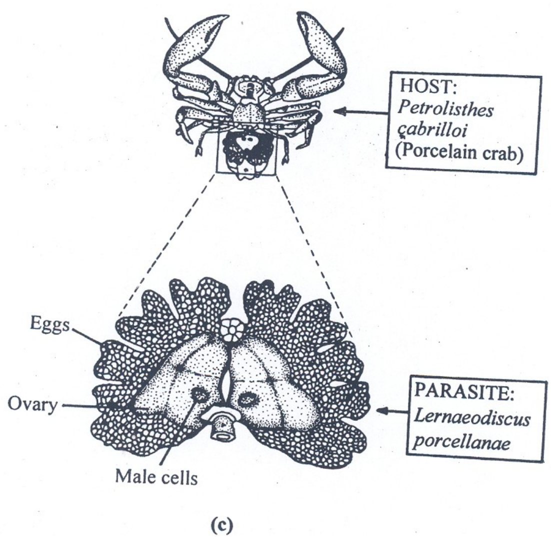


Fig.17.31a) Balanus a sessile barnacle;

b) Lepas a stalked barnacle. Baraacks the marine animals belong to order Thoracic of subclass Cirripedia, that are usually enclosed in a shell of calcareous plates. In these arthropods head is reduced, abdomen is absent and the thoracic legs are long and many jointed cirri with hair like setae

c) Lernaeodiscus pornefaw, the rhizocephalan barnacle, parasitic on the porcelein crab.

Most Crustacea, except the sessile and parasitic cirripedes (Fig. 1:31), are active swimmers. Their thoracic and abdominal appendages are adapted, for swimming. These are oar-like and are usually provided with fringed setae which increase surface area of the swimming organs. In Branchiopoda (small fresh-water crustaceans) all appendages are adapted for swimming and respiration (Fig. 17.32).

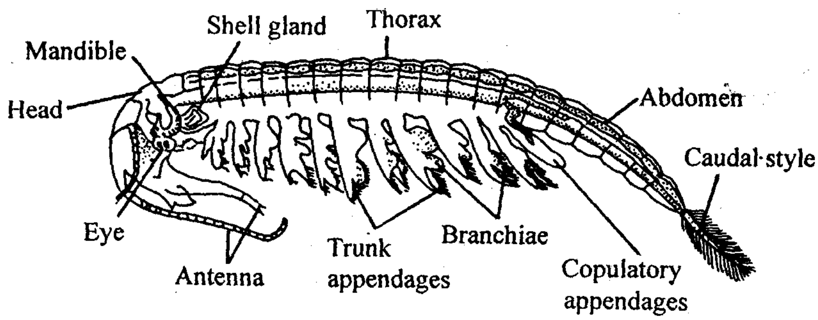
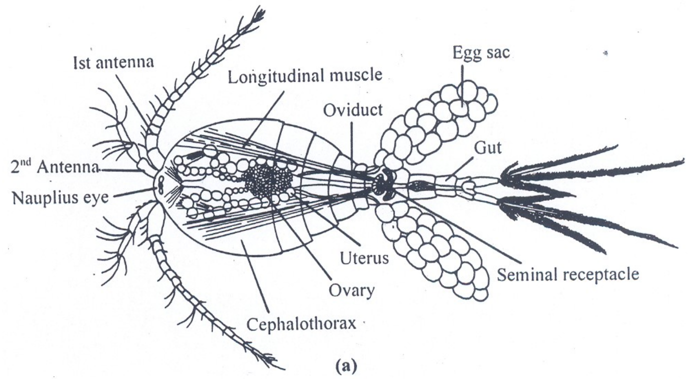


Fig.17.32: Branchiopoda: Appendages used for swimming and respiration

The water fleas swim by strong second antennae. The free living tiny copepods also use mainly their second antennae for swimming (Fig. 17.33 a). Most crustaceans have become crawlers, though they can also swim and burrow. Whereas many parasitic copepods (Fig.17.33 b) have become highly modified for parasitic mode of life, the prawns, lobsters, crabs and many others possess well-formed swimming and walking appendages. The walking in prawns and lobsters is effected by five pairs of walking legs, which are the posterior thoracic appendages (Fig.17.34a). For swimming, these animals have six pairs of abdominal appendages, named pleopods and uropod (Fig.17.34 b). The crabs have abandoned swimming and are adapted for walking. Consequently they have their abdomen shortended, abdominal appendages absent and five pairs of thoracic legs developed for walking.



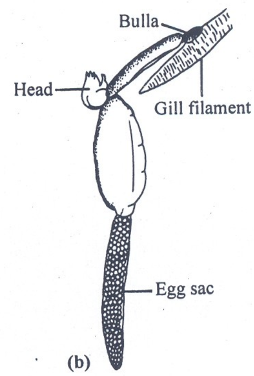


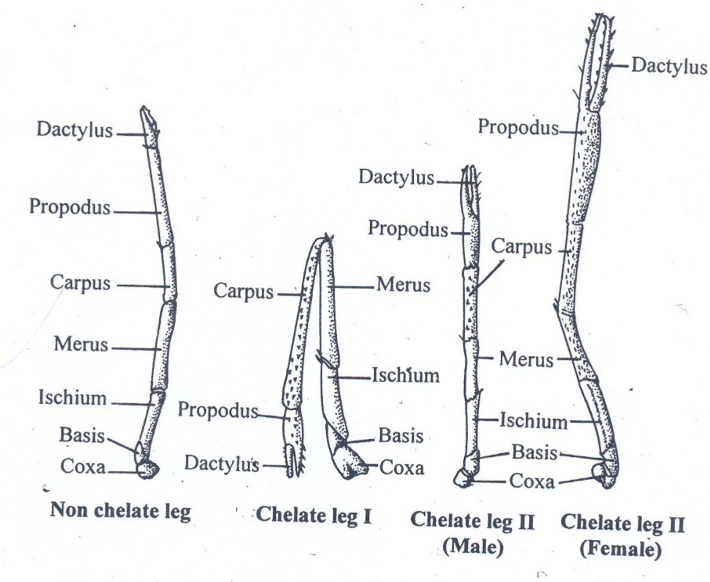
Fig. 17.33: a) A copepod Macrocyclops albidus;

b) **Salmincola salmonea a parasitic copepod. The mature female is attached to the gill of European salmon.**

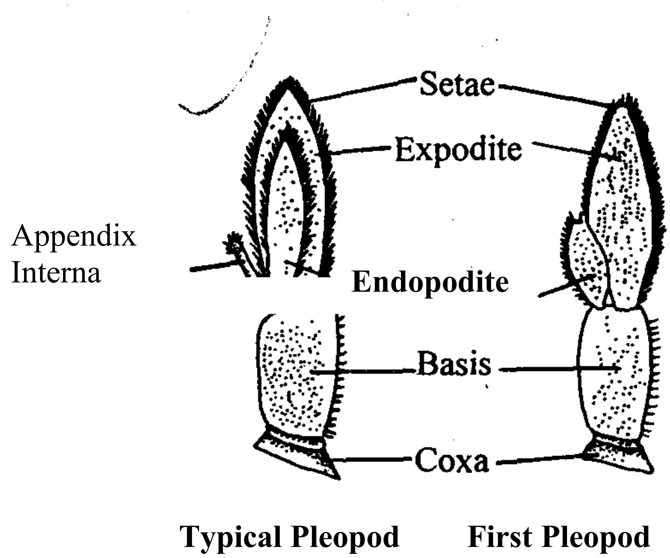
Crustaceans have exploited all types of aquatic niches thus exhibiting high degree of adaptive radiations. They are the dominant arthropod group in marine environment and also share dominance of fresh water habitat with insects. Invasion of terrestrial environment is, however, much limited. The most diverse class is Malacostraca and the most abundant group is Copepoda. Both these groups include planktonic suspension feeders and numerous scavengers.

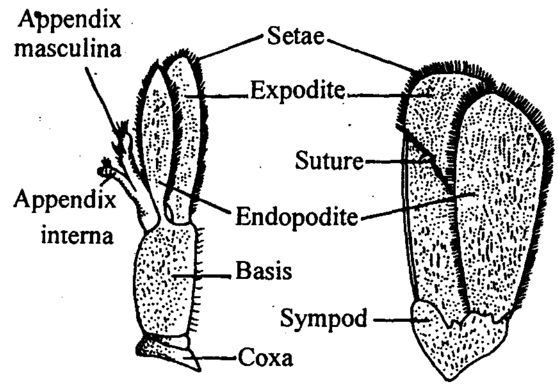
Copepods also include parasites of both vertebrates and invertebrates. Cirripedes include sessile and parasitic crustaceans. Parasitic copepods exhibit varying degree of modifications as compared to the free living ones. In most parasitic copepods the adults are parasitic exhibiting free swimming larval stages. Parasitic cirripedes also show modifications as compared to free living ones. Their body is saccular and the mantle is devoid of calcareous plates. There is also the absence of appendages and segmentation.

In aquatic insects swimming is effected by variously modified legs (Fig.17.35 a). In many larval forms hairy bristles help in swimming e.g. rudder-bristles on the ninth abdominal segment of mosquito larvae (Fig. 17.35 b).



(a)





Second Pleopod of male **Uropod**

Fig. 17.34: Walking legs of prawn (a) Swimming appendages of prawn (b)

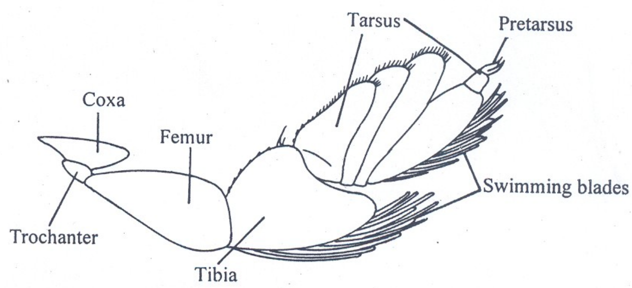
Locomotion in Terrestrial Arthropoda

In most adult terrestrial arthropods well developed walking legs are present, which are adapted to the needs of their habitats. Their number and structure are variable. Scorpions possess four pairs of walking legs (Fig. 17..28 a) meant for running fast. In spiders also four pairs of walking legs are present and all of them are used in walking. These arthropods can move very rapidly for short periods.

Centipedes and millipedes are adapted for living in soil and among litter and in crevices among stones, logs and bark. Centipedes have one pair of legs per segment while in millipedes there are two pairs per diplosegm-ent. Unlike other arthropods these legs are short and stumpy. They are adapted for crawling, swift walking and. running. Millipedes can also effectively push into soil.

Adult insects, as a rule, possess three pairs of legs and are appropriately called hexapoda i.e, six footed. An insect leg is attached to, the thoracic wall by means of a ring-shaped coxa. Besides coxa it has five more segments viz. trochanter, femur, tibia, tarsus and pretarsus, (Fig. 17.36).

The tarsus may have three to five sub segments called tarsomeres. The insect legs not only serve the function of locomotion but also undertake other roles like jumping (hind-legs in grasshopper, Fig. 17:37a), swimming (hind-legs in Gyrinus, Fig. 17:35 a), digging (fore-legs in mole-cricket, Fig. l7.37 b), grasping (forelegs in praying-mantis, Fig. 17.37 c) and grooming (toilet-organ in the hind- legs of honey-bees, Fig.17.37 d).



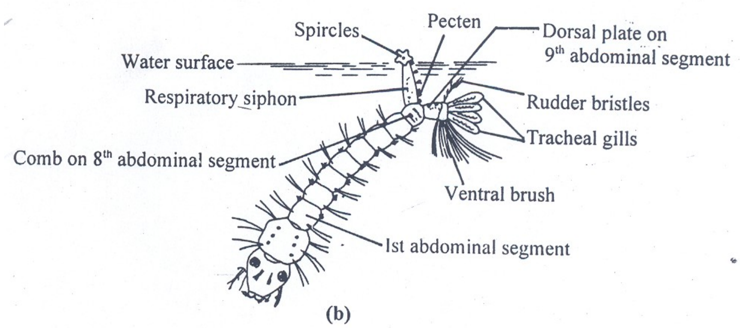


Fig. 17.35: An insect leg adapted for swimming (a); Rudder-bristles of mosquito larva

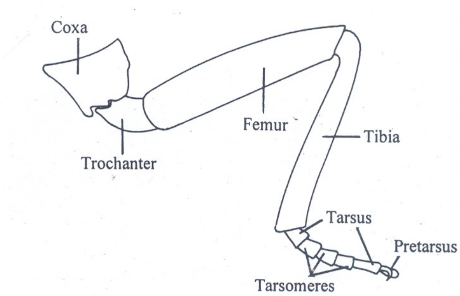
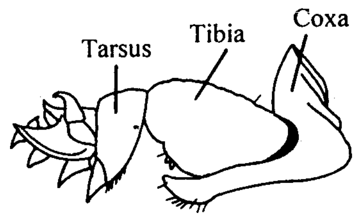
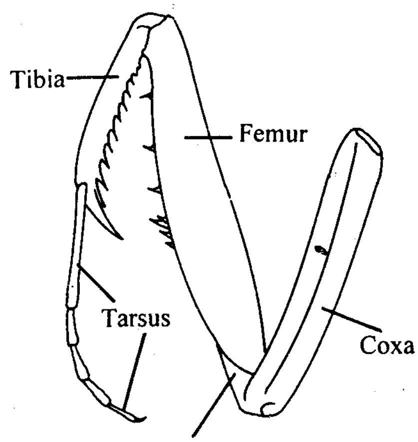


Fig. 17.36: Insect leg adapted to different functions.



(b)



(c) **(d)**

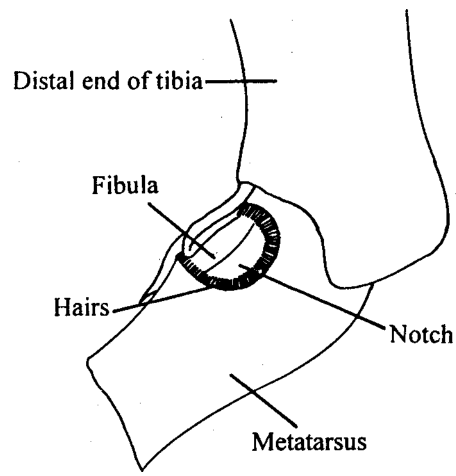


Fig. 17.37: Insect legs adapted for

a) Jumping;
b) Digging;
c) Grasping;
d) Toilet organ of honey bee for grooming.

Insect Wings:

The outstanding success of insects as terrestrial animal is, to a great extent, on account of their ability to fly. For this purpose most of them usually bear two pairs of wings on their thoracic segments. We will discuss the wing structure and the mechanism of flight, in insects in section 3 .3

SAQ 7

1. Indicate whether the following statements are correct or incorrect.

1) Mouth parts in Arthropoda are modified segmental appendages.

2) In prawns and lobsters walking is effected by abdominal appendages.

3) In aquatic insects swimming is brought about by six pairs of abdominal appendages

4) The hind-legs in grasshoppers are adapted for jumping.

5) In centipedes two pairs of legs are presenrin each segment.

6) Rudder-bristles in mosquito larvae are used for respiration.

Adaptive Radiation in Mollusea

Presence of shell, mantle, radula and fo6t distinguishes mollusca from the other animal phyla. Present-day molluscans are represented by forms like *Neopilina* (Monoplacophora), chitons (Polyplacephora), Dentalium (Scaphopoda), snails and slugs (Gastropoda), mussels and oysters (Pelecypoda), and squids and octopuses (Cephalopoda). Respiration in aquatic forms talker place by means of gills and in terrestrial molluscs by lung.

The adaptive modifications in Molluscs are chiefly reflected in the shell, foot and respiratory apparatus. You have already studied extensively the structure and types of molluscan shell in Unit 8 and the various modifications of the foot in Unit, this course. You may recall those portions here. We will now discuss the ructuraal modifications of respiratory mechanism in Molluscs in the following paragraphs.

Respiration in Molluscs

Molluscs are mostly marine. Some gastropods and pelecypods are found in fresh-water while the pulmonate gastropods occur on land. Aquatic molluscs employ gills or ctenidia (singular- ctenidium) for respiration. The terrestrial forms, on the other hind, breathe by means of the **pulmonary chamber**, usually referred to as the 'lung'.
In some molluscs exchange of respiratory gases takes place through the general body surface. Thus we have branchial, pulmonary and cutaneous respiration in Molluscs.

Branchial or ctenidial respiration occurs in aquatic molluscs. Formed as an outgrowth of the bodywall the ctenidia are present in the **mantle cavity**. In all molluscan groups the basic structural plan of the ctenidium is the same. A gill has a horizontal main axis, which remains attached to the body. The axis possesses on one or both sides a row of delicate, flexible **respiratory lamellae** (singular-lamella) with their surface covered with ciliated epithelium (Fig. 17.38).

When the lamellae are present on one side only, the gill is called monopectinate and if the lamellae are present on both sides, **bipectinate**. The ciliary movement drives a continous flow of water over the richly vascular gills, which receive deoxygenated blood through inlet veins or **afferent branchial** veins. The gills return oxygenated blood through outlet or **efferent branchial** veins. The direction of flow of water current over the gills is always opposite to the direction of blood-flow within the gills (Fig. 17.38c). This countercurrent flow ensures maximum and efficient gas exchange.

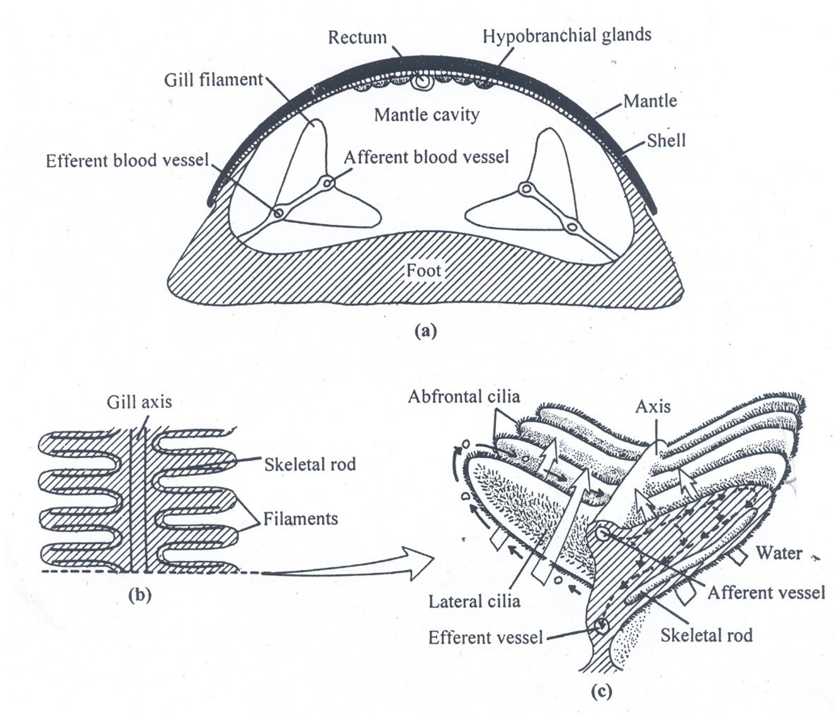
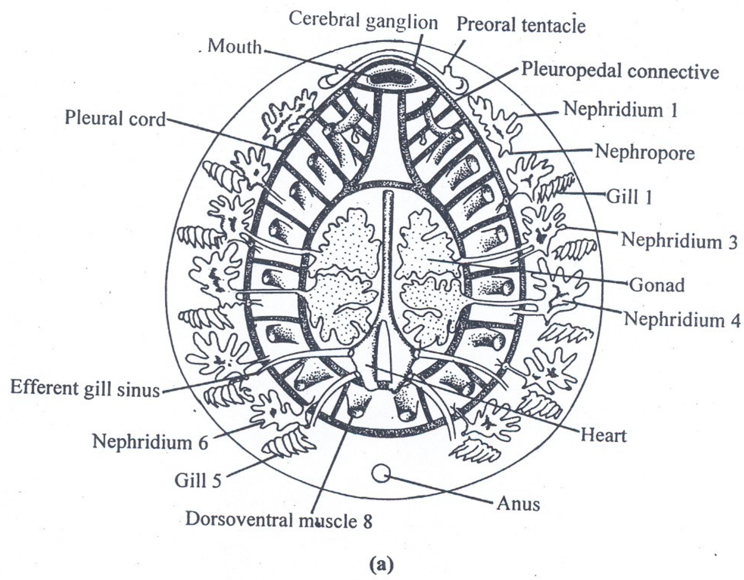


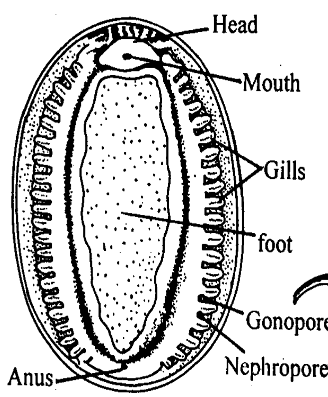
Fig. 17.38: Transverse sections through the body of a mollusc at the level of mantle cavity
a). Frontal section through the gill showing gill lamellae

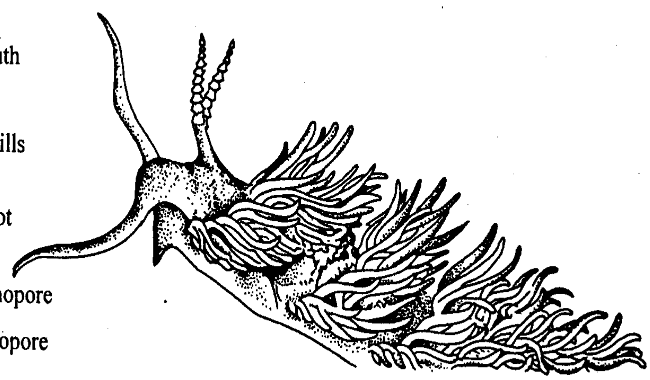
b). Transverse section through current and blood flow

c). The gill lamellae showing directions of water current.

The ctenidial arrangment differs in different classes of Mollusca. In Pelecypoda the gills subserve not only respiration but help in feeding also. In Monoplacophora there are five pairs of monopectinate gills with finger-like lamellae (Fig. 17.39 a). The position of the gills in this class shows segmental nature of the Mollusca, which otherwise is not apparent in other classes. In Polyplacophora the chitons have six to eighty bipectinate gills arranged in a row within the two mantle cavities (Fig. 17.39 b). While in the Aplacophora (Solenogastres) the gills are reduced or absent







(b) (c)

Fig. l7.39: Molluscan gill –
a) Monoplacophora (Neopilina);
b) Chiton;
c) Sea slug (Aeois)

Gastropoda Has Three Subclasses:

Prosobranchia, Opisthobranchia.and Pulmonata. In Prosobranchia the gills are shifted in front along with the mantle cavity due to torsion and there may be one monopectinate gill (as in Pila) or two bipectinate gills (as in Haliotis). In **Opisthobranchia** the mantle cavity and the organs it contains shift to the right side due to detorsion (see earlier unit for torsion).

Forms like Aplysia (sea-hare) possess one ctenidium on the right side while Doris and Aeolis (Nudibranchia) have altogether lost true gills. Instead, they have acquired secondary gills which are present either around the anus or on the lateral edge of the mantle or in rows on dorsal body surface (Fig. I7.39 c). In pulmonates, gills are absent. Mantle cavity is on the right side. This becomes a vascularised "lung" for air breathing.

Pulmonary Respiration:

In terrestrial gastropods the mantle cavity is transformed into a pulmonary chamber or lung, the roof of which is richly supplied with blood vessels. The evolution of the pulmonary sac is a land adaptation. Alternate muscular contraction and relaxation of the mantle floor causes the air to enter in and pass out of the pulmonary sac through a small aperture guarded by a valve. The exchange of gases occurs through the mantle wall. In some forms the pulmonary sac may also help in aquatic respiration.

The gills in Pelecypoda have a complex structure. Besides breathing, they also help in collecting food and serve as a brood-pouch. There is one pair of bipectinate gills in the mantle cavity, one on either side of the body. These extend from the anterior to the postrior end of the animal. On either side of the axis in each gill, long filaments extend ventrally and then bend upward like a hairpin (there being two "hair pins" on each side) (Fig.17.40).

There is an ascending and a descending limb in each "hairpin". These filaments may hang freely or the adjacent ones may be joined by inter filamentar junctions forming a gill-plate or demibranch. There are two gill plates on each side, an outer and an inner one. Each gill-plate has two lamellae each made of an ascending and a descending limb. The outer and the inter lamellae are joined together by interlamellar junctions (Fig. 17.40).

The gill-plates divide the mantle cavity into an upper suprabranchial and a lower infrabranchial chamber. The former opens to the exterior by excurrent (exhalant) or dorsal siphon which drains the water out. The infrabranchial chamber has an incurrent (inhalant) or ventral siphon through which the water enters the mantle cavity. The action of the cilia present on the gills maintains a continuous water current over their surface in the mantle cavity, where exchange of gases take place.

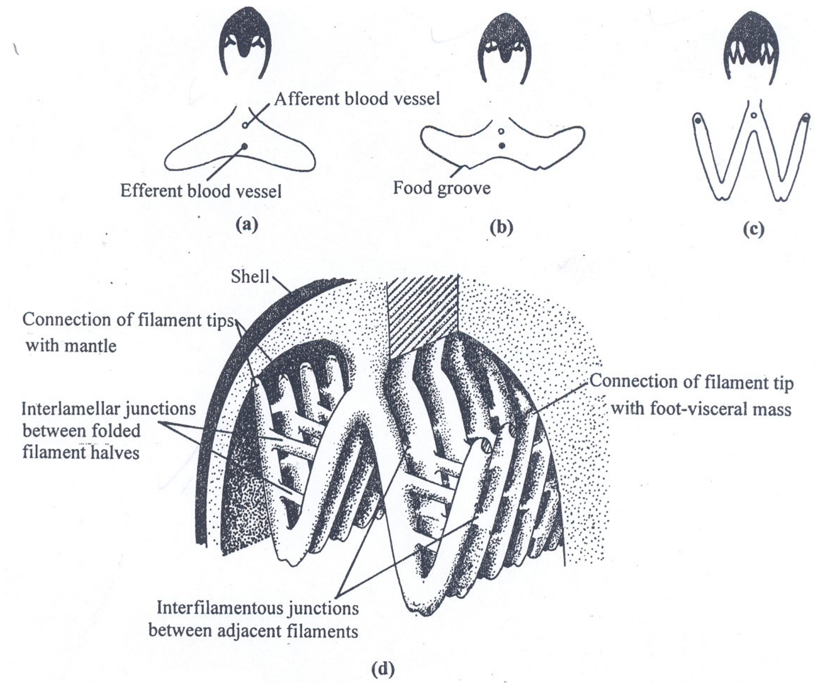


Fig.17.40: Evolution of Lamellibranch gills in Pelecypoda. a) Primitive protobranch gill b) Food groove development to create Lamellibranch condition. c) At food groove the filaments fold to form lamellibranchs conditions. d) Lamellibranch gills with tissue junctions providing support to the folded filaments.

Filter Feeding

Pelecypods are sedentary feeders and wait for the food to come their way. The constant inflow, of water through the incurrent siphon into the mantle cavity brings in food particles which include micro-organisms and organic debris. When water enters the mantle cavity the heavier particles sink down and are expelled.

The lighter food particles pass over the outer surface of the gill lamellae where they get entangled in mucus secreted by the gills. The mucus-mixed food particles pass into food grooves on the ventral edges of the gills, which take these towards the mouth. Near the mouth the labial palps further sort out the particles according to their nature. Smaller digestible particles are taken to the mouth while larger indigestible ones are thrown out of the mantle cavity.

Cephalopods have simple bipectinate gills situated on either side of the anus. The leaflike lamellae are arranged in a linear row on the axis. There are no cilia on the gill surface and the flow of water is regulated by the muscular mantle, funnel and the inlet-valves. There are two gills in the cuttlefish, squids and octopuses and four in nautiloids.

Cutaneous Respiration

1n Scaphopoda, Aplacophora and parasitic or terrestrial Opisthobranchia respiration occurs through the moist integument of the mantle cavity or through the general body surface. It is called cutaneous respiration.

SAQ 8

i) Fill in the blanks in the following sentences using words given in the parenthesis below:

(deoxygenated, efferent branchial, ctenidia, afferent branchial, oxygenated, flow, drives, vascularised)

1. Formed as an outgrowth of the bodywall, the .... are present in the mantle cavity.

2. The ciliary movement drives a continuous flow of water over the richly .... gills, which receive .... blood through inlet veins or .... veins and return .... blood through outlet veins or .... veins.

ii) **Indicate whether the following statements are true (T) or false (F).**

- ✓ In Pelecypoda gills also serve food capture.
- ✓ There is one monopectinate gill in Pila.

- ✓ Aeolis and Doris do not possess true gills.
- ✓ The gill surface in Cephalopoda is ciliated.
- ✓ Pulmonary chamber is found only in aquatic Mollusca.
- ✓ In Opisthobranchia the gills are anteriorly placed.

3.3 Flight in insects

Insects are unique among non-chordates to have evolved the ability to fly. For this purpose most adult insects possess one or two pairs of wings on their thoracic segments. The wings form an important basis of insect classification. There are chiefly two types of insects: winged and wingless. Wingless insects may be primarily wingless or secondarily wingless. In the former (primarily wingless insects) the wings have not evolved.

The primarily wingless insects include silverfish and springtails. Secondarily wingless insects lost the wings during their evolution from winged insects. The ants, lice and fleas fall in the category which has secondarily lost wings. The dragonflies, butterflies, houseflies, mosquitoes, bugs, beetles etc. are winged insects. The wings of insects evolved as lateral outgrowths of the body.

Structure of Wings

The wing (Fig. 17.41) arises as dorso-lateral outgrowths of the bodywall on mesothorax and metathorax. It is a thin membrane and is supported by a system of tubular'veins. The membrane actually consists of two layers of closely apposed integument. The Veins are 'the heavily sclerotised regions where the two layers remain separate. The veins have branches of nerves and trachae. Blood circulates through the veins in the wing.

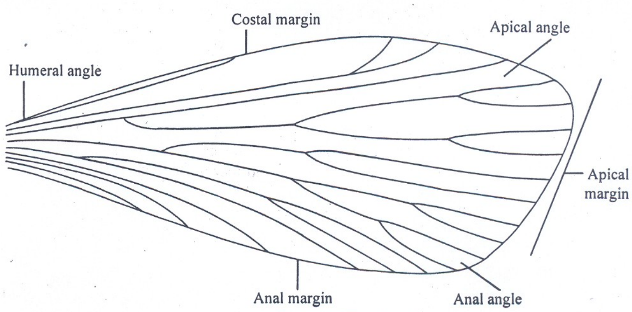


Fig. 14.41: Wing of an insect.

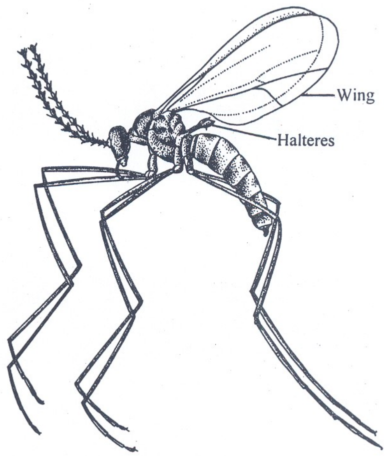


Fig.17.42. A gall gnat showing wings and halteres. Halteres are responsible for equillibrium during the flight.

The forewings sometimes become har
dened serving to protect the hindwings, as in the beetles. In the dipterans (eg. housefly and gnat) the hind wings have become modified into a sense organ called haltere (Fig. 17.42).

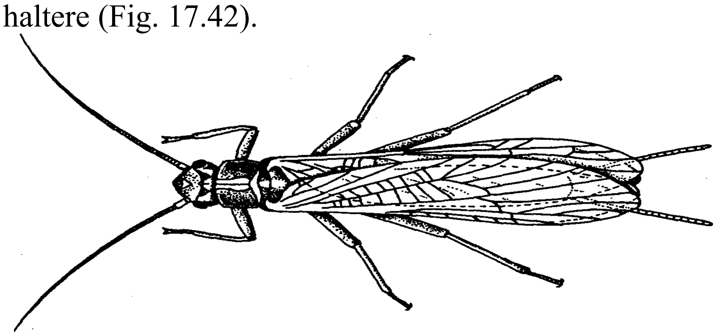


Fig. 17.43: Stonefly showing the wings folded at rest.

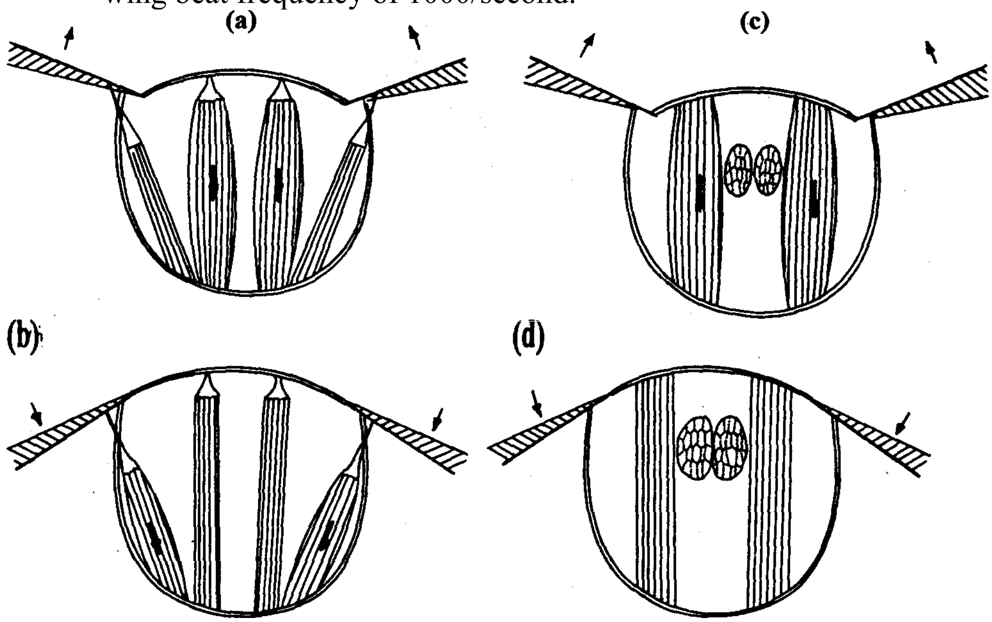
Inmost insects however thé two wings on each side are membranous and can be folded at rest (Fig. 14.43). They are coupled to function as a single wing functionally. This increases their efficiency during flight.

Wing Movement

Flight in insects is the result of co-ordinated wing beats. These movements are highly complex, involving various components like elevation (upward movement), depression (downward movement), and forward as well as backward movements. These wing movements are produoéd mainly by (1) muscles directly inserted into the wing base (direct flight muscles); (2) distortions of thorax brought about by muscles which are not directly associated with wings (indirect flight muscles) (Fig. 17.44 a-d); (3) elasticity of wing hinge.

Once the muscles have moved the wings in a particular unstable position, the, elasticity movements result in bringing the wings automatically into the stable position, with great force. This is known as "click" mechanism. Presence of a protein called "resilin" with considerable elastic property, in the hinge joints of insects, enables insects to bring about this "click" movement.

Insects thus fly with a wing beat frequency of 4-20/second as in butterflies or 190/second in honeybees and house flies. Some small dipterans may show a wing beat frequency of 1000/second.



Direct flight muscles of locusts and dragon flies

Indirect flight muscles of flies and midges

Fig.17.14C (a) and (b) Flight muscles of insects such as dragonflies and locust where upward stroke is by indirect muscles and downward stroke is by direct muscles.

(c) and (d) Flight muscles of insects like bees where both upstroke and downstroke are by indirect muscles.

Flight

The wing movements are very complicated. The whole mechanism of flight may be described in simple words as follows: The various wing movements create a low air pressure zone above and a high pressure zone below the wings due to which the body of the insect lifts above in the air.

Similarly the wing twisting creates an area of low, air pressure ahead and high air pressure behind the insect. This provides a forward thrust to the body. Many insects can remain stationary during flight. In their case wing movements create only lift and no thrust. Steering during flight is effected by shifting the centre of gravity or by altered wing- beats.

SAQ 9

i) Mark the correct alternative in the following statements.

1. The insects, in which wings have not evolved at all, are called primarily/ secondarily wingless insects.

2. Dragonflies are winged/wingless insects.

ii) Match the words in list I with those in list II.

List I	**List II**
l. Silverfish	a. Secondarily wingless
2. Ants	b. Primarily wingless
3. Haltere	c. Modified hind wings
4. Resilin	d. Help the click movement

3.4 Migrations In Insects

In insects mainly two types of flight activity occurs. Trivial flight serves routine activities such as feeding and mating while during migration flight activity dominates. Migration is essentially dispersal. Whenever in a partciular habitat any environmental factor hinders feeding or breeding activity, the insects fly out to explore new pastures for food and reproduction.

This is what we call migration. In the adult life of many insects there is a particular phase when this activity predorhinates. It is called the migratory phase and varies from a few hours as in many insects, to many days (as in some Coleoptera and Lepidoptera). In migration usually the animals move out from the feeding ground at the end of that activity in search of breeding ground and after breeding, they come back to the old habitat.

Since the main aim of migration is dispersal, females invariably participate in it, while males may or may not do so. In the locust, Schistocerca both sexes are included in migratory flights, but in the bug, Furygaster males as well as females migrate from breeding to feeding grounds but only the females return to the breeding ground. In Rhyacionia, a lepidopteran, females are fertilized before they start migration to the breeding ground. The males do not migrate.

Direction of Migration

Direction of migration is mainly influenced by the wind-speed and direction of the wind. Wind speed increases as one moves higher in the air. The speed of insects in flight in relation to air is called air-speed. Wind-speed is comparatively lower closer to the ground. This forms what is called boundary layer. Air speed is greater than the wind speed at the boundary layer. However at higher levels, wind speed exceeds air speed.

The insect can determine the direction and course of migration on its own in the boundary layer. For example, the moth Ascia monuste in Florida (US) flies 1 to 4 m above ground level. It can easily proceed against a wind current of 10 km/hour velocity. The direction of migration in this moth is determined by availability of flowers in the area.

In other insects, factors responsible for determining the direction of migration may include position of the sun, landmarks such as roads, coastline etc. In the boundary layer the migration may be initiated by a number of factors but ultimately the position of the sun, pattern of the polarized light in the sky and the visual landmarks decide the migratory path.

Migration outside the boundary layer is seen in many insects. Sometimes those insects which usually migrate in the boundary layer, are seen flying above the boundry layer.

Ascia monuste has been reported flying at a height of 1500 m and above in Argentina. At higher altitude the insects fly in the direction of the wind current. Denser swarms of locusts at higher levels, in higher wind-speeds, fly in the direction of the wind.

Aphids with a low air speed (0.6 m/second) find it difficult to fly against wind currents or to migrate within the boundary layer. They ascend up in the air due to positive phototactic reaction to ultra violet rays, and are then carried to long distances by wind currents. Many other insects such as dragonflies, beetles, butterflies and moths also move down-wind (in the direction of wind) at higher levels. Once the insects are carried to higher altitudes by mhigher wind currents (convection current) these carry the insects over long distance in a shorter duration. It is observed that swarms of locust Schistocerca cover a distance of 1200 km within 24 hours at 700 ni above ground at a wind-speed of 45 km/hour.

Return Migration

Some insects show to and fro migratory movements. The monarch butterfly, **Danaus plexippus** in the United State migrates in autumn from the north where winter temperature becomes too low and food scarce, to the south where temperature is moderate and food supply plenty. In February these insects start return migration northward. This sentence is not fitting properly. Such two way migration by the same individuals is exhibited by *Agrotis infusa* (Lepidoptera) in Australia and *Hippodamia convergens* (Coleoptera) as well as a number of other insects.

Locust Migration

Locusts exhibit mass migration or swarms. The swarms of the desert locust, Schistocerca gregaria may cover an area of 10 to 250 square km. You may be surprised to know that a swarm spread over about 20 square km may contain about 100 crore individuals. The swarms may cover a distance of up to 100 km a day.

Locusts form two types of swarms viz. **stratiform** and **cumuliform**. In the former the locusts fly flat in the form of the thin layer within few meters above the ground and there may be I to 10 individuals per cubic meter. In cumuliform swarms locusts fly in a towerlike column extending up to 1000 m above the ground, with a low density of only 0.001 to 0.1 individual per cubic metre. The stratiform swarms are formed in the absénce of convective currents to take them up while the cumuliform ones occur when there is convection current.

An interesting aspect of locust swarms is that all individuals in a swarm do not face forward. Their heads face in different directions. This is called random orientation. However, the locusts at the edge of the swarm face towards the body of other locusts. This helps to maintain the integrity of the swarm.

Beginning and End of Migration

Let us now examine the cause of migration. Migration is often initiated not by the actual onset of adverse environmental conditions. For example, in the monarch butterfly, the southward migration begins before the onset of cold conditions in the north, and locust swarms leave their habitats while plenty of food is still available.

This shows-that migration is an evolved adaptation in these cases and does not result from adverse environmental stimuli as such. Migration begins even before the onset of adverse conditions. This may be called spontaneous migration.

On the contrary, in some cases migration may be stimulated by some physiological or behavioural phenomena which put the insect into a state of readiness to migrate. This type may be called facultative migration. Photoperiod, temperature and food supply are some such factors.

Once the insects are kept in a state of readiness to migrate, the actual take off may be stimulated by another set of factors, like light of a particular intensity, wind speed, temperature etc. Similarly, it is not the physical exhaustion which brings migration to an end, but different wave-lengths of light being reflected by leaves (as in aphids), smell of salt-marshes (as in Ascia) and odour from host trees (as in beetle Melolontha) etc. may be responsible for the termination of migration.

Significance of Migration

Migration enaables the species to cope with the changes in the location of its habitats. It is more common in those insects which occupy temporary habitats. For example, many species of Odonata, which live in, permanent streams do not migrate whereas more than half of those living in temporary pools do so. The temporary nature of habitats may be due to changes in temperature, humidity, rainfall, etc. Migration is a way of over coming the adverse environmental conditions.

SAQ 10

1. Indicate whether the following statements are true (T) or false (F)

1. Trivial flight serves feeding and mating.

2. In the locust Schistocerca, only males are included in migratory flights.

3. Boundary layer of the air is near the ground and within this layer the air-speed is greater than the wind-speed.

4. Monarch butterfly, Danais plexippus in the US migrates in winter from south to north.

5. At higher altitudes in the air the insects fly downwind i.e. in the direction of the wind.

6. Spontaneous migration is initiated by one or the other environmental factor.

7. Physical exhaustion of the insect brings migration to an end.

8. Migration is common in those insects which live in temporary habitats.

4.0 Conclusion

In this unit you have learnt that:

- Animals which lead their lives as individuals are called solitary and those living in organised groups are known as colonial. True colonies in which individuals or zooids are organically connected by living matter, are present in protozoans and coelenterates. Polymorphism and division of labour are some of the important features of colonial life.

- If the animals of the same or closely related groups adapt for different modes of life, they are said to show adaptive radiation or adaptive divergence.

- The basic needs of animals viz. food and safety, lead to adaptive radiation. Among non-chordates Annelidà, Arthropoda and Mollusca exhibit clear adaptive radiation.

- Adaptive radiation is chiefly refle.cted in method of feeding and exploitation of different habitats in Annelida, respiratory modifications and limb modifications in Arthropoda as well as modifications of shell, foot and respiratory apparatus in Mollusca.

- Wings are unique acquisitions of insects. Formed as dorso- lateral outgrowths of the body wall, these are moved by direct and indirect flight muscles as well as by elasticity of the thorax, of flight musIces and of wing hinge .They impart capability of flight to the insects.

- Two types of flight activity are shown by the insects. Trivial flight for routine activities like feeding mating etc., and migration for dispersal. Migration is common in many species of insets and may be either spontaneous or facultative.

5.0 Summary

Most primitive orgamisnms especially the protest lie solitary lives, alone, with no depending on othermemebrs of the species. Some live in colonies in which individuals are organically connected by living matter as in protozoans and coelentrates. Polymorphism and division of labour are important features of colonial life.

Adaptive radiation is where the same colsley related gropus adapt for different modes of life as in feeding and exploitation of different habitsa.

Insects have advance tyher feature of colonial living wuings are unique acquision of isects which ebable them to fly.

6.0 Tutor Marked Assignement (TMA)

1. Differenatiate between adaptive convergence and adaptive divergence.Write the answers in two or three lines in your own words.

   ____

   ____

   ____

2. Name three flagella – bearing protozoa which form advanced colonies. Odes any of these show polatity and if yes, explain why you think so.

   ____

   ____

   ____

3. Define polymorphism. Why do you say that siphonophora colony is polymorpihic?

   ____

   ____

   ____

4. Mark the correct alternative in the following statements:

   a) The animals which would wait for the food to come their way, acquired radial/bilateral symmetry.

   b) Filter-feeding has evolved in sedentary/active food- seekers.

   c) Eversion of proboscis affects feeding in predatory/parasitic Polychaeta.

   d) Earthworms lack/possess antennae and palpi.

   e) One full meal by a leech may last for four hours/months.

5. Give two advantages and two disadvantages of the hard and tough body cover in Arthropoda. ____

   ____

6. Match the words in the List A with the most appropriate ones in the List B.

List A	**List B**
1. Branchiae	a.Dipteran larvae
2. Tracheae	b.Stonefly larvae
3. Anal (tracheal) gills	c. Insects
4. Blood-gills	d.Crustacea

7. Molluscans are believed to have evolved from annelidan ancestors, though they show no trace of segmentation. Give two grounds on the basis of which their ancestry may be linked with Annelida. ____________________

8. Indicate whether the following statements are correct or incorrect.

   a) Migration in insects is meant for feeding only.

   b) In a stratiform swarm locusts fly in a column at about 1000 m above ground.

   c) In random orientation all individuals in a locust swarm face forward.

   d) The, course and direction of the insect migration is determined by the position of the sun alone.

7.0 References and Further Reading

4. Hickman, C.P.1970 Intergrated princplesd of zoology C.V. Mesby. Company St Loius

5. Rupert and Barnesd 1994 invertebrates Zoology 6th international Edition.

6. Hickman, C.P. Ribert and Larson 1995. Intrgrated principles of zoology. 9th Editon C. V. Mesby st Loius.

ANSWERS

Self Assessment Questions

1. i) (a) environment, adaptive convergence.

      (b) adaptive divergence.

   ii) (a) F, (b) T, (c) F, (d) F

2. i) (1) c, (2) a, (3) b, (4) d.

   ii) Monopodial, sympodial, permanent.

3. i) Osborn, ii) Lamarck, iii) errant polychaetes, (iv) oceans

4. i) (a) F, (b) T, (c) F, (d) T.

ii) (a) food, (b) safety.

5. i) and ii) incorrect,
iii) and iv) correct.

6. i) booklungs, four, ii) book-gills, iii) Phyllo-branch, trichobranch and dendrobranch, iv) Odonata, v) Nepa.

7. i) Correct, ii) and iii) incorrect, iv) Correct, v) and vi) incorrect.

8. i) (a) ctenidia, (c) vascularised, deoxygenated, afferent branchial, oxygenated, efferent branchial.

ii) (a) T, (b) T, (c) T, (d) F, (e) F, (t) F
.

9. i) (a) primarily, (b) winged,
ii) 1-b; 2-a; 3- c; 4-d

10. i) a)T,b)F,c)T,d)F;e)T,t)F,g)F,h)T.

Unit 18

BEHAVIORAL PATTERN

Table of contents

1.0 Introduction

Behavioural patterns of animals are the patterns of their gestures and movements in response to stimuli in their environment. Behaviour patterns are purposeful and may be for procurement of food, finding mate, for locating convenient and sheltered site, or communication. with animals belonging to the same species or to different species.

When an animal moves its body in response to a stimulus, the movements are termed taxes and kineses. Behavioural activities occurring with clock work precision at regular intervals are called biorhythms. Elaborate ritualistic behaviour patterns are associated with courtship and mating, communication with members of one's own species as well with other species.

Certain groups of animals live in groups to form societies and exhibit social behaviour. They also possess special means of communication with members of their own species. Some communication signals are for self defence. In this Unit you shall learn about the various taxes and kineses, rhythms, social organisations, courtship and communication behaviour and the behaviour of

2.0 Objectives

After studying this Unit you shall be able to:

- Distinguish between taxis, kinesis,
- Explain endogenous and exogenous biological rhythms,
- Describe different types of communication methods in non-chordates,
- illustrate how non-chordates attract their partners and mates,
- Describe the caste system, division of labour and advantages of living in social groups,

- Distinguish between different types of parasites, and

- Discuss parasitic adaptations.

3.1 Taxis and kinesis

Animals are characterised by great mobility. Stimuli from the environment direct these movements. These movements may be either taxis or kinesis.

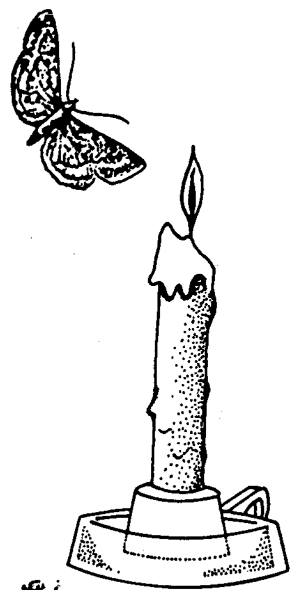


Fig. 18.1: A moth flying towards a source of light is an example of taxis.

Taxis (plu Taxes) is a directional movement, either toward or away from a source of stimulation. The animal is oriented along a line that runs through the source of stimulation and the long axis of the animal's body. Taxis are termed positive if the movement of the animal is towards the stimulus and negative, if away from it.

Taxis are behavioural response that cannot be modified by learning. A moth flying towards light (Fig. 18.1) is a classical example of taxis. So is the migration of an earthworm to the surface of soil after a heavy rain. [Taxes are easily demonstrable in animal - like protists such as Amoeba and Paramecium (Fig. 18.2).]

Taxes are classified according to the nature of stimulus. Table 15.1 shows the various types of taxes - thermotaxis, phototaxis, thigmotaxis, rheotaxis, galvanotaxis and geotaxis.

Table 1: Different kinds of Taxes.

Nature of Stimulus	Name of Taxis	Type of taxis (positive + or negative	Examples
Temperature	Thermotaxis	+ or -	Animals thrive in different ranges of temperature. Optimum range 20-25°C, cold blooded animals avoid temperatures above and below the range of temperature that, they can tolerate.
Light	Phototaxis	+	Hydra, Musca (housefly), Ranatra(an aquatic insect) move towards light
		-	Earthworms, mosquitoes Cockraoches, woodlice move away from light.
Mechanical	Thigmotaxis	+	contact with food causes positive taxis in most animals
Chemicals	Chemotaxis	+	Odour from chemical ingredients of food orient house flies towards it, also Hydra;
		-	Mosquitoes avoid mosquito repellents Animals show negative response to injurious chemicals
Water and Wind currents	Rheotaxis	+	Moths and butterflies fly into wind current
		-	Planaria, the free living flatworm moves against water current
Electric Current	Galvanotaxis	+	Hydra reacts to weak currents of electricity, it bends towards the anode.

Gravity	Geotaxis	+	Cnidarian larva planula swims towards sea bed.
		-	Ephyra larvae of jelly fish swim away from sea bed. Drosophilids (fruit fly) fly up against gravity to dry parts of a jar.

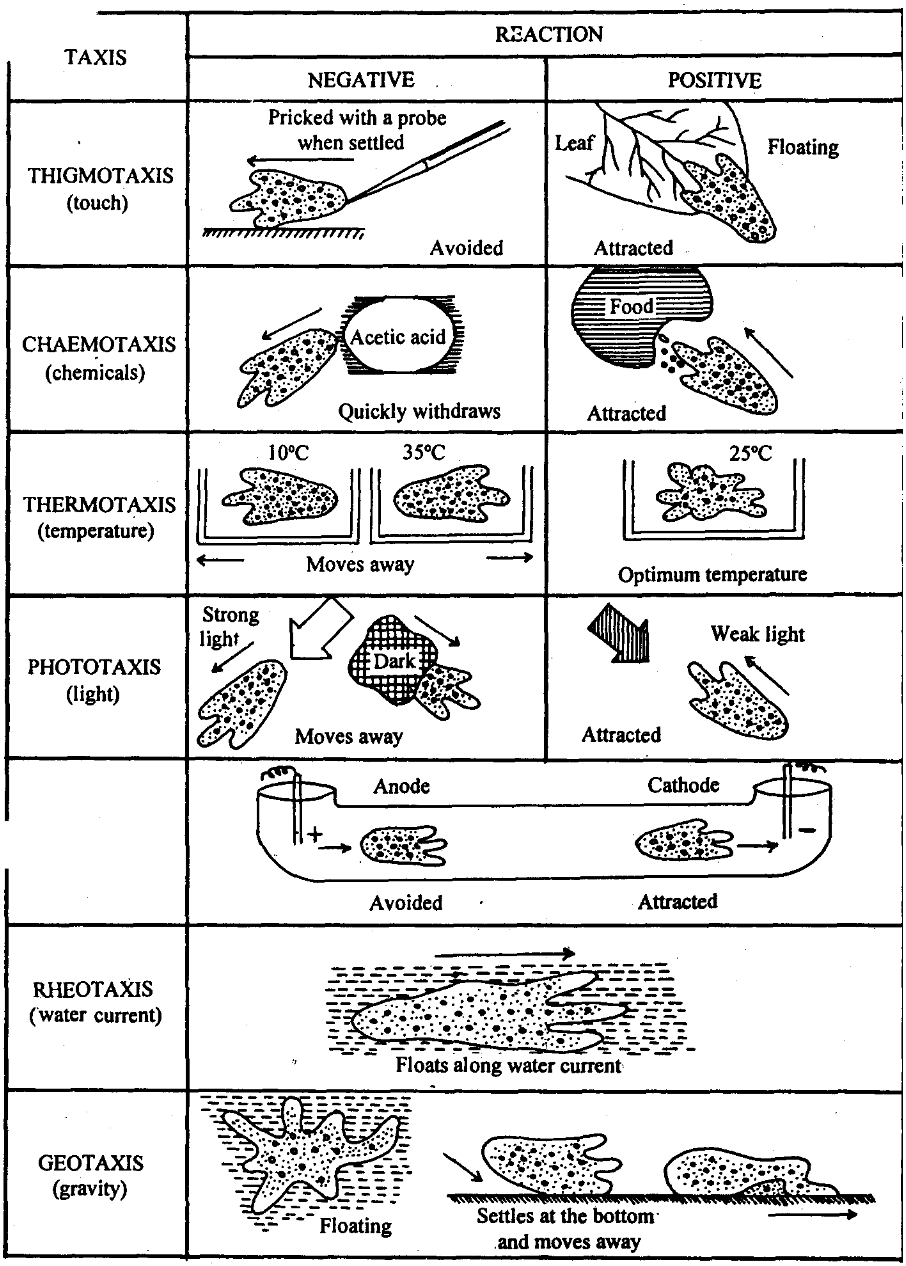


Fig. 18.2: Reaction to various stimuli in Amoeba, arrows indicate the direction of movement.

3.1.2 Kinesis

Kinesis is a **non-directional** movement. Here the animal's body is not oriented with respect to the source of stimulation, but the rate of speed of movement changes with the intensity of the stimulus. Hydra moves its tentacles at random in search of food but if food is kept close to tentacles, they are moved faster.

an

Fig. 18.3: kinesis is Woodlice.

If the woodlice Porcellio scaber are given a choice between humid and dry areas, they tend to collect in humid areas gradually. This is due to their non-directional movement. In other words, they do not seek out humid areas, but movement is random. What happens here, is that their movement increases on dry areas but their movement decreases when they occupy humid areas. The random movement with speed is an attempt to find out optimal conditions. Once they reach humid areas, their speed slows down and they settle there (Fig. 18.3).

SAQ 1

1. What is taxis?

   ……………………………………………………………………
   ……………………………………………………………………
   ……………………………………………………………………
   …………………………………………………………………..

2. What is kinesis?

   ……………………………………………………………………
   …………………………………………………………………..

3. What are the terms used for the following taxes

   (i) Movement towards light.

   ………………………………………………………………

(i) Movement away from electric current.
…………………………………………………………..

(ii) Movement in response to gravity.
………………………………………………………….

3.2 Biological rhythms

Many behavioral activities are carried out by animals at regular intervals of time. Most animals are active during the day and rest at night (**diurnal** animals), while some animals such as cockroaches are active during the dark hours of the night and rest during the day (**nocturnal** animals). Similar behavioral activities occurring with cyclical regularity constitute **biorhythms.**

Some biological activities which show rhythmic oscillations are feeding, mating, egg laying, emergence from pupa (in case of insects) and migratory behaviour. The rhythmic activities are co-ordinated with the cycles of nature such as day and night cycles, annual seasons, lunar cycle of one moon-rise to the next.

This kind of rhythmic activity is to avoid adverse environmental factors and to fully make use of favourable factors. For example, it will be beneficial for bees and other diurnal insects like butterflies, to be active during the day when the flower's they visit open so that they can collect nectar and pollen.

Thus organisms have evolved their own rhythms which co-ordinate their activities with environmental rhythms. Daily rhythms such as feeding, drinking and sleep follow a cycle of approximately twenty four hours and are termed **circadian rhythms** (Latin circa: approximately; diem, day). Many littoral shore animals become active when the tide leaves them exposed. This is **tidal rhythm** eg. fiddler crab emerges from its burrow to feed at low tide. Certain intertidal snails release eggs at very high tides which occur once in two months.

The palolo worm and some other polychaete annelids show **lunar rhythm.** They rise to the surface of the sea to spawn (lay eggs) during certain phases of the moon. Certain animals show courtship behaviour, mate and reproduce once a year (**circa annual rhythm**). Many animals migrate to and from breeding grounds twice a year.

Many insects or their stages go into a state of dormancy or **diapause** during winter when the climate is not congenial. For example, eggs of the mosquito

Aedes, larvae of flesh fly (Sacrophaga) and certain dragonfly nymphs show diapause in winter. Thus biorhythms are behavioural activities performed at regular intervals.

3.2.1 Control of Biorhythms

Certain activities require an external stimulus to maintain them at regular intervals. These rhythmic activities are termed exogenous rhythms. A major external factor regulating rhythmic activities is photoperiod or relative length of day (or light hours) and night (or dark hours). Temperature and humidity are other such factors which may control rhythms palolo worm swarms and mates once a year, on the first day of the last lunar quarter of the year. Lunar cycle is the exogenous factor triggering this activity.

However an internal biological clock exists in almost all eukaryotes which can detect the passage of time even if the environmental cues are absent. Behavioral activities controlled by the biological clock within an organism are termed endogenous rhythms.

Behaviour of many terrestrial insects appears to be controlled by endogenous rhythms related to photoperiods. Drosophila always emerge from pupae at dawn. Insects generally have an inbuilt biological clock. Circadian or diurnal rhythms are the most common of these biorhythms and they are controlled by endogenous biological clocks.

How would you distinguish whether the rhythm exhibited by an animal is exogenous or endogenous? For example, cockroaches are nocturnal, they begin their activity by the onset of night, and stop their activity before daybreak. Is this rhythm exogenous (i.e. controlled by outside darkness in this case) or by its own internal clock?

An easy way to find it out, is to transfer cockroaches to continuous darkness or to continuous. light. You will then see that irrespective of whether they are under conditions of constant dark or constant light conditions, they will exhibit a-periodicity or rhythm of approximately 24 hrs. This indicates an endogenous rhythm, independent of external light/dark conditions.

3.2.2 Biological Clock

Biological clocks are internal mechanisms that provide a means of measuring time. These internal clocks are set to cyclic events in nature such as day and night,temperature changes during the seasons, high and low tides (in case of marine organisms) etc. Animals accordingly show feeding behaviour and other activities, sleep and rest or migrate (in case of migratory animals), controlled by the internal clock. A biological clock is therefore a necessity for most organisms.

Entrainment and free running of biological clock

Biological clock is autonomous and does not vary in its time keeping property. However, if the environmental cycle is changed as happens when animals travel long distances during migration or are transported for experimental purposes to a different continent, the internal clock sets into phase with the external clock prevailing in the new place. The biological clock is then said to be entrained.

Entrainment is like setting a clock to correct time so that it does not give wrong signals at wrong times. In other words, entrainment is setting of the biological clock in phase with the environmental cycle. Once the biological. clock is set, it continues to run on set time for a while even if environmental conditions are suddenly changed. As time passes, biological clock resets or entrains and gets into phase with the new set of environmental conditions.

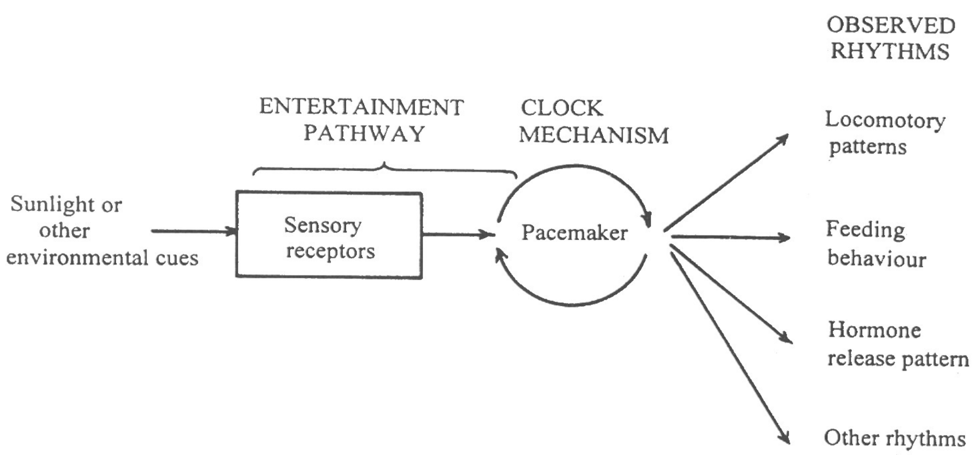


Fig.18.4: A master clock may, in some species, act as a pacemaker to regulate the many other clocks that control the circadian rhythm of the organism.

If animals are isolated from environmental influences then the cycle does not stick to a 24 hour rhythm. For example cockroaches are nocturnal, but if they are kept in constant darkness their rhythmic activities continue but instead of an exact 24 hour cycle, they may exhibit a slightly different cycle of say 23.8 hour. This property of the cycle becoming slightly shorter or longer than the exact 24 hour schedule is referred to as **free running of the biological clock.**

Free running period is the internal clock's repetitive cycle when an animal is isolated from environmental cycle and kept under constant conditions.

Zeitgeber

The environmental stimulus which entrains a biological clock is called Zeitgeber (from German: Zeit - time; geber - giver). Light, temperature and tides are important Zeitgebers. Several environmental factors have been shown to act as Zeitgebers (Fig. 18.4).

Where is the biological clock located?

Researchers have tried to locate the biological clock in the nervous system. But what generates the rhythms is as yet unknown. From some experiments on cockroaches and the fruit fly, it is believed that the rhythm originates in the optic lobes of the brain. Optic lobes, therefore, form the pacemaker of biological clock (Fig. 18.5) in these organisms.

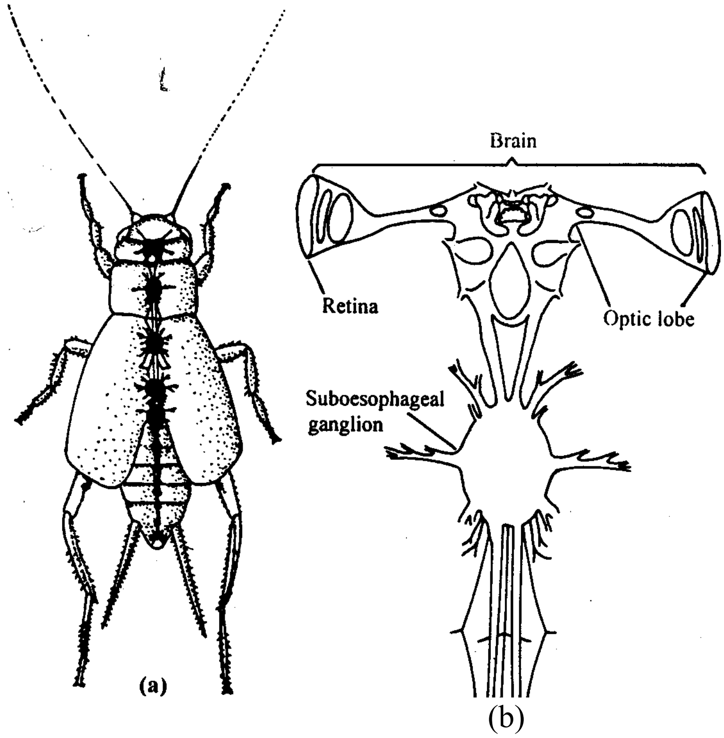


Fig.18.5 Nervous system in cricket. Visual information is relayed to the optic lobes of the brain. If the optic lobes are surgically disconnected from the rest of the brain, the cricket-loses its ability to maintain its circadian rhythm.

Nature of Biological Clock

The nature of biological clock seems to be biochemical. This biochemical mechanism neither slows down in cold weather nor speeds up during warm days, inspite of the fact that in cold blooded or poikilothermic animals, biochemical activities double with each rise in 10° C. Internal clocks are little affected with changing temperature conditions. Thus biological clocks are said to be temperature compensated.

Characteristics of the Biological Clock

a) Biorhythm or biological clock has repeating units called cycles of activity and rest, sleep and wakefulness etc.

b) Each cycle takes a particular time period.

c) It shows peaks and troughs a phase of peak activity followed by a phase of low activity.

d) Rhythms are said to be temperature compensated. That is, rhythm (or biological clock) keeps the same time irrespective of a rise or fall in temperature outside

e) Metabolic inhibitors do not affect biological clocks or biorhythms.

SAQ 2

1. Define biorhythm.
   …………………………………………………………………..
   ………………………………………………………………….

2. match the terms in Column I with words or statements in Column II.

Column I	Column II
1. Circadlian rythm	a.Light hours
2. Photoperiod	b. rhythm under constant darkness
3. Zeitegeber	c. marine invertebrates.
4. Lunar rhythm	d. environmental stimuli that set the biological clock.
5. Free running	e. 24 hour cycle of earth's Rotation.

3. What is the difference between exogenous and endogenous rhythm?
   …………………………………………………………………..

4. What does entrainment of the biological clock mean?
   ………………………………………………………………….

5. Which organ system, seems to control the biological clock?
   ………………………………………………………………….

3.3 Communication Behaviour

Animals need to interact with their conspecifics (members of the same species) as well as animals of other species. Interaction requires effective means of communication. Various means of communication among animals have thus evolved. Communication behaviour is highly developed in animals that exhibit social behaviour. Though there are many definitions for communication for our purposes the following definition of communication between two organisms can be acceptable.

An action on part of one individual organism which alters the pattern of behaviour in another organism-is known as biological communication. The action is in the form of a signal from one animal to another and the sender of the signal usually benefits from the response of the receiver.

Human beings usually communicate through language made of words. Words can be rearranged in infinite ways to construct numerous messages. Language of animals; other than humans is in the form of signals. These mutually recognisable signals may be visual, auditory, tactile or chemical. Signals are exchanged between individuals and these influence the behaviour of each other. One signal may convey one or more messages.

Types of Signals and Their Purposes

Signals for communication may be of four types.

1. **Visual** - Which can be recognised by seeing.

2. **Mechanical** - Which are recognisable through the tactile sense.

3. **Auditory -** These are sound signals of various frequencies which convey different messages.

4. **Chemical** - Signals are due to secretions. The secretions include pheromones.

   Signals are used to communicate various messages. The messages may be regarding

   1. Availability of food.

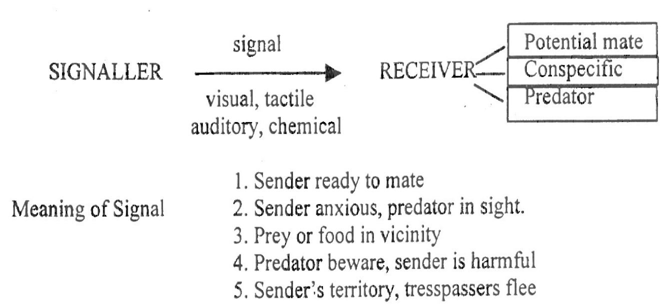
   2. Need for defence from predators

   3. Availability of mating partners.

An animal may utilise a channel of communication for more than one purpose. For example, many spiders respond to captured prey through web vibrations. Through web vibration they also communicate with prospective mates. Jumping spiders use visual signals to stalk and capture prey.

They utilise these signals for courtship also. All signals of display are behaviour patterns established through evolution to become effective for communication. This is called ritualisation. Through ritualisation,,simple movements or traits become more intense, conspicuous and precise and their original undifferentiated function acquires a signal value.

Communication behaviour often occurs in regular sequences. These sequences become stereotyped and then they are termed fixed action patterns. Most stereotyped signals are for courtship and territoriality.



3.3.1 Visual Signals

The posture of the body and the colour patterns of the animal are the two major visual signals among invertebrates. In general molluscs and arthropods have well developed eyes. Their efficient eyes and well developed nervous systems are able to discriminate visual signals. Hence these animals communicate a lot through visual signals. Many of these animals can distinguish shapes and movements.

In nocturnal animals and deep sea inhabitants, communication by visual signals is limited to flashes of light or bioluminiscence. (Fig. 18.6. A,B).

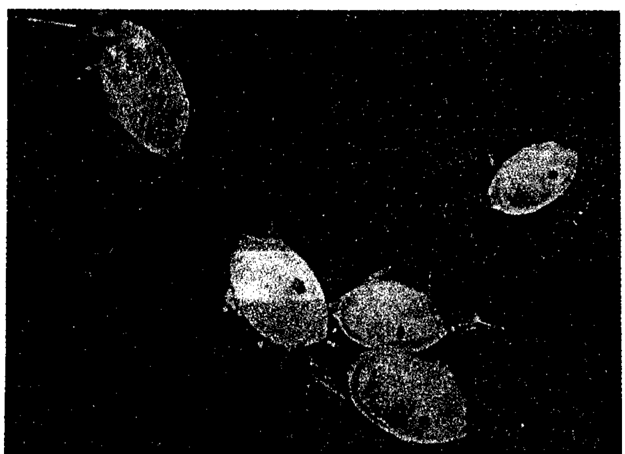
Visual signals are mainly used for

1) Frightening the predator

2) Luring the prey and

3) For attracting a mate

The advantage of visual signals is that if the receiver can see the signal, the sender can be located immediately. But visual signals cannot be used at night except for bioluminiscence. They cannot pass many physical barriers unlike auditory and chemical signals. Another great disadvantage is that the sender can easily be detected by its predator.



(a)

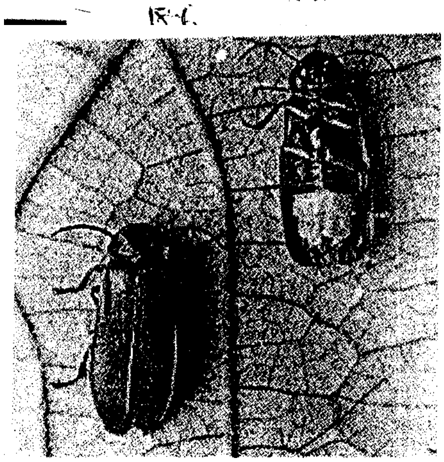


Fig. 18.6: Bioluminiscent invertebrates: a) Cypridina (crustacean),

b) Firefly is actually a beetle. The white abdominal segments with photocyts are supplied oxygen by the abundant trachioles. The oxygen oxidises the luciferin +ATP in the presense of Mg ions and enzyme luiciferase.

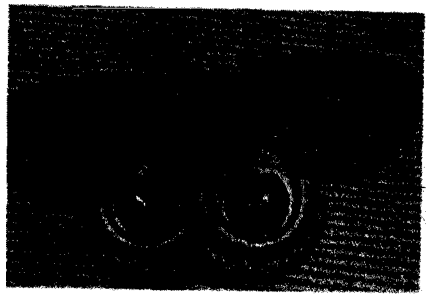


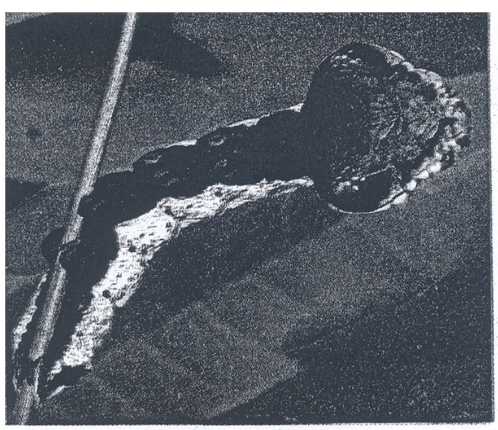
Fig.18. 7 Moth with eyespots on wings

There are various examples of communication through visual signals among the invertebrates, which have been listed for your knowledge you may observe and add more examples to this list.

1. To startle the predator, some moths the eye like spots on the hind wings (Fig. 18.7).

2. The large coloured eye spots on the caterpillar of the swallow tail butterfly gives it the appearance of a snake head (Fig.18.8) which scares the predator.

3. The ant Crematogaster adopts an alarm and defence posture by curving its abdomen upwards which warns and sends alarm signals to the predator, of its toxic sting (Fig. 18.9).



Snake head caterpillar.

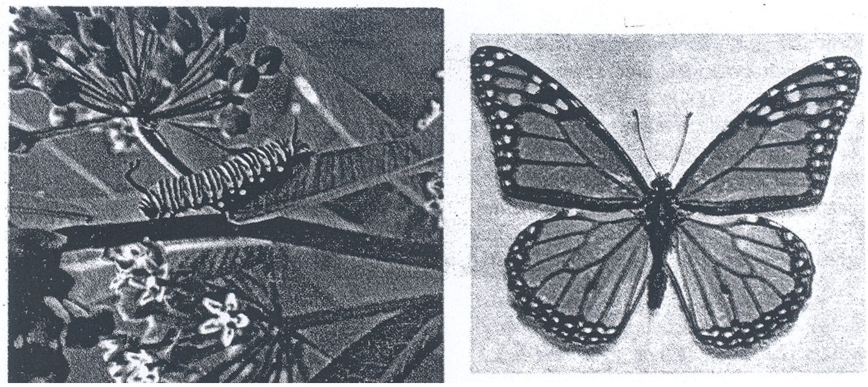


Fig.18.10: Larva and adult monarch butterfly showing sposematic. Colouration warning predators of the presence of cardiac glucosides in their bodies.

4. The monarch butterfly Danaus and its caterpillar are brightly coloured. The bright colouration keeps predators away as they associate bright colours with the presence of toxic cardiac glycosides (Fig. 18.10).

5. The reef squid Sepioteuthis sepioidea manipulates its chromatophores to exhibit colour patterns which, along with the body posture and position of tentacles, alarms the predator.

6. The crustacean Cypridina (Fig. 18.6 a) comes to feed at night and releases bioluminescent substances (luciferin) into water. The bioluminescence attracts the prey.
7. Female of the polychaete.Odontosyllis emits green light continuously during their mating'period. Circles of light attract male worms. They in turn respond by emitting intermittent flashes of light. Eggs and sperms are deposited in water, resulting in fertilisation.

8. The male and female fireflies of the genus Photinus (18.6b) have bioluminescent organs. They emit flashes of light. These serve as visual signals for mating.

Deceit in Visual Communication

Colouration and mimicry are antipredatory behavioural patterns. Kallima the dead leaf butterfly, which resembles (mimics) a dry leaf when it rests folding its wings (Fig. 18.11), is an example of mimicry for it mimics a leaf in this case.

The leaf insect, is green in colour and shaped like a leaf; the spotted leaf katydid resembles the leaves on which it feeds; the stick insect resembles the twig on which it rests (Fig. 18. 12 a and b). There are many other examples of mimicry. These insects convey visually that they are inedible or inanimate. The deceiving visual signals protect these insects from the predator.

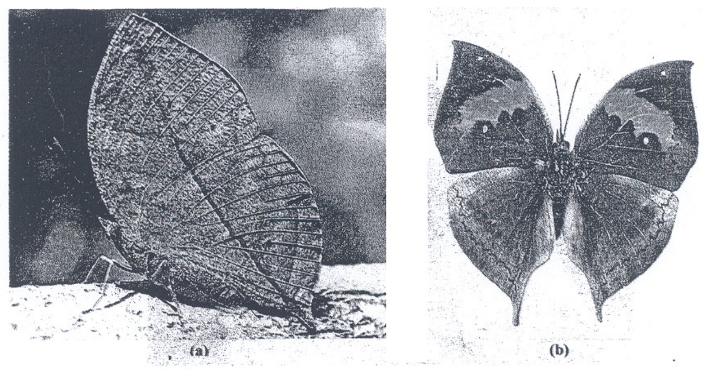
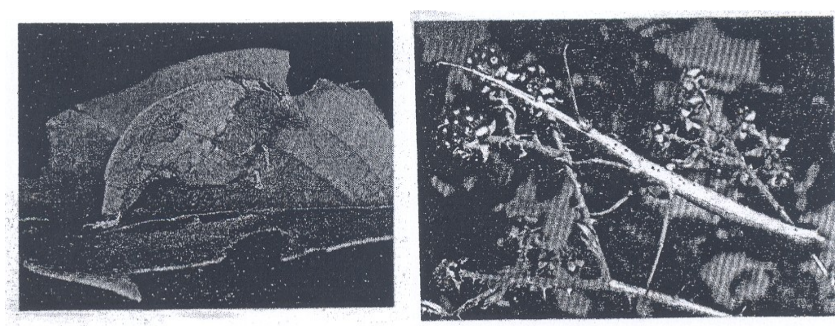


Fig.18.11:a) Kallima looks like a dry leaf when it folds up its wings (1) Note the fine lines on its wings suggesting the veins of a leaf, b) a preserved specimen of kaUlma with its wings open.



a b

fig. 18.12:a The spotted leaf katydid is exactly like the leaf on which it rests, b) Stick insect can hard be noticed. Note the spines on the body of the insect that resemble the spines on the plant c which it rests.

Some bioluminescent fireflies even deceive the prey (species of fireflies belonging to another genus) through visual signals. For example, the predatory female of the firefly Photuris answers the courtship flashes of light given by the males of the firefly Photin species. If the Photuris female succeeds in attracting male of the species, she, grabs him kills and eats him.

3.2.2 Mechanical Signals

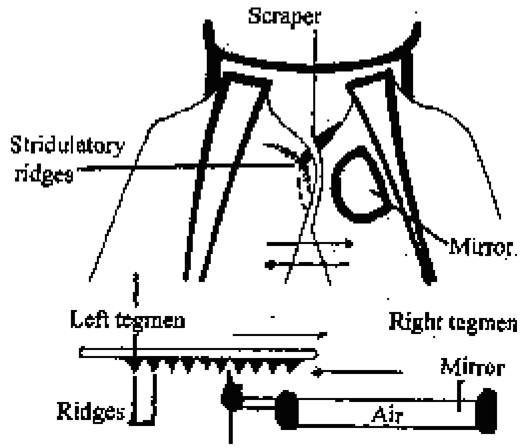
Mechanical signals of communication include the tactile signals in which communication is through touch and auditory or acoustic signals in which sound is.generated through movement of wings or special stridulatory organs.

A good example of tactile signal is the food begging behaviour of the larvae of the Formica ant. When touched by an adult worker ant's mouthparts or antennae, the larva tries to make contact with the head and mouthparts of the worker by tapping its mouth parts with the mandible of the worker as though begging for food. The worker, immediately regurgitates a food droplet and offers it to the larva. When an adult Formica ant taps another worker with its antennae, the signal is to stop moving about.

Auditory Signals from the sender reach the receiver through airborne sound waves. Special sound producing organs and organs of hearing are common among insects. Sound signals are efficient means of advertising the presence of the signaller.

They may thus be used as (i) courtship songs; warning devices, advertising territorial claims. Sound can pass round corners and a great deal of information can be sent by modifying frequencies of sound produced. The disadvantage of sound signals is that they can easily be exploited by predators. For example the male cricket sings to lure the female into his burrow. But the predator receives the sound of his song, locates and preys upon the cricket.

Among invertebrates, insects as a class have very effective sound communication system. Everyone is familiar with the buzz-of the bee, chirps of crickets, loud noise of cicadas, and buzzing of mosquitoes at night. In insects sound is usually generated by frictional methods-, rubbing specialised surfaces of two parts of the body, like thorax, abdomen, wings and legs. This is called stridulation. Sound reception is by hair like mechanoreceptors distributed in connection with the tympanal organs.



projection

Fig. 18.13: Stridulatory Organs of Cricket.

Courtship singing is a daily programme with male crickets and begins in the evening. Wings are moved so that a ridge--on the edge of one elytm (forewing) forming the "scraper" moves across the toothed files on the underside of the other elytron (forewing) like a bow across the strings of a violin creating various patterns of sound (Fig. 18.13).

Song patterns are specific for a species as also specific in their meaning. The commonest song is the calling song to beckon and guide the sexually receptive females into their, burrows. Once the. couple meet, a courtship song ensues. After mating, the male sings a **triumphal** song.

The courtship movements and songs of Drosophila are likewise, characteristic. The male touches the female and extends its wings. It then moves the body and makes a characteristic sound which the female effective even in the dark, can pass round obstacles and disperse over great distances. Such chemicals released as signals for commmunication are called **pheromones.**

Pheromones are chemicals which are released by one organism and produce a response in conspicifics (members of the same species). Pheromone communication has been discovered in unicellular organisms as well as in nearly all animal groups. Many kinds of chemicals act as pheromones and many types of signals can be conveyed by pheromones.

Pheromones generally act as releasers, (signalling pheromones) stimulating the recipient to show a very specific but transitory type of behaviour. Sex phenomenes of insects generally belong to this category. Some pheromones act as **primers** and evoke slower but longer lasting physiological responses from the receiver. An example is the chemical in the "queen substance" that. inhibits ovary development in the worker honey bees.

Communication in social Insects by Pheromones.

Trail marking pheromones are used by some insects to find mates, communicate information on the location and quantity of food and to ensure that migrating groups retain their integrity. Amongst social insects, for example in ants, trail marking pheromones are deposited on the ground as foraging workers return to recruit other workers to a food source (see Fig. 18.23).

Most trails fade away soon unless reinforced continuously. The chemical nature of relatively few trail marking pheromones is known. In termites and some ants they appear to be long chain acids, alcohols, aldehydes or hydrocarbons.

Pheromones also help in recognition of members of the social group in insects. Alarm pheromones warn members of a species about foreign intruders. If termites from another nest enter a colony of termites, soldier members release an alarm pheromone which attracts other soldier termites that chase away foreigners.

The nature of alarm pheromones is varied but specific for each group. In honeybees, the pheromone is released from the stingshaft that is buried inside the invader. This attracts other bees to attack.

In a honey bee colony, the queen secretes the "queen substance", by the mandibular glands. It has two components oxydecanoic acid and a - hydroxy decanoic acid, which act synergistically on the gonad development within the workers and their construction of special cells in -which larvae would develop as queens.

These primer pheromones inhibit the workers from raising a new queen and also inhibit the development of ovaries in workers.

Sex Attractants or sex pheromones in moths

Virgin female silk moths have special pheromone glands whose secretions act as chemical sex attractants. Males "smell" these chemicals with their large bushy antennae with numerous sensory hairs functioning as olfactory receptors. These receptors are highly sensitive to Bombykol, the pheromone produced by the female silk moth.

The female rests at a place and releases her pheromone, a little bombykol, which travels downwind and reaches the male antennae. Immediately the male gets stimulated and flies upwind to find the female. He moves randomly till he is close to the female flying towards her by the smell of bombykol, finds her and mates with her. This is clearly then a releaser pheromone.

In the gypsy moth, a similar releaser pheromone, gyplure is involved in bringing the two sexes together.

3.3.4 Communication Among Honey Bees - The Dance Language

The Austrian ethologist Karl von Frisch received Nobel prize for his research on communication in honey bees.

The honey bee, Apis exhibits social behaviour: Worker bees collect enormous quantity of pollen and nectar to feed the the colony mates. This is accomplished through co-operative effort whereby the worker bees who discovers a rich source of pollen and nectar, comes back to the hive and communicates the information regarding the sdurce through specific dancing patterns, to the other workers.

For instance, when a forager bee finds a garden of flowers fairly close to the hive, say within a distance of 50 meters, it performs the round dance (Fig. 18.14 a) at the hive. In the round dance, the bee turns in alternate circles to the left and right. The bee penetrates the hive and runs in a circular fashion excitedly. Other workers follow this worker bee. The dancing bee ultimately regurgitates .the nectar. From the taste and the scent picked up from the dancing bee, other worker bees locate the food'source.

If the food source is beyond 50 meters from the hive, the bee performs the waggle dance. This is a modified round dance, which incorporates in it a straight run. During the straight run, the worker waggles (moves) its abdomen from side to side. Greater the distance to the foraging site, longer is the straight run'component in the waggle dance (Fig. 18.14 b). The waggle dance thus indicates the distance and direction of a nectar source.

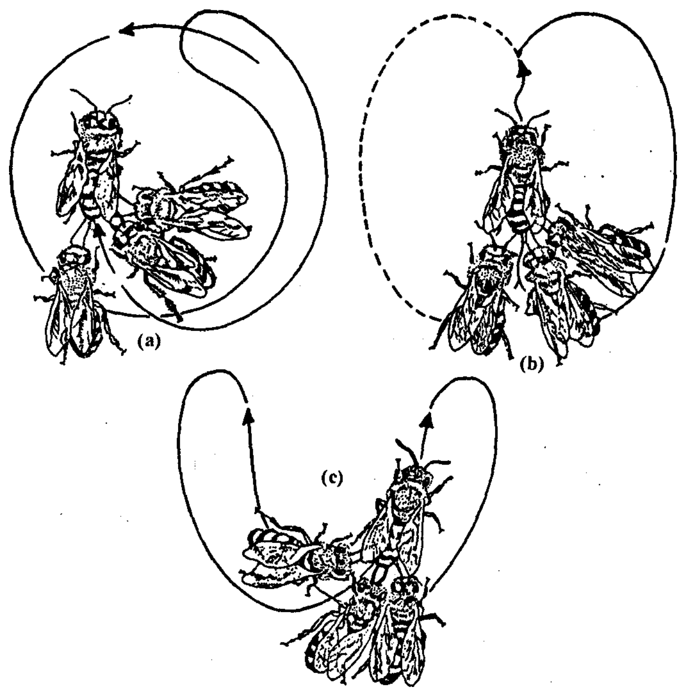


Fig. 18.14: Honey bee workers dance in different patterns to communicate the distance of the food from the hive to the workers.

Sickle Dance is also another modification of the round dance, and is performed by the Italian bee. She moves to make a flattened figure of eight, when the source is at intermediate distance from the hive. The opening of the sickle faces the source of food (Fig. 18.14 c). A dancer is always followed by her hivemates.

SAQ 3

1. Define biological communication.

   …………………………………………………………………………
   ………………………………………………………………………..

2. What is ritualisation?

   ………………………………………………………………………..
   ……………………………………………………………………….
   ……………………………………………………………………….

3. What do fixed action patterns' mean?

   …………………………………………………………………………
   …………………………………………………………………………

4. Name any two purposes for which
   a) Visual signals are used.
   b) Auditory signals are used.

5. What is stridulation?
   …………………………………………………………………….
   …………………………………………………………………….

6. Which head a ppendage of the insect generally has sex pheromone receptors.
   ……………………………………………………………………
   ……………………………………………………………………

7. What is the significance of (a) round dance (b) waggle dance in honey bees.

3.4 Courtship Behaviour

Specialised behavioural patterns of animals for attracting the opposite sex for reproductive purposes is termed courtship behaviour. These behavioural patterns may be in the form of display of bright colouration or accessory morphological structures, or in the form of offering nuptial gifts, or making specific gestures in front of the opposite sex. Courtship behaviour culminates in mating unless the prospective mate refuses to be satisfied with the courtship behaviour.

It is usually the male which shows various kinds of elaborate courtship behaviour, sometimes strange, to attract the female. The female rarely shows courtship behaviour, but responds to his overtures. Choice of mate seems to be her privilege. Interactions between sexes cease with copulation.

3.4.1 Need for Courtship Behaviour

Courtship behaviour serves the following purposes.

1. Synchronisation and orientation of sexual partners.

For successful fertilisation, sperms and ova have to be discharged by the two sexes at th same time. The male and female of the same species have to be properly oriented. The courtship behaviour of the male attracts the sexually mature female ultimately culminating in fertilisation or inseminatign.

2. Persuasion

The male exhibits courtship behaviour patterns and the female examines and decides about the fitness of its mate based on these patterns. More often than not the behaviour the male persuades her to accept him as the mate.

3. Mating with Conspecifcs

Courtship patterns are species specific. The female of a particular species can recognise; the courtship behaviour of a male belonging to her own species. This ensures mating between members of the same species.

4. Reproductive Isolation

As a consequence of specificity of courtship behaviour, mating with members of anot species (interspecific mating) is prevented. Courtship is thus a means of reproductive isolation. Courtship patterns that prevent interspecific breeding and hybrid formation termed **ethologicai isolation.**

3.4.2 Sex Differences in Courtship Behaviour

The behavioural patterns of males to woo females are diverse and often strange. No less strange is the choosiness that females exhibit. Why males take the initiative to court females and why females sometimes reject males following his courtship may be attributed to the difference in the investment of either parent in the offspring in term time and energy.

Such differences in the reproductive tactics of male and female ma have helped to create a kind of natural selection termed **sexual selection.** Sexual selection occurs when individuals vary in their ability to? (a) Compete with others for mates or (b) to attract members of the opposite sex. Sexual selection involves.

1. Competition to gain access to mates, often_ but not always among males. (Intrasexual competition) Males compete with other males of the species for a mate. This probably led to the evolution of aggressivë, behaviour which males at times show.

2. Competition to choose the best possible mates mostly among females (intersexual selection)

Mate preference exhibited by females probably resulted from practical value of:

i) What kind of genes the male has to offer, and

ii) If the chosen mate is of any other value.

The theory of sexual selection was first suggested by Charles Darwin (1871). He recognised that the reproductive success depended on the ability of individuals of one sex to locaté the opposite sex, fight with other conspecific members of its own sex and win over a mate. Competition for mates among the individuals of one sex was thought to be responsible for the evolution of the characteristic features of that sex, including the behavioural mechanisms involved in selection of mate.

It is now known that reproductive success or ability to produce large number of viable offspring is more variable with males than females. This is due to difference in contribution of reproductive resources by male and female to the zygote and hence to the developing embryo i.e., parental investment of the male in the offspring is less than that of the female.

In case of females parental investment is more because:

(i) The female gamete, egg, is larger than sperm, the male gamete,

(ii) Generally only a few eggs are liberated by the ovary at a time,

Egg contains nutritive substance such as yolk for the developing embryo,

Females, in many cases, spend extra time after mating for parental care.

All these activities take time energy and materials and consequently limit the number of young that can be produced. On the contrary:

(i) Males release, larger number of sperms,

(ii) Sperms are much smaller than ova,

(iii) Males contribute only their genes through sperms, but no nutrients,

(iv) In most invertebrate species, males do not do anything beyond transfer of sperms to the female.

Sexual selection should produce different degrees of variation in reproductive success of males and females. Some males may mate with several females while some males may fail altogether. Females need only to mate once or twice for they can receive all the sperms from one or two males to fertilise the relatively few eggs they produce.

Thus reproductive output of males will depend on how many females it can inseminate and hence vary among males. Females, on the other hand will produce more or less the same number of offspring.

Females, the choosy sex, prefer certain attributes in males which leads to mate selection. -The preference differs in different species. Some of these attributes are:

- Large size,
- Visual, mechanical and chemical signals or display by the male,
- Offer of nuptial gifts from the male,
- Superior fighting ability and aggressive behaviour of male,
- Ability of the male to guard the mate,
- Attempt of a male to become socially dominant.

In certain species, males force the female into copulation.

Let us now examine some examples of male courtship behaviour patterns used for attracting conspecific females.

3.4.3 Visual, Mechanical and Chemical Displays

The crab Uca waves an enlarged chela (Fig. 1.8.15) to attract the female. Horns and snouts of certain male beetles have a similar effect.

Male crickets and locusts stridulate to produce species specific sounds. The sounds differ in frequency and may-mean mating receptivity, victory etc., (see subsection J~.3.2 - for auditory signals).

Fig. 18.15: Male fiddler crab had enlarged chela used to attract females.

In scorpions, both male and female, indulge in a courtship dance during the monsoon (Fig. 18.16). The male and female face each other, raise the post abdominal part high into air, then move in circles. The male holds the pedipalpi (clawed appendages on the cephalothorax) of the female with his own pedipalpi and both intertwine with post abdomen above them.

Then they walk forward and backward and in rings. While moving in a ring, male retreats and drags the female along. The courtship play may last for hours or even days. The male digs a burrow. Both enter and mate. The male scorpion deposits a spermatophore and moves the female so that her genital area is above the spermatophore. Sperms enter through the female genital opening. The female eats up the male after mating!

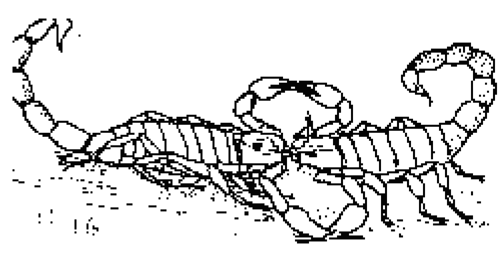


Fig. 18.16: Courtship dance of scorpions

In some spiders, the female sits at the centre of its web. The male approaches the web and plucks a thread of the web at a specific frequency. The female reduces her natural aggressive form. But if the male, by chance, tries to attract the female of another species, it is killed.

Pheromones also act as sex attractants (see section 3.3.3). The pheromone is released by eversible glands at the tip of the abdomen of unfertilised adult female moth. Antennae of male moths have olfactory receptors for these pheromones, and they fly towards the female in a definite species specific pâttern and mate. Male of butterfly Danaus gilippus brushes, pheromone laden 'hairpencils' everted from the tip of his abdomen on the female. The female is stimulated to mate.

3.4.4 Nuptial Gifts

Gifts offered by males to court females may either be in the form of (a) food or (b) spermatophore.

The female black-tipped hangingfly (Hylabittacus apicalis) chooses for mating, the male which offers a large edible nutritional gift. The gift is a dead insect (Fig. 18 17). If unpalatable lady bird beetles are offered as gifts, the female rejects the male. Duration of mating depends on size and quality of the prey which is gifted by the male. If the gift is small, female unhooks itself from the male to give up mating without accepting sperms.

Among katydids, relatives of grasshoppers the male offers "spermatophore" (a packet of sperms). The spermatophore is rich in protein and after copulation, the.female feeds on it. 1f the male offers a small spermatophore, the female does not permit entry of sperm into her spermatheca (sperm storage organ of female).

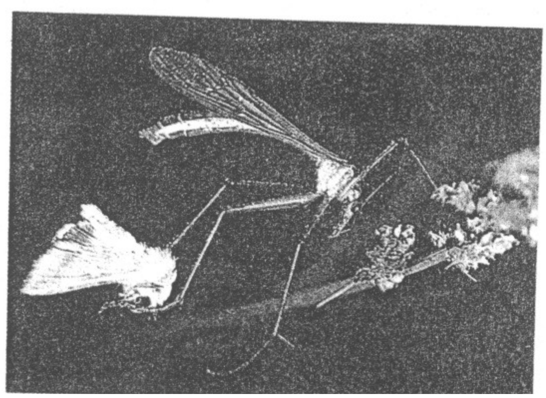


Fig.18.17: Male hanging fly carrying captured prey as nuptial gift for the mate.

1n the Mormon cricket, Anabrus simplex the male attaches a two-part spermatophore to the mate's genital opening during copulation (Fig.

18.18). The male separates after copulation and the female feeds on one part of the spermatophore the spermatophylax leaving the other part containing the sperms in place. Larger the spermatophore, longer she feeds and more time elapses with more sperms entering the female spermatheca from the sperm ampulla. When the first part is eaten she eats up whatever is left of the second part the ampulla.

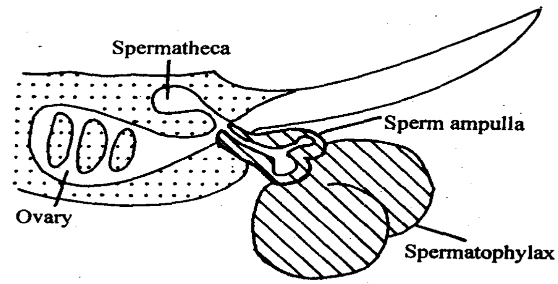


Fig.18.18: Diagram of the posterior part of a female katydid showing male spermstpbore after mating. The spermatophore is made up of the ampulla containing the sperm and the spermatophyla: containing nutritional material.

The male balloon fly (Hilara sartor), an empid fly constructs silken balloons as nuptial gifts (Fig. 18.19). A group- of balloon carrying males display collectively to visiting females. The female selects one balloon carrying male and accepts the balloon as a precondition to mating.

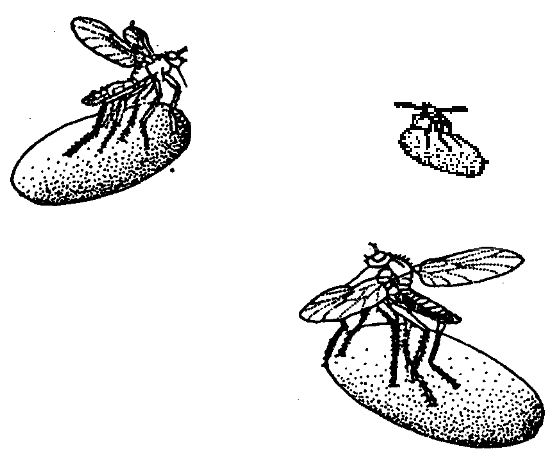


Fig. 18.19: Males of emphids. Carrying silken balloons for mates.

3.4.5 Sperm Competition and Mate Guarding

Sperm competition and mate guarding is particularly important in insects, because female insects can store sperms in an organ called spermatheca and use the sperm later. Copulation by one male does not exclude successful copulation by other rival males. An interesting example of sperm competition is seen in damsel fly *Calopteryx maculata*. Some males defend a territory of one to three meter long stretch of the bank of a stream, from which they drive away all other males.

Females come to lay eggs on underwater vegetation, the male courts her and mates with her before she oviposits. The male has specialised claspers at the tip of his abdomen to grasp her. He bends the abdomen to form a loop so that sperms are transferred to the penis. The receptive female swings her abdomen and places her genitals on the penis.

The penis is inserted by the rhythmic movement of the abdomen. If there are speims of another male stored in the spermatheca, they are brushed out of the spermatheca before fresh sperms are deposited by the penis. He then releases her but guards her while she lays eggs in his territory. If the male cannot guard her, she flies away to. another territory to mate with another male who repeats the performance.

3.4.6 Alternative Tactics of Mate Competition

Not all males of a species compete for mates in the same way. In many species the males often adopt alternative means of mating. For example, the scorpionfly *Panorpa* employs three tactics for mating. (1) Some males defend dead insects which attract receptive females that feed upon them. (2) Others secrete salivary material on leaves and wait for females to come and consume them. (3) Still others, the smaller males, do not give any gifts to the female but force her into copulation.

Not only scorpionflies but males of other insect species also force females to copulate. The assaulting males especially pounce on females while they are laying eggs. Some species may have the potential to behave in any of the available ways depending on the prevailing conditions.

Mate choice by males

Uptill now we have examined examples where mate competition occurs between males and mate choices by females. If and when parental investment is made by males rather than females, the role of the sexes can get reversed. In high density population of Mormon crickets, where the food becomes scarce, when a male gathers enough resources to. produce a spermatophore, he climbs up a bush and begins to sing.

Hungry females are attracted and when more than one female arrives they compete to copulate. The male accepts only that female that is significantly heavier than the rejected females. Such sex role reversals are rare and show that when parental investment is greater by the male then competition for mate arises amongst the females.

3.4.7 Rejection and Deceit in Courtship

Females of certain species have specific signals for rejection of the mate. The female ground beetle *Plerostichus lucublandus* sprays the rejected male with toxic liquid and the male may be in coma for a long time.
Female butterfly Colias is unreceptive during egg laying and if courted, flies very high when the males run away, she descends and oviposits in peace.

Deceit in courtship is shown by some males of the hangingfly *Hylobittacus*. A male without a nuptial gift poses as a female, takes a gift from another male which mistakes him for a female and gives the gift to a female.

SAQ 4

1. What is courtship behaviour?
   ……………………………………………………………………
   …………………………………………………………………..

2. What is the major difference between the courtship tactics of a male and female?
   …………………………………………………………………..
3. What are some of the nuptial gifts offered to the females by males?
   ....,...
   ....

3.5 Social Organisation In Insects

The term social organisation refers to populations or groups and not to individuals and defines how members of a species interact with each other. Social organisation among non-chordates is best examplified in insects. Insects such as ants, wasps, honey bees and termites survive through cooperative living.

A number of individuals live as a society or colony. Work such as, building the abode, procuring food, cleaning etc., are divided among members of the society. Thus when a number of individuals of a species cooperate and live together sharing the duties of life they are said to exhibit social behaviour.

3.5.1 Advantages and Disadvantages of Social Behaviour

Social life has several benefits. A collective defence strategy can easily drive away predators. The young ones can be better looked after and protected in a colony of individuals. Social life has its disadvantages too. The following table (Table 112) shows some major advantages and disadvantages of sociality.

Table18.12: Benefits and cost of social organisations

ADVANTAGES	DISADVANTAGES

1. Defence from predators (i) One member detects predator, can warn and save other members (ii) A joint attack can easily repel the enemy. (iii) The sight of a colony of prey individuals has a better chance of scaring the predator.	**I**. Competition within the group Members of the society may compete amongst themselves for food, nest material, nest site and mate.
2. Collection of food (i) Food resources may be spotted by one member and others are led to the food source. This saves energy expended onsearching foraging grounds. (ii) Gathered food is shared by the young, the aged, the infirm apart from others.	2. Risk of epidemic and parasites Increased risk of infection by contagious diseases and parasites.
3. Care of offspring Improved care pecifes of offspring through communal feeding and protection from enemies.	3. Exploitation of parental care by conspecifes The lazy members may leave the care of their, progeny to others.
4.Defence of occupied territory Intruders from other groups of the same species looking for the same habitat and food are driven away through a joint effort.	4. Risk of loss of one's progeny Increased risk of progeny being killed by away through a joint effort. conspecifics.

3.5.2 Characteristics of Social Insects

You have already read about polymorphism in highly organised insect societies of termites (Isoptera); ant and bees (Hymenoptera), in, Unit-11 section 3.2.2 of this course. In these societies we find such remarkable adaptation to social life that they are not called just social but eusocial insects.

All truly eusocial insects possess three traits.

(I) Many individuals of the same species cooperate in caring for the young;

(2) There is division of labour with sterile individuals working on behalf of fecund (fertile) individuals;

(3) There is an overlap of at least two generations in life stages capable of contributing to colony labour, so that offsprings assist parents during some period of life.

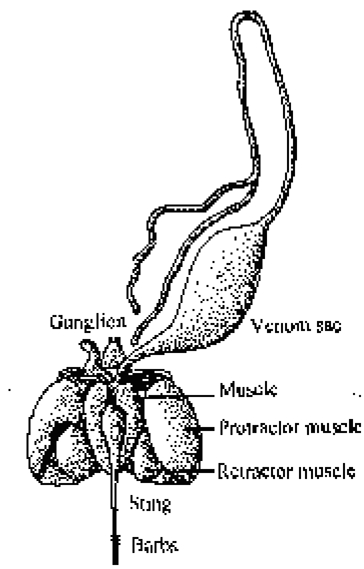


Fig. 18.20: Sting apparatus of the honey bee. The barbs of the sting get lodged in the victim's flesh. As a result the sting apparatus tears out of the bee's body and she dies. The muscles left back with the apparatus continue to contract, pumping more venom into the victim.

You would recall that these societies are divided into castes, such as soldiers, workers and reproductives which are morphologically different from one another and each has a separate role to perform in the colony. Eusocial insects show cooperation.and altruism in an incredible manner. They build elaborate nests where temperature and humidity are kept constant. Group foraging allows sharing and harvesting of widely spread food resources.

Communication involved in foraging and maintaing the colony structure are complex and the nest dr hive is fiercely protected as in the case of. honeybees. When the honeybee worker stings, she leaves her sting along with the poison gland and a set of contracting muscles behind as she pulls away. As a result she continues to pump poison in, the victim even though she herself dies.

Fig. 18.20 shows the sting apparatus which consists of the muscles, pheromones that attract other guard bees and venom sac. The evolution of nonreproductive castes showing a readiness for self sacrifice is intriguing: In the following subsections we describe some interesting social organisations in insects.

3.5.3 Social Wasps

Among wasps eusocial behaviour is limited almost entirely to family Vespidae. The paper wasp *Polistes*, with its painful sting is a familiar example.These wasps build small open nests beneath roofs of houses, barns, garages and other outhouses. They build annual colonies. The colony consists of three castes: the queens (fertile females); the workers (nonfertile females) and drones (males).

Reproductive females (queen) emerge from cells of their papery nest late in the breeding season, mate and hibernate in winter.In spring, these females emerge and construct either alone (foundress) or with co-operation of other similar queens (auxiliary queens) a nest.

The foundress queen lays eggs and rears the first group of her larvae on macerated insects. All of these beçome workers. These workers thereafter, maintain the nest. They add new cells to the nest, look after the queen henceforth, forage and bring food (Fig. 18.21).

The foundress remains in the nest thereafter, and lays eggs. The colony now grows rapidly as more and more workers emerge. At the end of summer, some new queens and a number of males emerge. These leave the nest, mate and hibernate. After winter they build new nests. The old queen and the old workers die and the original colony disappears.

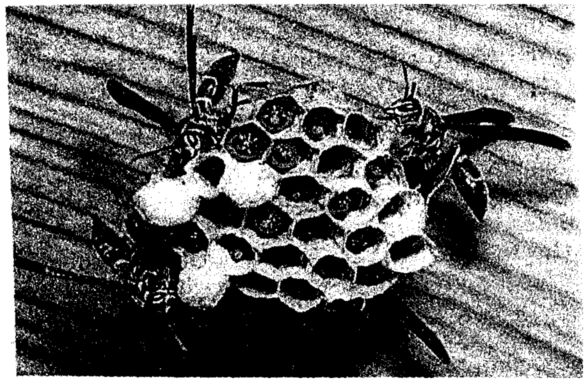


Fig. 18.21: A social wasp *Polistes*. One of the adults shown is the queen the others are workers that assist in building the nest and caring for the young i.e. the larvae inside the cells.

3.5.4 Ants

The ants belong to the family Formicidae *(Order Hymenoptera).* Common ants are the small black *Monomorium* and the large black *Camponotus. Formica, Lasius* are other genera. They build nests in cavities in plants, in the soil, or under stones or logs. The tropical ant *Oecophylla smarsedina* weaves leaves of trees into a nest with threads of silk.

All ants are social and polymorphic you have already learnt in unit-7, Block 1 of this course that there are mainly three castes.

(1) Wingless and sterile females are either soldiers, having huge head and well developed mandibles, or ordinary workers.

(2) Winged fertile females which lay eggs (queens) and

(3) Winged fertile males which are short lived and die after mating.

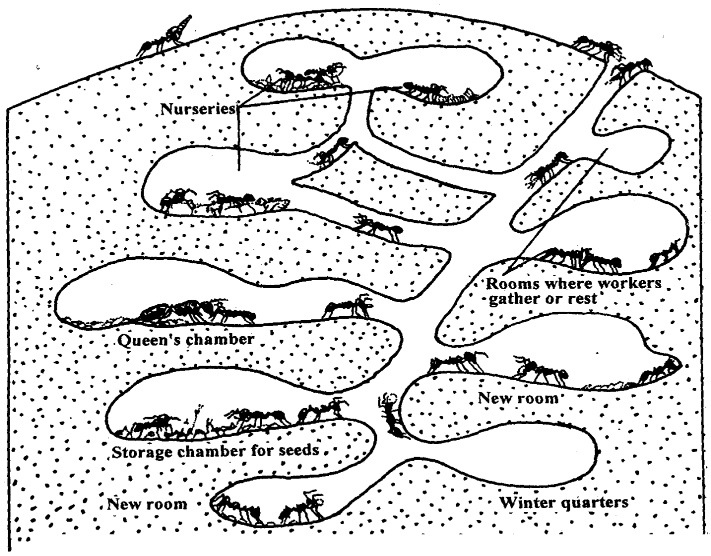


Fig.18.22: An underground harvester ant colony. The nest consists of various chambers and connecting tunnels. One chamber houses the queen. There are' several nurseries where workers take care of the young. Harvester ants also have storage chambers for seeds.

The underground nests of ants are called formicaria (Fig.18.22). After mating in air, females dealate (drop their wings) build a new nest and lay eggs in cells or chambers. Initially the queen performs all the work also. But once the initial clutch of eggs hatch into workers they take up the work of the colony. Then the queen is free to concentrate on egg laying and growing.

Ants have glands for secreting trail laying pheromones (Fig. 18:23). These pheromones help in communication and troops of ants can be seen marching along the trails laid. Certain ants also have beetles and other insects living in their nests as guests. Some ants even cultivate fungus garden.

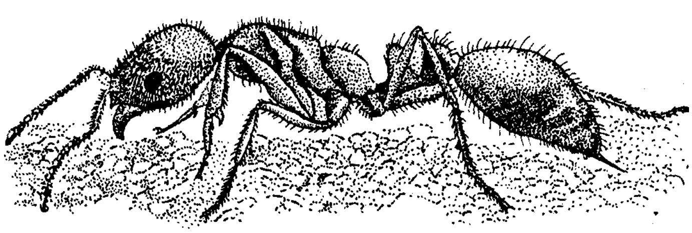


Fig. 16.23: Fire ant worker laying a trail by releasing pheromone along its extended sting. The sting is touched to the ground periodically.

3.5.5 Honey Bees

Honey bees belong to family Apidae (Order Hymenoptera). There are three common species of honey bees in our country namely the giant bee *Apis dorsata*, the little bee *Apis florea* and the Indian honey bee *Apis indica*. Honey bees are socially very well organised. About 10000 to 16000 individuals may live in a honey comb.

Recall from Unit 7 of this course that each colony has only one queen - the fertile female, about 500 to 1000 males (drones) and the rest are sterile, female workers. The queen, the drones and workers are all winged. The functions of the colony are divided among these three castes. The queen is the mother of the colony. She remains in the live except during nuptial flight when she mates with a drone in air.

The workers build the honey comb with wax which is secreted by wax glands on the abdomen. They collect nectar from flowers, for which their mouth parts are suited. Pollen is an important part of the food of the larvae and adult bees. The legs of the workers are modified for collection of pollen. The hind legs (Fig. 18.24) have tibia fringed with long, curved hairs and these forms the pollen brush.

The space enclosed by the hairs form the pollen baskets. The legs have spurs and bristles to clean antennae and pollen sticking to body. The workers have a sting at the abdominal tip into which leads a poison gland (see Fig.18.20). The queen has a very well developed sting to drive away rival queens. Drones do not have sting.

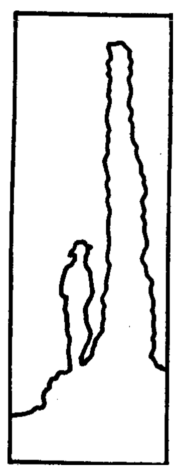


Fig. 18.25: Termite mounds are elaborate constructions. The nests of Aftrican termites *Macroternses betttcosus* can reach skyscraper proportions. The nests have rock hard water tight walls of earth

and plant material bound together with the saliva and excreta. The walls help to insulate the nest from extremes of temperatures.

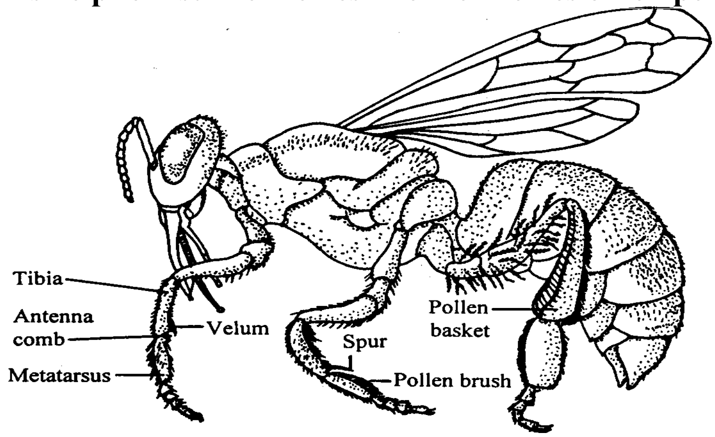


Fig.18.24: Legs of honeybee workers that are especially modified for collecting pollen. The hind leg has long hair forming a pollen basket. The joint between tibia and metatarsus of front leg is modified as an antenna cleaner.

3.5.5 Termites

All termites are social insects, and belong to the primitive order Isoptera. They are popularly called white ants. Examples. are *Kalotermes flavicollis* and *Reticulitermes lucifugus*, *Miacrocerotermfes sp*. The immense damage done to wooden components of houses and furniture by termites is well known.

Termites are also polymorphic (refer to page 164-165 of unit 7 of this course for a detailed description of termite castes) and live in communities leading a social life, in galleries. Most termite species live in soil inside mounds of earth known as termitaria (Fig. 18.25). Termites feed on wood which they digest with the help of symbiotic flagellate protozoans in their intestine. Some termites have fungal beds or gardens in their nests specially prepared by workers.

SAQ 5

i) Name the different castes found in
(a) Honey bee
(b) Termites.
....
....

ii). What is meant by eusocial insects?

....
....

3.6 Parasitism

In the earlier section you learnt how eusocial insects show cooperative behaviour and often go to suicidal lengths to protect their colony from invaders. In this section we shall learn about another behaviour - parasitism - that is the other end of the spectrum. While social behaviour is an intraspecifc behaviour, parasitism is a regular and close interspecific association in which one of the animals, the parasite is benefitted especially nutritionally.

The parasite in other words, lives at the expense of the host. The parasite is usually smaller and weaker. It lives within or on the surface of body of the larger and stronger host. The parasite gets its food from the host.

Parasitism evolved separately in many major groups of animals. Platyhelminthes, Nemathelminthes, and Arthropoda are the main non-chordate groups that show examples of parasitic behaviour.

3.6.1 Types of Parasites

Parasites may be classified.into the following types. **Ectoparasites** are those that attach to the surface of the host (eg. leech on cattle).

Endoparasites live inside the body of the host Round worm *(Ascaris)* and tape worm *(Taenia)* live inside the human intestine.

Facultative parasites may live without a host.

Obligatory parasites spend at least part of their life in the host to complete their life cycle eg. Taenia. They cannot complete their life history without the host.

Apart from Platyhelminthes and Nemathe/minthes, parasitic species are common among Arthropoda (many among crustaceans, arachnids & insects). You would come across more examples of arthropod parasites from relevant sections, in the next unit Harmful and Beneficial Non-chordates.

3.6.2 Effects of Parasitism on Parasites

Majority of Platyhelminthes and Nemathelminthes lead a parasitic life. The greater the degree of parasitism, the more is their departure from normal morphology and physiology. All these deviations, however, are adaptations to a parasitic life. You may recall here the adaptations discussed in the relevant units in the course.

The Main Parasitic Adaptations are:

1. **Loss of surface epidermis** and its replacement by a tegument which plays an. important role in the physiology of the parasite, is a common feature among parasitic platyhelminths. In nematodes, the cuticle is impervious. There are shells around eggs and cyst walls around larvae, for protection.

2. **Presence of organs of adhesion** to fix to the host. Hooks, claws, various types of suckers and in certain cases adhesive secretions. Consequent on the development of adhesive organs there is loss of motility. Parasites remain firmly attached to hosts.

3. **Loss of sense organs:** Progressive parasitism is accompanied by corresponding loss of sense organs and a concomitant degeneration of nervous system.

4. **Simplification and eventual loss of digestive system:** Parasites depend on hosts for food. In tapeworms there is a complete loss of digestive system but flukes possess a mouth, a auctorial pharynx and a blindly ending intestine. Tapeworms absorb wholly digested food of the host, through the tegument.

5. **Reproductive system** of parasites is highly complex. They show excessive capacity for egg production. Tapeworms show multiplication of sex organs along the strobila (proglottides of the body) for further augmentation of egg production. Many parasites are hermaphrodites to ensure fertilisation.

5. **Life cycle of parasites is complicated**. Flukes have stages of life cycle passing through one to three intermediate hosts. To suit this, the parasites often have a number of larval stages. These often show polyembryony giving the animal a further reproductive advantage, resulting in multiplication.

SAQ 6

1. Define parasitism.
   ………………………………………………………………………………
   ………………………………………………………………………………

2. What are the usual organs of attachment of parasites?
   ……………………………………………………………………………..

3. Why is the digestive system of parasites incomplete or lost?
   ……………………………………………………………………………..

4.0 Conclusion

In this unit you have studied:

1. Taxis and kinesis involve movements in response to environmental stimuli. Taxis are a directional movement of the organism. Taxis can be classified according to stimuli into:

   - Phototaxis in response to light
   - Thermotaxis in response to temperature
   - Thigmotaxis in response to mechanical contact
   - Chemotaxis in response to chemicals
   - Rheotaxis in response to wind and water currents
   - Galvanotaxis in response to electric currents
   - Geotaxis in response to gravity.

2. Kinesis is a non-directional movement.

3. Biorhythms are behavioural activities performed at regular intervals. Daily rhythms in which activities follow approximately twenty four hour cycle are circadian rythms. Activities regulated by tides in marine animals are termed tidal rhythms while those controlled by phases of moon are lunar rhythms. Rhythms shown once a year, is called circaannual rhythms. Biorhythms are exogenous when rhythmic activity is controlled by external stimuli such as by photoperiod. Endogenous biorhythms are regulated by an inbuilt biological clock.

4. Biological clocks are internal mechanisms which can measure time. They are set to cyclical events such as day and night. In case of change in the environmental cycle that is, such as when kept in continous darkness, the timing of biological clock changes slightly and this is termed free running of the clock. If the organism moves to a different photoperiod such as when animals travel from one part of the -world to another, the biological clock sets to new environmental conditions and this is termed entrainment. Stimulus which sets the time of biological clock is called *Zeitgeber.*

5. Animals communicate with each other through signals. Various signals are visual, mechanical, auditory, chemical etc. and indicate availability of food, predator around mate etc. When communication signals occur in regular stereotyped sequences they are fixed action patterns.

6. Some visual signals such as changes in body posture or specific colour patterns lure prey or mate, or frighten or warn the predator. Tactile signals are employed by ants where touch makes the ant regurgitate food for consumption by the larva. Auditory signals are common among insects. Pheromones play an important role in chemical communication. Honey bees employ "dance language" for communication among the members of the hive.

7. Courtship behaviour helps to attract the opposite sex of the same species for mating and reproduction. Courtship behaviour brings about synchronisation of mating activity and proper orientation of the mates. Courtship behaviour is usually initiated by the male and the female has the privilege of choosing the mate. Courtship behaviour patterns include visual displays, production of sex attracting, pheromones, nuptial gifts.

8. Ants, termites, wasps and bees are some examples of social insects. All these four groups show polymorphic castes with division of labour. The castes are broadly similar among all these. But there are some basic differences also between hymenopteran groups (bees, ants and wasps) on the one hand and isopterans (termites) on the other. The most important of these is that the worker caste in hymenopterars consists of adult females only, whereas in termites (isopterans) the workers consist of both adult males and females. The immatures also contribute to work of the colony. The advantages of social life are:

    - Collective defence from intruders and predators;

    - Co-operative collection and sharing of food;

- Community care of young and sick.

The disadvantages are competition within the social group; risk of epidemics and parasites; and exploitation of parental care by conspecifies.

9. Parasitism is a regular and close interspecific association in which the parasite is beneftted at the expense of the host. Advantages of parasitism are: parasite gets ready supply of food; shelter and other metabolites without any effort. Disadvantages are that the parasite has to produce large number of eggs so that at least a few will find a host. Once it finds a host it depends on the host for its life.

10. Adaptations to parasitism are:

- Presence of impervious cuticle, cyst or shell,
- Presence of hooks or suckers for attachment to host; loss of motility,
- Loss of sense organs and poorly developed nervous system,
- Simple digestive system or its absence altogether, accompanied by development of a special tegument for absorption of predigested food in the environment,
- Well developed complex reproductive system,
- Capable of producing enormous number of eggs, and hermaphroditism,
- Life cycle complicated with many larval stages accompanied with polyembryony in each stage.

5.0 Summary

Taxes and Kineses are movements of an animals body in response to a stimulus. Biorythms are behavioural activities that occur with clock – work precision at regular intervals. Courtship and mating behaviour paterns occur within species while certain species form societies and exhibit social behaviour members of the same society may exihibt special means of communication which amy involve the secretion of hormones.

6.0 Tutor Marked Assignments

1. Enumerate the different types of biorhythms and explain with examples.
   ……………………………………………………………………………
   ……………………………………………………………………………

2. Write a short paragraph on "biological clock".
   ……………………………………………………………………………..
   ……………………………………………………………………………

3. With two examples each,, explain the different types of signals used for communication among invertebrates.
   ……………………………………………………………………………..
   ……………………………………………………………………………

4. Elucidate how insects employ pheromones in communication.
   ……………………………………………………………………………..

5. What does mate selection mean?
   ……………………………………………………………………………..

6. What is the significance of courtship display in animals.
   ……………………………………………………………………………..

7. What is social behaviour? Enumerate its merits and demerits?
   ……………………………………………………………………………..

7.0 References and Further Reading

7. Hickman, C.P.1970 Intergrated princplesd of zoology C.V. Mesby. Company St Loius

8. Rupert and Barnesd 1994 invertebrates Zoology 6th international Edition.

9. Hickman, C.P. Ribert and Larson 1995. Intrgrated principles of zoology. 9th Editon C. V. Mesby st Loius.

Answers

Self-Assessment Questions

l. i) Taxis is directional movement in response to a stimulus.

ii) Kinesis is non-directional movement in response to a stimulus.

iii) (i) Positive phototxis;

(ii) Negative galvanotaxis;

(iii) Geotaxis.

2. i) Behavioural activities performed at regular intervals.

ii) i- e; ii- a; iii- d; iv -c; v-b.

iii) In exogenous rhythm, an external stimulus triggers the behavioural pattern of an animal at regular intervals. In endogenous rhythm, an internal biological clock triggers activities of an organism at regular intervals.

iv) Setting the biological clock in phase with the environmental cycle.

v) Nervous system.

3. i) Action/signal of an individual which alters the pattern of behaviour of another individual.

ii) Behaviour patterns for communication established through evolution. iii) Stereotyped sequences occurring at regular intervals.

iv) a. Frightening predator/luring prey/attracting/attracting mate
b.Courtship/ alarm

v) Sound made by rubbing surfaces against one another.

vi) Antennae

vii) a. To inform the workers that source of food is close by (within 50 meters from the hive).

b. To inform fellow worker bees that source of food is far beyond 50 meters from the hive.

4. i) Specialised, behavioural patterns in animals for attracting the opposite sex for reproductive purposes.

   ii) Male exhibits visual displays, offers nuptial gifts, or fights with çonspecifics to attract female.. Female chooses to accept or reject him.

   iii) Food/spermatophores/silk balloons.

5. a) Honey bee - Queen (fertile female), workers (sterile females), drones (fertile males)

Termites

1) King and queen (Primary reproductives)

2). Supplementary reproductives (males and females)

3) Workers (sterile males and females)

4) Soldiers (sterile males and females)

b) Insects with highly developed and defined castes.

6. i) Close and regular interspecific association in which one of the organisms derives nourishment from the other.

   ii) Hooks, suckers, adhesive secretions.

   iii) Parasites absorb food which is already digested by host.

Terminal Questions

1. Refer Sub-sections 3.2.1

2. Refer Sections 3.2

3. Refer Sub-sections 3. 3. 3

4. Refer Sub-sections 3.3.3

5. Refer Sub-section 3.4.2

6. Refer Sub-section 3.4. 1

7. i) A number of individuals of a species living together co-operatively sharing the duties of life.

   ii) Collective means of defence from predators/intruders; cooperative collection and sharing of food; care of young.

   iii) Competition within group; risk of loss of progeny; proneness to epidemics/ parasites.

Credits

Figs.18.3; 18.12 b from the Illustrated Encyclopaedia of Animals (Exeter Books).

Figs.18.6a and b; 18.7; 1811; 18.l2a from Living Invertebrates, Pearse and Bu'chsbaum (Blackwell Scientific Publication).

Fig18.8a from the Unity and Diversity of Life, Starr and Taggart (Wadsworth Publishing Company Inc.).

Fig.18.l0a and b from Biology, Arms and Camp (CBS College Publishing) 3rd Edition.

Fig. 18.15 from Animal Behaviour (Time Life Series).

Fig. 18.21 from Animal Behaviour John Alcock.