UNIT – I PHYLUM: PROTOZOA

General Characters

- Protozoans are minute, unicellular (acellular) organisms without any tissue grade of organization.
- They are the first formed animals and hence the name Protozoa.
- When man is placed at the apex of the animal kingdom, protozoans should be placed at the base.

- Phylum Protozoa is characterized by the presence of the following characters:
  - ✓ Protozoans are the simple and primitive organisms.
  - ✓ They are minute and microscopic.
  - ✓ They are free living or parasitic.
  - ✓ All the free living forms are aquatic.
  - ✓ They are asymmetrical or radially symmetrical or bilaterally symmetrical.
  - ✓ They are unicellular (acellular).
  - ✓ They have protoplasmic grade of organization.
  - ✓ All the activities are carried out by the cytoplasm of a single cell.
  - ✓ Tissues and organs are absent from protozoans.
  - ✓ Locomotion is effected by flagella, cilia or pseudopodia.

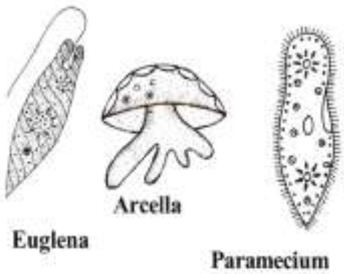

Fig.: Some protozoans

  - ✓ Nutrition is holophytic, holozoic, saprozoic or parasitic
  - ✓ Digestion is intracellular
  - ✓ Respiration occurs by diffusion
  - ✓ Excretion occurs by diffusion
  - ✓ In freshwater protozoans, osmoregulation is carried out by the contractile vacuoles

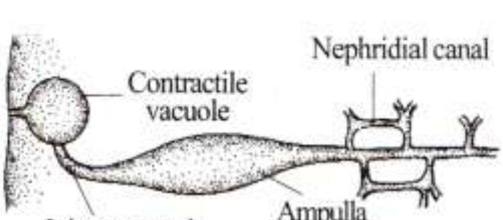

Fig.: Contractile vacuole of *Paramecium*

  - ✓ Encystment is a common phenomenon
  - ✓ Reproduction occurs by asexual and sexual methods

Classification of Protozoa:

The phylum protozoa has been divided into four classes. The classification is based principally on their mode of locomotion.

Class I:

Rhizopoda (Rhiza= root; podus = foot). Protozoa having peculiar temporary organelles for locomotion, called pseudopodia or false feet. Examples—Amoeba proteus; Entamoeba histolytica (causing dysentery).

Class II:

Mastigophora (Mastix =whip; phoros=bearer) or Flagellata (flagellum = whip). Protozoa that move by the lashing of whip-like organelles called flagella. Example—Euglena viridis; Trypanosoma gambiensi (causing African sleeping-sickness); Leishmania donovani (causing kala-azar).

Class III:

Sporozoa (Spora —seed; animal). Parasitic protozoa possessing no locomotor organelles and reproducing by means of spores. Example—Monocystis gregarina; Plasmodium vivax (causing malaria).

Class IV:

Ciliophora (Cilium— eyelash). Protozoa that move by hair-like cilia. Example—Paramoecium caudatum (the slipper- animalcule); Vorticella campanula (the bell-animalcule).

PARAMECIUM

Structure

- ✓ *Paramecium* is a unicellular or acellular or non-cellular animalcule. Hence it is included in the phylum Protozoa.
- ✓ It moves with the help of cilia. Hence it included in the class ciliata or ciliophora
- ✓ Paramecium lives in freshwater like ponds, pools, ditches, rivers, lakes and so on.
- ✓ It swims freely in the water. It is omnivorous in habit
- ✓ Paramecium looks like a slipper. Hence it is called slipper animalcule.
- ✓ It has a distinct anterior end, a posterior end, a dorsal side and a ventral side.
- ✓ The anterior end is blunt; the posterior end is pointed; the ventral side has an oral groove.
- ✓ *Paramecium* is smaller in size. It is minute and microscopic. It has a length of 0.17mm to 0.29mm
- ✓ Paramecium is covered by a thin, elastic membrane called pellicle.
- ✓ The pellicle bears hair-like structures called cilia.
- ✓ The body is filled with cytoplasm. The cytoplasm contains nucleus, contractile vacuole, food vacuoles, basal granules, trichocysts, etc

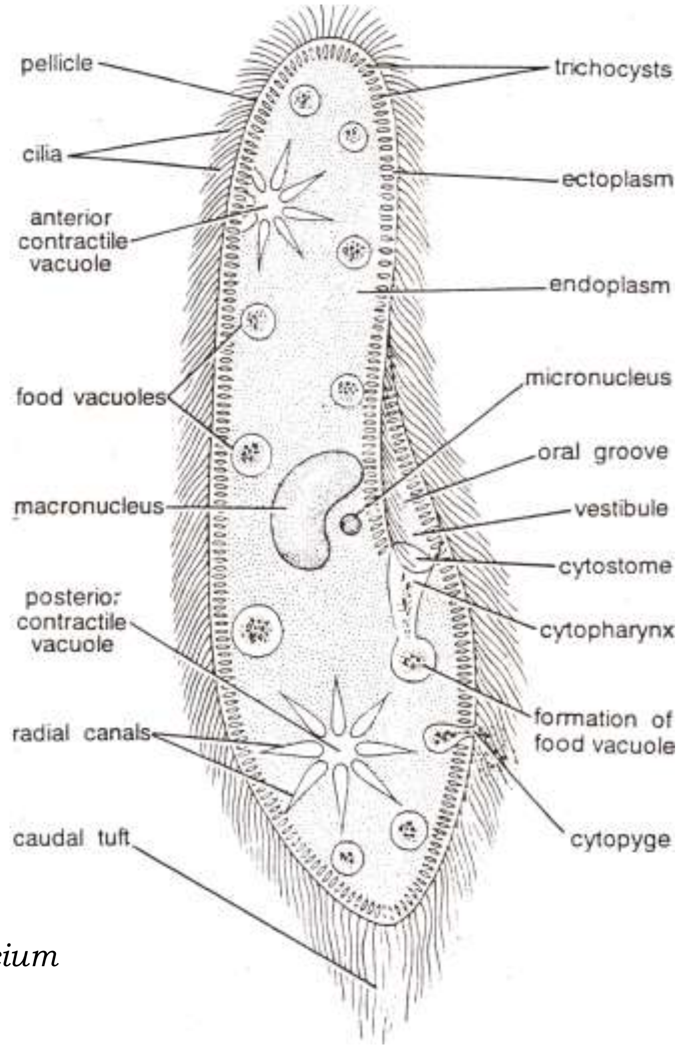

Fig. *Paramecium*

Trichocyst

- ✓ Trichocysts are conical bag-like structures located in the ectoplasm of *Paramecium.*
- ✓ They are formed from basal granules.
- ✓ They lie perpendicular to the body surface in between the basal granules.
- ✓ The inner end has a capsule. The capsule is filled with a gelatinous fluid.
- ✓ The fluid contains a swelling substance. The refractive fluid and the swelling substance together form the matrix.
- ✓ At the outer end of the trichocyst there is a spine like structure called spike. The spike is covered by a cap
- ✓ When the *Paramecium* is disturbed, the trichocysts shoot out. The cap ruptures.
- ✓ The discharged trichocyst is in the form of a sticky elongated thread.
- ✓ It has a shaft. The shaft has cross bands.
- ✓ One end is attached to capsule.
- ✓ The free end has the spike. The main function of the trichocyst is both offense and defence

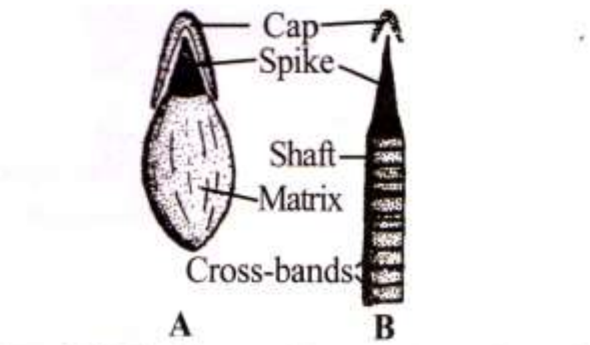

Fig.: Trichocyst. A.Resting, B.Discharged

Nutrition

Nutrition is a general term which includes ***oral apparatus, food, mode of feeding, digestion, absorption*** and ***egestion*** (defaecation). *Paramecium* swallows or engulfs the solid food materials. This mode of nutrition is called ***holozoic.***

Food

Paramecium feeds on bacteria, diatoms, algae, small protozoans and small pieces of animals and plants. As it feeds on animal and plant materials, *Paramecium* is called an ***omnivorous*** animal.

Oral Apparatus

Paramecium feeds with the help of oral apparatus. The oral apparatus is located on the ventral side. It is formed of ***oral groove, vestibule, buccal cavity, cytostome*** and ***cytopharynx.*** The cytopharynx opens into the endoplasm. The oral apparatus is well ciliated.

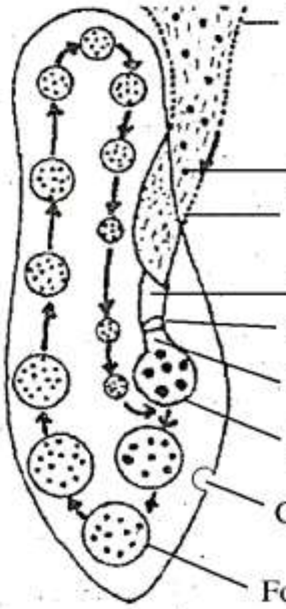

Fig. *Paramecium*: Nutrition

Behind the cytopharynx, a temporary opening is formed at the time of egestion. This opening is called ***cytopyge*** or ***cell anus*** or ***anal spot.***

Feeding Mechanism

Paramecium feeds when it is at rest. It moves to a place where there is plenty of food. The cilia of the oral apparatus beat vigorously. This causes a ***water current***. The water current along with food particles passes through the ***oral groove*** and ***vestibule***. The cilia of the vestibule direct the food particle into the ***cytopharynx*** through the ***cytostome***. The food particles are collected at the tip of the cytopharynx in a membranous vesicle. When sufficient amount of food particles are collected, it is separated from the cytopharynx as a vesicle. This vesicle is called ***food vacuole.*** The food vacuole is a drop of water containing food particles. The food vacuole is formed every 1to 5 minutes.

Locomotion

Locomotion is the movement of animals from one place to another. *Paramecium* moves mainly with the help of cilia. Hence the locomotion in *Paramecium* is called ***ciliary*** locomotion. It can move forwards as well as backwards.

Mechanism of Locomotion

Paramecium moves by beating the cilia. The beating of each cilium can be compared to the oscillation of a pendulum. Each oscillation has a backward movement and a forward movement.

The backward movement is called ***effective stroke***. During effective stroke the cilium becomes slightly curved rigid and it strikes the water backwards like an oar. As a result of effective stroke, the animal is propelled forwards.

The forward movement of cilium is called ***recovery stroke.*** During recovery stroke, the cilium becomes loose and is brought to its original place. It is now ready for the next effective stroke.

The cilia of the transverse row beat simultaneously. But the cilia of the longitudinal row beat one after another. This brings about a wave-like movement of cilia similar to the wave-like movement of paddy crop in a paddy field as wind flows. This wave like movement of cilia is called ***metachronal rhythm.***

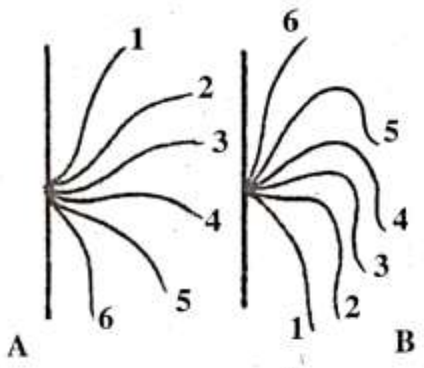

Fig.: *Ciliary movement: A. Effective stroke, B. Recovery stroke.*

Paramecium does not move in a straight line; but rotates spirally like a bullet. This is due to two reasons

1. The cilia of the oral apparatus beat vigorously, and
2. The cilia of the body do not beat straight but obliquely.

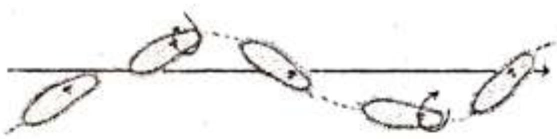

Fig.: *Spiral path and rotation of Paramecium.*

Reproduction

Reproduction is a process by which offspring are produced by the parents. *Paramecium* exhibits asexual reproduction and sexual reproduction.

Asexual Reproduction

In asexual reproduction, offspring are produced without the involvement of gametes. The most common asexual reproduction exhibited by *Paramecium* is ***binary fission.***

Binary Fission

Binary fission is an asexual reproduction where a fully grown *Paramecium* is equally divided into two offsprings. Here the division occurs ***transversely***; hence the binary fission is called ***transverse binary fission.***

It occurs during ***favourable seasons***. During binary fission, the *Paramecium* stops feeding; oral apparatus disappears. The micronucleus elongates and becomes divided into two daughter micronuclei by mitosis. The macronucleus also elongates and becomes divided into two daughter macronuclei by amitosis. At the sametime a transverse constriction appears in the middle of the body. This constriction deepens gradually and finally the body is divided into two daughter *Paramecia.*

Each daughter *Paramecium* receives a contractile vacuole from the parent. The second contractile vacuole is developed newly. Each daughter also develops an oral apparatus.

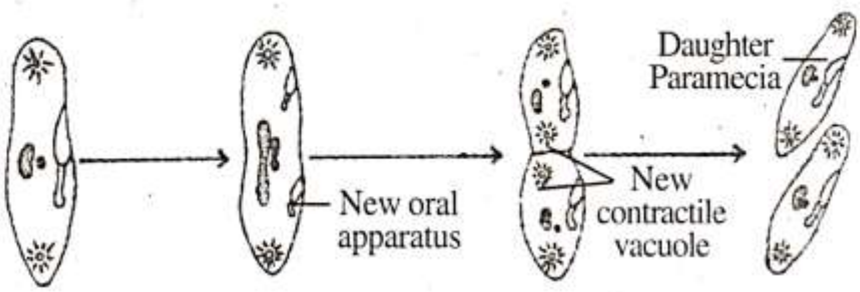

Fig. *Paramecium*- Binary fission

The entire process of binary fission is completed within ***30 minutes***. A *Paramecium* undergoes binary fission once in every 26 hours.

Significance of binary fission

1. It occurs during favourable season.
2. It produces a large number of offspring within a limited duration.

SEXUAL REPRODUCTION

- In sexual reproduction gametes are produced for the production of offspring. *Paramecium* exhibits about 5 types of sexual reproduction. They are
    1. Conjugation
    2. Autogamy
    3. Endomixis
    4. Hemixis and
    5. Cytogamy

1.Conjugation

- ✓ Conjugation is the temporary union of two individuals for the exchange of nuclear materials.
- ✓ In conjugation two Paramecia of different mating types come closer and contact with their ventral surfaces. These Paramecia are called conjugants
- ✓ They stop feeding and their oral apparatus disappears. The pellicle and ectoplasm of the two individuals disappear at the point of contact. The conjugants are connected by a cytoplasmic bridge called conjugation canal
- ✓ The macronucleus has no role in conjugation. It simply breaks into fragments and is absorbed into the cytoplasm. The micronucleus divides by meiosis (reduction division). As a result four haploid daughter nuclei are produced in each conjugant Then three nuclei in each conjugant disappear
- ✓ The remaining nucleus unequally divides into two nuclei called pronuclei or gametic nuclei. The large pronucleus is called stationary pronucleus or female pronucleus. The smaller pronucleus is called migratory pro-nucleus or male pronucleus The migratory nucleus of each conjugant passes through the conjugation canal into the other conjugant and fuses with the stationary nucleus
- ✓ The fused nucleus is called synkaryon or conjugation nucleus or zygotic nucleus. It is diploid
- ✓ After the formation of zygotic nucleus, the two conjugants separate
- ✓ The separated conjugant are called exconjugants
- ✓ In each exconjugant, the zygotic nucleus divides thrice to produce 8 nuclei
- ✓ Of these, four nuclei enlarge to become macronuclei and the remaining form micro-nuclei
- ✓ Then three micronuclei disappear
- ✓ The micronucleus divides into two with the binary fission of each exconjugant into two daughters. Now each daughter will be carrying one micronucleus and two macronuclei. Then the micronucleus again divides into two with the binary fission of the daughter *Paramecium*
- ✓ Thus each exconjugant produces 4 daughter Paramecia. As there are two exconjugants, in conjugation 8 daughter Paramecia are produced

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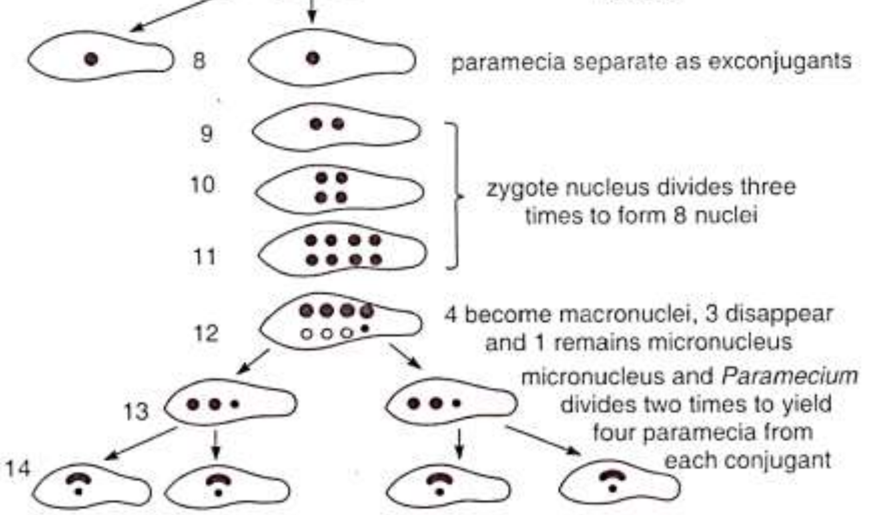


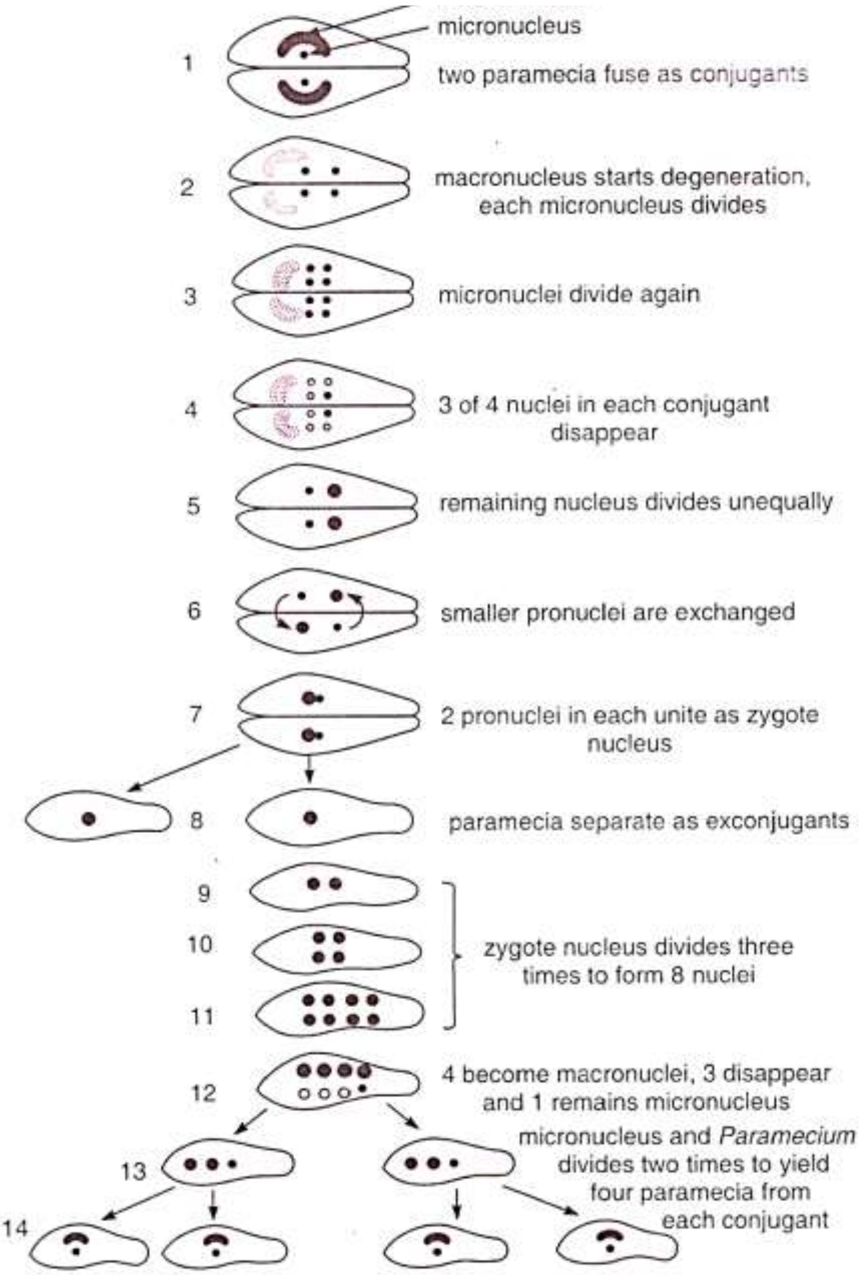


Fig. *Paramecium*: stages of Conjugation

Endomixis

- ✓ It is another type of sexual reproduction occurring in *P. aurelia.*
- ✓ In endomixis, reorganization of nuclear material occurs in a single individual.
- ✓ The macronucleus divides into fragments and is absorbed into the cytoplasm.
- ✓ The micronuclei divide twice to produce eight daughter nuclei; six nuclei degenerate; *Paramecium* undergoes binary fission; each daughter receives one nucleus.
- ✓ Then the micronucleus divides twice, in each daughter producing four nuclei.
- ✓ Two nuclei enlarge to become macronuclei and the remaining two become the micronuclei.
- ✓ Then the micronuclei divide with the binary fission of the individual into two daughter *Paramecia.*

- ✓ Each daughter *Paramecium*receives one macronucleus and two micronuclei.
- ✓ Thus endomixis produces four daughter individuals from a single *Paramecium*

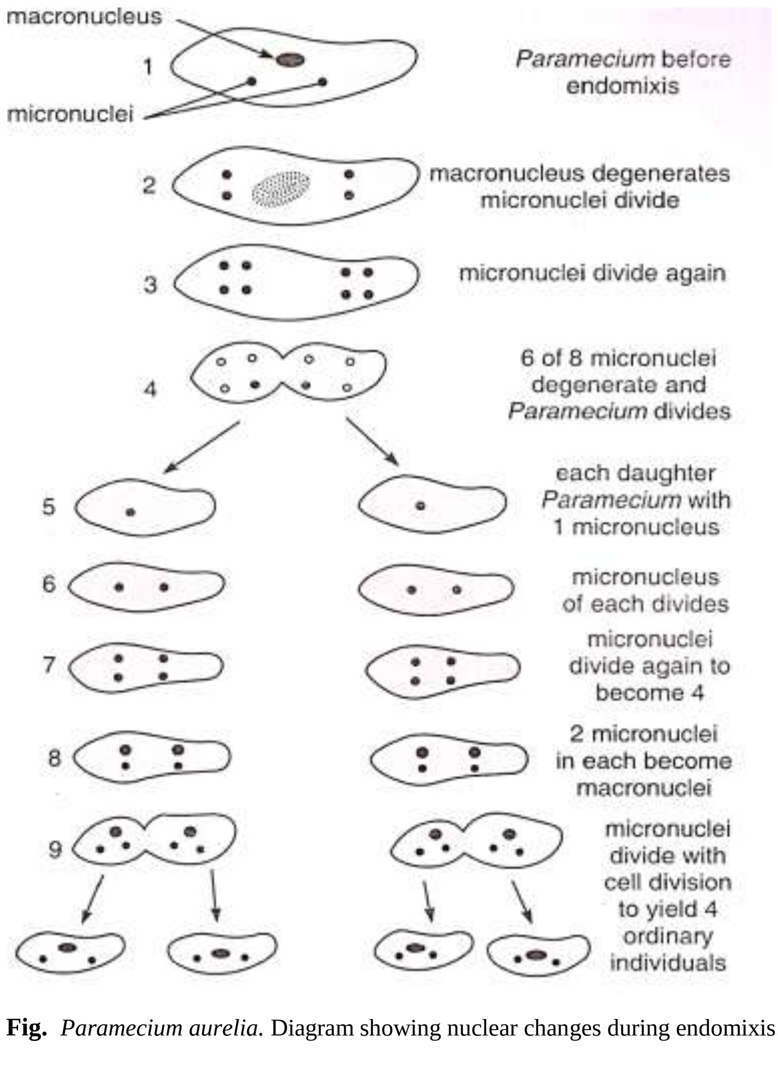


Fig. *Paramecium aurelia.* Diagram showing nuclear changes during endomixis.

Cytogamy

- ✓ It is a kind of sexual reproduction where two individuals temporarily fuse and then separate without any nuclear exchange. It occurs in *Paramecium caudatum*.
- ✓ In cytogamy, two Paramecia come together by their ventral surfaces.
- ✓ But the pellicle does not break.
- ✓ The micronucleus divides thrice to form eight micronuclei.
- ✓ Six micronuclei disintegrate.
- ✓ The remaining two nuclei fuse together to form a synkaryon.
- ✓ The two Paramecia now separates

LOCOMOTION IN PROTOZOA

Locomotion is the displacement of animals from one place to another. Protozoa exhibits four types of locomotion. They are as follows:

1. Amoeboid movement   *3. Ciliary movement*

2. Flagellar movement   *4. Metabolic movement.*

1. Amoeboid Movement

Movement by means of ***pseudopodium*** is called ***amoeboid movement***. Amoeboid movement is a characteristic feature of *Amoeba*. But it is also exhibited by certain flagellates and sporozoans.

Pseudopodium

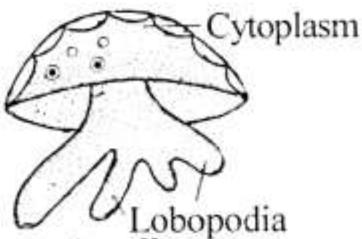
Pseudopodium is a temporary projection of cytoplasm formed on the body. There are four types of pseudopodia, namely

1. Lobopodia   3. Reticulopodia and

2. Filopodia   4. Axopodia

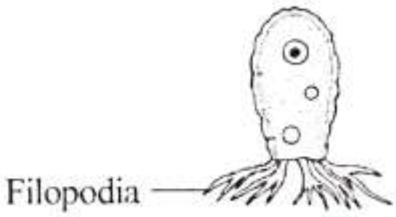
1. Lobopodia

These are lobe-like pseudopodia with rounded tips. Eg. *Amoeba*, *Arcella*, etc.



Arcella

Fig.38.1: Lobopodia.



Euglypha

Fig.38.2: Filopodia.

2. Filopodia

Filopodia are filamentous pointed pseudopodia. They are formed exclusively of ectoplasm. They may be branched. Eg. *Euglypha*.

3. Reticulopodia (Rhizopodia)

These are filamentous pseudopodia. They are highly branched and the branches anastomose to form a network Eg.*Globigerina, Chlamydophrys,* etc.

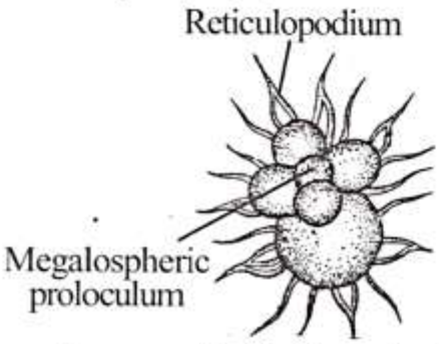


Fig. Reticulopodia in Globigerina.

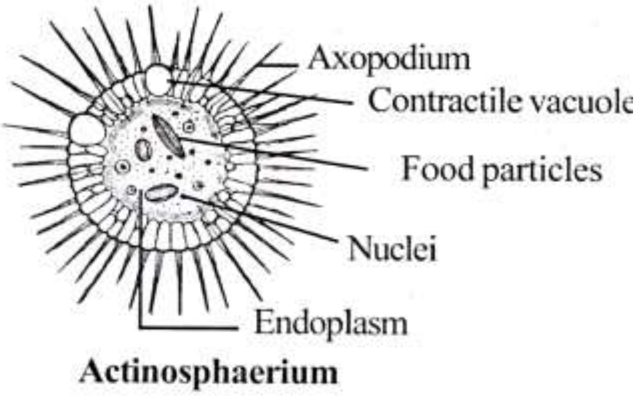


Fig. Axopodia.

4. Axopodia

These are stiff, straight, pointed pseudopodia radiating from the circular body in all directions. Each axopodium has a cytoplasmic ***sheath*** and an ***axial rod***. Eg. *Actinophrys, Actinosphaerium*, etc.

Mechanism of Amoeboid Movement

There are many theories and interpretations on the mechanism of amoeboid locomotion. They are given below:

1. Walking movement theory 3. Surface-tension theory and

2. Rolling movement theory 4. Sol-gel theory.

1.Walking Movement Theory

This theory was proposed by ***Dellinger*** (1906). According to this theory, *Amoeba* walks on the substratum using ***pseudopodia*** as legs. During its movement, the ***pseudopodium*** located at the anterior end is firmly attached to the substratum. It contracts and pulls the body forwards. Another pseudopodium is formed and it is attached to the substratum infront of the previous one and the process is repeated.

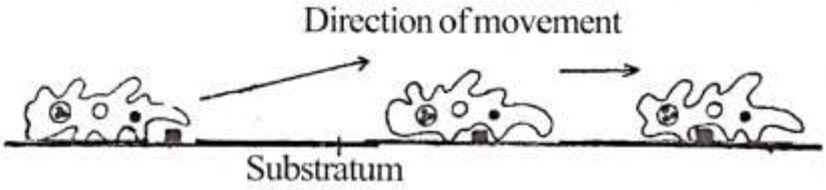


Fig. Walking movement in Amoeba.

2. Rolling Movement Theory

This theory was proposed by ***Jennings.*** According to this theory, the *Amoeba* moves by the rolling of the body on the substratum. This is brought about by the streaming movement of the cytoplasm. This type of movement is exhibited by *Amoeba verrucosa.*

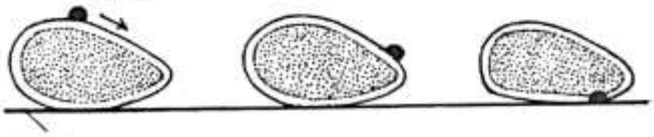


Fig. Rolling movement in Amoeba verrucosa.

3. Surface-tension Theory

This theory was proposed by ***Berthold.*** This theory says that the pseudopodium is formed from the surface of the body by a change in surface tension. It occurs in the following methods:

1. As protoplasm is a fluid, it remains spherical due to surface tension.

2. The surface-tension may decrease at any point on the surface due to external or internal changes.

3. At the point of low surface tension, the protoplasm flows out in the form of ***pseudopodium.***

4. The *Amoeba* now moves in the direction of ***pseudopodium.***

4. Sol-gel theory or Changes of Viscosity Theory

This theory was proposed by ***Hyman*** (1917). It is the most accepted theory. This theory says that the pseudopodium is formed by the change of cytoplasm from ***gel*** to ***sol*** and ***sol*** to ***gel.*** It occurs in the following methods:

1. The plasmalemma is attached to the substratum.

2. At the anterior end, the plasmagel is converted into plasmasol.

3. The plasmagel of the posterior end contracts. This produces a hydraulic pressure on the plasmasol located inside.

4. As a result of the hydraulic pressure, the plasmasol is pushed forwards as a small projection.

5. By the continuous ***accumulation*** of plasmasol, the ***pseudopodium*** is formed.

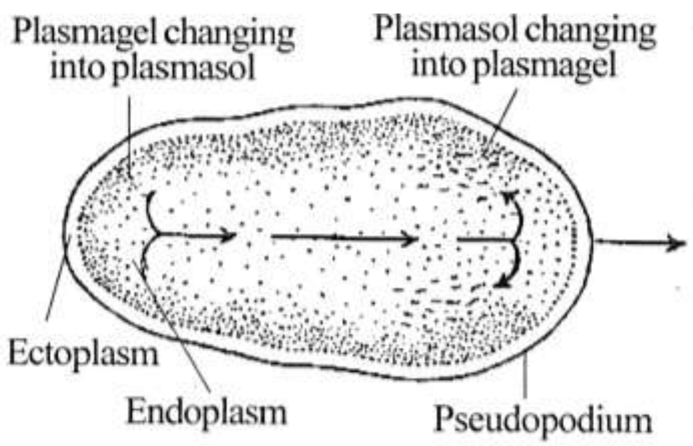


Fig.. Sol-gel theory-mechanism of locomotion in Amoeba.

6. At the periphery of the pseudopodium the plasmasol is converted into the plasmagel.

7. The plasmagel of the posterior end is continuously changed into plasmasol and it flows forwards.

8. This results in the withdrawal of pseudopodium from the posterior end and helps the continuous supply of the plasmasol to the developing pseudopodium at the anterior end.

9. By producing pseudopodia continuously in one direction in the above manner, *Amoeba* slowly moves.

2. Flagellar Movement

Flagellar movement is *the swimming brought about by the beating of flagella.* It is exhibited by flagellates. Eg. *Euglena.*

Flagellum

Flagellum is a whip-like structure. Each flagellum has a central axis called ***axoneme***

and a ***protoplasmic sheath***. The axial filament originates from a ***basal granule***. The basal granule is connected with the ***parabasal body*** or the nucleus by a root-like structure called ***rhizoplast.***

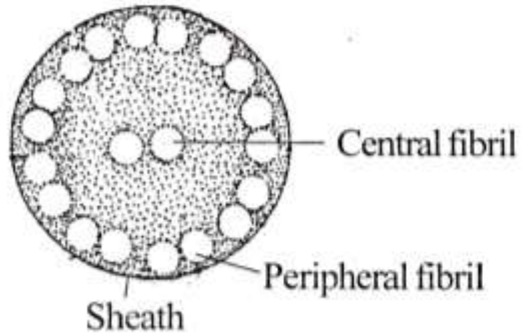


Fig. T. S. of flagellum.

Each axoneme is formed of two ***central fibres*** and nine paired ***peripheral fibres***. Each peripheral pair bears a pair of ***short arms.*** All the fibres are embedded in the ***matrix.***

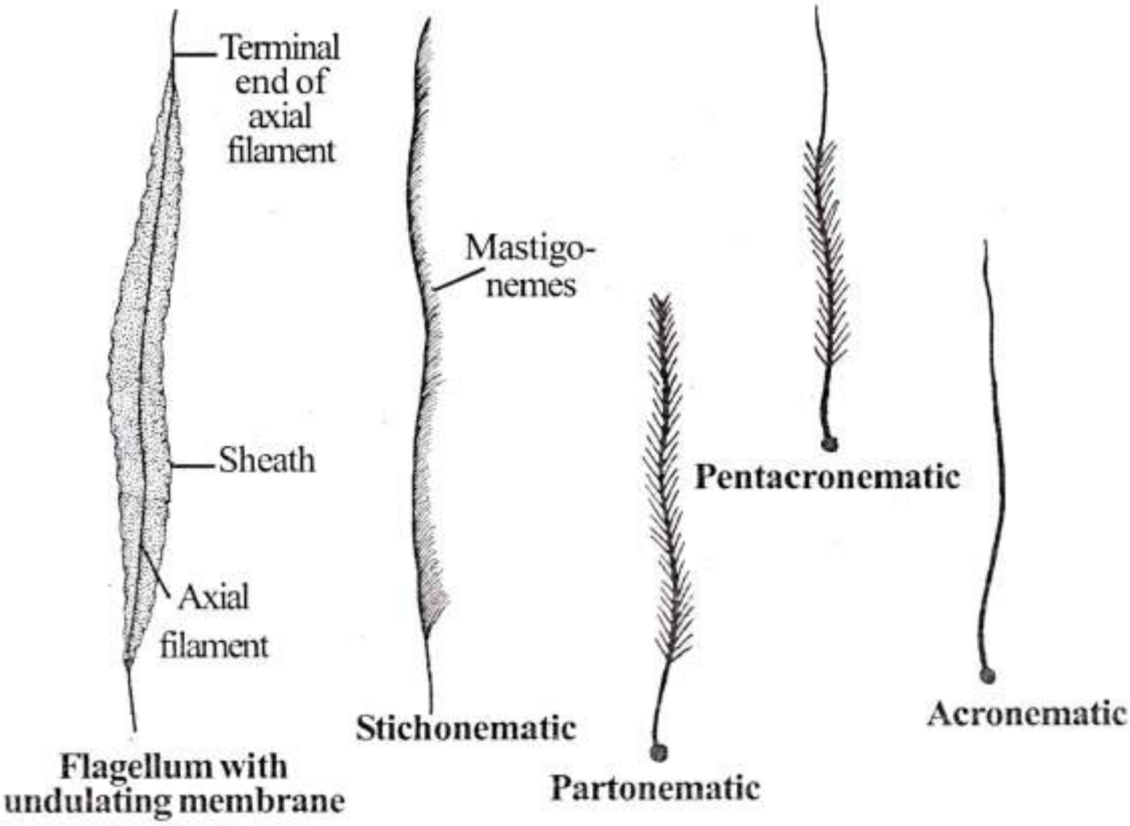


Fig.: *Types of flagella.*

The flagella bear small fibres on the sides. These fibres are called ***mastigonemes***. Based on the arrangement of mastigonemes, the flagella are classified into the following types:

1. Stichonematic flagellum: This type of flagellum contains a single row of mastigonemes. Eg. *Euglena.*

2. Pantonematic flagellum: In this flagellum, mastigonemes are arranged in two or more rows. Eg. *Paranema.*

3. Pentachronematic flagellum: This type of flagellum has two or more rows of mastigonemes and a terminal filament.

4. Acronematic flagellum: Here mastigonemes are absent; but a ***terminal filament*** is seen.

5. Simple flagellum: In this type, mastigonemes and ***terminal filament*** are lacking. Eg.*Chlamydomonas.*

6. Flagellum with undulating membrane: In *Trypanosoma,* the flagellum is provided with an ***undulating membrane.***

Number of Flagellum

The number of flagellum in an animal may be one or two or more. Of these many flagella, one flagellum pulls the body forwards. This flagellum is called ***tractellum.*** It is directed forwards. The flagella which are directed backwards are called ***trailing flagella.*** Certain flagella situated at the posterior end of the body are used to push the body forwards. These flagella are called ***pulsellum.***

Types of Flagellar Movement

The flagellum causes the animal to swim in the water. The swimming is brought about by the oscillation of the flagellum. There are two types of oscillation of the flagellum. They are as follows:

1. Rowing and 2. Undulations.

1. Rowing: During normal locomotion, the flagellum beats. Each beat consists of an ***effective stroke*** and a ***recovery stroke***. During effective stroke, the flagellum is held rigidly with a slight concavity in the direction of the stroke. The effective stroke pushes the water backwards. This draws the body forwards. During recovery stroke, the flagellum is relaxed and well curved and is brought to its original position passively. The flagellum beats obliquely. Hence when the animal moves, it ***rotates*** on its longitudinal axis.

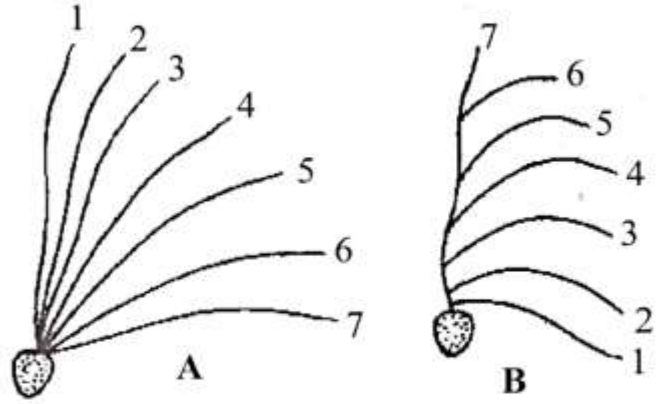


Fig. Rowing: A. Effective stroke; B. Recovery stroke.

2. Undulations: Some times the flagellum does not beat. But wave-like movements pass along the flagellum. These movements are called ***undulating movements***. When the undulations pass from the base to the tip, the animal moves ***forwards***. When the undulations pass from the tip to the base, the animal moves ***backwards***. As these undulations are spiral, the organism moves in a ***spiral*** path around a central axis. At the same time the body ***rotates*** on its own axis.

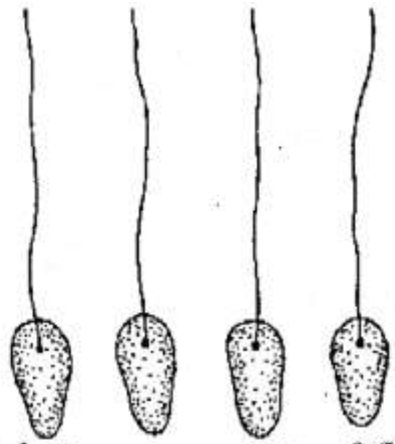


Fig.. Undulating movements of flagellum from the tip to the base.

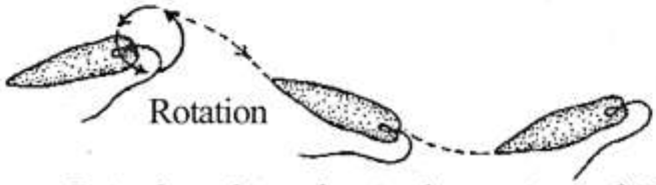


Fig.: Spiral path and spiral rotation of Euglena.

3. Ciliary Movement

Ciliary movement is brought about by the beating of the cilia. It is characteristic of ciliates. Eg. *Paramecium, Opalina,* etc.

Cilia

Cilia are hair-like structures. They arise from ***basal granules.*** Each cilium has a ***protoplasmic sheath*** and an ***axial filament.*** The axial filament has same structure as that of the flagellum.

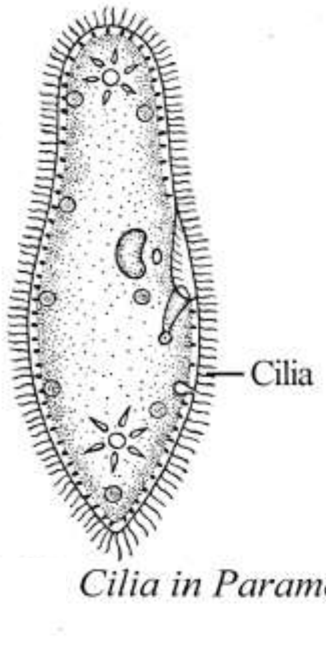


Fig. Cilia in Paramecium.

The cilia are arranged in longitudinal rows. They may be arranged all over the body uniformly or in restricted areas.

Mechanism of Ciliary Movement

Ciliary movement is very similar to that of flagellar movement. It has also an ***effective stroke*** and a ***passive recovery stroke***.

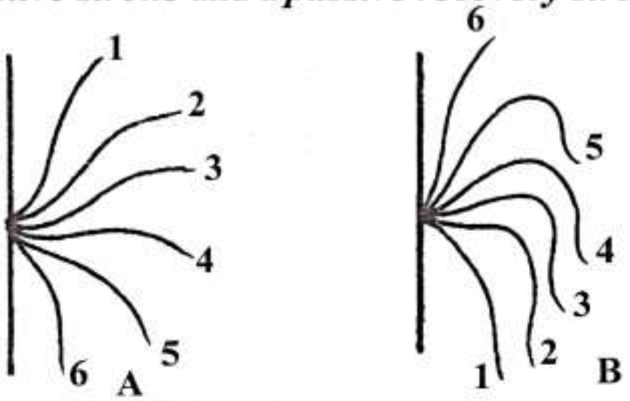


Fig. Ciliary movement:
A. Effective stroke; B. Recovery stroke.

The cilia beat ***independently***. All the cilia of the same body do not beat at the same time. But all the cilia of a transverse row beat at the same time. The cilia of a longitudinal row beat one after another. This causes a wave-like movement of cilia which is exactly like the movement of paddy in a paddy field. This type of movement of cilia is called ***metachronal rhythm.***

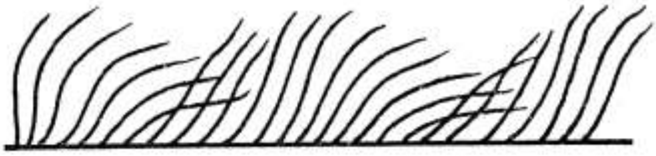


Fig. Metachronal rhythm.

The cilia do not beat directly backwards; but they beat ***obliquely***. Hence when the animal moves forwards, ***it rotates spirally like a rifle bullet.***

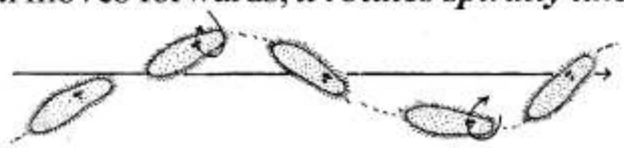


Fig. Spiral path and rotation of Paramecium.

4. Metabolic Movement

The metabolic movement is brought about by the contraction and relaxation of the ***body.*** This type of movement is brought about by the presence of very fine contractile fibrils in the cytoplasm. These fibrils are called ***myonemes.*** Metabolic movement is exhibited by flagellates, ciliates, sporozoans, etc.

The metabolic movement carried out by *Euglena* is called ***euglenoid movement***. During this type of movement, a peristaltic wave of contraction and expansion passes over the entire body from the anterior end. The body becomes shorter and wider first at the anterior end, then in the middle and later at the posterior end. This is brought about by the contraction and relaxation of myonemes. Myonemes are situated longitudinally or transversely or spirally in the cytoplasm.

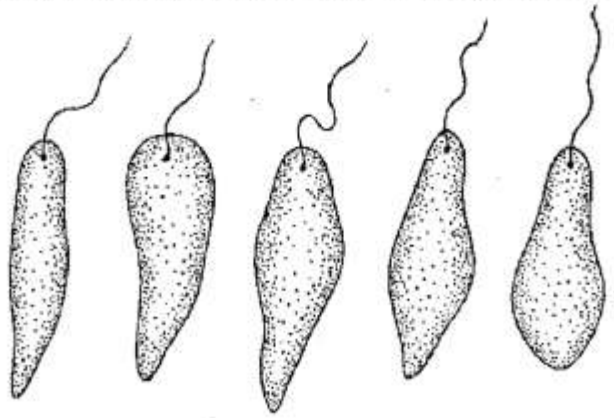


Fig. Euglenoid movement.

HUMAN PROTOZOAN DISEASES

Parasites are available from all the four classes, namely ***Rhizopoda, Mastigophora, Ciliophora*** and ***Sporozoa.*** Certain parasites are harmless, but the majority of them produce ill-effects causing diseases. The following are the diseases caused by protozoans:

1. Malaria
2. Diarrhoea
3. Amoebiasis
4. Trypanosomiasis
5. Leishmaniasis
6. Trichomoniasis
7. Toxoplasmosis and
8. Balantidial dysentery.

MALARIA

Malaria is a kind of fever caused by *Plasmodium.* It is transmitted by female *Anopheles* mosquito. Malaria is characterized by the following symptoms:

1. Loss of appetite
2. Nausea
3. Constipation
4. Headache
5. Pain in the muscles and joints
6. Shaking chillness
7. Sweating
8. Anaemia
9. Rise of body temperature as high as 106^0F at an interval of 48 hours.

Control/Prevention of Malaria: Malaria can be controlled/prevented by the following methods:

1. Destruction of mosquito and its larva.
2. Spraying DDT in and around the houses.
3. Sterilization of mosquito.
4. Rearing the enemies of mosquito and its larvae like larvivorous fishes (sticklebacks, minnows and trouts), ducks, dragon flies, etc. This method is called ***biological control.***

AMOEBIASIS

Amoebiasis or ***amoebic dysentery*** is caused by *Entamoeba histolytica.* It is characterized by the following symptoms:

1. *Entamoeba* feeds on the mucous epithelium. This causes ulcer in the intestine.
2. In the ulcer, blood vessels are damaged and hence blood oozes into the intestine.
3. The stool contains mucous and blood.
4. The stool becomes loose.
5. The patient defaecates frequently.
6. There is severe pain in the intestine.

Prevention: Infection by *Entamoeba* and amoebiasis can be easily prevented by the following methods:

1. Before every meal, the hands should be properly washed and cleaned.
2. Finger nails should be closely cut.
3. Vegetables and other food stuffs should be properly cooked.
4. Drinking water should be well boiled.
5. Food stuffs and water should be protected from houseflies and other insects.

Treatment: Amoebiasis is a curable disease. It can be treated with the following drugs: 1. ***Emetine***, 2. ***Dehydroemetine,*** 3. ***Chloroquine***, 4. ***Diodoquine,*** 5. ***Terramycin***, 6. ***Aureomycin*** 7. ***Erythromycin.***

LEISHMANIASIS

It is caused by *Leishmania. L. donovani* lives in the blood cells of spleen, bone-marrow, etc. It causes ***Kala-azar.*** It leads to a considerable enlargement of spleen. It is treated with ***antimony*** compounds.

L. tropica lives in the endothelium of the capillaries of skin. It causes ***Delhi boils.*** Treatment includes dressing the boils and injecting Atebrine and Berberine sulphate around them.

References:

1. N.C. Nair et al., A text book of Invertebrates, Saras publication, Tamilnadu, India.
2. E.L.Jordan and P.S. Verma, Invertebrate Zoology, S.Chand & Company PVT, LTD, NewDelhi, India.

Principles of Taxonomy and Binomial Nomenclature

The assembling of animals into groups based on their similarity is called ***classification.*** *The science of classification* is called ***taxonomy.***

Linnaeus is referred to as the ***father of taxonomy.***

In a Library or a Store, all the articles are orderly arranged. This order helps in finding the right thing in right place. It quickens the work and avoids confusion. Such orderly arrangement is called ***classification.*** Its purpose is to create an order in disorder.

There are three types of classification. They are as follows:

1. Natural Classification

2. Artificial Classification

3. Practical Classification

1. Natural Classification

Natural classification is based on morphological similarities and common ancestry. This system of classification is followed in the field of zoology.

In classifying animals, the following characters are considered:

1. Morphological similarity
2. Common ancestry
3. Levels of organization
4. Symmetry
5. Coelom
6. Number of germ layers
7. *Metamerism*
8. *Unique features* like ***nematocysts*** in Platyhelminthes, ***pedicellariae*** in Echinoderms, etc.

All animals are placed in a very large group called ***animal kingdom*** or ***animalia.***

The animal kingdom is split into large groups called ***phyla.***

The phyla are divided into small groups called ***classes.***

The classes are divided into still smaller groups called ***orders.***

The orders are divided into ***genera.*** Finally each genus is divided into smallest groups called ***species.***

Animal Kingdom
Phylum
Class
Order
Genus
Species.

These are the main units of classification. Sometimes these main units are subdivided into subunits by pre-fixing ***sub*** or ***super.*** For example, ***Sub-phylum, Sub-class, Super-class, Sub-order, Super-order,*** etc. Species is the smallest unit of classification. Species is defined as a ***group of genetically similar individuals which interbreed among themselves.*** So there is free ***gene flow*** between the members of a species.

Binomial Nomenclature

The binomial nomenclature was proposed by ***Linnaeus*** (1737). It is a system of naming animals. Such a name is called ***binomial name*** or ***binomen*** or ***scientific name.***

It is named in ***Latin*** words. Hence it is also called ***Latin name.***

According to this system, ***each animal*** is named by ***two words.*** The first word is called ***generic name*** and the second word is called ***species name.*** The generic name starts with a ***capital letter*** and the species name starts with a small letter. Both names should be written in ***italics.*** Eg. *Ascaris lumbricoides. Ascaris* is the generic name and *lumbricoides* is the species name.

Working of the Systems of Classification and Nomenclature

The method of classifying and naming animals can be easily understood by studying tape-worm and frog.

Unit		***Tape-worm***	***Frog***
Kingdom	-	Animalia	Animalia
Phylum	-	Platyhelminthes	Chordata
Class	-	Cestoda	Amphibia
Order	-	Taenioidea	Anura
Genus	-	*Taenia*	*Rana*
Species	-	*solium*	*hexadactyla*

Trinomial Nomenclature

Trinomial nomenclature is a method of naming the animals. Here each animal is named by three words. The first word represents the ***genera,*** the second word represents the ***species*** and the third word represents the ***sub-species.*** This system is followed when there are two or more varieties (sub species) within a species. Eg. The house crow contains many varieties and they are named as follows:

Corvus splendens splendes - House crow of India and Pakistan

Corvus splendens insolens - House crow of Burma

Corvus splendens protegatus - House crow of Sri Lanka

Rules of Nomenclature

The International Commission on Zoological Nomenclature (ICZN) framed certain rules in 1901 for naming the animals. They are the following:

1. All the animals must be named by two words (binomial). The subspecies can be named by three words (trinomial).

2. In case several names have been given to a single animal by different scientists, the earliest name is to be considered valid. The duplicate names are called ***synonyms.***

3. Scientific names should be derived from ***Latin.***

4. The genus name is a single word. It must begin with a ***capital letter.***

5. The species name may be a single or compound word. It must begin with a ***lower letter.***

6. The scientific name should be printed in ***italics.*** If it is hand written or typed, it must be ***underlined*** to indicate italics.

7. The name of the author, who first publishes the name, should follow the species name. Eg. *Rana tigrina* Daud.

8. When the name is changed, the original author's name is given in parentheses.

9. The name of the family is derived by adding ***idae*** to the name of the genus. Eg. *Trypanosomatidae.* The name of the sub-family is derived by adding ***inae.*** Eg. *Euglenoidinae.*

Advantages of Nomenclature

The scientific nomenclature has the following advantages:

1. Each and every animal has been provided with a scientific name.

2. One name always refers to only one animal.

3. The scientific names are international. ie, one name for one animal is used universally. An Indian student knows what exactly *Amoeba proteus* stands for and so does a German or a Russian.

4. The scientific names are self descriptive and they indicate important features of animals.

5. The scientific names indicate relationship of animals with one another. The dog, wolf and jackal have the same scientific name ***Canis.*** This means that all these animals are inter-related.

2. Artificial Classification

This classification is based on the following factors: 1. Animals are classified based on their habit, habitat, etc. For example, animals are classified into ***oviparous*** and ***viviparous.*** They are classified into ***herbivores, carnivores*** and ***omnivores*** on the basis of their food habits.

2. Animals are classified based on the places where they live. For example, animals are classified into ***aquatic, terrestrial*** and ***aerial.***

3. Practical Classification

This classification is based on the utility of animals to man. Eg. Animals are classified into ***harmful*** animals and ***useful*** animals. Similarly they are classified into ***edible animals*** and ***inedible animals.***

UNIT – III

Phylum- PLATYHELMINTHES

General characters

- ✓ Platyhelminthes includes flatworms (Gk.Platys = flat; helminth = worm).
- ✓ They are bilaterally symmetrical, acoelomate, triploblastic invertebrates without an anus. The flatworms are both free living as well as parasitic
- ✓ They are dorsoventrally flattened like a leaf
- ✓ They show organ grade of organization
- ✓ They are acoelomate animals. The cavity between the body wall and the gut is filled with parenchyme or mesenchyme
- ✓ They are triploblastic animals. They contain three layers. They are the ectoderm, the mesoderm and the endoderm
- ✓ They are bilaterally symmetrical animals. The body of the animal can be divided into two equal similar halves through only one plane. Animals with this symmetry have definite polarity of anterior and posterior ends
- ✓ Some members have segmented body. The segmentation in platyhelminthes is called pseudometamerism
- ✓ Many of the parenchyma cells give rise to muscle fibres. The muscle fibres are arranged in circular, longitudinal and vertical layers
- ✓ The digestive system is completely absent from Cestoda and Acoela. The alimentary canal is branched in turbellarians. The anus is absent from them
- ✓ The respiratory organs are absent. In parasites, respiration is anaerobic
- ✓ There is no circulatory system
- ✓ The excretory system is formed of protonephridia (flame cells).
- ✓ The nervous system is well developed.
- ✓ They are hermaphrodites, i.e., both male and female reproductive organs are present in the same animal
- ✓ Fertilization is internal in them. Self or cross fertilization takes place in them
- ✓ Their development is direct or indirect. Endoparasites show usually indirect development with many larval stages. Their life cycle is completed in one or two hosts
- ✓ They are free living or parasitic.
- ✓ In parasitic worms, adhesive organs like hooks, spines, suckers and adhesive secretions are present

Phylum Platyhelminthes (flatworms) Classification

The classification is from Hyman, L.H., (1951) up to suborder only with certain modifications.

Class 1- Turbellaria (L., *turbella*= a little string)

- Mostly free-living but some ectocommensals and endocommensals or parasitic called
- Terrestrial marine or freshwater.
- Body unsegmented and covered with ciliated cellular or syncytial epidermis, containing mucus-secreting cells and rod-shaped body called
- Mouth ventral. intestine preceded by the muscular pharynx.
- Adhesive organs(suckers) abundantly present.
- Sense organ i.e. Tango, chemo, and photoreceptors common in free-living forms.
- The excretory system consists of **protonephridia,** the **flame cells.**
- Mostly reproduction sexual, asexual and by regeneration.
- Life cycle simple.

Order 1- Acoela

- Small, exclusively marine, less than 2 mm.
- Ventral mouth; no muscular pharynx and no intestine.
- The excretory system is totally absent.
- No flame cells, definite gonads, gonoducts, and yolk glands.
- Mostly free-living, found under stones or bottom mud, algae, some live in the intestine of sea-urchins and sea-cucumbers.
- Some colored or brown by symbiotic algae.
- Examples: *Convoluta*, *Ectocotyle*, *Afronta*.

Order 2- Rhabdocoela

- Small (less than 3mm) freshwater, marine, and terrestrial form.
- Simple pharynx and sac-like intestine without diverticula.
- Nervous system with 2 main longitudinal trunks.
- Protonephridia excretory system.
- Eye usually present.
- The reproductive system comprises few compact gonads, gonoducts and a cuticularized structure instead of penis papilla present. Yolk gland present or absent.
- Marine, freshwater or terrestrial. Free-living, commensal or parasitic form
- Examples: *Catenula*, *Microstomum*, *Macrostomum*, *Mesostoma*.

Suborder 1. Notandropora

- Exclusively freshwater forms.
- Simple pharynx.
- The excretory system consists of a single median protonephridia.
- Testes single compact mass, penis unarmed.
- No yolk gland.
- Asexual fission occurs with the formation of the chain of zooids.
- Examples: *Catenula*,

Suborder 2. Opisthandropora

- Freshwater or marine form.
- The excretory system consists of paired nephridia.
- Testes compact, penis armed with a stylet.
- No yolk gland.
- Asexual reproduction with a chain of zooids.
- Examples: *Macrostomum*, *Microstomum*.

Suborder 3. Lecithopora

- Freshwater, marine or terrestrial forms.

- Bulbose pharynx.
- The excretory system consists of paired nephridia.
- Separate ovaries and yolk glands.
- Reproduction is exclusively sexual.
- Mostly free-living, some commensals or parasitic form.
- Examples: *Anoplodium*, *Mesostoma*.

Suborder 4. Temnocephalida

- Freshwater ectocommensals form.
- The anterior end of the body provided with 2-12 tentacles.
- Posterior end of the body provided with 1-2 adhesive discs.
- Dolii form pharynx.
- Simple gonopore.
- Examples: *Temnocephala*, *Monodiscus*.

Order 3- Alloecoela

- Moderate-sized between 1 and 10mm.
- Mostly marine, freshwater and brackish water form.
- Pharynx simple, Bulbose or plicate; intestine straight or branched (short diverticula).
- The excretory system consists of paired protonephridia having 2 or 3 main branches and nephridiopores.
- Nervous system with 3or 4 pairs of longitudinal nerve cords provided with transverse connectives.
- The reproductive system consists of numerous testes and a pair of ovaries.
- Penis papilla is mostly present.
- Some are ectoparasitic or ectocommensals in the habit.
- Examples: *Prorhynchus, Plagiostomum*, *Geocentrophora*.

Suborder 1. Archophora

- Marine form.
- Plicate pharynx.
- Primitive female reproductive system, no female ducts.
- Male copulatory apparatus simple opening posteriorly.
- Examples: *Proporoplana* (only examples).

Suborder 2. Lecithoepitheliata

- Marine, freshwater or terrestrial form.
- Simple or Bulbose pharynx.
- Penis with the cuticular stylet.
- Simple or none female ducts.
- No yolk glands.
- Nutritive cells surround ova.
- Examples: *Prorhynchus, Geocentophora*.

Suborder 3. Cumulata

- Freshwater or marine form.
- Bulbose or plicate pharynx.
- Intestine usually devoid of diverticula.
- Unarmed penis.
- The female reproductive system consists of **germovitellaria** or separate ovaries and yolk glands.
- Examples: *Hypotrichina*.

Suborder 4. Seriata

- Mostly marine and freshwater form.
- Plicate pharynx.
- Intestine usually with lateral diverticula.
- The female reproductive system consists of separate ovaries and yolk glands.

- Statocyst is mostly present.
- Examples: *Otoplana*, *Bothrioplana*.

Order 4- Tricladida

- Large-sized turbellarians (2 to 60cm long).
- Marine, freshwater or terrestrial forms.
- Mouth mid-ventral.
- Pharynx plicate usually directed backward.
- Intestine with 3 branches, each with many diverticula.
- Eyes usually present.
- Protonephridia as lateral networks with many nephridiopores.
- The male reproductive system consists of 2 or numerous testes; a penis papilla present.
- The female reproductive organ consists of a pair of ovaries with yolk glands and a copulatory brusa.
- Single gonopore.
- Examples: *Gunda*, *Dugesia*, *Bdelloura*, *Geoplana*.

Suborder 1. Maricola

- Exclusively marine form.
- A pair of eyes and auricular grooves present.
- Typical penis papilla sometimes armed with the stylet.
- Rounded copulatory brusa present.
- Only sexual reproduction takes place.
- Examples: *Bdelloura,*

Suborder 2. Paludicola

- Mostly freshwater, rarely brackish water forms.
- Eyes 2 to many or completely absent.
- Brusa usually presents anterior to the penis.
- Mostly asexual reproduction.
- Examples: *Planaria* or *Dugesia*.

Suborder 3. Terricola

- Terrestrial, tropical and subtropical forms.
- Elongated body mostly.
- 2 to many eyes.
- Brusa is mostly absent.
- Male and female antra usually separate.
- Asexual reproduction may also occur.
- Examples: *Bipalium*, *Geoplana*.

Order 5- Polycladida

- Moderate -sized turbellarians (2 to 20 mm).
- Marine, many bottom dwellers or littoral zones.
- Plicate pharynx, intestine highly branched.
- The nervous system consists of numerous radially arranged nerve cords.
- Numerous eyes.
- Male and female gonopore separate.
- No yolk glands.
- Testes and ovaries are numerous and scattered.
- Examples: *Leptoplana*, *Notoplana*, *Cestoplana*, *Planocera*, *Thysanozoon*.

Suborder 1. Acotylea

- Usually vertical curtain-like pharynx.
- Suckers absent behind the gonopore.
- Nuchal type tentacles.

- Eyes never occur as a pair of clusters on the anterior margin.
- Examples: *Euplana*, *Leptoplana*, etc.

Suborder 2. Cotylea

- Tubular pharynx.
- Sucker present behind the female pore.
- A pair of marginal tentacles bearing eyes or a cluster of eyes at the anterior margin.
- Examples: *Thysanozoon*, *Yungia*.

Class 2- Trematoda (Gr., *trematodes*= having pore)

- **Ectoparasitic** or **endoparasitic** commonly called
- Body unsegmented dorsoventrally flattened **leaf-like.**
- Teguments thick but without cilia and rhabdites.
- Body undivided and covered with cuticle.
- Suckers and sometimes hooks present.
- Digestive tract incomplete consists of the anterior mouth, simple pharynx and two forked or many branches intestine; anus absent.
- 3 pairs of the longitudinal nerve cord.
- Protonephridial excretory system consisting of **flame cells.**
- Mostly hermaphrodites**(monoecious).**
- Single ovary, 2 to many testes.
- Development direct (in ectoparasites) or indirect (in endoparasites) with alternation of hosts.

Order 1. Monogenea

- Mostly ectoparasites in cold-blooded aquatic vertebrates.
- Oral suckers either weak or absent.
- Anterior end provided with a pair of adhesive structures.
- Posterior end provided with an adhesive disc usually with hooks.
- Excretory pores paired situated anteriorly on the dorsal side.
- Male and female gonopore usually separate.
- Vagina one or two. Uterus is small with a few shelled eggs.
- Only **one host** in the life cycle.
- Free-swimming ciliated larva called
- Examples: *Diplozon*, *Polystoma*, *Gyrodactylus*, *Dactylogyrus*.

Order 2. Digenea

- Endoparasites of vertebrates and invertebrates.
- 2 suckers without hooks; oral sucker around the mouth and ventral sucker or acetabulum.
- Single posterior excretory pore.
- No vagina. The uterus usually long with many shelled eggs.
- The life cycle complicated involving many larval stages.
- One to more intermediate hosts in the life cycle.
- Larval forms reproduce asexually before metamorphosis.
- Examples: *Fasciola*, *Bucephalus*, *Opisthorchis*, *Paragonimus*, *Schistosoma*.

Order 3. Aspidocotylea (=Aspidogastraea)

- No oral suckers.
- Large ventral suckers subdivided into several suckers without hooks.
- Only one testis in the male system.
- Endoparasites in the gut of fishes and reptiles.
- Examples: *Aspidogaster*, *Cotylapsis*, *Stichocotyle*.

Class 3- Cestoda (Gr., **ketos,** gridle+ **eidos**, form)

- Endoparasitic in the intestine of vertebrates.
- Commonly called tapeworm.
- Body divided into many segmented **(proglottids)** but rarely undivided, elongated, flat, ribbon-like.
- Tegument without microvilli.
- Body without epidermis and cilia but covered with cuticle.
- Anterior end (scolex) is provided with adhesive structures **(hooks, suckers)** except in cestodaria.
- Mouth and digestive systems totally absent.
- The excretory system consists of **protonephridia** with typical terminal **flame**
- The nervous system usually comprises a pair of ganglia and 2 lateral longitudinal nerve cords.
- Each mature segment or proglottids monoecious, with male and female organs.
- Life cycle complicates usually involving 2 or more hosts.
- Embryos with hooks.

Subclass 1. Cestodaria

- Endoparasitic in the coelom or intestine of vertebrates.
- Body unsegmented, leaf-like without scolex and strobila **(monozoic).**
- No alimentary canal.
- Only one set of the monoecious reproductive system.
- Larva **lycophore** with 10 hooks.

Order 1. Amphilinidea

- Endoparasitic forms in the coelom of fishes.
- Body flattened, oval or elongated.
- No sucker.
- Scolex absent.
- Protrusible pharynx.
- Anterior end bears frontal glands.
- Male and vaginal pores situated posteriorly.
- The uterus is very much coiled opening near the anterior end.
- Examples: *Amphilina*.

Order 2. Gyrocotylidea

- Endoparasitic forms in the intestine of fishes.
- Body elongated and flattened.
- An anterior sucker and a posterior rosette-shaped adhesive organ present.
- Anterior end bears eversible proboscis.
- Uterine, male and vaginal pores are together situated in the anterior half of the body.
- Uterus short straight runs directly to pores.
- Examples: *Gyrocotyle*.

Subclass 2. Eucestoda

- Endoparasitic form in the intestine of fishes.
- Body long, ribbon-like.
- The body is divided into scolex, neck, and strobila with many proglottids (**polyzoic).**
- Scolex expanded bearing adhesive structures.
- Mostly with several sets of monoecious reproductive organs.
- Larva with 6 hooks.

Order 1. Tetraphyllidea

- Endoparasitic forms; exclusively in the intestine of elasmobranch fishes.
- Scolex with 4 leaf-like **bothria (sessile suckers)** often provided with

- Testes are anterior to ovaries.
- Vitelline glands scattered.
- Cirrus armed with spines and hooks.
- Common genital atrium marginal.
- Examples: *Phyllobothrium*, *Myzophyllobothrium*.

Order 2. Diphyllidea

- Parasitic in the intestine of elasmobranch fishes.
- Scolex with 2 bothria and spiny head stalk.
- Strobila consists of not more than 20 proglottids.
- Examples: *Echinobothrium*.

Order 3. Trypanorhyncha

- Parasitic in the spiral valve of the digestive tract of elasmobranch fishes.
- Moderately sized body.
- Scolex with 4 bothria and 4 protrusible spiny proboscides.
- Vitellaria in cortical parenchyma placed in a continuous layer.
- Testes extend behind the ovary posteriorly.
- Lateral gonopores; ventrally open uterus.
- Examples: *Haplobothrium*, *Tetrarhynchus*.

Order 4. Pseudophyllidea

- Parasitic in the intestine of teleost fishes and terrestrial vertebrates.
- Body segmented into strobila or unsegmented.
- Scolex with 2 to 6 shallow bothria (Suckers) rarely without adhesive organs.
- Bilobed ovary, testes numerous, follicular and scattered in the mesenchyma of proglottids.
- Vitellaria follicular, numerous.
- Midventral gonopores.
- Examples: *Bothriocephalus*, *Dibothriocephalus*.

Order 5. Taenioidea or Cyclophyllidea

- Parasitic in the intestine of reptiles, birds, and mammals.
- Large-sized tapeworm.
- Scolex bears 4 larges in cupped suckers **(acetabula)** often with an apical rostellum armed with hooks.
- Ovary two or many lobed; uterine opening absent.
- Gonopores on one or both margins.
- The excretory system consists of 4 longitudinal vessels.
- Vitellaria (yolk gland) single and compact.
- Examples: Taenia, Echinococcus, *Hymenolepis*, *Moniezia*.

LIVER FLUKE (*Fasciola hepatica)*

Classification

Phylum	:	Platyhelminthes	-	Acoelomate; organ grade and flatworms
Class	:	Trematoda	-	Ecto or endoparasitic; body wall without epidermis andwell developed suckers present
Order	:	Digenea	-	Endoparasitic; mostly with two suckers without hooks
Genus	:	*Fasciola*		
Species	:	*hepatica*		

- ✓ *Fasciola hepatica* is an endoparasite with a leaf-like, dorsoventrally flattened body.
- ✓ It is commonly known as liver-fluke
- ✓ It is a flattened worm. Hence it is included in the phylum Platyhelminthes and class Trematoda
- ✓ The liver fluke is an endoparasite. It lives inside the bile-duct of liver in sheep, goats and cattle. It causes a disease called liver-rot in sheep
- ✓ It is conical in shape and flat-like a leaf.
- ✓ It is about 25 mm long and about 15mm in breadth
- ✓ It is narrow at the anterior end, broad in the middle and tapers towards the posterior end
- ✓ The entire body is covered by cuticle
- ✓ At the anterior end there is a triangular projection, the head-lobe
- ✓ It has two suckers, an oral sucker or anterior sucker at the tip of the head lobe and a ventral sucker or acetabulum behind the head lobe, on the ventral side
- ✓ The oral sucker encloses the mouth and the ventral sucker has no aperture.

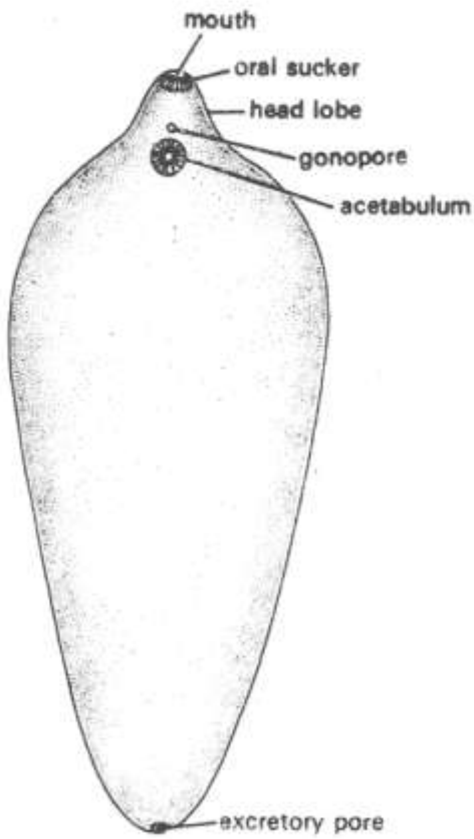


Fig. *Fasciola hepatica* –ventral view

- ✓ The suckers help in the attachment of the parasite to the host
- ✓ Between the two suckers there is or genital opening or gonopore.
- ✓ An excretory pore is present at the hind end

Digestive System

- ✓ The digestive system is very simple. It is formed of a mouth, the pharynx, oesophagus and the intestine
- ✓ The mouth is sub-ventral in position. It is surrounded by the oral sucker. It leads into a funnel-shaped muscular pharynx
- ✓ The pharynx is surrounded with pharyngeal glands. The lumen of the pharynx is very narrow, which leads into a short, narrow oesophagus
- ✓ The oesophagus is followed by the intestine. The intestine soon after its origin divides into two branches called caeca. Each caecum runs upto the posterior end where it ends blindly.
- ✓ Each caecum is divided into a number of branching diverticula.
- ✓ The anus is absent
- ✓ The liver fluke feeds on the blood and bile of the host.
- ✓ It sucks the liquid food by the muscular pharynx. As the food is already in the digested state and fit for absorption, the digestive glands are completely absent.
- ✓ The food is absorbed in intestine. The branches of diverticula transport the digested food to the different parts of the body along the parenchyma

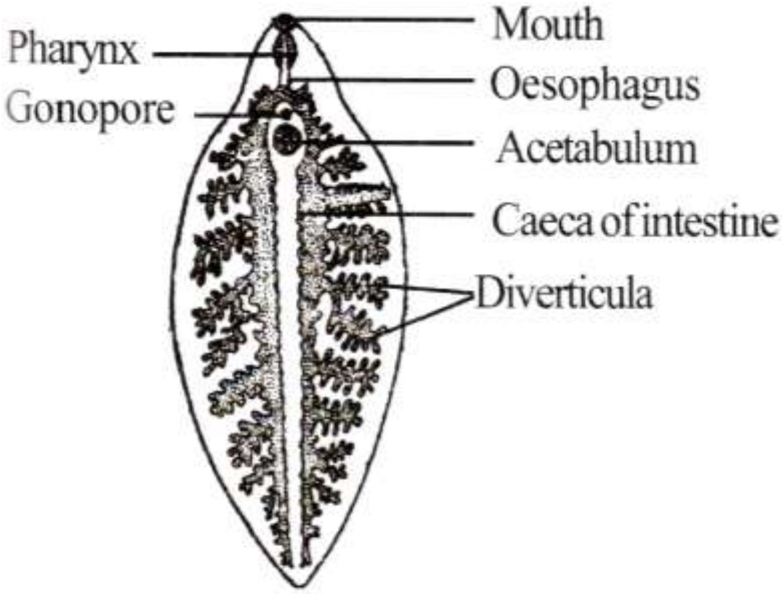


Fig. *Fasciola hepatica;* Digestive system

Excretory System

- ✓ The excretory system in liver fluke is formed of protonephridia.
- ✓ It has no internal opening. It consists of a median longitudinal excretory canal.
- ✓ The canal opens to the outside at the posterior end of the animal by an excretory pore
- ✓ The excretory canal gives out many branches. Each branch ends in a cell called flame cell
- ✓ Each flame cell is formed of a single cell It has an elastic thin wall with a nucleus and a cavity. The cavity contains a bundle of cilia.
- ✓ The cilia show flickering movement like a flame; hence the name flame cell
- ✓ The surface is produced into pseudopodia
- ✓ The liquid wastes are absorbed from the surrounding tissues by the flame cells.
- ✓ By the movement of cilia, the wastes are sent out through the excretory pore

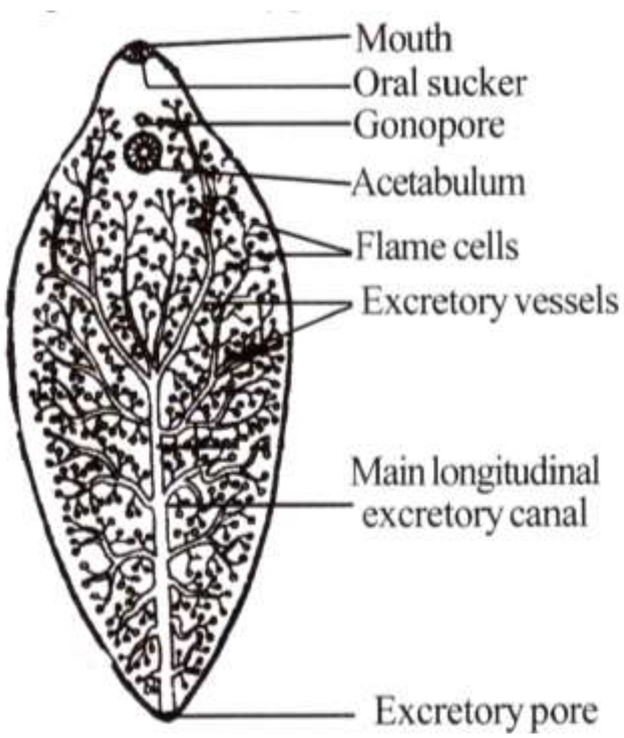


Fig. *Fasciola hepatica;* Excretory organs

Reproductive System

- ✓ Liver fluke is hermaphrodite. Both male and female reproductive organs are present in the same animal. It contains complicated reproductive organs.
- ✓ The male and female genital ducts open into a common chamber, the genital atrium. The genital atrium opens outside through the common genital aperture

Male Reproductive System

- ✓ It consists of two testes. They are tubular and highly branched.
- ✓ A vas deferens arises from each testis. The two vasa deferentia run forward and join to form a median bag-like structure the seminal vesicle
- ✓ The sperms produced by the testes are stored in the seminal vesicle.
- ✓ The seminal vesicle leads into a narrow tube, the ejaculatory duct.
- ✓ The ejaculatory duct opens into a muscular tube called penis. It opens into the genital atrium by the male genital aperture

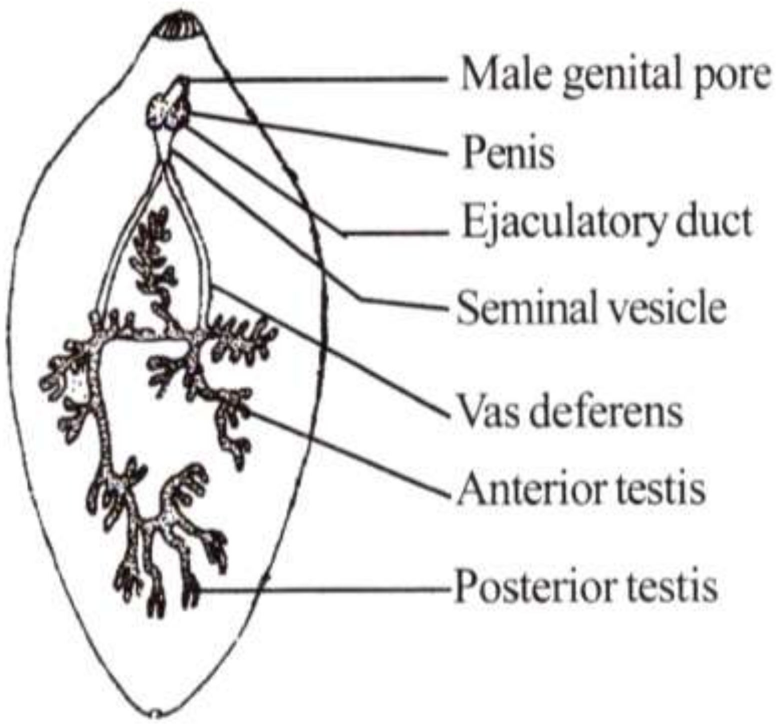


Fig. *Fasciola hepatica;* Male reproductive system

Female Reproductive System

- ✓ The female reproductive system is formed of a single ovary. It is tubular and branched. It lies in the middle of the body in front of the testes. An oviduct arises from the ovary. It runs forward and joins the vitelline duct
- ✓ There are numerous small rounded yolk glands or vitellaria on the sides of the body. These glands secrete yolk and the shell
- ✓ A minute duct known as yolk duct arises from each yolk gland. All yolk ducts unite into an anterior longitudinal vitelline duct and a posterior longitudinal vitelline duct on each side
- ✓ The two longitudinal ducts join to form a transverse vitelline duct
- ✓ The transverse vitelline ducts of the two sides run inward and join to form a median vitelline duct which runs forward and joins the oviduct
- ✓ The junction of median vitelline duct and the oviduct is slightly dilated to form an ootype.
- ✓ Around the ootype there is a mass of unicellular Mehli's glands or shell glands. The secretion of Mehli's glands lubricates the passage of eggs in the uterus. It also activates the sperm and hardens the egg shell
- ✓ From the ootype arises a large duct called ovo-vitelline duct or uterus. The uterus runs forwards as a coiled tube and opens to the exterior through the female genital pore close to the male genital pore
- ✓ From the ootype arises another canal known as Laurer's canal. It runs vertically upwards and opens on the mid-dorsal surface
- ✓ During copulation, the sperms are received from the other fluke through this canal. So it is also termed copulation canal

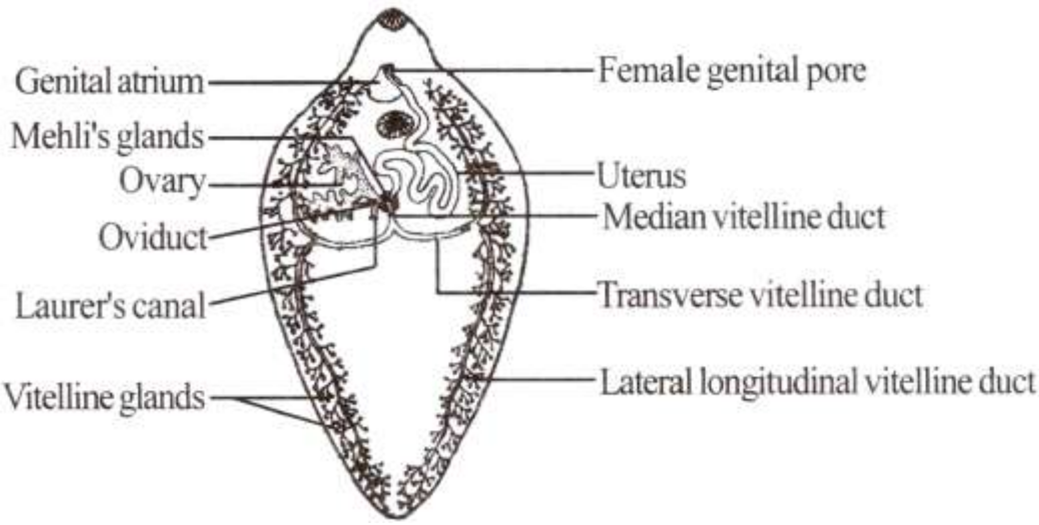


Fig. *Fasciola hepatica;* Female reproductive system

Parasitic adaptations of Helminth Parasites

Parasitism is a kind of animal association between two different animals. In this association, one animal is larger in size and the other is smaller in size. The smaller animal is called ***parasite*** and the other larger animal is called ***host.*** The parasite lives inside (endoparasite) or outside (ectoparasite) the body of the host.

In this association, the parasite lives at the expense of the host; the parasite gets the benefit in the form of ***food*** and ***shelter;*** at the same time the host is harmed. Hence parasitism is a ***one-sided*** relationship. Based on the above information, parasitism can be defined as a *special way of living in which an organism, the parasite, uses an organism of a different species, the host, both as a habitat and as food.* According to ***Beneden*** "a parasite is he whose profession is to live at the expense of his neighbour and whose only employment consists in taking advantage of him and not to endanger his life".

Table 1: Table showing Helminth parasites.

Sl. No	**Parasite**	**Intermediate host**	**Disease**
1	*Taenia solium*	Pig	Taeniasis
2	*Ascaris*	--	Ascariasis
3	*Ancylostoma*	--	Ancylostomiasis
4	*Enterobius*	--	Enterobiasis
5	*Wuchereria*	--	Elephantiasis

Serious problems and diseases are caused to man by helminth parasites. A few human parasites and diseases are given in the above table.

1. Protective Covering

The outer covering of the intestinal parasites becomes resistant to digestive juices of the host. They develop a thick ***cuticle.*** The outer surface of the cuticle is formed of a fibrous protein called ***keratin.*** In some other parasites, the outer covering contains ***scales.*** Since the cuticle and scales are not dissolved by the digestive enzymes, they protect the parasites.

2. Loss of Locomotory Organs

Locomotion is necessary to search food materials and to run away from the enemies. The parasites live in a medium of food. Inside the host; there are no enemies for the parasite. So there is a loss of organs of locomotion. The muscles associated with the locomotory organs also disappear.

3. Organs for Penetration

The parasites must penetrate the host's body for entering it. So the parasites develop adaptations for penetration. ***Miracidium larva*** has a conical process at the anterior end called ***apical papilla.*** This is used to penetrate the soft body of the intermediate host, the snail. There are a pair of penetration glands inside the body near the anterior end.

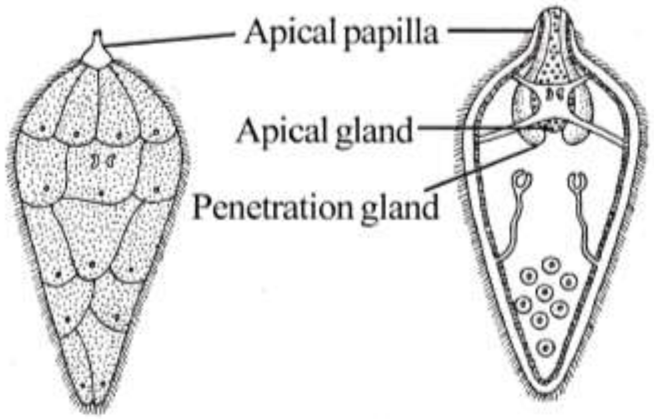


Fig. : Miracidium larvae showing apical papilla and penetration gland.

These glands secrete a histolytic secretion which is used for penetration. The hooks are also used for penetration. Almost all the endoparasites possess hooks. The hooks of ***hexacanth*** (6 hooks) and ***decacanth*** (10 hooks) larvae of tape worms are used for penetration.

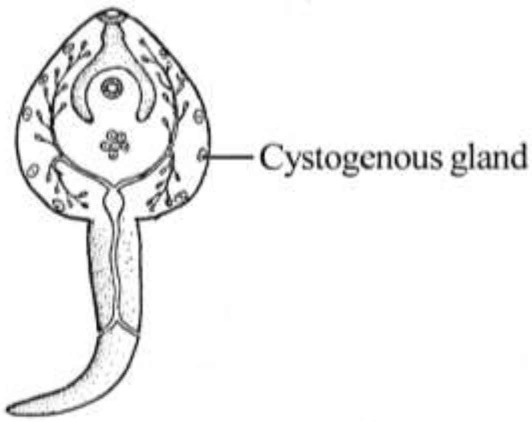


Fig. : Cercaria larva showing cystogenous gland.

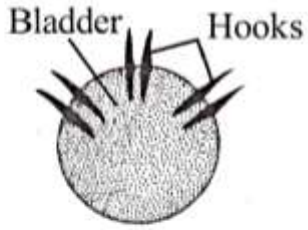


Fig. Hexacanth larva showing 6 hooks.

4. Sense Organs

Progressive parasitism is accompanied by the loss of sense organs. The sense organs are of vital importance to free living animals, for they enable them to detect the fluctuations of different factors in the environment. In the host the environment is more or less uniform and so the sense organs are not essential. Hence they are reduced.

The endoparasites are generally provided with ***tangoreceptors.*** The loss of sense organs is accompanied by the degeneration of the nervous system.

5. Alimentation

The digestive tract undergoes simplification and in extreme cases it is totally absent. In *Taenia*, the digestive tract is completely absent. It obtains its food entirely from the surrounding medium, by diffusion.

The digestive glands are absent. The purpose of digestive gland is to simplify the complex food materials into simpler ones. Since the food is already in digested or semi-digested form, the digestive glands are not necessary for the parasites.

6. Anaerobiasis

The intestinal parasites live in an environment completely devoid of oxygen. So parasites are adapted for a low metabolic rate which requires minimum amount of O_2. Moreover the respiration is of the anaerobic type consisting of extracting O_2 from the food stuffs. In the absence of O_2 energy is obtained by the fermentation of glycogen in which by ***glycolysis, glucose*** is broken into ***lactic acid.***

7. Osmoregulation

The osmotic pressure of the parasite remains the same as that of their host, so that there is no difficulty in maintaining life. ***Cestodes*** and ***Trematodes*** have well developed osmoregulatory system. Flame cells remove excess of water along with waste products.

8. Anti Reactions

Most of the intestinal parasites secrete ***antienzymes*** in order to protect themselves from the digestive enzymes of the host. A dead worm cannot produce this antienzyme and is quickly digested by the host. Some of the new medicines aim at nullifying the protective effect of the antienzymes resulting in the digestion of the worms by their hosts.

9. Cystogenous Glands

The cercaria larva possesses a large number of ***cystogenous glands*** in their body. They secrete a cyst around the larva. The cyst protects the larva.

10. Periodic Appearance

There are some parasites which appear at definite periods. The larva of *Wuchereria bancrofti* (microfilaria), circulates in the blood of man. For further development it must enter the body of the *Culex* mosquito. The culex generally bites a man at night i.e. nocturnal in habit. The microfilaria circulates into the peripheral blood circulation in the night between 10 p.m, and 4 a.m, correlated with the nocturnal habit of *Culex*. So this can be considered as a parasitic adaptation.

11. Retro Infection

Enterobius vermicularis is the human intestinal parasite. Females lay the fertilized eggs in the perianal region. In such cases the zygote hatches into the larvae which migrate into the rectum and intestine. This type of infection is called ***'retroinfection'.*** In this process, the wastage of eggs and the destruction of larvae are avoided. So it can be considered as a parasitic adaptation.

12. Complicated Life History

Many parasites require more than one host to complete the life history. According to some authors this also has been considered as an adaptation. If one host becomes extinct, then the parasite can develop adaptations to live in another host or it can select a new host.

13. Complicated Reproduction

Production of large number of eggs and young ones is an adaptation for parasitic mode of life. For this the reproductive system is variously modified in the parasites. They are:

1. Most of the parasites are ***hermaphrodites.***

2. Most of the ***Cestodes*** are formed of many ***proglottids.*** Each proglottid contains a set of male and female reproductive organs. In extreme cases each proglottid contains two sets of male and female reproductive organs.

3. The uterus is much coiled and elongated and can accommodate thousands of zygotes.

4. ***Budding*** or ***fission*** is another adaptation. The sporocyst larva produces daughter sporocyst by simple fission.

5. ***Parthenogenesis*** is another adaptation for producing large number of individuals. Parthenogenesis is the development of eggs without fertilization. The ***'germ cells'*** present inside the ***Sporocyst*** and ***Redia larva*** develop into succeeding larvae by parthenogenesis.

6. In some cases, the males and females are attached together permanently. In this attachment, the vagina of one individual opens close to the vas deferens of the other. Thus they remain in permanent copulation throughout their life. Eg. *Schistosoma.*

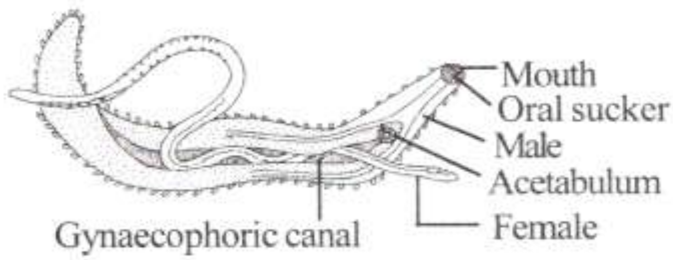


Fig. : Schistosoma, an endoparasite. The male and female remain together in permanent copulation.

14. Neoteny

Neoteny is a special phenomenon in which the larvae develop reproductive organs and they produce young ones. ***Ligula*** (Cestoda) exhibits neoteny. This can produce young ones even from the larval stages. So neoteny can also be considered as an adaptation for parasitic mode of life.

15. Adhesive Organs

The important adaptation met with in parasites is the development of organs of attachment. The adhesive organs are in the form of ***sucker, acetabulum,rostellum, bothridium, bothrium, hooks, spines, adhesive secretions,*** etc.

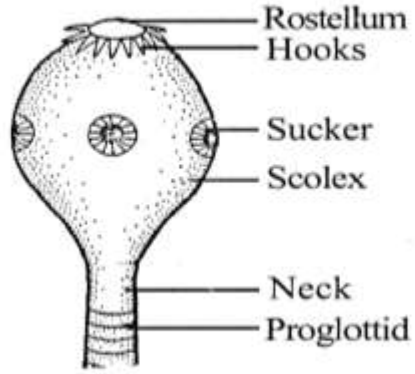


Fig. Scolex of Taenia solium showing hooks and suckers.

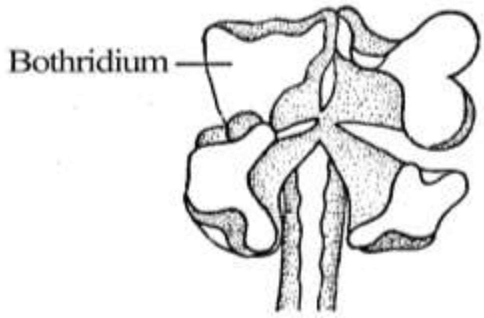


Fig. Anthobothrium showing bothridium.

In ***Trematoda*** and ***Cestoda,*** suckers are well developed. They work on the vacuum-cup principle. The scolex bears rostellum with recurved hooks. Bothridium is a leaf like outgrowth on the scolex. *Anthobothrium* has four bothridia. *Phyllobothrium* has 4 bothridia and each bothridium bears a sucker. Bothrium is a shallow groove on the scolex. *Bothridium pithonis* has two bothria. The two edges of the bothrium may be fused to form a tube opening at both ends. *Tetrarhynchus* has four bothria and four eversible proboscis beset with spines.

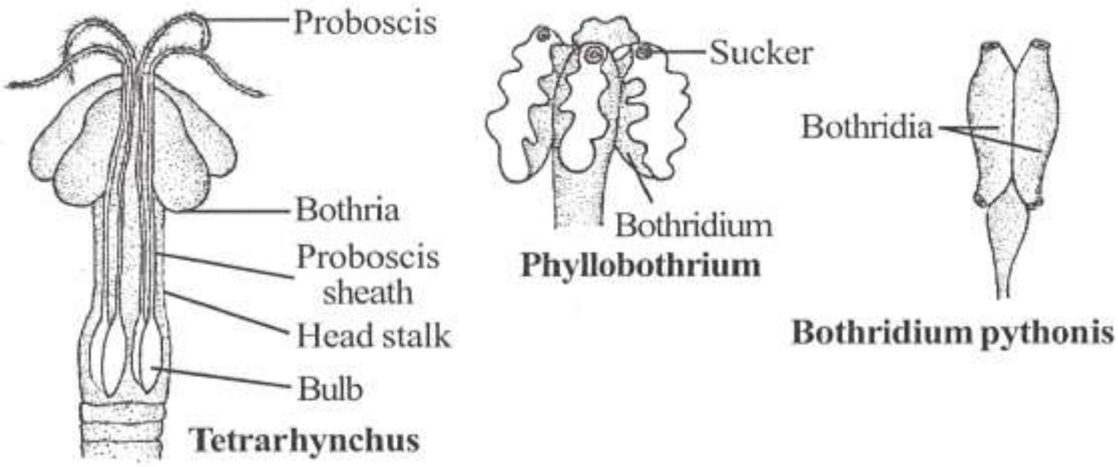


Fig. Some cestodes with adhesive organs.

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