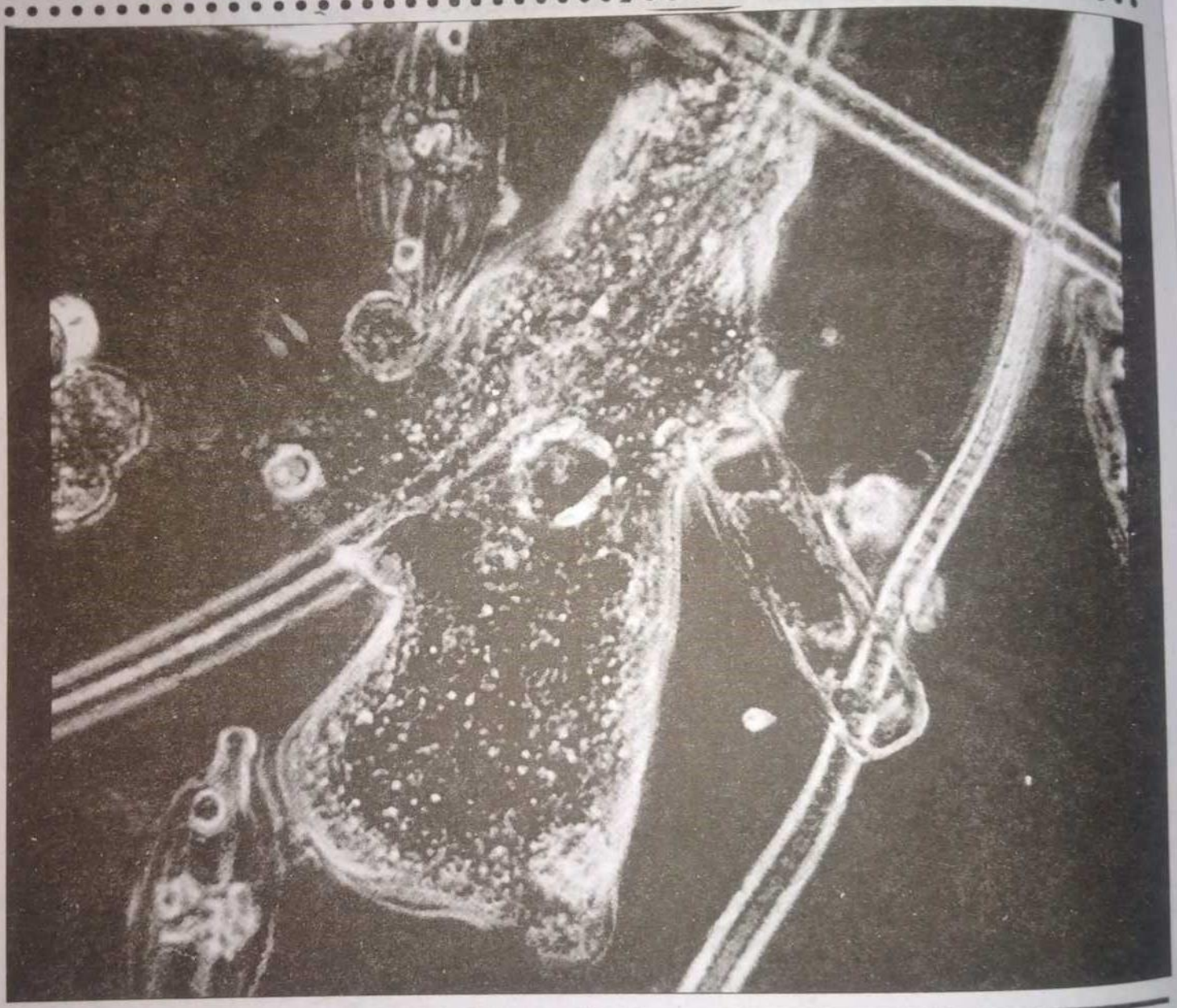
CHAPTER 7

# THE KINGDOM PROTOCTISTA
## (PROTISTA)



Protoctists are eukaryotic and thus even the simplest ones are much more complex than the prokaryotes. The first eukaryotes to evolve from prokaryotic ancestors were probably unicellular and would therefore be called protists. The primal eukaryotes were not only the predeccessors of the great variety of modern protists but were also ancestral to all other eukaryotes–plants, fungi and animals.

The most controversial group of organisms is the ***Protista (protoctists)*** because it is probably an unnatural group. It contains eukaryotes that are generally regarded as identical or similar to the ancestors of modern plants, animals and fungi. The Protoctista includes two groups, the algae and the protozoan, which formerly had separate taxonomic status, and which are now regarded as containing organisms too widely different to be placed in one phylum. In addition, it includes one group of organisms which were previously placed in the fungi, the oomycota or oomycetes, but which are now regarded as ancestral to fungi. The slime moulds, a group of organisms which are motile but which produce spores in sporangia, are also included in the Protoctista.

**Diversity among Protista (Protoctista)**

Due to diversification, biologists regard protist kingdom as a polyphyletic group of organisms. It means they do not share a single common ancestor. Here we have divided them into three groups:

1. Plant-like Protoctists —— Algae
2. Fungi-like Protoctists —— Primitive fungi
3. Animal-like Protoctists —— Protozoa

## 7.1 PLANT-LIKE PROTOCTISTS: ALGAE (Chlorella and Ulva)

Algae (Sing Alga) —— Algin = Sea-weed

Algae are responsible for more than half of the amount of photosynthesis being carried in the world.

Previously Algae were regarded as plants due presence of cell-wall and chlorophyll-b as an accessory photosynthetic pigment.

Algae differ from plants being aquatic where as plants are nearly all terrestrial. Living on land poses very different problems from living in water, and it is a set of structural, chemical and reproductive adaptations for terrestrial living that distinguishes plants from algae. Zygote is not protected by parent body.

> The protists are usually single-celled organisms that are grouped according to their mode of nutrition. There are the heterotrophic protozoans, the photosynthetic algae, and slime molds and water molds, which somewhat resemble fungi.

Algae ranges from unicellular to filamentous and to huge multicellular structures. In addition to green chlorophyll, carotenoids, xanthophylls and phycoerythrin are also present. Classification of algae is largely based on their pigment composition.

### 7.1.1 CHLORELLA

It is fresh water algae found floating in stagnant water of ponds, pools, ditches etc. It is easily cultured and has been used as an experimental organism in research on photosynthesis as well as being investigated as an alternate source of food.

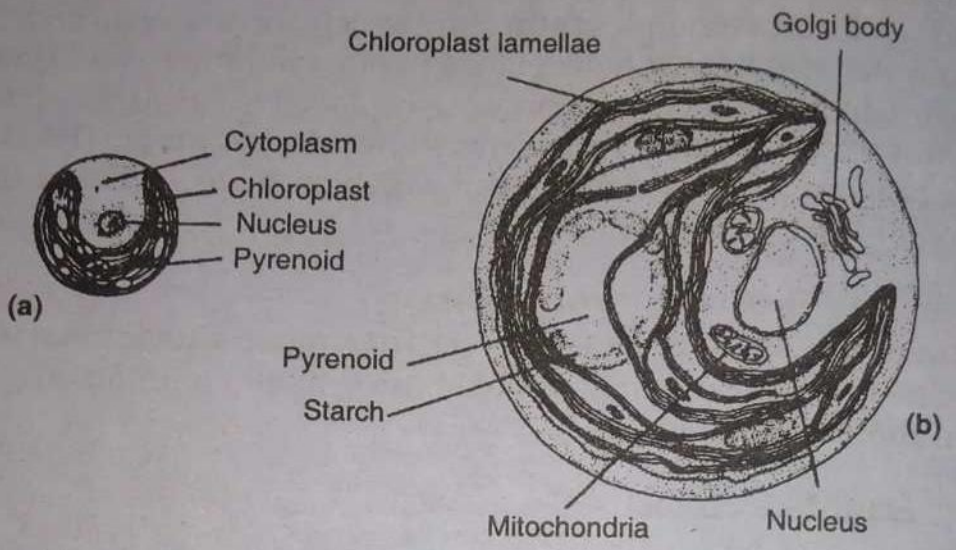



***Fig. 7.1 Chlorella (a) A single plant and (b) Structural details as studied with the help of electron microscope.***

The body is one-celled, spherical in outline and solitary. It contains a single nucleus and a cup-shaped chloroplast with or without a pyrenoid.

The sole method of reproduction is by aplanospores, which involves the division of protoplast into 8-16 daughter protoplast. Each daughter protoplast secrets a wall to produce a nonmotile aplanospore. On release from the parent cell each aplanospore forms a new vegetative cell. Zoospores and gametes are unknown. It is of great economic importance as recently an antibiotic called chlorellin useful for the control of bacterial diseases has been prepared from the plant.

### 7.1.2 ULVA

It is a marine alga commonly called 'sea-lettuce'. It is found growing along the sea-coasts between high and low tides. It is found attached to rocky edge of Manora and Kiamari areas of Karachi coast. The body called thallus is composed of elongated wrinkled blade about 30 cms. long. It is attached to rock and other objects in the sea by means of hold fast, consisting of long thread like cells. The thallus is very thin only two cells in thickness. Thallus in Ulva is of two types. The one with 26 chromosomes is called **sporophyte** and the other with 13 chromosomes is called **gametophyte**. Morphologically both gametophyte and sporophyte are exactly alike hence called **isomorphic**.

***Ulva*** reproduces asexually as well as sexually.

***Asexual reproduction*** takes place in asexual Ulva (Diploid sporophyte with 26 chromosomes or 2n) by quadri-flagellate zoospores. These spores are formed by meiosis in all the cells of the body (thallus) except the basal cells. Eight to sixteen haploid zoospores are formed in a single parent cell. The zoospore production continues until all the cells are used and nothing remains of the thallus blade but a filmy mass of empty cell-walls. Liberation of zoospores usually takes place at the time when the plant is reflooded by an incoming tide. The liberated haploid zoospores after a period of swimming and rest lose their flagella and grows into *Ulva* thalli.

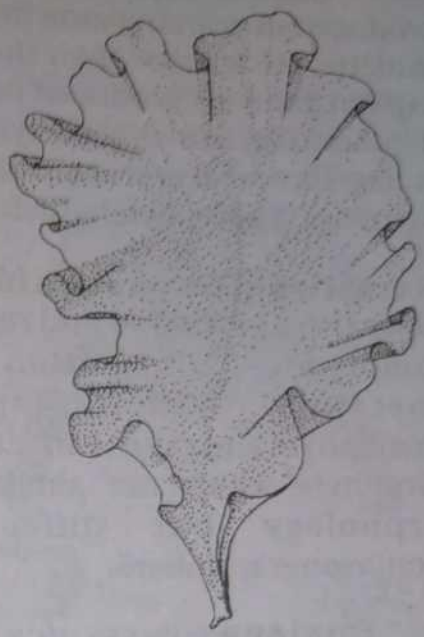


***Fig. 7.2 Ulva, a marine green alga with a three dimensional leaflike thallus.***

Green algae are a diverse group that have some of the same characteristics as plants. The haplontic life cycle is typical but Ulva has a life cycle that has 2 distinct generations, like that of plants.

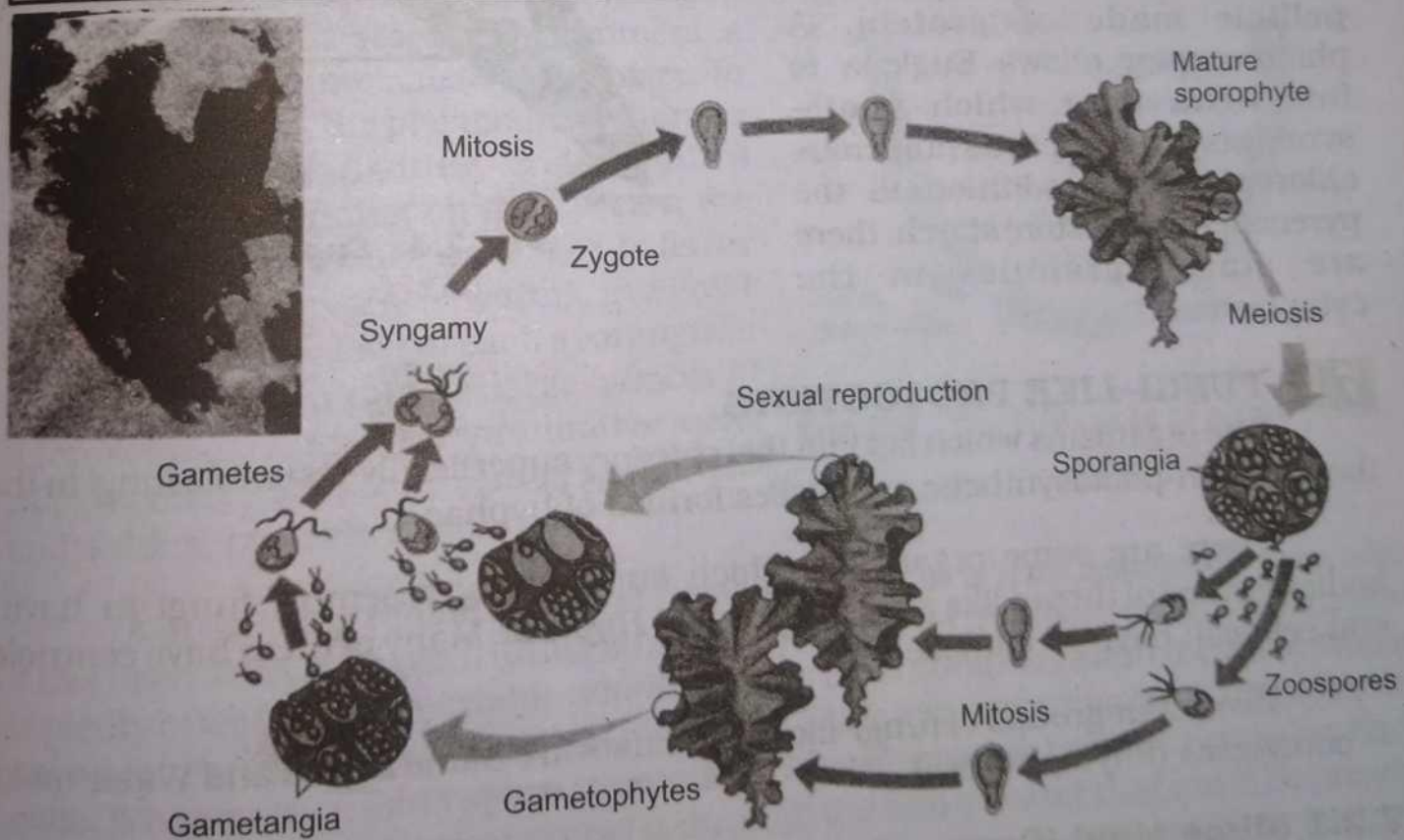



***Fig. 7.3 The life cycle of Ulva: an example of isomorphic alternation of generations.***

***Sexual reproduction*** is isogamous. The gametes are biflagellate and produced in sexual plants (haploid gametophytes with 13 chromosomes(n)). These gametes are smaller than the zoospores. The fusion takes place only between two haploid gametes produced by different plants. The fusion results in the formation of quadriflagellate diploid zygote which, after a period of swimming and rest, loses its flagella and secretes a wall and after repeated divisions it develops into another *Ulva* plant (Sporophyte) which is similar to sexual plant (Gametophyte) in morphology.

**Alternation of Generation in Ulva** shows there is distinct and regular isomorphic alternation of generation. The haploid gametophyte alternates with diploid sporophyte which are similar in morphology but differ in chromosome numbers.

**Euglena** is typical of protoctists that have both animal-like and plant-like characteristics. A very long flagellum propels the body, which is enveloped by a flexible pellicle made of protein. A photoreceptor allows Euglena to find light, after which photo-synthesis can occur in its numerous chloroplasts. In addition to the pyrenoids, which store starch, there are starch granules in the cytoplasm.

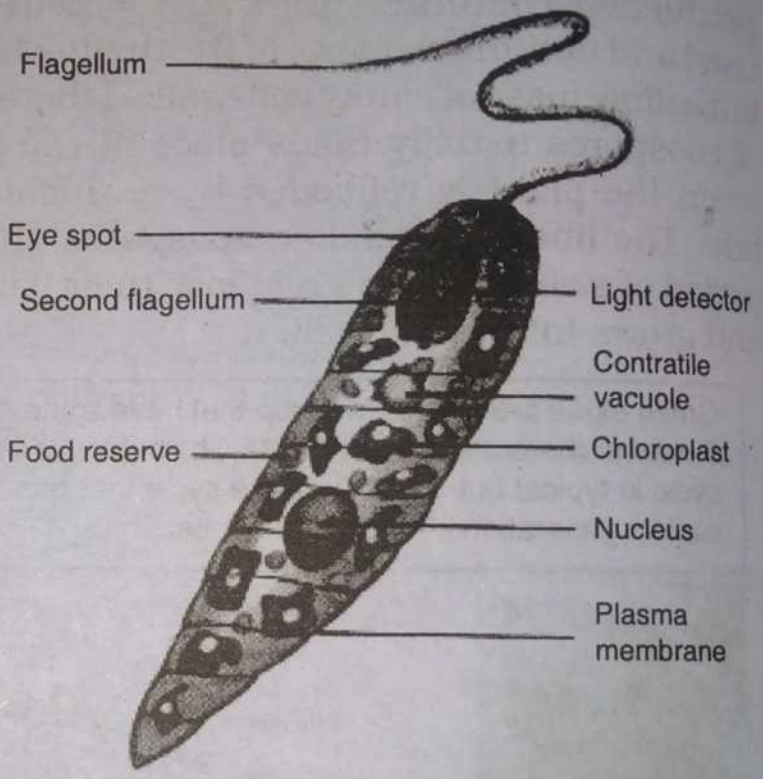



***Fig. 7.4 Euglena***

## 7.2 FUNGI–LIKE PROTOCTISTS

The organisms which fall into this category superficially resemble fungi in that they are non-photosynthetic and bodies formed of hyphae.

There are some organisms which superficially resemble fungi in having bodies formed of thread like structures called ***Hyphae***. Many of them have centrioles and cell-wall having cellulose.

Two major groups of fungi-like protoctists are Slime molds and Water molds — oomycetes (Phytophthora).

### 7.2.1 Slime Mold (Gymnomycota):

A common slime mold is of no practical value whatever. You cannot make anything useful out of it, and it does not cause of serious disease. However, a slime

mold is a strange and truly wonderful "thing", its structure and behaviour have raised many questions, some of which are still unanswered.

At one stage in their life cycle, some species of slime molds are creeping masses of living substance, having the consistency of an unboiled egg white and the colour of the yolk. The movement of this living thing brings to mind a giant amoeba, for it sends out arms that engulf and digest bacteria from the surface of rotting log or leaves. This amoeboid stage of the slime mold is called a plasmodium. In nature, a large plasmodium may cover several square centimetres. It can crawl over grass, creep up the sides of trees, or go almost anywhere there is food and moisture. The plasmodium consists of cytoplasm in which are embedded many nuclei, food vacuoles, and undigested food particles.

Plasmodia move along the forest floor, onto dead leaves that are bathed in sunlight. In this dry, often warm, environment a miraculous metamorphosis takes place. In a matter of hours, the plasmodium changes into clusters of fruiting bodies called **sporangia**. Depending on the species, the fruiting bodies look like small golf balls, or feathers, or bird cages, or worms, in a great variety of colours. Part of each sporangium called **capsule**, produces a large number of microscopic, asexual reproductive cells called spores. Each spore has a single nucleus and a thick, protective wall.

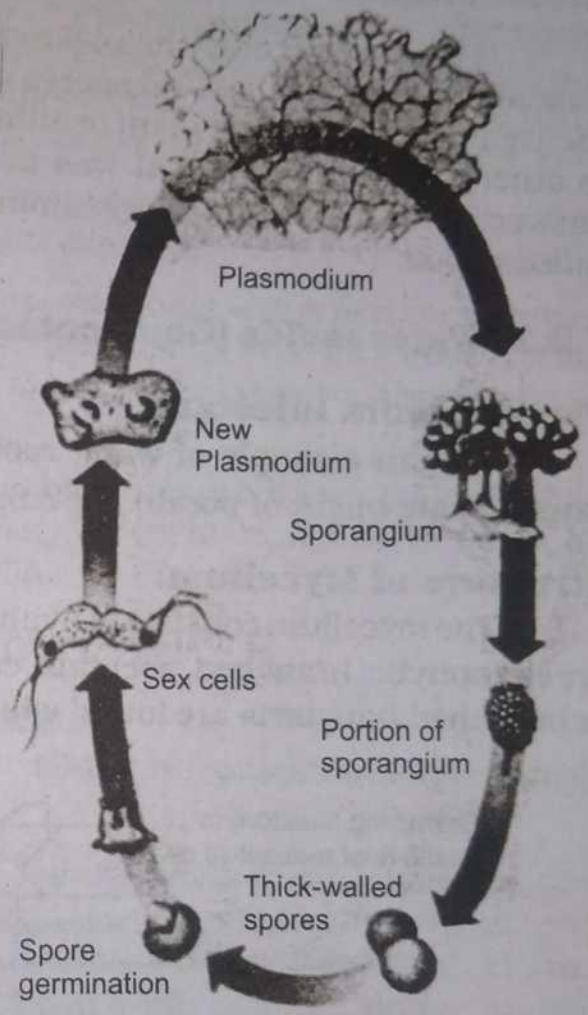



***Fig. 7.5 The life cycle of slime mold. (Physarium)***

A spore may remain inactive for a long time, or it may germinate soon after it has been shed from the fruiting body. Germination of the spore occurs when there is plenty of water and a suitable temperature. The fruiting stage and the thick-walled spores of the slime mold are very plant like. They are very important reproductive cells. When a slime mold spore germinates, it produces one or more tiny cells. Each cell has a pair of flagella that propel it through the film of water that must be present for spore germination. These flagellated cells may function as gametes (Sex cells) and fuse in pairs. This is true sexual reproduction, even though the gametes appear to be identical in structure.

Cells resulting from the fusion of gametes become amoeboid and form a new plasmodium that is multinucleate (containing many nuclei). The multinucleate condition can arise by growth of the amoeboid cell and subsequent divisions of the nucleus. It can also result from the fusion of many individual amoeboid cells, which thus lose their separate identity. This is a most unusual way for an organism to be formed. In slime mold, we can see that it combines characters of animals and plants.

If we observe only the plasmodium, we would certainly call slime mold an animal. If fruiting bodies and spores were the only parts we could see, we would call the organism a plant. Is it plant or animal? Can we really relate this strange organism to other living things? What was its evolutionary origin? We can get some help answering these questions by examining some other more familiar fungi, which are called molds.

### 7.2.2 Water molds (Oomycotes):

**Phytophthora Infestans:**

It is an example of water molds (oomycotes). It is a pathogenic organism causing Late blight of potato (fig:7.6).

**Structure of Mycelium:**

The mycelium consists of hyphae having a cellwall madeup of cellulose which are endophytic, branched, aseptate, coenocytic, hyaline and nodulated. The rounded or branched haustoria are found which absorb food material from the host cells.

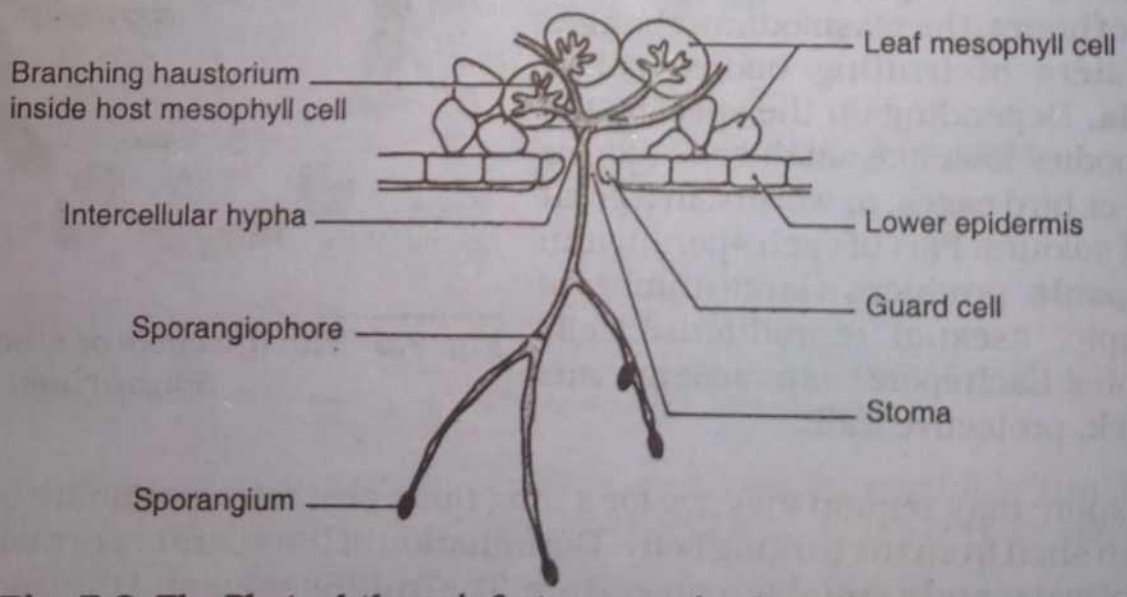



***Fig. 7.6 The Phytophthora infestans growing in a diseased potato leaf.***

**Reproduction:**

The reproduction takes place by means of asexual and sexual methods.

**Asexual reproduction** takes place by means of biflagellate zoospores produced inside the sporangia.

**Sexual reproduction** is oogamous (Clinton, 1911). The female sex organ is oogonium and the male organ is antheridium. The antheridium develops first and the oogonium later. Both the sex organs may develop on the same hypha or–on two adjacent hyphae lying side by side.

### 7.2.3 Economics importance of Phytophthora Infestans:

The most important species phytophthora infestans causes the "late" blight of potato. This is a havoc to potato crop and causes sufficient damage. The symptoms of the disease appear both upon aerial and underground parts. The whole plant becomes blighted in severe conditions. Dry and wet rots damage the tubers.

The first sign of the disease is appearance of small brown patches on leaves which in cloudy and muggy weather rapidly increase to the whole leaf surface.

In bad cases the crown also shows similar symptoms which becomes a rotten pulpy mass emitting foul odour. On the under surface of such infected leaves a cotton growth of mycelium consisting of fortification of the fungus is seen. This growth is absent in dry weather.

The underground parts especially the tubers are also affected which often remain smaller in size and show dry rot with rusty brown markings in the flesh and brown depressions at certain places, in the skin.

## 7.3 ANIMAL LIKE PROTOCTISTS (PROTOZOA)

### Protozoa (protos=first formed, zoa=animals):

They are earlist formed eukaryotic, unicelluler organisms which primarily feed by ingestive method.

The protozoans are unicellular organisms. Like animals, they are heterotrophs. Typically protozoa have a single nucleus and lead an independent existence but some have multinucleated cell, and in other species the cells are joined together to form a colony. A colonial protozoan can be distinguished from a multicellular animal, because its cells are quite similar and non specialized for any function. Most of the individuals in a population of protozoa are produced by simple cell division of the parent, although sexual reproduction by the mating of two individuals does occur. Protozoa are primarily aquatic and live in fresh, brakish and marine water. Some species of protozoa can form inactive spores or cysts that can be dried and distributed with particles of dirt or dust from one habitat to another. Parasitic protozoa live in the body of animals or in the plants. About 30,000 species of protozoa are divided into five classes, which differ in their means of locomotion.

1. Class Flagellata (Mastigophora)
2. Class Sarcodina (Rhizopoda)
3. Class Ciliata (Ciliophora)
4. Class Suctoria
5. Class Sporozoa

**1.** The ***Flagellata*** so called because they have one or more flagella. These organelles, constructed like those of higher animals, have a membranous covering and microtubules. Many members of this group are photosynthetic and they are as much like plants as animals e.g. Euglena.

The flagellates are generally considered to be the basic stock from which evolved not only other kinds of protozoa but also higher plants and animals e.g. Trypanosoma (Fig. 7.7).

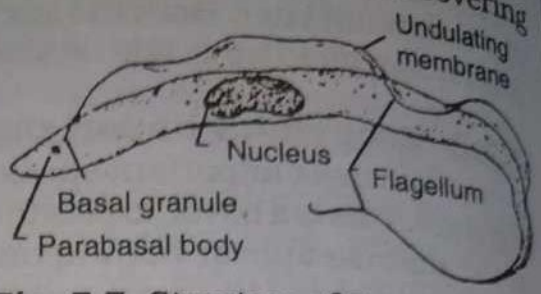



***Fig. 7.7 Structure of Trypanosoma***

**2.** The ***Sarcodina:*** The members of this class have no specific organelles for locomotion. They extend blunt or slender cytoplasmic projections called ***pseudopodia*** and then the cell content flows into the pseudopodium which can be pushed out and retracted repeatedly, such type of locomotion is called *amoeboid locomotion.*

Some parasitic Amoebae (Entamoeba-histolytica) can cause human dysentery. Marine shelled sarcodinians through geological time have deposited billions of skeletons, which now make layers on the bottom of the sea. The ***"Radiolarian Ooze"*** and ***"Globigerina Ooze"*** (Fig. 7.8) are studied by oil prospectors because the presence of certain species gives clues to possible petroleum deposits.

**3.** The ***Ciliata,*** Protozoa with both micro and macro nucleus and numerous short cilia, so named because of the resemblance of cilia to eyelashes (the word really means "eyelid"). They use their accurately synchronized cilia either to move themselves through water or, if they are attached, to bring water containing food particles near or into the animal's body. Many ciliates have a groove or depression called a gullet through which food can be brought inside the body by a process of engulfing e.g. *Balantidium, Opalina* (Fig. 7.9) *and Paramecium* (Fig. 7.10). Mostly reproduction is asexual, but conjugation between compatible strains of ciliates occurs, with a resulting exchange of genetic material.

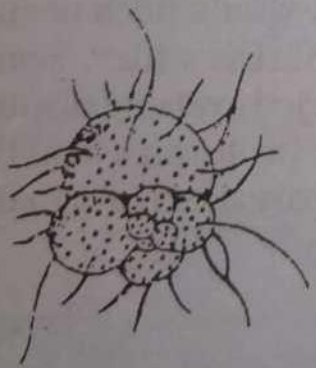


***Fig. 7.8 Globigerina***

***Fig. 7.9 Opalina ranurum***

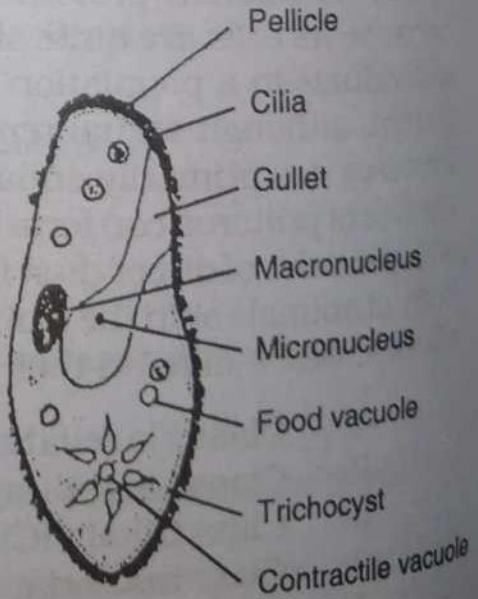



***Fig. 7.10 Paramecium***

**4.** The ***Suctoria:*** Suctorians are closely related to ciliates and appear to have been derived from them in evolution. The suctorians, have both a macronucleus and a micronucleus. Young individuals have cilia and swim about, but the adults are sedentary and have stalks by which they are attached to the substratum. The body bears a group of delicate cytoplasmic tentacles, some of which are pointed to pierce their prey, where as others are at their tips rounded adhesive knobs to catch and hold the prey. The tentacles secrete a toxic material which may paralyse the prey. Reproduction is asexual by budding e.g. Acineta (Fig. 7.11).

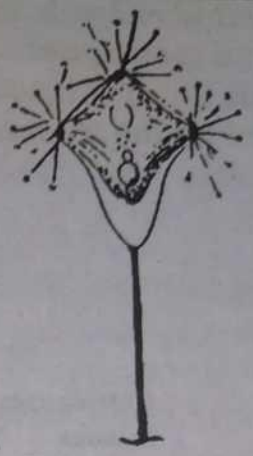


***Fig. 7.11 Suctorian – Acineta tuburosa***

**5.** ***Sporozoa:*** The sporozoans comprise a large group of parasitic protozoa, among which are the agents causing serious diseases such as *Coccidiasis* in poultry and *malaria* in man. Sporozoans have neither locomotory organelles nor contractile vacuole. Most sporozoans live as intracellular parasites in the host cells during the growth phase of their life cycle and absorb nutrients through their cell membrane. Common example of sporozoan are Plasmodium (malarial parasite) and *Monocystis* which lives in the seminal vesicles of earthworm.

### 7.3.1 Life-cycle of Malarial Parasite:

Life-cycle of *Plasmodium* is completed in two hosts: man and female *Anopheles* mosquito. Man serves as primary host whereas mosquito serves as secondary host. The parasite completes its life cycle in two main phases: a) asexual cycle in man and b) sexual cycle in mosquito.

### Asexual cycle in man (Schizogony):

A healthy person acquires infection when a female *Anopheles* mosquito, containing infective stages ***(sporozoites)*** of the parasite in its salivary glands, bites him for sucking his blood. Schizogony comprises of the following phases:

**1.** ***Pre-erythrocytic phase:*** Once within the human blood, the sporozoites invade the hepatic cells within an hour. After penetrating the hepatic cells, each sporozoite grows for number of days and becomes a schizont. It divides to form a large number of uninucleate ***exoerythrocytic (EE) merozoits***. These are liberated when the liver cell bursts. The exoerythrocytic (EE) merozoits may invade fresh liver cells and multiply producing enormous number of new generation. This phase is referred to as pre-erythrocytic phase.

**2.** ***Erythrocytic phase:*** It takes place in R.B.Cs. The exoerythrocytic (EE) merozoits, after escaping into the blood stream, invade the red blood corpuscles. Each becomes rounded and is called **trophozoite**. When it grows in size, the nucleus is

pushed to one side into the peripheral cytoplasm. It resembles a signet ring and is referred to as **signet ring stage**. The ***trophozoite*** ingests a large amount of cytoplasm of the R.B.C. The blood haemoglobin is broken down into its protein component, which is used by the trophozoite. It develops into an active **amoeboid trophozoite**. After

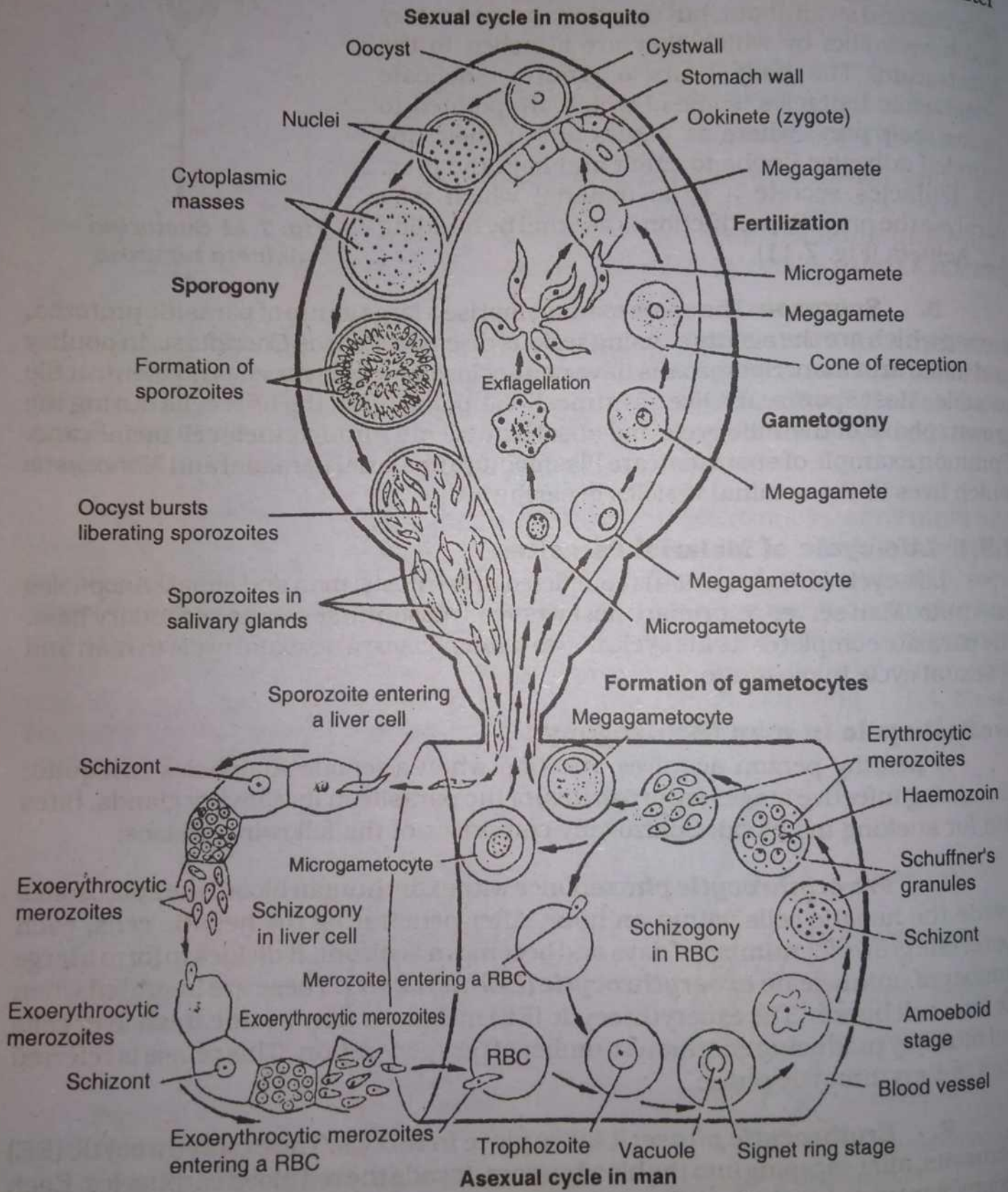



***Fig. 7.12 Life cycle of Plasmodium vivax***

active feeding it becomes rounded, grows in size and becomes a **schizont**. It now undergoes schizogony and produces **erythrocytic (E) merozoites**. With the rupture of R.B.C; the erythrocytic (E) merozoites along with malarial pigments formed by the residue of haemoglobin are liberated into the blood plasma. These erythrocytic merozoits invade fresh corpuscles to repeat the cycle. The time taken to complete one erythrocytic cycle depends upon the species of *Plasmodium*.

**3. Gametocytogenesis:** After few erythrocytic generations, erythrocytic merozoites which invade the R.B.C; increase in size to become *gametocytes*; male or microgametocytes, and female or macrogametocytes. The gametocytes do not divide, but remain within their host blood corpuscle until they are ingested by the vendor, in which they continue their development.

## Sexual cycle in mosquito (Sporogony):

Sexual life-cycle of *Plasmodium* is completed in the gut of female *Anopheles* mosquito resulting in the infective sporozoites. The cycle comprises of the following three stages.

***Gametogony:*** The gametocytes are taken up along with the blood into the stomach of the mosquito. The female gametocytes soon become macrogamete, which is ready to be fertilized. Each male gametocyte forms 6 to 8 sperm-like microgametes by a process of exflagellation.

***Fertilization:*** The two gametes of the opposite sexes fuse together to form a zygote. The process is called ***Syngamy***. The zygote becomes worm-like ***ookinete***. It penetrates the stomach wall to settle down just under the midgut. Here after absorbing the nutrients, it becomes rounded and encycts to form the oocyst.

***Sporogony:*** In 6 to 7 days the nucleus of the oocyst divides into thousands of slender sporozoites by the process of sporogony. The cyst bursts, and the liberated sporozoites are released into the haemocoele from where they migrate towards the salivary glands and wait to be transferred to a human host.

## Symptoms of Malaria:

The symptoms of malaria first appear when infected R.B.Cs are broken. The time taken by the parasite its entry into man upto the breaking down of R.B.Cs is called incubation period. The symptoms that appear in this period of infection include fever, nausea, loss of appetite, constipation and insomnia. Soon headache, muscular pains, aches in the joints develops followed by chills.

At the onset of malarial fever the patient, suffers from shaking chills and sweating. The body temperature may rise as high as 106°F. After few hours of fever, there is a profuse sweating and finally fever disappears. The recurrence of symptoms occurs usually after 48 hours or sometimes earlier.

# KEY POINTS

- Protoctista a group of unicellular eukaryotes which cannot fit any of the other four kingdoms.
- Due to diversification, biologist regard protists kingdom as a polyphyletic group of organisms.
- Plant like protoctists are Algae (Chlorella, Ulva).
- Fungi like protoctists are slime mold and water molds—oomycetes (Phytophthora).
- Animal like protoctists include all protozoans.
- Algae differ from plants by being aquatic and their zygote is not protected by parent body.
- Chlorella is fresh water alga found floating in stagnant water.
- Ulva shows isomorphic alternation of generation.
- Phytophothora is a pathogenic organism causing late blight of potato.
- Protozoa are divided into five classes, which differ in their means of locomotion.
- Amoeba histolytica causes human dysentery.
- Common example of sporozoan is Plasmodium (malarial parasite) causing malaria fever.
- At the onset of malarial fever, the patient suffers from shaking chills and sweating. The body temperature may rise as high as 106°F.

# EXERCISE

**1. Encircle the correct choice:**

(i) Ulva reproducing by quadriflagellate zoospores which has:

(a) 13 Chromosomes (b) Sexual reproduction
(c) Gametophytic phase (d) 26 Chromosomes

(ii) Protoctist having isomorphic alternation of generation

(a) Chlorella (b) Ulva
(c) Euglena (d) Phytophthora

(iii) Animal like phase of slime-mold

(a) Plasmodium (b) Fruiting bodies
(c) Spores (d) Sporangia

(iv) Pyhlophthora infestans causes disease known as

(a) Early blight of potato
(b) Late blight of tomato
(c) Late blight of potato
(d) Early blight of tomato

(v) Plant-like character found in euglena

(a) Flagellum (b) Pellicle
(c) Photoreceptor (d) Pyrenoid

(vi) Class of Protozoa where adults are sedentary

(a) Flagellata (b) Mastigophora
(c) Ciliata (d) Suctoria

(vii) Skeletons of marine shelled sarcodanias gives clues to possible deposits of

(a) Calcium (b) Magnessium
(c) Petroleum (d) Chromium

(viii) Which one is not the stage of plasmodium in mosquito?

(a) Schizogony (b) Gametogony
(c) Syngamy (d) Sporogony

(ix) Term used for asexual cycle of plasmodium in man:

(a) Schizogony (b) Gametogony

(c) Syngamy (d) Sporogony

(x) Which one is not the symptoms of malaria?

(a) Nausea (b) Loss of appetite

(c) Dysentary (d) Shivering

**2. Write detailed answers of the following questions:**

(i) Describe structure and reproduction in ulva.

(ii) Describe two fungi like protoctists.

(iii) Describe in detail protozoa and its classes with examples.

(iv) Describe life cycle of malarial parasite.

(v) Describe diversity among protoctists.

**3. Write short answers of the following questions:**

(i) Why asexual ulva is diploid?

(ii) Why we say that ulva has isomorphic alternation of generation?

(iii) Name the pathogene of late blight of potato and African sleeping sickness.

(iv) What are the symptoms of malaria?

(v) Why asexual and sexual ulva plants are called as sporophyte and gametophyte?

**4. Define the following terms:**

(i) Protoctista (ii) Protozoa

**5. Distinguish between the following:**

(i) Sexual and Asexual Ulva

(ii) Flagellata and sarcodina