CHAPTER

7

THE KINGDOM PROTISTA (OR PROTOCTISTA)

Animation 7.1: Kingdom Protista
Source & Credit: media.giphy

The Kingdom Protista consists of a vast assortment of primarily aquatic eukaryotic organisms whose diverse body forms, types of reproduction, modes of nutrition and lifestyles make them difficult to characterize. Basically, this kingdom is defined by exclusion i.e., all members have characteristics that exclude them from the other four kingdoms.

All protists are eukaryotic and have evolved from prokaryotes. Another reason for creating a separate kingdom arises from the difficulty in placing certain eukaryotic organisms in the appropriate kingdom. This difficulty is a consequence of the fact that the other eukaryotic kingdoms have their evolutionary origin in kingdom Protista. The other eukaryotic kingdoms Plantae, Fungi, and Animalia arose from protists in various ways.

The protists are unicellular, colonial or simple multi cellular organisms that possess a eukaryotic cell organization. Eukaryotic cells, the unifying feature of protists, are common to complex multi-cellular organisms belonging to the three eukaryotic kingdoms (Fungi, Plantae and Animalia) but clearly differentiate protists from members of the prokaryotic kingdom (Monera). Unlike plants and animals, however, protists do not develop from a blastula or an embryo.

The kingdom protista contains four major groups of eukaryotic organisms which are : single celled protozoans, unicellular algae, multicellular algae, slime molds and oomycotes.

HISTORICAL PERSPECTIVE

In 1861, John Hogg proposed the kingdom Protoctista for microscopic organisms. In 1866, Ernst Haeckel suggested creating the Kingdom Protista to include bacteria and other microorganisms (such as *Euglena*) that kingdom. He, however, separated blue green algae and bacteria (prokaryotes) from nucleated protists and placed them in a separate group he called Monera, within the kingdom Protista.

In 1938, Herbert Copeland elevated the prokaryotes to kingdom status, thus separating them from Protista. In five kingdom system of Robert Whittaker (1969) only unicellular eukarayotes were placed in kingdom Protista. Currently this kingdom also includes colonial and simple multicellular eukaryotes as well. Margulis and Schwartz (1988) modified the five kingdom system. Protista or Protoctista is one of the five kingdoms.

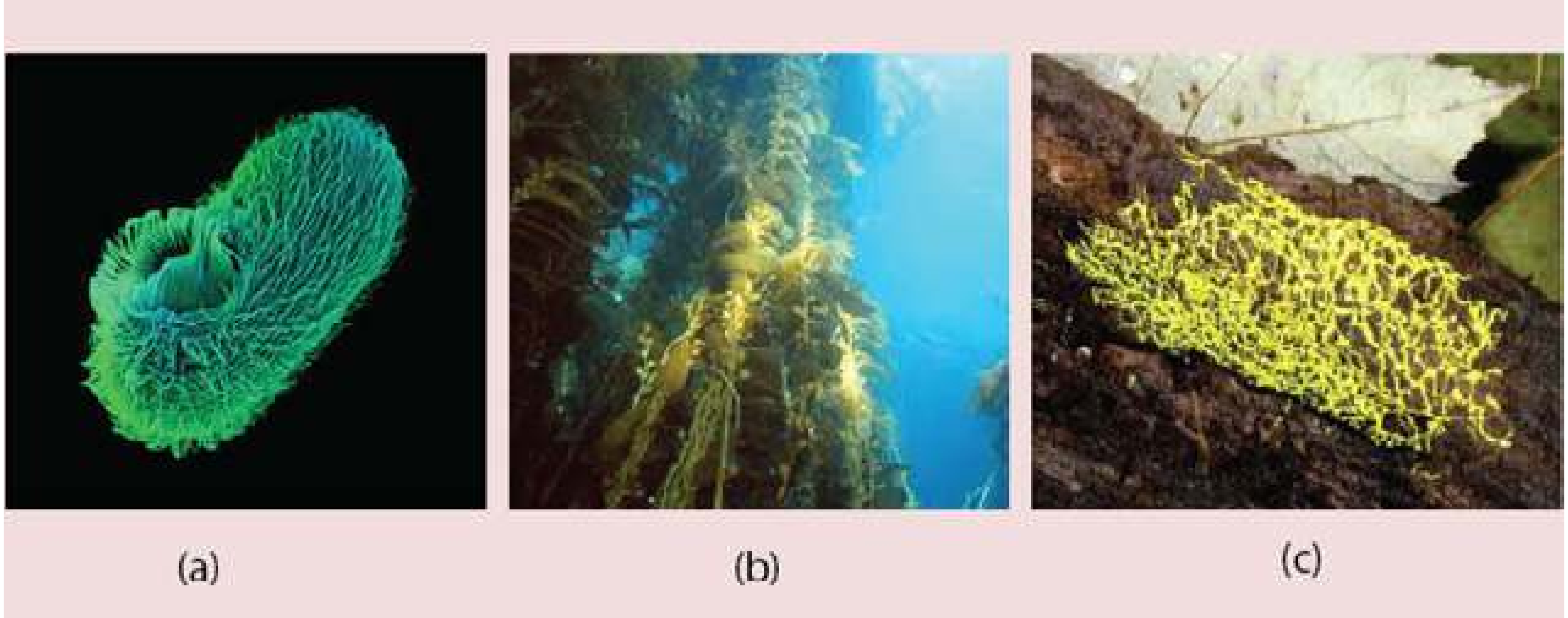


Fig 7.1 The kingdom protista includes such diverse species as (a) single celled ciliated protozoan, (b) giant brown algae (kelps) and (c) slime molds.

DIVERSITY AMONG PROTISTA

During the course of evolutionary history, organisms in the kingdom protista have evolved diversity in their (a) size and structure, (b) means of locomotion, (c) ways of obtaining nutrients, (d) interactions with other organisms, (e) habitat and (f) modes of reproduction. Diversity is exhibited by all of the major protist groups (Fig. 7.1).

Based on the diversity, most biologists regard the protists kingdom as a polyphyletic group of organisms; that is, the protists probably do not share a single common ancestor. Margulis and Schwartz have listed 27 phyla to accommodate this diverse assemblage of organisms.

MAJOR GROUPS OF PROTISTA

1. Protozoa : A. imal - like Protists

All protozoans are unicellular. Most ingest their food by endocytosis. A summary of protozoan diversity is given in Table 7.1.

Table 7.1 Some groups of protozoa

Common Name	Form	Locomotion	Examples
Amoebae	Unicellular, no definite shape	Pseudopods	*Amoeba, Entamoeba,*
Zooflagellates	Unicellular. some colonial	One or more Flagella	*Trypanosoma, Euglena,*
Actinopods	Unicellular	Pseudopods	Radiolarians
Foraminifera	Unicellular	Pseudopods	Forams
Apicomplexans	Unicellular	None	*Plasmodium*
Ciliates	Unicellular	Cilia	*Paramecium, Vorticella. Stentor*

(a) Amoebae:

This group includes all free living freshwater, marine and soil amoebae as well as those that are parasites of animals. Amoebae lack flagella and move by forming specialized cytoplasmic projections called pseudopodia (false feet). (Fig. 7.2).

The intestinal parasite, *Entamoeba histolytica*, causes; amoebic dysentery in humans.

Fig. 7.2 The flowing pseudopods of Amoeba constantly change shape as the organism moves and feeds.

Animation 7.2: Amoeba
Source and Credit: Gifsoup

The Giant Amoeba

The giant amoeba *Pelomyxa palustris* may be the most primitive of all eukaryote like forms. This species has multiple membrane-bound nuclei but none of the other organelles found in all other eukaryotes. The giant amoebas obtain energy from methanogenic bacteria, which reside inside them. Giant amoebas inhabit mud at the bottom of freshwater ponds, where they contribute to the degradation of organic molecules

Animation 7.3: Amoeba
Source and Credit: ironic

(b) Zooflagellates:

These protists are mostly unicellular (a few are colonial) organisms with spherical or elongated bodies with a single central nucleus. They possess from one to many long, whip-like flagella that enable them to move. Flagellates move rapidly, pulling themselves forward by lashing flexible flagella, that are usually located at the anterior end.

Flagellates obtain their food either by ingesting living or dead organisms or by absorbing nutrients from dead or decomposing organic matter. They may be free-living, symbionts or parasites. Trichonymphas are complex, specialized flagellates with many flagella which live as symbionts in the guts of termites and help in the digestion of dry wood (Fig. 7.3a)

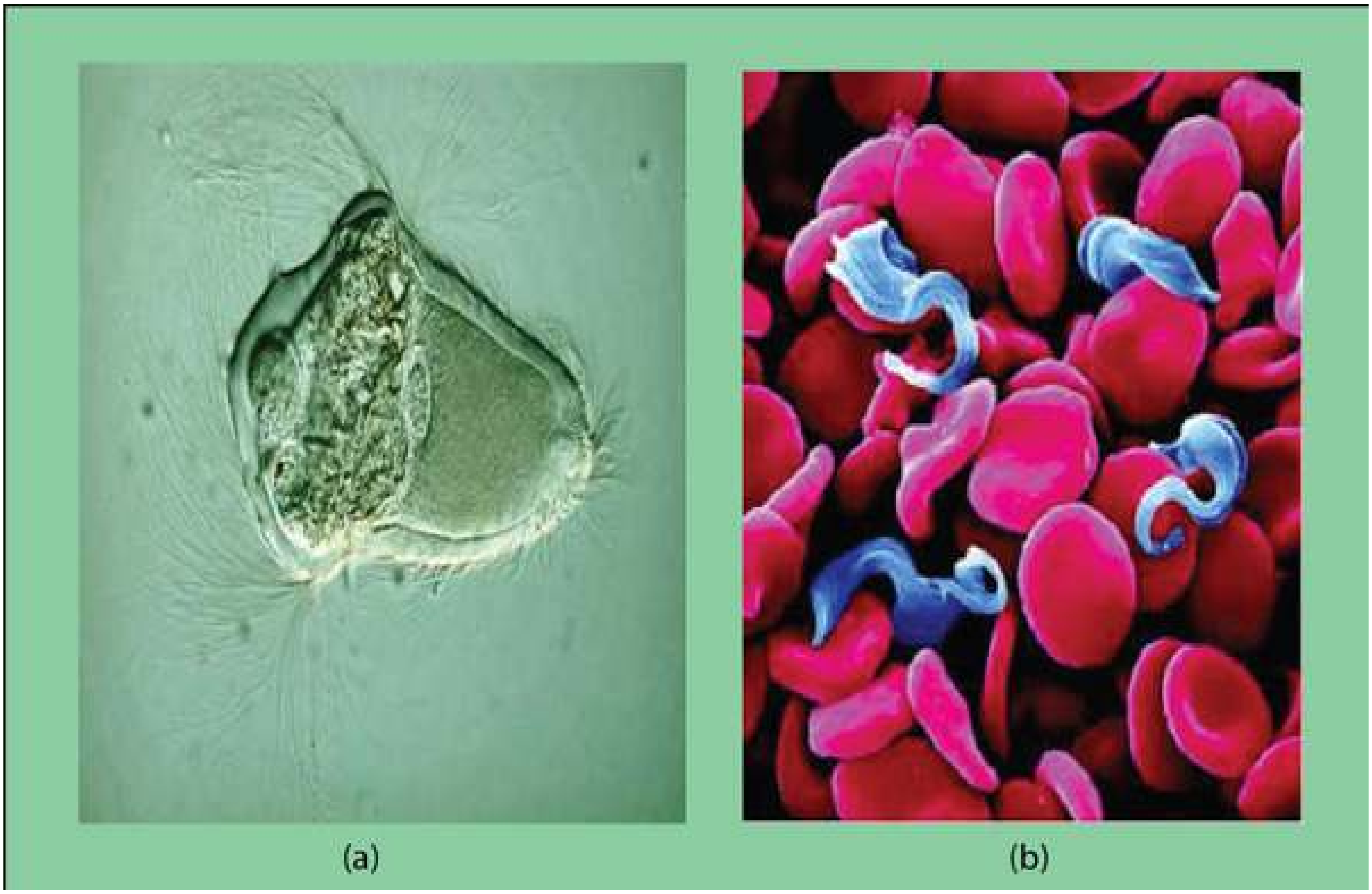


Fig. 7.3 Zooflagellates (a) Trichonympha has hundreds of flagella (b) Trypanosoma causes sleeping sickness.

Animation 7.4: Paramecium Contractile Vacuole
Source and Credit: gif2fly

Parasitic flagellates cause diseases. For example *Trypanosoma* is a human parasite causing African sleeping sickness. It is transmitted by the bite of infected tsetse fly (Fig. 7.3 b)

Choanoflagellates are sessile marine or freshwater flagellates which are attached by a stalk and their single flagellum is surrounded by a delicate collar. They are of special interest because of their striking resemblance to collar cells in sponges (Fig. 7.4).

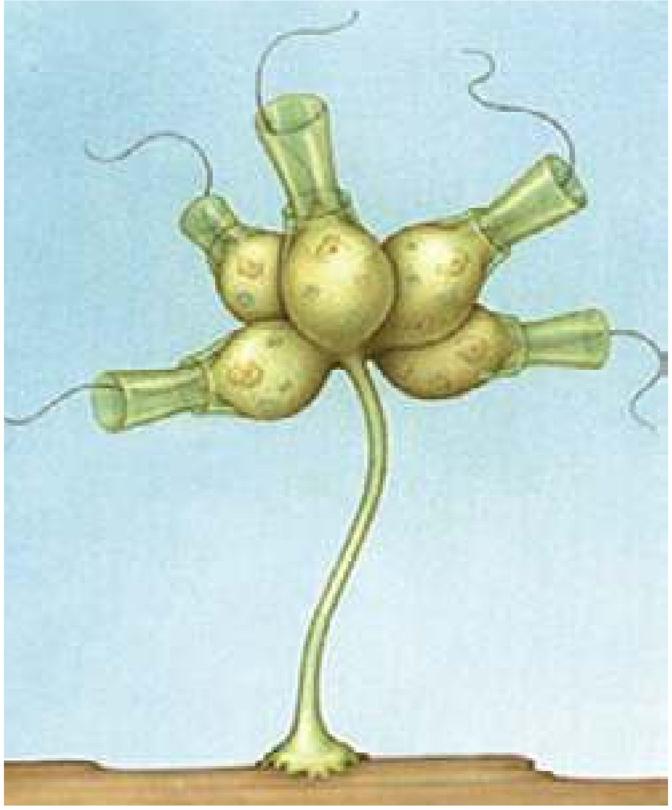
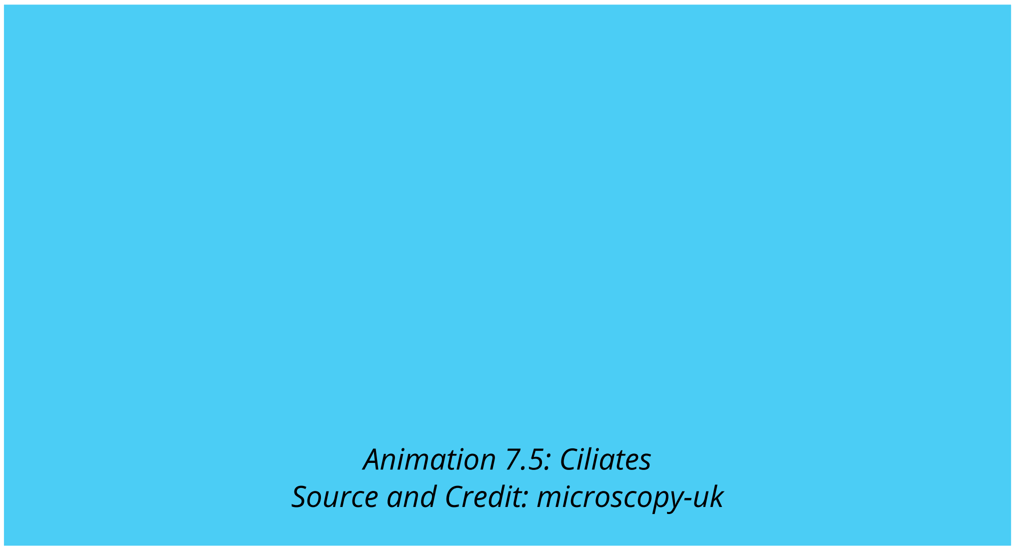


Fig. 7.4 A colonial choanoflagellate

(c) Ciliates

Ciliates are unicellular organisms with a flexible outer covering called a pellicle that gives them a definite but changeable shape. In *Paramecium*, the surface of the cell is covered with several thousand fine, short, hair-like structures called cilia. The cilia beat in such a precisely coordinated fashion that the organism can go forward, can also go back and turn around.

Some ciliates are sessile and remain attached to a rock or other surface. Their cilia set up water currents that draw food towards them. Most ciliates ingest bacteria or other tiny protists.



Animation 7.5: Ciliates
Source and Credit: microscopy-uk

Fig. 7.5 (a) Paramecium, conjugating individuals (b) Stentor, a sessile ciliate.

Water regulation in freshwater ciliates is controlled by special organelles called contractile vacuoles. Ciliates differ from other protozoans in having two kinds of nuclei. One or more small diploid micronuclei that function in sexual process, and a large, polyploid macronucleus that controls cell metabolism and growth. Most ciliates are capable of a sexual process called conjugation. During conjugation two individuals come together and exchange genetic material (Fig. 7.5).

Animation 7.6: Paramecium Reproduction
Source and Credit: buzzle

Animation 7.7: Paramecium Contractile Vacuole
Source and Credit: gif2fly

(d) Foraminiferans and Actinopods

These marine protozoans produce shells (or tests). Tests of foraminifera are made of calcium whereas those of actinopods are made of silica. The shells or tests contain pores through which cytoplasmic projections can be extended. These cytoplasmic projections form a sticky, interconnected net that entangles prey. Dead foraminiferans sink to the bottom of the ocean where their shells form a grey mud that is gradually transformed into chalk. Foraminiferans of the past have created vast limestone deposits.

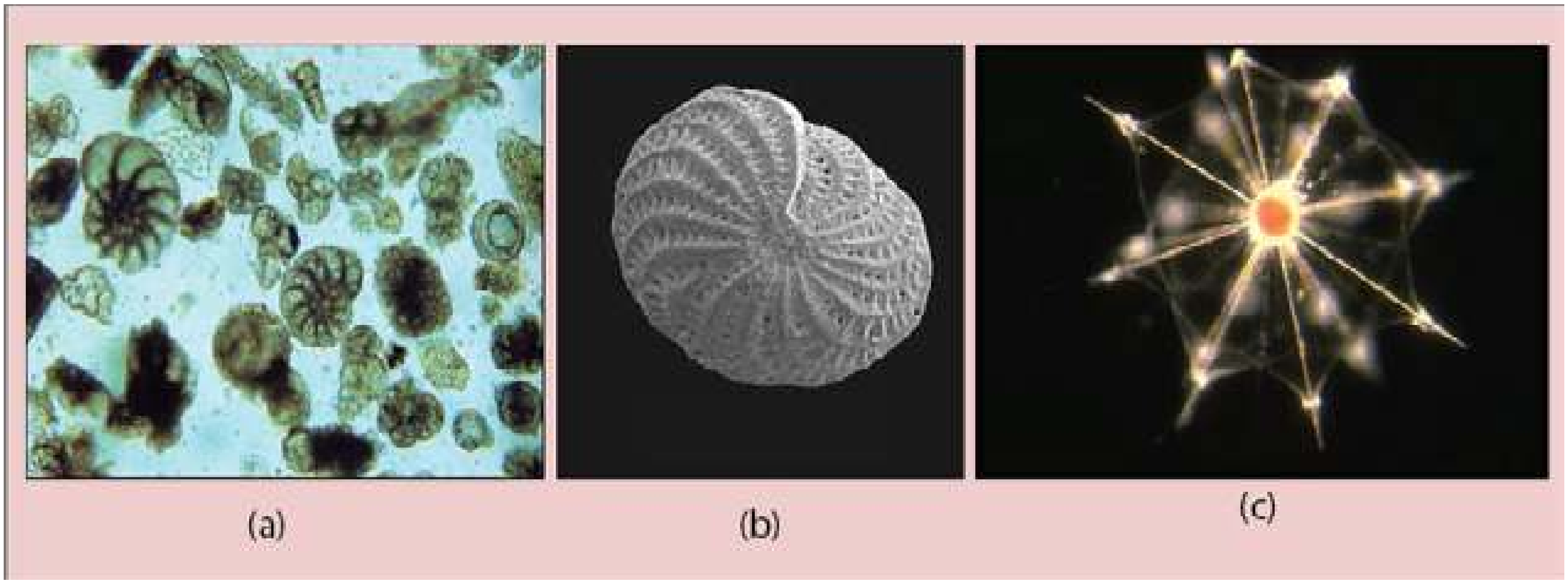


Fig. 7.6 (a) Foraminiferan tests have (a) beautiful geometric patterns and (b) pores through which cytoplasmic projections are extended (c) Radiolarians are actinopods with glassy shells.

(e) Apicomplexans

Apicomplexans are a large group of parasitic protozoa, some of which cause serious diseases such as malaria in humans. Apicomplexans lack specific structures for locomotion but move by flexing. At some stage in their lives, they develop a spore, a small infective agent transmitted to the next host. Many Apicomplexans spend part of their life in one host and part in a different host species (Fig. 7.7).

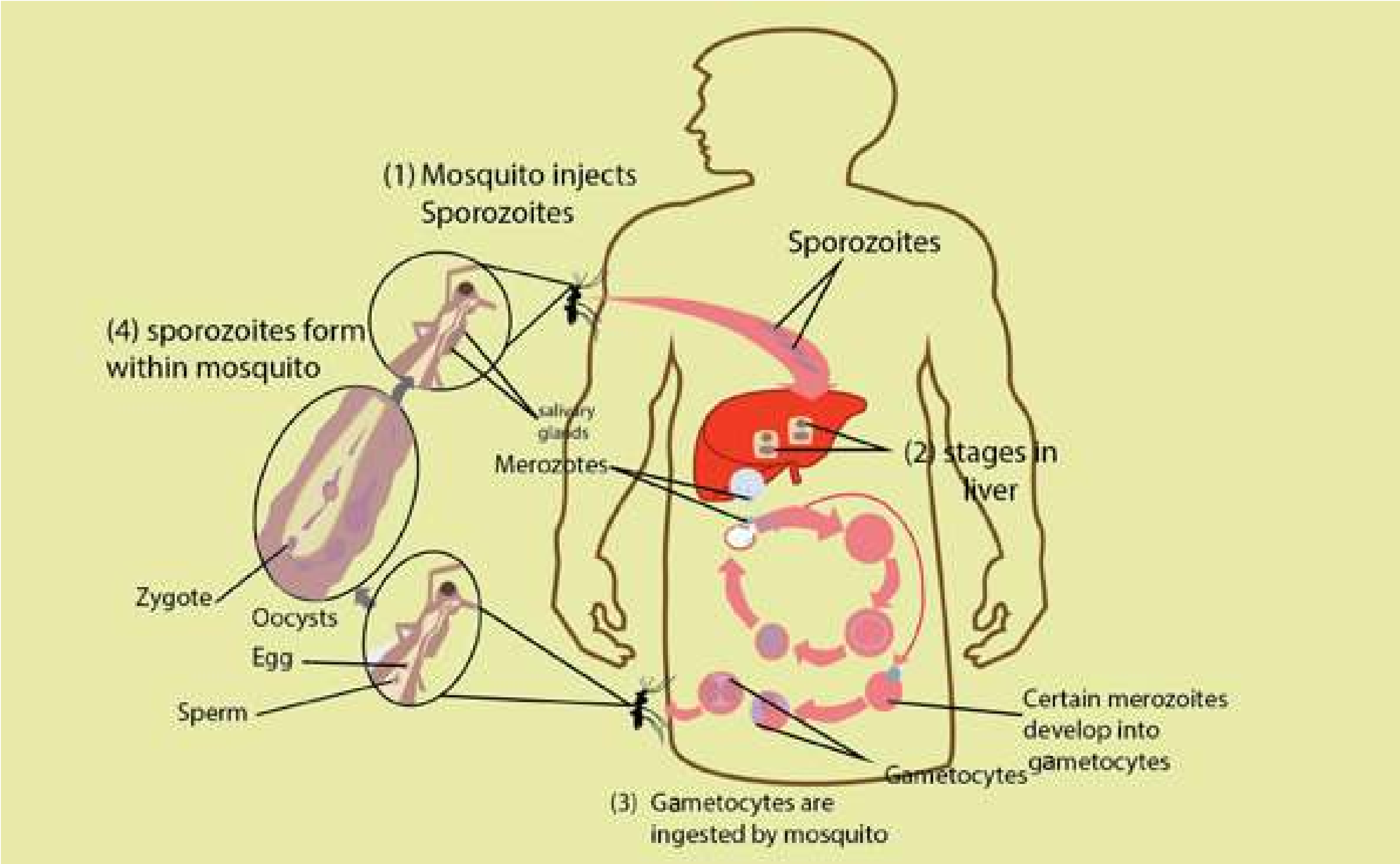


Fig. 7.7 The life cycle of the malarial parasite (Plasmodium).

Plasmodium, the apicomplexan that causes malaria, enters human blood through the bite of an infected female Anopheles mosquito. Plasmodium first enters liver cells and then red blood cells, where it multiplies. When each infected red blood cell bursts, many new parasites are released. The released parasites infect new red blood cells, and the process is repeated. The simultaneous bursting of millions of red cells causes the symptoms of malaria; a chill, followed by high fever caused by toxic substances that are released and affect other organs of the body (Fig. 7.7).

2. The Algae: Pla. t like protists

Algae (singular alga) are photosynthetic protists, carrying out probably 50 to 60 percent of all the photosynthesis on earth (plants account for most of the rest).

Algae differ from the plants in their sex organs which are unicellular and the zygote is not protected by the parent body. A plant zygote, on the other hand, grows into a multicellular embryo that is protected by parental tissue.

Algae exhibit a remarkable range of growth forms. Some are unicellular; others are filamentous. Filaments are composed either of distinct cells or coenocytes (multinucleate structures that lack cross-walls), still others (e.g. seaweeds) are multicellular and intricately branched or arranged in leaf-like extensions. A body which is not differentiated into true roots, stems and leaves and lacks xylem & phloem is called a **thallus**.

In addition to green chlorophyll a, yellow and orange carotenoids, which are photosynthetic pigments are found in all algae, other algal phyla possess a variety of other pigments (such as xanthophylls and phycoerythrin) that are also important in photosynthesis. Classification into phyla is largely based on their pigment composition.

Algal life cycles show extreme variation, but all algae except members of the phylum Rhodophyta (red algae) have forms with flagellated motile cells in at least one stage of their life cycle.

Almost all algae are aquatic. When actively growing, algae are restricted to damp or wet environments, such as the ocean; freshwater ponds, lakes, and streams; hot springs; polar ice; moist soil, trees, and rocks. Table 7.2 summarizes the classification of algae.

Animation 7.8: Algae cell,
Source and Credit: progressive-charlestown

Table 7.2 Classification of the photosynthetic Protoctists

Phylum	Common name	Form	Locomotion	Pigments	Examples
Euglenophyta	Euglenoids	Unicellular	Two flagella one long one short	Chl. *a*, Chl. *b* Carotenoids	*Euglena*
Pyrrophyta	Dinoflagellates	Unicellular	Two flagella	Chl. *a*, Chl. *c* Carotenes including Fucoxanthin	*Gonyaulax, Ceratium*
Chrysophyta	Diatoms	Usually unicellular	Usually none	Chl. *a*, Chi. *c* Carotenes including Fucoxanthin	*Diatoma, Frequilaria Pinnularia*
Phaeophyta	Brown algae	Multicellular	Two flagella on reproductive cells	Chl. *a*, Chl. *c* Carotenes including Fucoxanthin	*Fucusi Macrocvstis*
Rhodophyta	Red algae	Multicellular or unicellular	None	Chl. *a*, carotenes Phycoerythrin	*Chondrus Polysiphonia*
Chlorophyta	Green algae	Unicellular, colonial, multicellular	Most have flagella	Chl. *a*, Chl. *b*. carotenes	*Chlorella, Ulva, Acetabularia Spirogyra*

Animation 7.9: Euglenam
Source and Credit: microscopy-uk

(I) The Euglenoids

Euglenoids have at various times been classified in the plant kingdom (with algae) and in animal kingdom (in protozoans). Based on molecular data, euglenoids are thought to be closely related to zooflagellates. They are plant like in their pigments. However, some photosynthetic euglenoids lose their chlorophyll when grown in dark and obtain their nutrients heterotrophically by ingesting organic matter. Other species of euglenoids are always colourless and heterotrophic (Fig. 7.8).

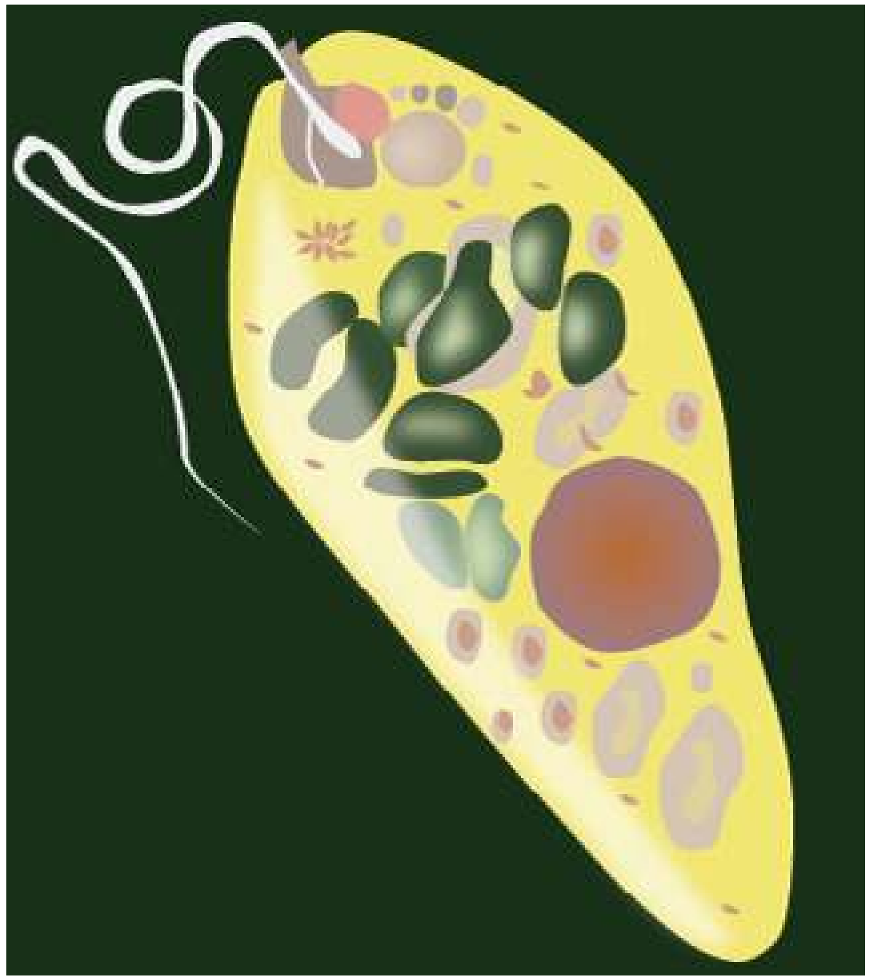
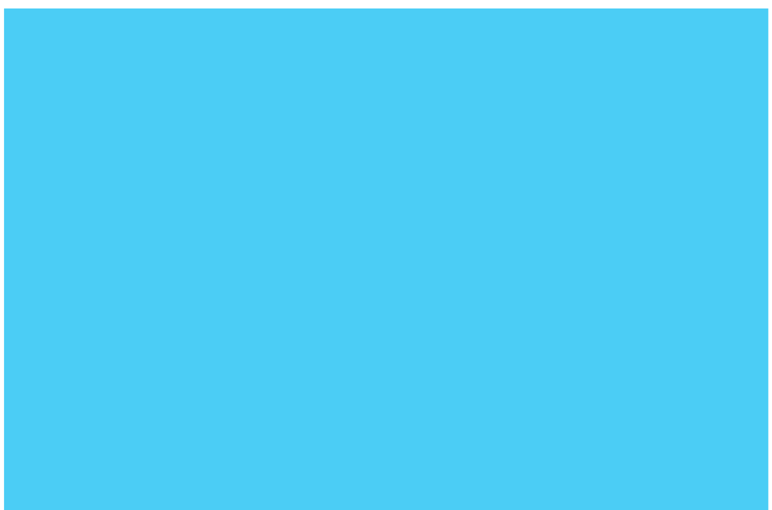


Fig 7.8 : Euglenoids have special evolutionary significance as they resemble with plants and green algae in having similar pigments and, on the other hand, are also related One of the most unusual protist to zooflagellates.



Animation 7.10: Euglenoids,
Source and Credit: gifsoup

Animation 7.11: Euglenoids
Source and Credit: sgprotist.files.wordpress

(ii) Dinoflagellates

One of the most unusual protist phyla is that of dinoflagellates. Most dinoflagellates are unicellular. Their cells are often covered with shells of interlocking cellulose plates impregnated with silicates.

Ecologically, dinoflagellates are one of the most important groups of producers (second only to diatoms) in marine ecosystem. Dinoflagellates are known to have occasional population explosions or blooms. These blooms frequently colour the water orange, red or brown and are known as red tides (Fig. 7.9).

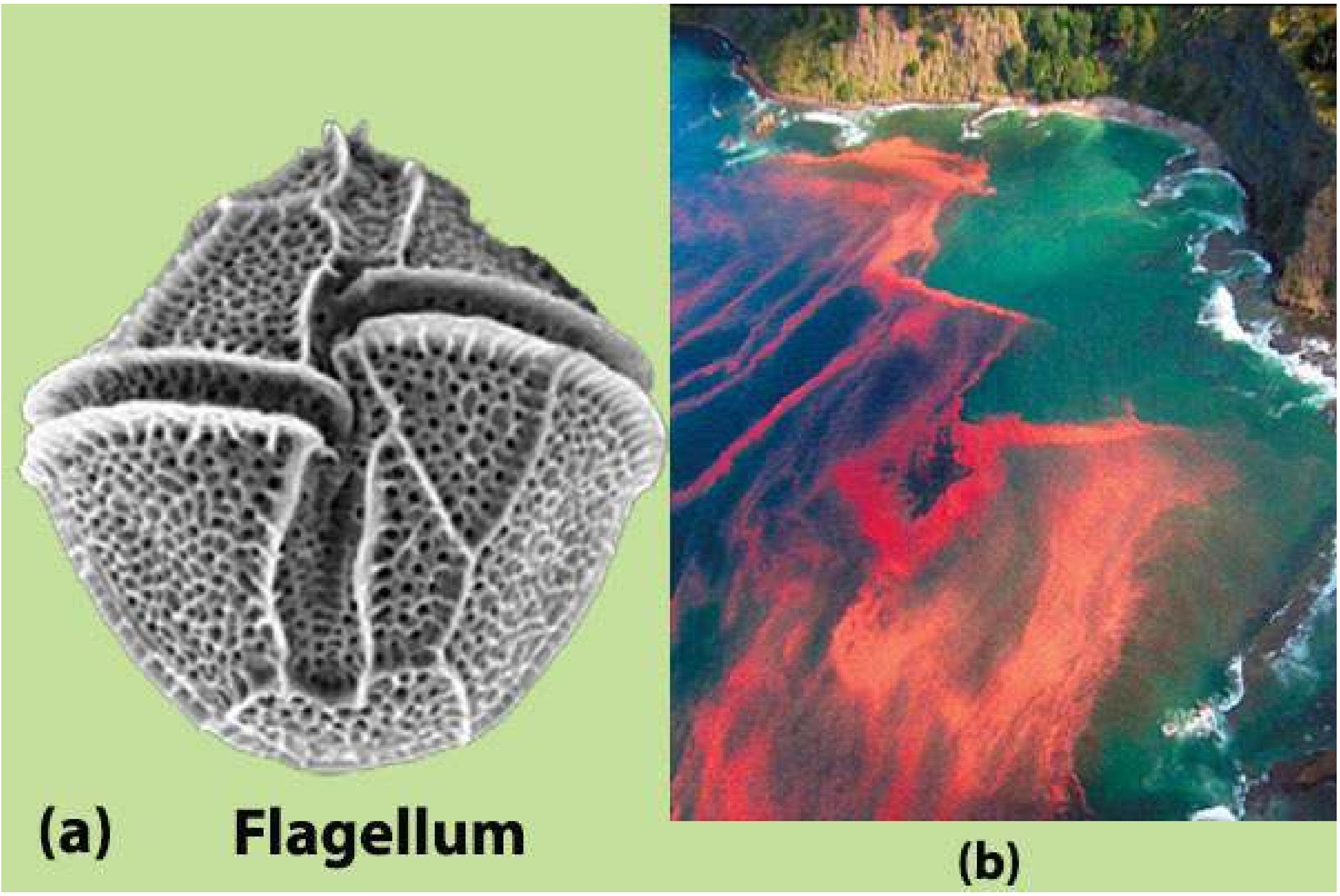


Fig. 7.9 (a) A dinoflagell ate showing cellulose plates in the shell and flagella located in the grooves, (b) A red tide.

Animation 7.12: Dinoflagellates
Source and Credit: microscopy-uk

(iii) Diatoms

The cell wall of each diatom consists of two shells that overlap where they fit together, much like a petri dish. Silica is deposited in the shell, and this glasslike material is laid down in intricate patterns.

Fig. 7.10 Diatoms have silica shells with extremely beautiful symmetrical patterns

Diatoms are the major producers in the aquatic (marine and freshwater) ecosystems because of their extremely large numbers. Diatoms are very important in aquatic food chains (Fig. 7.10).

Animation 7.13: Diatoms
Source and Credit: 49.media.tumbl

Animation 7.14: Diatoms
Source and Credit: infinity-usa

(iv) Brown Algae

Brown algae include the giants of the protist kingdom. All brown algae are multicellular and range from a few centimeters to approximately 75 meters in length. The largest brown algae, called the kelps are tough and leathery in appearance. They possess leaflike blades, stemlike stipes, and rootlike anchoring holdfast. Brown algae are common in cooler marine waters, especially along rocky coastlines in the intertidal zone (Fig. 7.11).

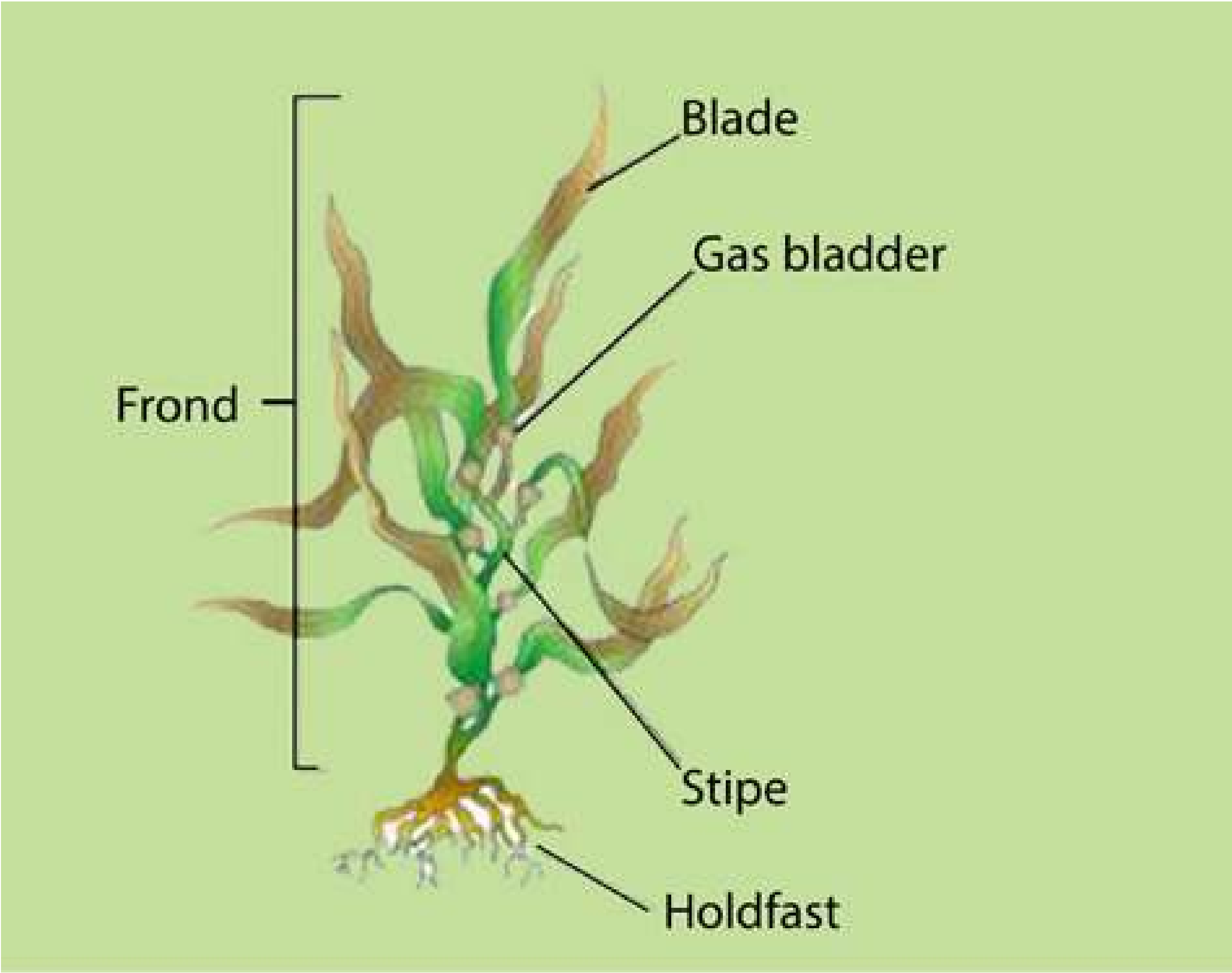


Fig. 7.11 Laminaria, a brown alga showing blades, stipes and holdfast

Animation 7.15: Brown algae
Source and Credit: easterncapescubadiving

(v) Red Algae

The multicellular body form of red algae is commonly composed of complex interwoven filaments that are delicate and feathery. A few red algae are flattened sheets of cells. Most multicellular red algae attach to rocks or other substances by a basal holdfast. Some red algae incorporate calcium carbonate in their cell walls from the ocean and take part in building coral reefs alongwith coral animals (Fig. 7.12).

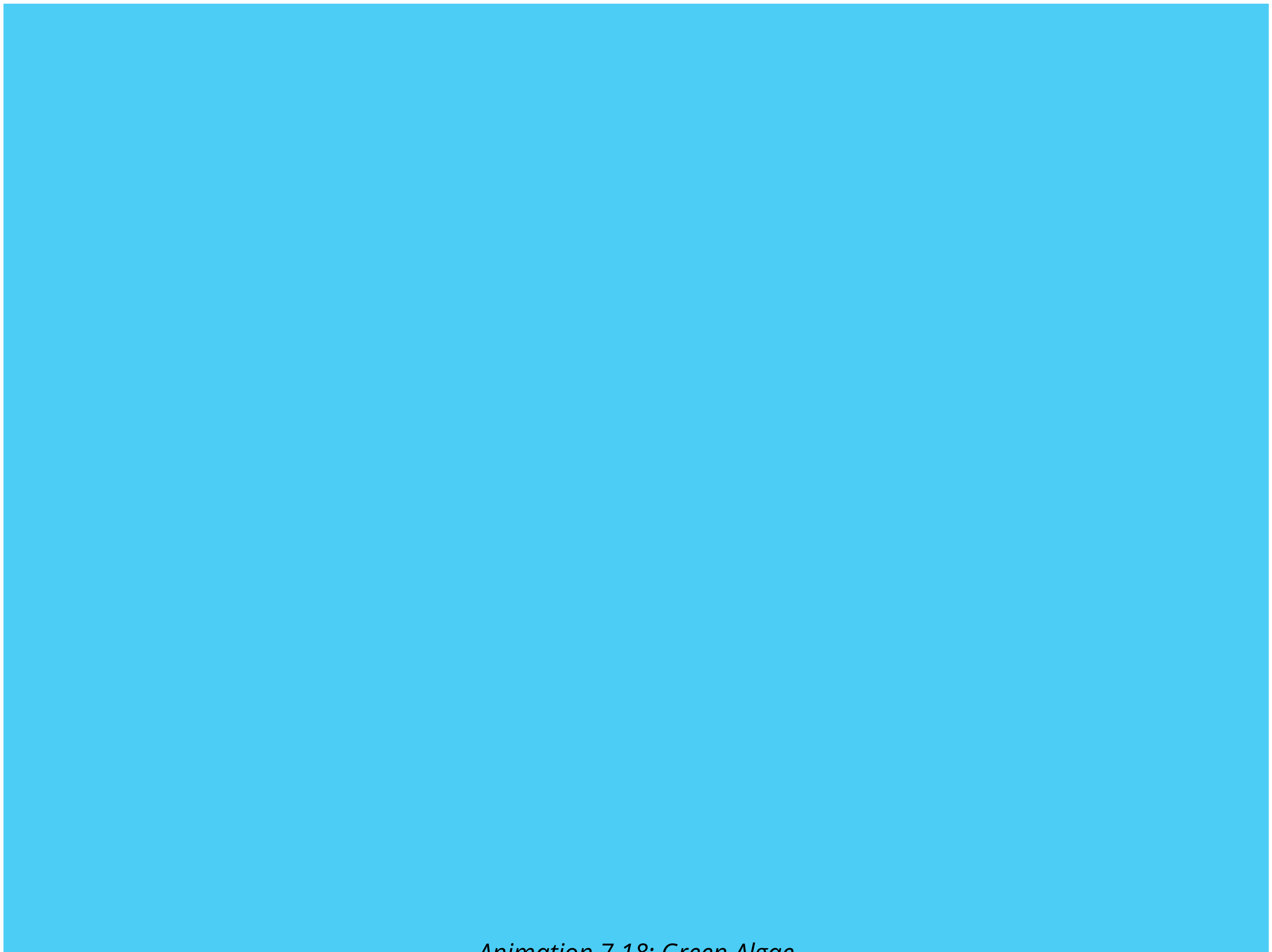
Fig. 7.12 Polysiphonia is a representative red alga with world wide distribution

Animation 7.16: Red Algae
Source and Credit: easterncapescubadiving

Animation 7.17: Red Algae
Source and Credit: makeagif

(vi) Green Algae

Green algae have pigments, energy reserve products, and cell walls that are identical to those of plants. Green algae are photosynthetic, with chlorophyll a, chlorophyll b, and carotenoids present in the chloroplasts. Their main energy reserves are stored as starch. Most green algae possess cell walls with cellulose. Because of these and other similarities it is generally accepted that plants arose from ancestral green algae. Evidence from RNA sequencing also indicates that green algae and the plants form a monophyletic lineage (Fig. 7.13).



Animation 7.18: Green Algae
Source and Credit: easterncapescubadiving

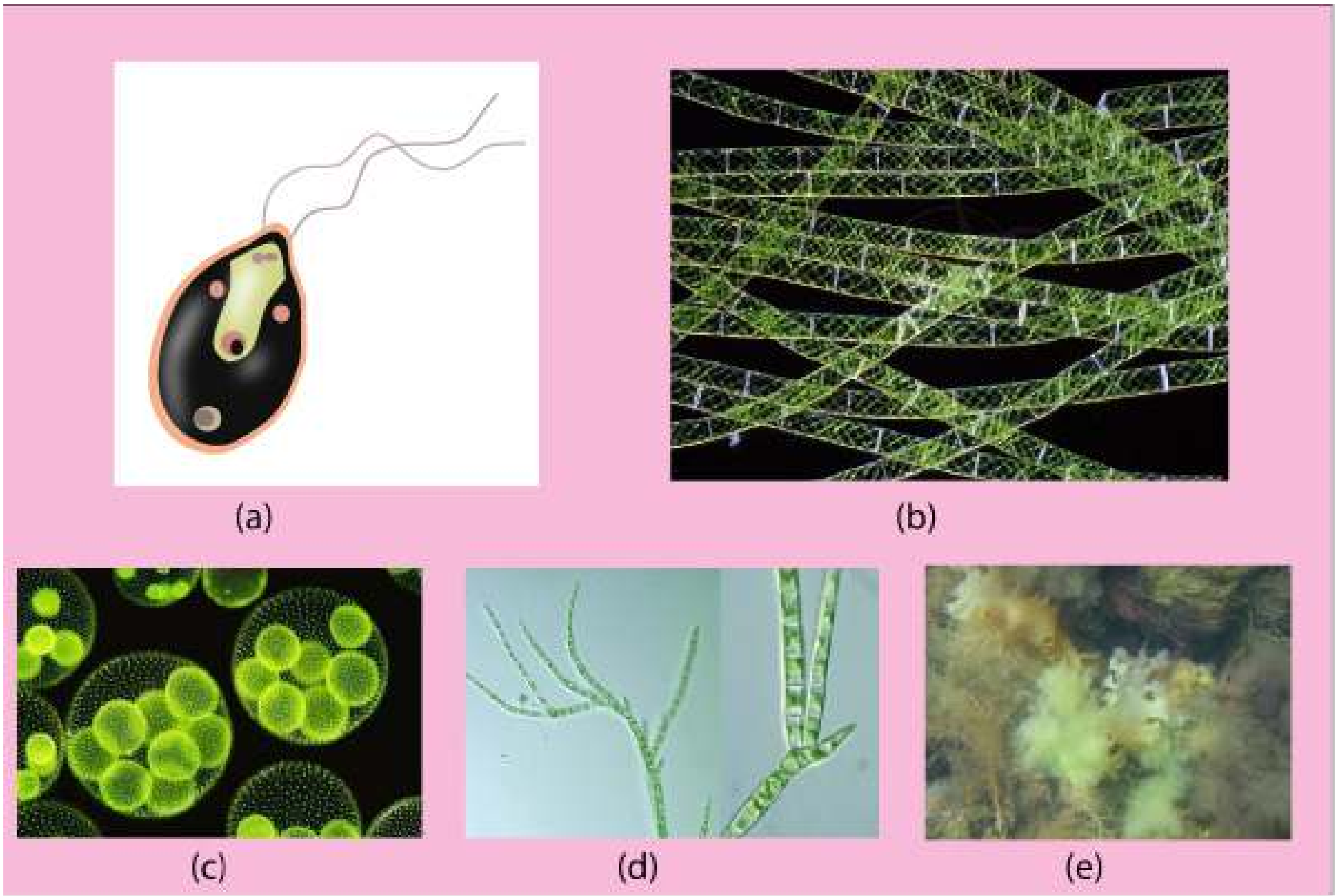
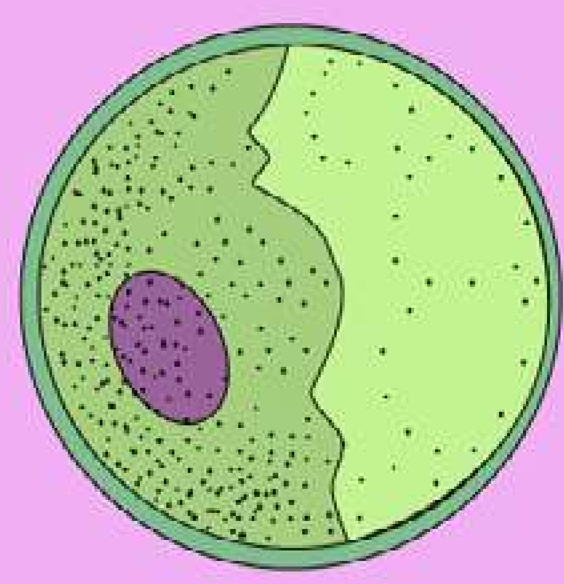


Fig. 7.13 Green algae exhibit diverse forms, (a) Unicellular Chlamydomonas (b) Desmids have cells with two halves. (c) Colonial Volvox (d) Filamentous Spirogyra (e) Ulva, having sheet like body.



Chlorella is a unicellular non-motile green alga. Its habitat is fresh water ponds and ditches. 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.

Importance of Algae

Algae have great economic and environmental importance for us. Some algae such as kelps are edible and may be used to overcome shortage of food in the world. Marine algae are also source of many useful substances like algin, agar, carrageenan, and antiseptics. Algae are major producers of the aquatic ecosystem, thus they play a basic role in food chains, providing food and oxygen to other organisms.

3. FUNGUS-LIKE PROTISTS

Some protists superficially resemble fungi in that they are not photosynthetic and some have bodies formed of threadlike structures called hyphae. However, funguslike protists are not fungi for several reasons. Many of these protists have centrioles and produce cellulose as a major component of their cell walls, whereas fungi lack centrioles and have cell walls of chitin. Two major groups of fungus-like protists are : Slime molds and water molds (oomycotes).

(i) Slime molds or Myxomycota

The feeding stage of a slime mold is a plasmodium, a multinucleate mass of cytoplasm that can grow to 30 cm (1 ft) in diameter. The plasmodium, which is slimy in appearance, streams over damp,

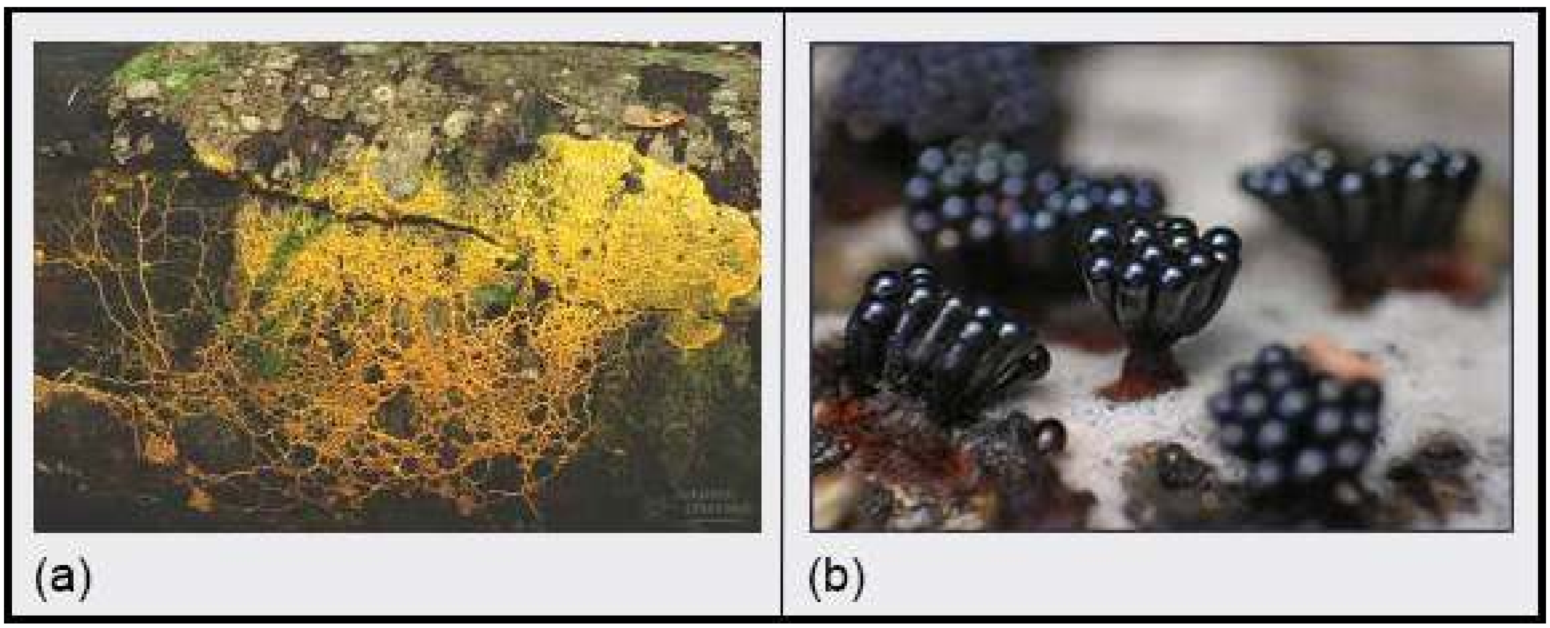


Fig. 7.14 Slime mold **Physarum** *(a) The plasmodium is a naked mass of cytoplasm having many nuclei. (b) Reproductive structures are stalked sporangia.*

decaying logs and leaf litter. It often forms a network of channels that cover a large surface area. As it creeps along, it ingests bacteria, yeasts, spores and decaying organic matter (Fig. 7.14).

During unfavourable condition, slime mold forms resistant haploid spore by meiosis within stalked structures called sporangia. When conditions become favourable again, spores germinate into biflagellated or amoeboid reproductive or swarm cells which unite to form diploid zygote. Zygote produces multinucleate plasmodium, each nucleus being diploid.

The plasmodial slime mold *Physarum polycephalum* is a model organism that has been used to study many fundamental biological processes, such as growth and differentiation, cytoplasmic streaming, and the function of cytoskeleton.

Animation 7.19: Slime mould
Source and Credit: 49.media.tumbl

Animation 7.20: Slime mold physarum
Source and Credit: waynesword.palomar

Water molds or Oomycotes

Oomycotes show close relations with the fungi and have a similar structure, but are now regarded as more ancient group. Their cell walls contain cellulose, not chitin. Their hyphae are aseptate (without cross walls). Oomycotes include a number of pathogenic organisms, including ***Phytophthora infestans***, which have played infamous roles in human history.

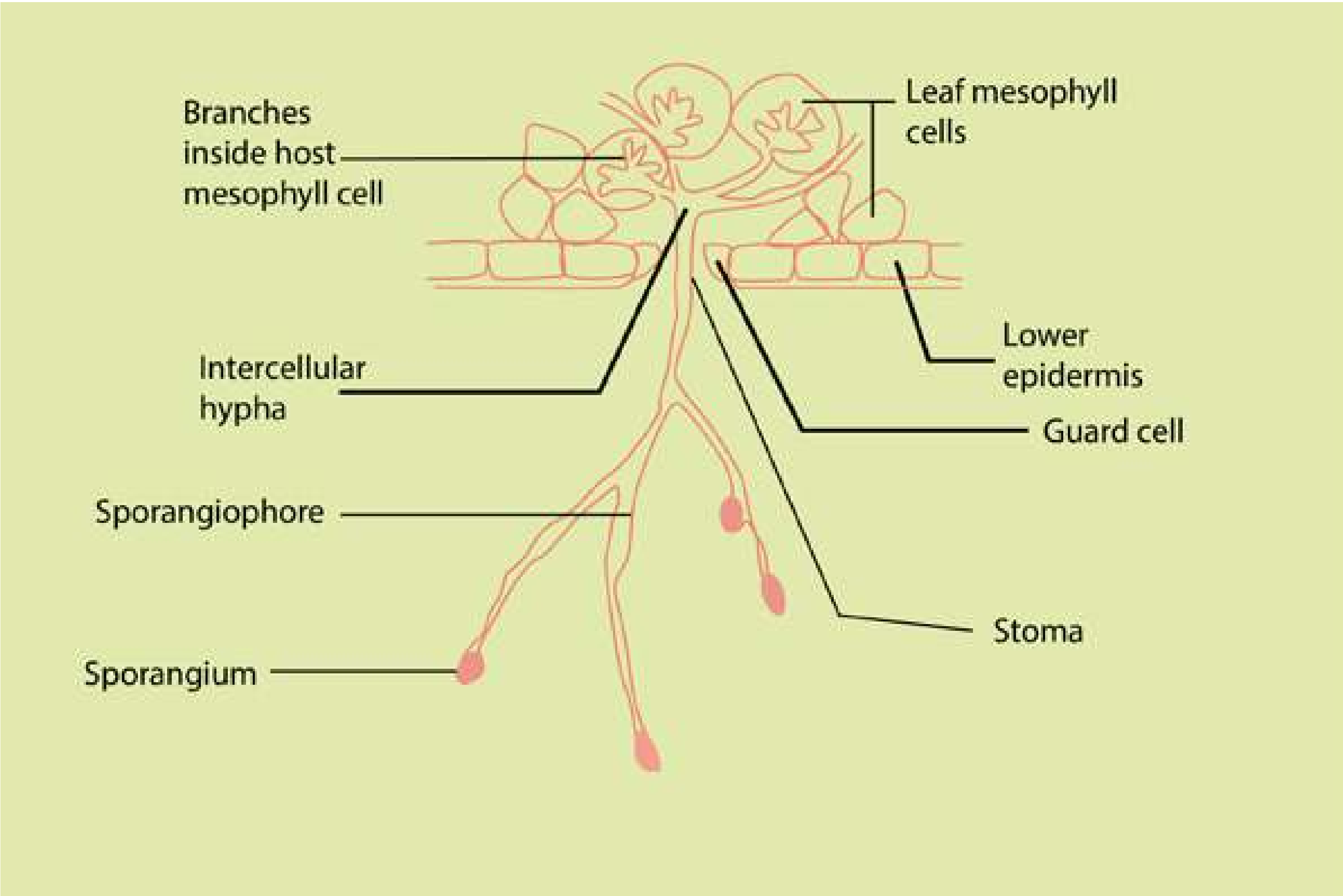


Fig. 7.15 Phytoplithora infestans growing in a diseased potato leaf, with sporangiophores emerging from the underside of the leaf.

Phytophthora infestans was the cause of Irish potato famine of the 19th century. It causes a disease commonly known as late blight of potatoes. Because of several rainy, cool summers in Ireland in the 1840's, the water mold multiplied unchecked, causing potato tubers to rot in the fields. Since potatoes were the staple of Irish peasants' diet, many people (250,000 to more than 1 million) starved to death. The famine prompted a mass migration out of Ireland to such countries as the United States (Fig. 7.15).

EXERCISE

Q.1. Short Questions

Write two characteristics of each of the following groups:

(i) Protozoa (ii) Dinoflagellates

(iii) Diatoms (iv) Slime molds

(iv) Oomycetes

Q.2. Extensive question.

(i) Discuss important features of protists. Why are protists so difficult to classify?

(ii) What are the reasons for grouping simple eukaryodc organisms into a separate kingdom, protista?

(iii) How are protists important to humans? What is their ecological importance?

(iv) What are three major groups of protists?

(vi) Discuss general characteristics of algae.

(vii) Green algae are considered ancestral organisms of green land plants. Discuss.

(viii) What features distinguish Oomycotes from fungi?

(ix) Describe structure and reproduction of slime molds.