CHAPTER 7

PROTISTS AND FUNGI

Major Concepts:

Number of allotted teaching periods: 11

7.1 Protists – The Evolutionary Relationships (1 Period)

7.2 Major groups of Protists (4 Periods)

7.3 General characteristics of Fungi (1 Period)

7.4 Diversity among Fungi (3 Periods)

7.5 Importance of Fungi (2 Periods)

Kingdom Protista consists of a vast assortment of primarily aquatic organisms whose diverse body forms, types of reproduction, modes of nutrition, and life styles make them difficult to characterize. Biologists estimate that there are as many as 200,000 living species of protists—unicellular or simple multicellular organisms that possess a eukaryotic cellular organization. The word **protist**, from the Greek, meaning "the very first," reflects the idea that protists were the first eukaryotes to evolve. Protists are defined by exclusion from other groups.

7.1 PROTISTS – The Evolutionary Relationship

Eukaryotic cells, the unifying feature of protists, are common to complex multicellular organisms from three other kingdoms (fungi, animals, and plants) but clearly separate protists from members of the kingdom Prokaryotae (bacteria). Eukaryotic cells have nuclei and other membrane-bounded organelles such as mitochondria and plastids. There is no universal acceptance among biologists about what comprises a "protist." Many biologists, interpret the protist kingdom broadly to include heterotrophic protists (the protozoa, slime molds, and water molds) and autotrophic protists (the algae).

Polyphyletic Origin

The protist kingdom is a **polyphyletic group** of organisms; that is, protists do not share a single common ancestor. Any eukaryotic organism not considered a fungus, animal, or plant is classified in the protistic kingdom solely for convenience. If a cladist were classifying these organisms into monophyletic kingdoms, **kingdom Protista** would be split into numerous kingdoms-perhaps as many as twenty.

Protists Exibit Ramarkable Variation

The **size** varies considerably within the protist kingdom, from microscopic protozoa to giant kelps, which are brown algae that can reach 60 metres (almost 200 feet) in length. Although most protists are unicellular, some have a colonial organization (a colony is a loose aggregation of cells), some are **coenocytic** (multinucleate but not multicellular), and some are multicellular. Unlike animals, fungi, and plants, multicellular protists have relatively simple body forms without specialized tissues.

Methods of obtaining nutrients differ widely in kingdom protista. The autotrophic protists, e.g. the algae have chlorophyll and photosynthesize as plants do. Some of the heterotrophic protists, the water molds, obtain their food by absorption as fungi do. Other heterotrophs i.e. the protozoa and slime molds resemble animals i.e. they ingest food derived from the bodies of other organisms. The **mode of life** shows that many protists are free living while others form symbiotic association with different organisms. These associations range from **mutualism**, a more or less equal partnership in which both organisms benefit, to **parasitism** in which one organism lives on or in another and is metabolically dependent on it. Most protists are aquatic and live in oceans or fresh water. They make up a part of the **plankton**.

Reproduction is quite varied in the kingdom protists. All protists reproduce asexually and many also reproduce sexually with both meiosis and syngamy (the union of gametes). However most protists do not develop multicellular sex organs, nor do they form embryos.Most protists are motile at some stage of their life cycle and have various means of **locomotion**. Movement may be accomplished by **amoeboid motion** i.e. extending cell protrusions, by waving cilia or by lashing **flagella**. Many protists use a combination of two or more means of locomotion e.g. both flagellar and amoeboid motion.

> Protists are divert group of organisms. The manner in which protists are currently divided is artificial.

7.2 MAJOR GROUPS OF PROTISTS

Protists include four major groups: Protozoa, Algae, Myxomycota and Oomycota. We will discuss the **salient features** of major groups of protists.

PROTOZOA: The Animal Like Protists

The name protozoa comes from the Latin word meaning "first animals" (sing, protozoon). The name was first given to animal like organisms that are not multicellular and the term protozoa is used today to designate an informal group of protists that ingest food. Protozoa are polyphyletic group.

Protozoans are mostly aquatic, **fresh water** e.g. *Amoeba*, *Paramecium*, **parasitic** e.g. *Plasmodium, Entamoeba histolytica*. Some are **marine** e.g. Actinipods. Body of the protozoan is a single mass of cytoplasm and consists of one cell containing all the structures of a typical cell. Protozoan show all the features of life e.g. nutrition, respiration, locomotion, homeostasis, reproduction etc. Protozoans have organelles called **vacuoles** to perform special function. Their food is digested inside food vacuoles. Fresh water protozoan have **contractile vacuoles** for the elimination of water. Some protozoans have shell e.g. foraminifera.

Reproduction takes place by asexual and sexual method. The organs of **locomotion** are pseudopodia e.g. *Amoeba*, cilia e.g. *Paramecium*, flagella e.g. *Trypanosoma*, the parasitic protozoans do not have any specific means of locomotion e.g. *Plasmodium* (malarial parasite). **Regeneration** is common in protozoans. Protozoans form resistant cyst to overcome unfavourable conditions.

Amoebas

They are free-living organisms found in fresh water, marine, soil, and also as parasites of animals. *Amoeba* move and feed with the help of pseudopodia e.g. *Amoeba proteus*, *Entamoeba histolytica*

Zooflagellates

Protozoa that move by means of flagella are called zooflagellates. *Trypanosoma* (fig. 7.2 a) is a human parasitic flagellate. It is transmitted by the bite of tse-tse (se-se) fly and it is the cause of African sleeping sickness.

Choanoflagellate is a marine or fresh water flagellate, is sessile and remains attached by a stalk. Flagellum is surrounded by a delicate collar which resembles the collar cell of sponges (fig. 7.2 b).

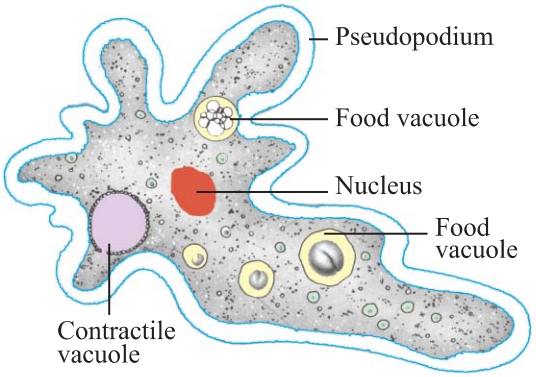
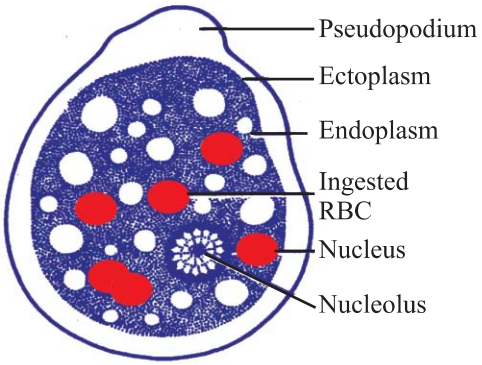


Fig: 7.1 *Amoeba proteus*



Entamoeba histolytica

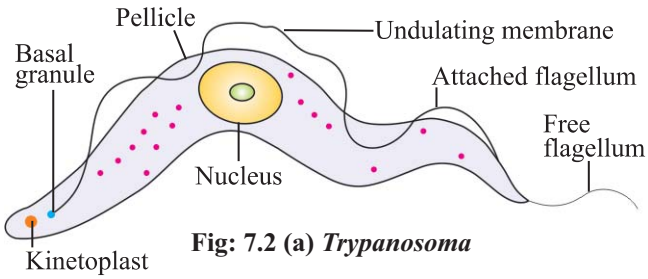


Fig: 7.2 (a) *Trypanosoma*

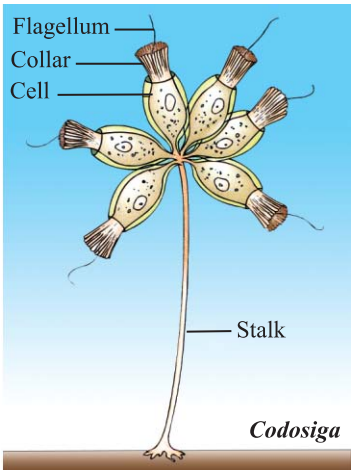


Fig: 7.2 (b) Zooflagellates A colonial Choanoflagellate

Ciliates

Ciliates get their name from a Latin word meaning "eyelash", a name that is description of the fact that all parts of these cells are covered with hair like extensions called **cilia** e.g. *Paramecium, Stentor* and *Vorticella*.

Science Titbits

Trichonymphas are complex specialized flagellates with many flagella. They live as symbionts in the gut of the termites. It contains a bacterium that enzymatically converts the cellulose of wood to soluble carbohydrates that are easily digested by the insect.

Trichonympha

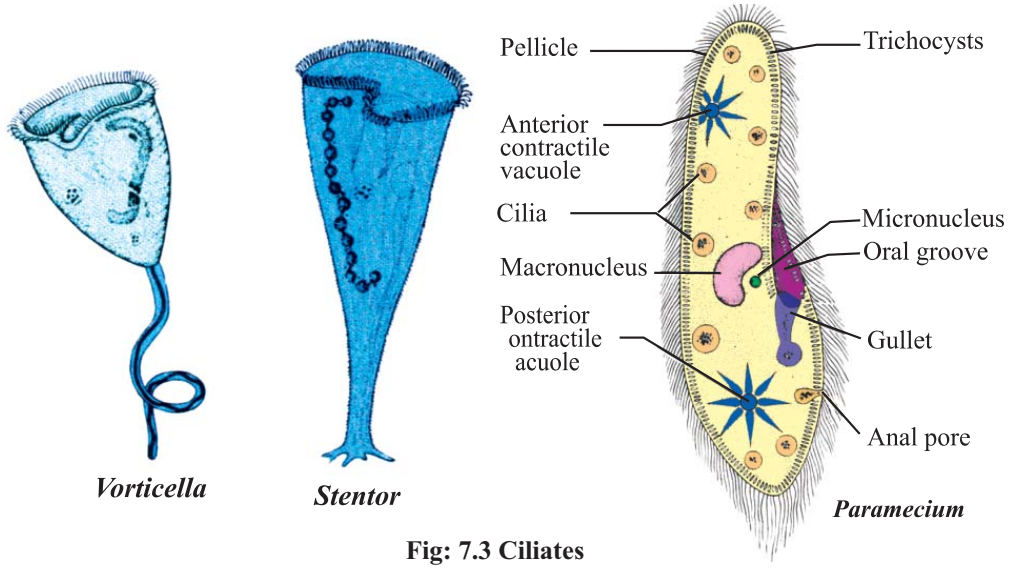


Fig: 7.3 Ciliates

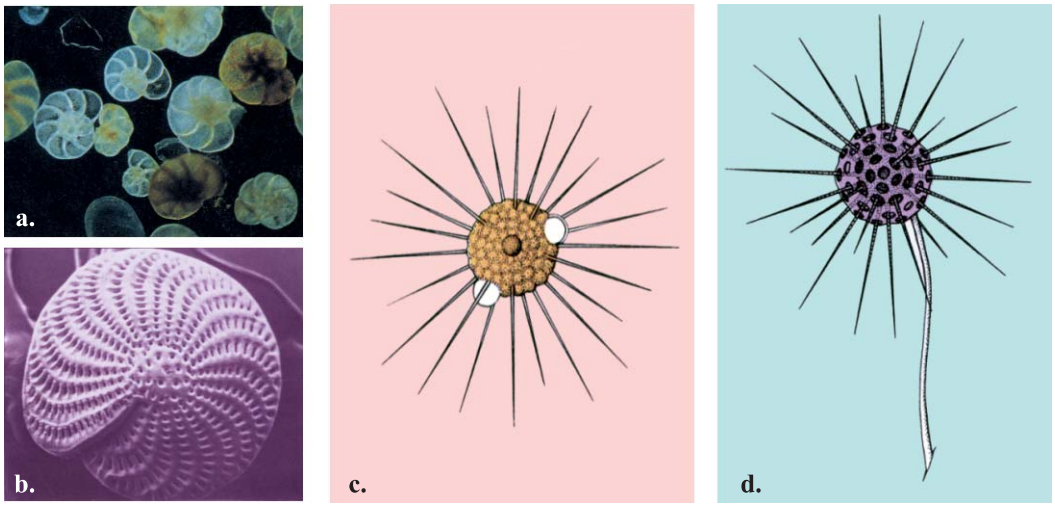


Fig: 7.4 (a, b) Foraminifera (c, d) Actinopods

Foraminifera and Actinopods

These are marine protozoans. They produce tests or shells. In foraminifera (commonly called forams) shells are made up of calcium. In actinopods shells are made up of silica.

Apicomplexans

This is a large group of parasitic protozoa. Some cause diseases in man e.g. *Plasmodium* (malarial parasite).

ALGAE: The Plant like Protists

Algae (singular. *alga*) are found in ocean, freshwater ponds, lakes, streams, hot springs, polar ice, moist soil, trees and rocks. 50 to 60% photosynthesis is carried out by algae. Algae may be unicellular, filamentous or multicellular. Filaments are composed of multicellular structures, which lack cross-walls (coenocytes) or distinct cells. In multicellular algae e.g. sea weeds, the body is branched or leaflike called **thallus**. A thallus has no root, stem, leaves and vascular tissues. The photosynthetic pigments found in algae are chlorophyll "a", yellow and orange carotenoids, xanthophyll and phycoerythrin. Algal life cycle shows extreme variations. All algae except the red algae (Phylum Rhodophyta) have forms with flagellated motile cells in at least one stage of their life cycle. Algae differ from the plants in this respect that the sex organs in algae are unicellular, the zygote is not protected by the parent body and embryo is not formed. **Alga**e is classified into six phyla. The basic features and examples of each phylum are being discussed here.

Euglenoids: These are small fresh-water organisms. They are plant like in their pigments. One third of all genera have chloroplasts, the rest do not. Those which lack chloroplasts ingest or absorb their food. e.g *Euglena* (fig. 7.5)

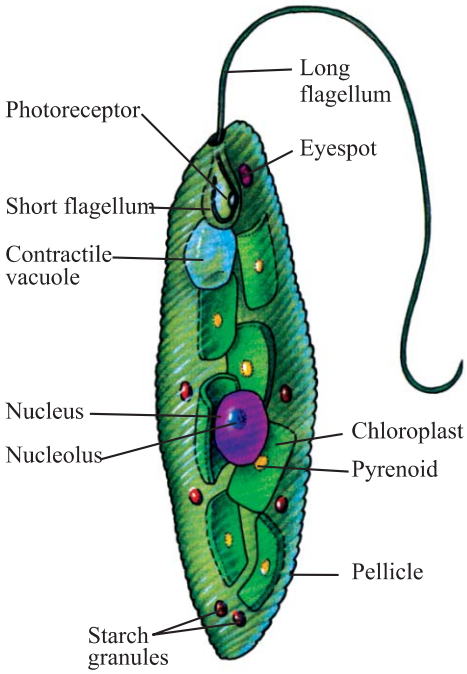


Fig: 7.5 *Euglena*

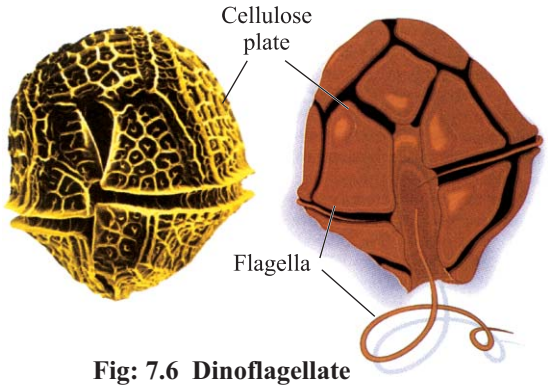


Fig: 7.6 Dinoflagellate

Science Titbits

Most dinoflagellates are unicellular and are extremely numerous and have occasional population bloom. These blooms frequently colour the ocean water orange, red or brown and are known as red tides.

Dinoflagellates: Many dinoflagellates are bounded by protective cellulose plates impregnated with silica. Most have two flagella. They vary in colour from yellow, green to brown (fig. 7.6).

Diatoms: Diatoms (fig. 7.7) are the most numerous unicellular algae in the oceans. They are also plentiful in fresh water. The structure of a diatom is often compared to a box because the cell wall has two halves, with the larger halves acting as a "lid" for the smaller half.

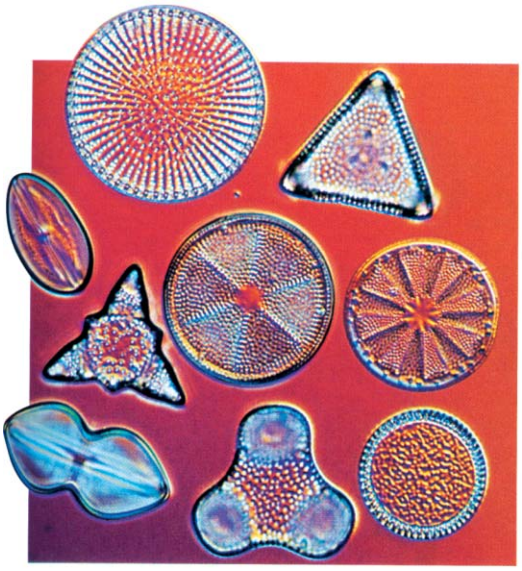


Fig: 7.7 Diatoms.

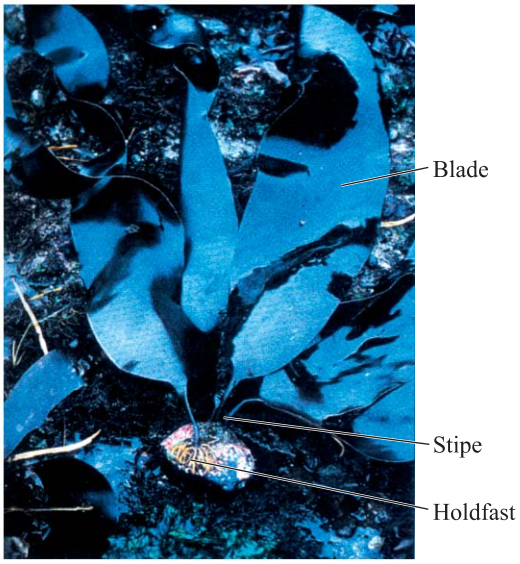


Fig: 7.8 Brown algae Laminaria

Brown Algae: Brown algae range from small forms with simple filaments to large multicellular forms up to 75 metre in length, live in cooler marine water. The large brown algae are called **kelps**

Red Algae: Red algae are multicellular present chiefly in warmer seawater growing in both shallow and deep waters. They can be up to a metre long attached to rocks or other substances by a basal holdfast (fig. 7.9).

Fig: 7.9 Red Algae

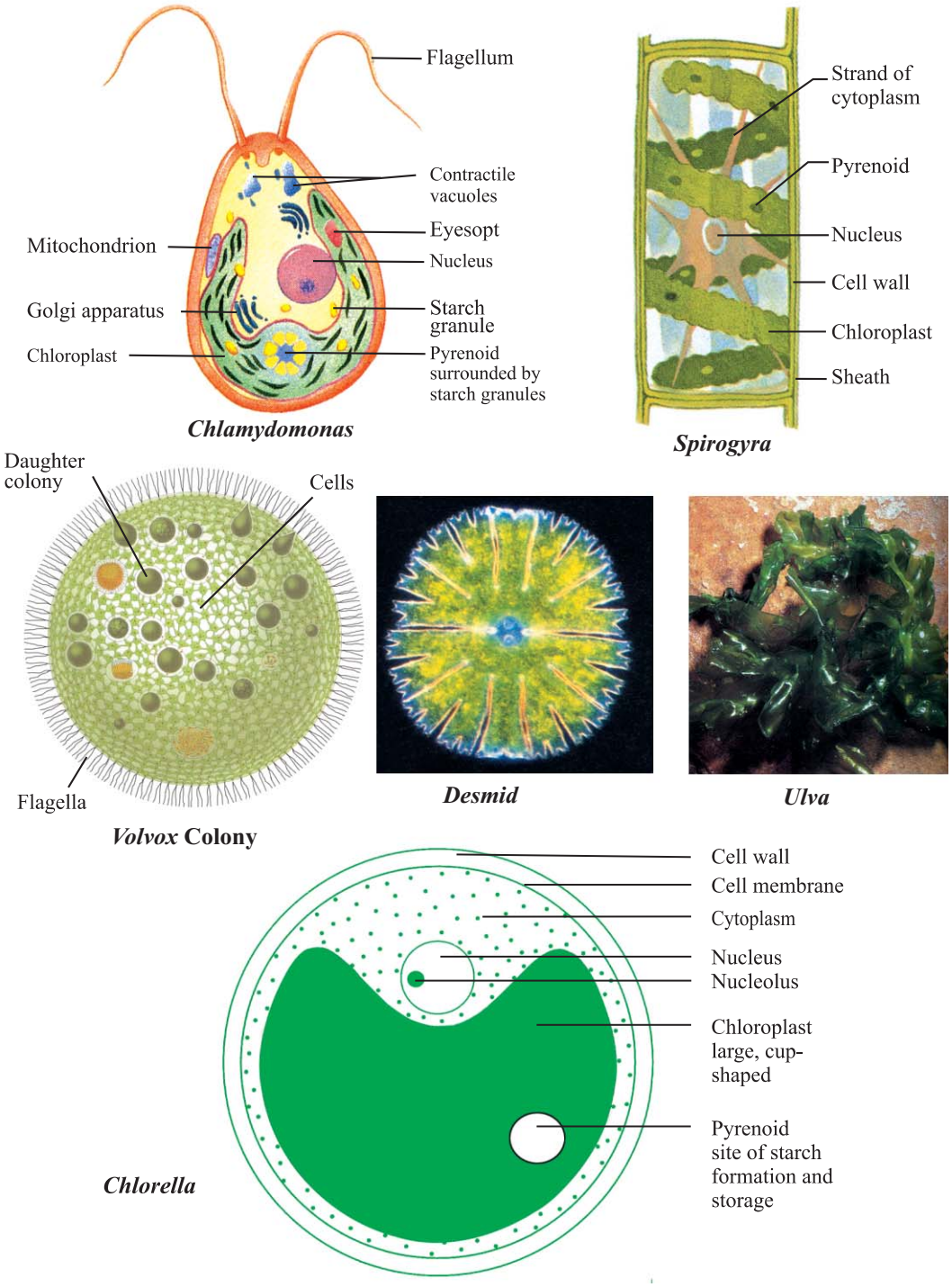


Fig: 7.10 Green Algae

Green Algae

Green algae live in the ocean but are more likely found in fresh water and can even be found on land e.g. *Chlamydomonas*, *Spirogyra*, *Volvox*, *Chlorella*, *Ulva*.

Science Titbits

Green algae are believed to be closely related to the first plants because both of these groups: Have a cell wall that contains cellulose. Possess chlorophyll **a** and **b**. Store reserve food as starch inside the chloroplast.

Fungi Like Protists: Myxomycota and Oomycota

MYXOMYCOTA: Slime Molds

Usually **plasmodial slime molds** exist as a **plasmodium**. It is a diploid multinucleated cytoplasmic mass enveloped by slime sheath. At times unfavourable to growth, such as during drought the Plasmodium develops many sporangia. A sporangium (Gk. *spora*, seed, and *angeion*, vessel) is a reproductive structure that produces spores by meiosis. In **plasmodial slime**, spores release a haploid flagellated cell or an **amoeboid cell**. Eventually two of them fuse to form a diploid **zygote** that feeds and grows, producing a

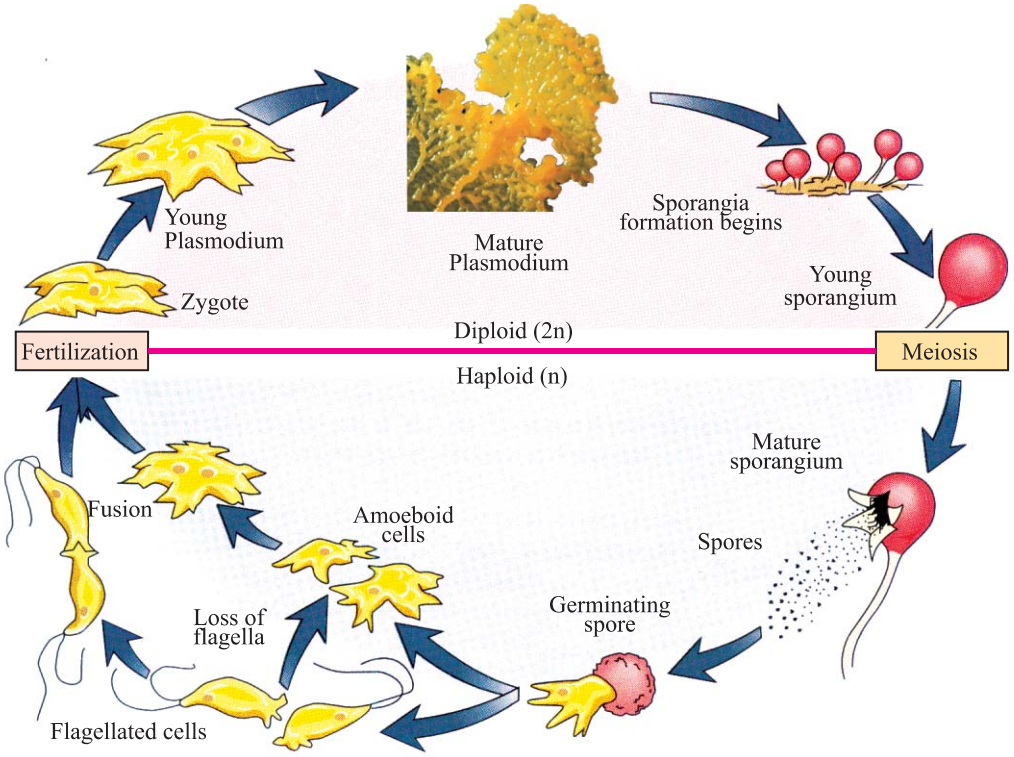


Fig: 7.11 Life Cycle of Plasmodial Slime Mold (*Physarum*)

multinucleated Plasmodium once again. Characteristics of slime molds are interesting to biologists because the life cycle involves many changes in form. These different forms resemble other types of protists.

Science Titbits

Slime molds are organisms that are fungus like in one phase of their life cycle and amoeba like in another phase of their life cycle. Slime molds are similar in some respect to fungi i.e. body is filamentous, saprotroph, formation of zygote, and having nonmotile spores. Slime molds differ from fungi due to the presence of motility in the life cycle.

OOMYCOTA: The Water Molds

Oomycotes include water molds, white rusts and downy mildews. The characteristics of oomycotes are: All of the members of the group are either parasites or saprotrophs. The cell wall contains cellulose, not chitin like fungi. Their life cycles are characterized by gametic meiosis resulting in a diploid phase. The filamentous structures are called **hyphae** as in fungi. The hyphae are **aseptate** i.e. without intercellular cell wall. Most oomycotes live in fresh water or salt water or in soil. Some are plant parasites. A few aquatic oomycotes are animal parasites. **Zoospores** are motile and have two flagella. Zoospores are produced asexually in sporangium. For sexual reproduction there are two types of

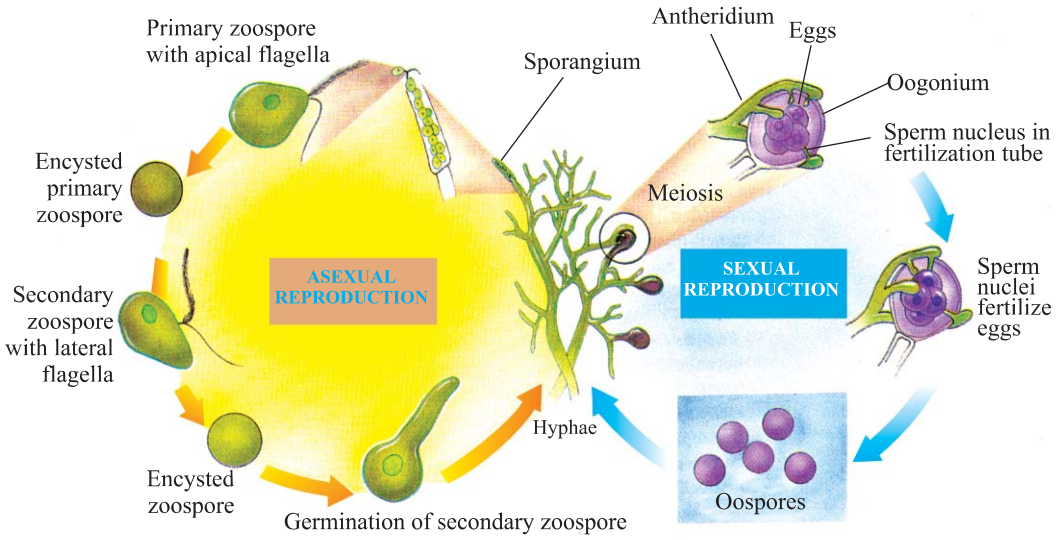


Fig: 7.12 Life cycle of Oomycotes

gametangia. The female gamentagium is called **oogonium** and the male gamentagium is called an **antheridium**. The antheridia contain numerous male nuclei, which are functional male gametes and the oogonia contain from one to eight eggs which are female gametes. The flowing of the contents of an antheridium into an oogonium leads to the individual fusion of one or more pairs of male nuclei with eggs. This is followed by the thickening of the cell wall around the resulting zygote or zygotes. This produces a special kind of thick walled cell called an **oospore**. The structure gives the phylum its name i.e. phylum oomycota e.g. *Phytopthora infestans*.

Importance of Protists to Humans

Some dinoflagellates at times produce a neurotoxin that can kill fish and cause paralytic shell fish, poisoning humans who eat shell fish that have fed on these dinoflagellates and suffer paralysis of the respiratory muscles. Usually the dinoflagellates are an important source of food for small animals in the ocean.

Diatoms are an important source of food and oxygen for heterotroph in both fresh water and marine ecosystem. **Brown algae** not only provides food to organisms, but is also harvested for human food and for fertilizer in several parts of the world.

Red algae are economically important. The mucilaginous material in the cell walls of certain genera of red algae is a source of agar used commercially to make capsules for vitamins and drugs, as a material for making dental impression and a base for cosmetics. In laboratory agar is a culture medium for bacteria.

Green algae are important producers. *Chlorella* has been used as an experimental organism in research in photosynthesis. A relatively new food source is single cell protein (SCP). In Japan and Taiwan dried *Chlorella* is sold as 'health food.'

Malaria caused by *Plasmodium*, is one of the world's most common serious infectious disease. According to world health organization about one to two million people die each year from malaria.

Other important protozoans are *Entamoeba histolytica* causes amoebic dysentery, *Trypanosoma* causes sleeping sickness. Some amoeba like *Acanthamoeba* usually free living but can produce opportunist infections such as eye infections in contact lens users. In oceans, fresh water lakes and ponds, are **zooplanktons** that feed on phytoplanktans, and are important as primary consumers in the food chain.

Potato plants infected with *Phytopthora infestans* show individual leaflets, with small, brown, dead and blighted areas. It obtains its nourishment from the mesophyll cell by short specialized branches known as **haustoria** (singular, *haustorium*) which penetrate them. Some sporangia may fall to the ground and infects tubers. As a result the whole plant is killed. It can be prevented by not planting infected tubers. All diseased parts of the infected plant should be destroyed before lifting tubers.

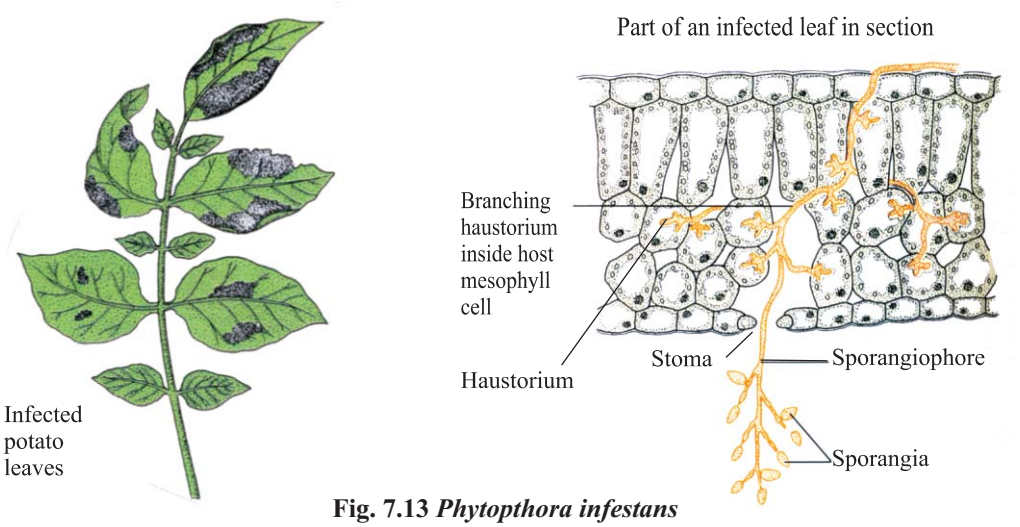


Fig. 7.13 ***Phytopthora infestans***

Science, Technology and Society Connections

Explain what clues protists provide with respect to the evolution of the three kingdoms of eukaryotes.

7.3 GENERAL CHARACTRERISTICS OF FUNGI

Fungi do not have root stem or leaves. Fungi (singular, fungus) can live in darkness and also in light. The study of fungi is called **mycology**. The person who studies fungi is called **mycologist**.

Fungi occupy a wide range of **habitats**, aquatic, terrestrial and as parasites on plants and animals. The **mode of life** shows that fungi can be parasites, saprotrophs or mutualists. Fungi range in **size** from the unicellular yeasts to the large toadstool. Fungi lack chlorophyll, so they are nonphotosynthetic. Thus **mode of nutrition** is heterotrophic. Digestion takes place outside the body and nutrients are absorbed directly. **Cell walls** are rigid containing chitin as fibrillar material. If carbohydrate is stored, it is usually as glycogen and not starch. The thallus or the body of most fungi is a

multicellular structure known as **mycelium**. A mycelium (Gk: *mycelium*, fungus filaments) (pl. mycelia) is a network of filaments called **hyphae** (Gk: *hyphae*, web). Hyphae give the mycelium quite a large surface area per volume of cytoplasm, and this facilitates absorption of nutrients into body of the fungus. The hyphae may be nonseptate (aseptate) or septate. Nonseptate (*L. septum*, wall) hyphae have no cross walls, are multinucleated i.e. they have many nuclei in the cytoplasm, such hyphae are called coenocytic hyphae. e.g. *Rhizopus*. Septate fungi have cross wall e.g. *Penicillium*. Fungi are non-motile, lack basal bodies and do not have flagella at any stage of their life cycle. They move towards a food source by growing towards it. A fungus reproduces both asexually and sexually.

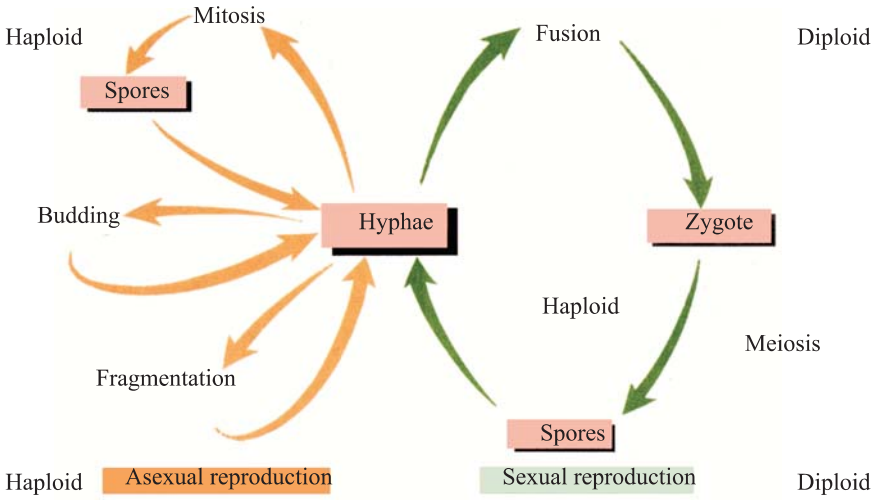


Fig. 14 (a) A Generalised life cycle for Fungi. Fungi alternate between sexual and asexual reproductive stages

Why Fungi are Classified as Separate Kingdom?

According to five kingdom system of classification, 'Fungi' is now a separate kingdom. Fungi have resemblance with plants in: (1) having cell wall (2) lack centriole (3) are non-motile (4) produce spore and sporangium. Fungi different from plants as : (1) fungi have no cholorophyll (2) fungi never have flagella (2) fungi are saprotrophs.

Fungi resemble animals. Both: (a) are heterotrophs (b) lack cellulose in their cell wall and contain chitin so it is thought that fungi and animals arise from common ancestors. Fungi are different from animals. Fungi: (i) have cell wall (ii) are absorptive heterotrophs (iii) are non-motile.

So fungi are neither plants nor animals. They show "nuclear mitosis". During nuclear mitosis nuclear envelope does not break, instead the mitotic spindle forms within the nucleus and the nuclear membrane constricts between the two clusters of daughter chromosomes. In some fungi nuclear envelope dismantles late.

Fungi were originally classified in the plant kingdom, but biologists today recognize that they are not plants. Interestingly, recent studies suggest that fungi are more closely related to animals than to plants. Because fungi are distinct from plants, animals and other eukaryotes in many ways, they are assigned to a separate kingdom-fungi.

7.4 DIVERSITY AMONG FUNGI

The kingdom fungi are diverse group of more than 100000 known species most of which are terrestrial. The ancestry of fungi which evolved about 570 millions years ago, has not been determined. It has been suggested, that fungi evolved from red algae because both fungi and red algae lack flagella in all stages of their life cycle. Fungi are mostly multicellular eukaryotes of varied structure that share a common mode of nutrition.

Classification of Fungi

Classification of fungi into four main groups is based primarily on the type of their sexual reproductive structures and methods of reproduction. However, these groups also differ in the type of hyphae and some other characters.

Zygomycota (Conjugating Fungi)

The phylum or division zygomycota are called zygospore fungi, and mainly saprotrophs living on plant remains, on bakery goods, on vegetables and fruits. Some are parasites of small soil protists. Hyphae are nonseptate, mycelium well developed and branching. **Asexual reproductions** takes place by conidia or spores. e.g. *Rhizopus nigricans*. It is known as black or bread molds. It is a mass of mycelium. Asexual reproduction in *Rhizopus* takes place by the sporangia containing spores.

Sexual reproduction takes place by **conjugation**. Conjugation occurs only between a member of a plus (+) strain and one of a minus (-) strain. When hyphae (stolon) of opposite mating types meet, hormones are produced that cause the tips of the hyphae to come together and to form **gametangia**, structures that produce gametes. These structures become separated from rest of

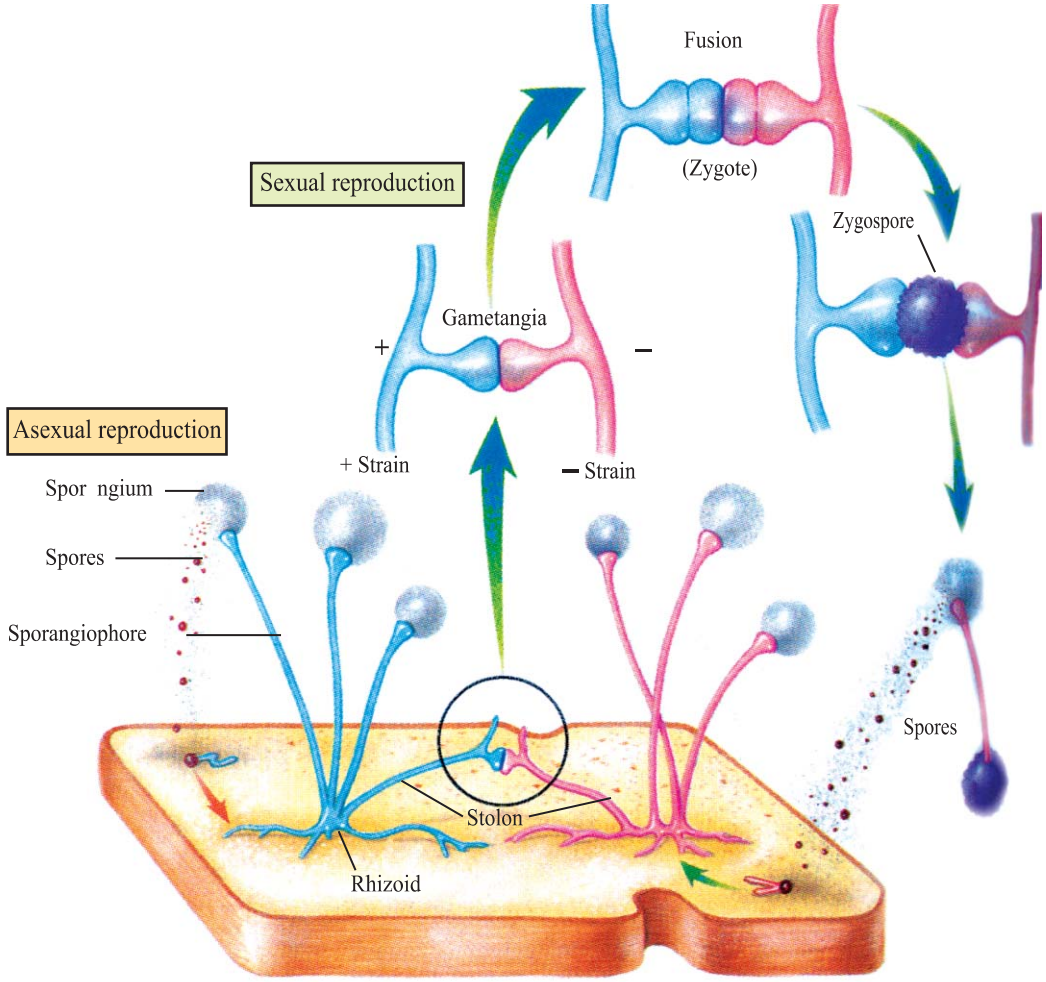


Fig: 7.15 Reproduction in *Rhizopus*

the mycelium by the formation of **septa**. Plus and minus nuclei then fuse to form a diploid nucleus, the **zygote**. The zygote develops into a **zygospore**. The wall of the zygospore is thick and resistant to unfavourable conditions. The division or phylum name refers to the **zygospore.** Zygospores **germinate** under favourable conditions and divide by **meiosis**. The wall of the zygospore splits and hyphae grows upward. The tip of the hypha develops into a **sporangium**. The sporangium contains many nuclei. The wall of the sporangium ruptures and the spores are liberated. Each spore grows into a new plus or minus strain of mycelium. Thus the life cycle of *Rhizopus* is continued.

Q. What is the purpose of sporangiophores?

Ascomycota (Sac Fungi)

Ascomycotes are the members of phylum or division ascomycota. It is a large group. Ascomycotes are also known as **sac fungi** because their sexual spores are produced in little sacs called **asci** (sing: *ascus*). Their hyphae usually have septa but the cross walls are perforated so that cytoplasm can move from one compartment to other. Ascomycotes reproduce both asexually and sexually.

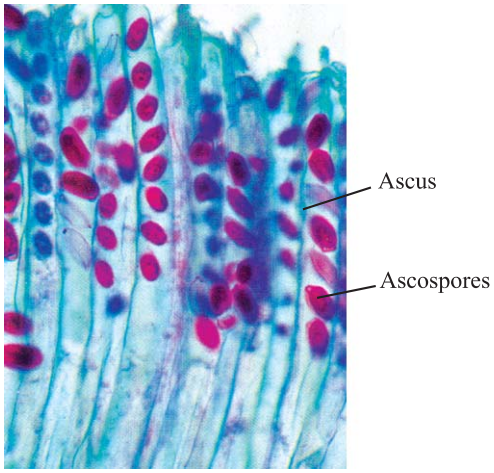


Fig: 7.16 Asci and Ascospore

Asexual reproduction involves production of spores called **conidia** (singular: *conidium*) or **conidiospores** (Gk: *konis*, dust, and *spora*, seed). Conidia vary in shape, size and may be multicellular. There are no sporangia in Ascomycotes.

Fig: 7.17 Conidia

The conidia develop directly on the tips of modified aerial hyphae called **conidiophores**. When released conidia are wind blown. Conidia occur in various shapes, sizes and colours in different species. The colour of conidia is what gives the characteristic brown, blue, pink or other tint to many of these molds.

In unicellular **yeasts**, asexual reproduction takes place by **budding**. In this process a small protuberance (bud) grows and eventually separates from the parent cell. Each bud can grow into a new yeast cell. Yeast also reproduces asexually by fission.

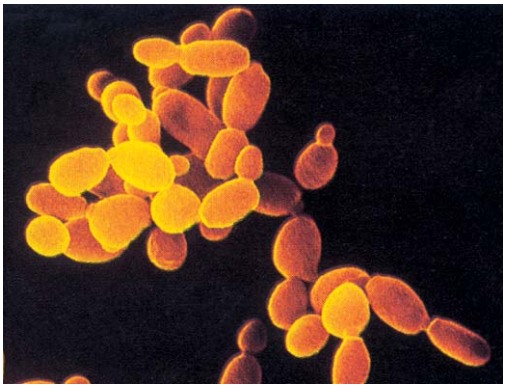


Fig: 7.18 Budding in Yeast

Sexual reproduction takes place after two hyphae grow together and their cytoplasm mingles. Within

this fused structure, nuclei from the parent hyphae pair but do not fuse. New hyphae develop from the fused structure and the cells of these hyphae are **dikaryotic**. The n + n hyphae form a fruiting body known as **ascocarp**.

The **asci** develop in the ascocarp. The asci are usually surrounded by sterile hyphae. An ascocarp is a **fruiting body**. It is a reproductive structure where spores are produced and released. Ascocarps can have different shapes. In cup fungi they are cup shaped, in molds they are flask shaped and in the **morels** they are stalked and crowned by bell shaped structure.

Within an ascus the two nuclei fuse and form a **diploid** nucleus the **zygote** which undergoes **meiosis** to form four haploid nuclei. This process is usually followed by one mitotic division of each of the four nuclei, resulting in eight haploid nuclei. Each haploid nucleus develops into an **ascospore**.

So there are usually eight haploid ascospores within the ascus. In most ascomycotes the asci become swollen as they mature and then they burst liberating the ascospores, which are then wind blown if lands in a suitable location and germinates to form a new mycelium. e.g. in Yeasts, *Neurospora* etc. Sac fungi produce sexual conidiospores. During sexual reproduction, asci within a fruiting body produce conidiospores. The examples of sac fungi are Yeasts, *Neurospora*, Morels,Truffles.

Basidiomycota (Club-Fungi)

Basidiomycotes are included in the phylum **Basidiomycota**. Included in this phylum are mushrooms, bracket fungi, rust, smut and puffballs. These structures are all fruiting bodies called **basidiocarps**. Basidiocarp contains the basidia. Each **basidium** is a club shaped structure. It is a hyphal cell on the tip of which develops four **basidiospores**, from which this phylum takes its name. Each individual fungus produces millions of basidiospores and each basidiospore has the potential to give rise to a new primary mycelium. Hyphae of primary mycelium are composed of monokaryotic (n) cells. The mycelium of a basidiomycote e.g. *Agaricus* (Mushroom), consists of mass of white, branched, thread like hyphae that occur mostly below ground. The hyphae are divided into cells by septa. The **septa** are perforated and allow cytoplasmic streaming between cells.

Although club fungi occasionally do produce conidiospores asexually, they usually **reproduce** sexually. A hyphae of a primary mycelium encounters another monokaryotic (n) hyphae of a different mating type and the two hyphae fuse. However the two haploid nuclei remain separated from each other. In this way a secondary mycelium with a **dikaryotic** (n + n) hyphae is

produced, in which each cell contains two haploid nuclei. The n + n hyphae of the **secondary mycelium** grows and forms compact mass, called **buttons**, along the mycelium. Each button grows into a **fruiting body** known as **mushroom**. A mushroom, which consists of a stalk and a cap, is more formally referred to as **basidiocarp**. Each basidiocarp actually consists of interwined hyphae that are matted together.

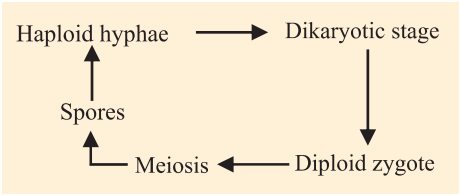


Fig. 7.19 Main Steps of Life Cycle of a Mushroom

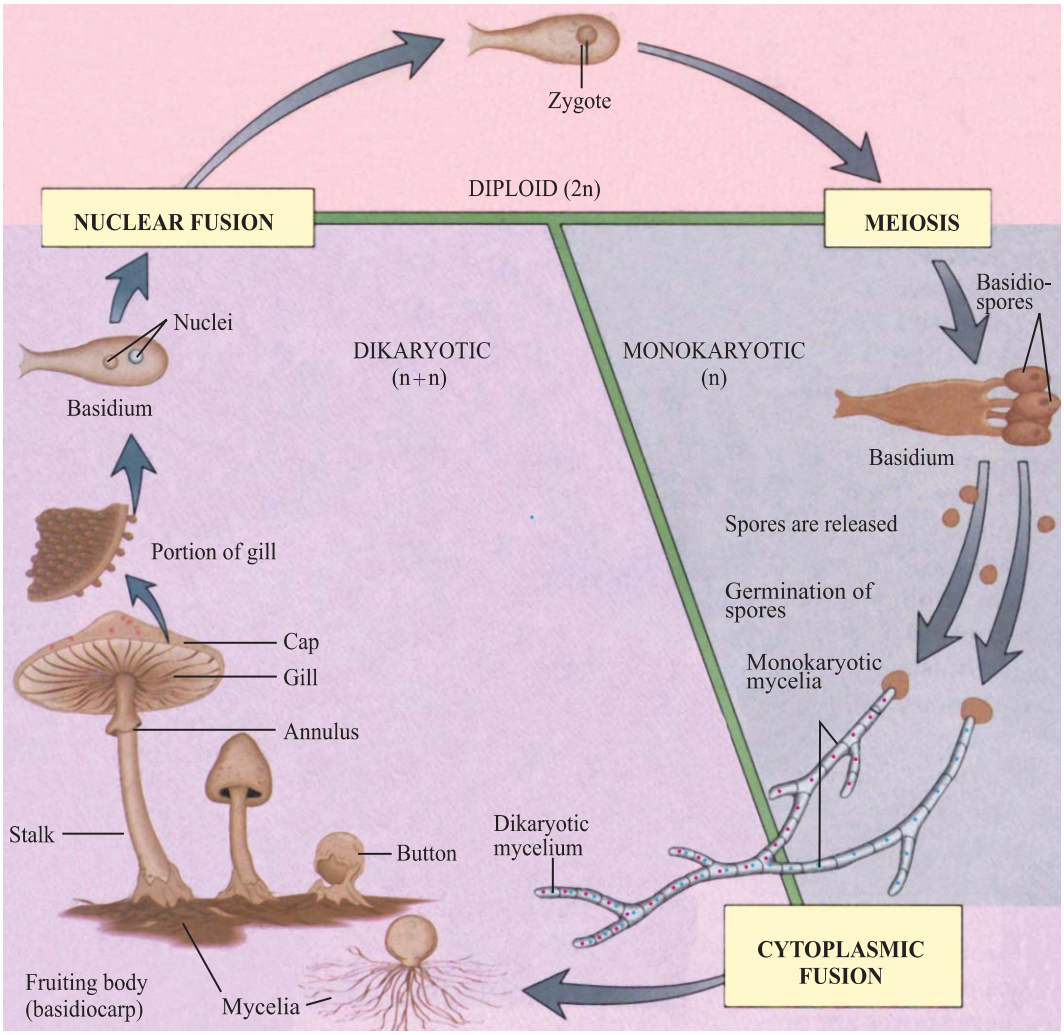


Fig: 7.20 Life Cycle of a Mushroom

The walled off ends of the tightly packed hyphae become the club shaped basidia. The lower surface of the cap usually consists of many thin perpendicular plates called **gills** that radiate from the stalk to the edge of the cap.

On the gills of the mushroom haploid nuclei of the dikaryotic cells fuse to form diploid zygotes. Meiosis then takes place forming four haploid nuclei that move into finger like projections forming basidiospore, which are released later.

Deuteromycota (Imperfect Fungi)

These fungi are called "imperfect" fungi because of the absence of the sexual stage in their life cycle. Imperfect fungi always reproduce asexually by forming conidiospores.

Usually cellular morphology and biochemistry indicate that these fungi are sac fungi which have lost the ability to reproduce sexually. These fungi live either saprophytically or parasitically on plants. Several imperfect fungi have economic importance. The examples of imperfect fungi are: *Penicillium*, *Aspergillus*, *Alternaria* and *Fusarium*.

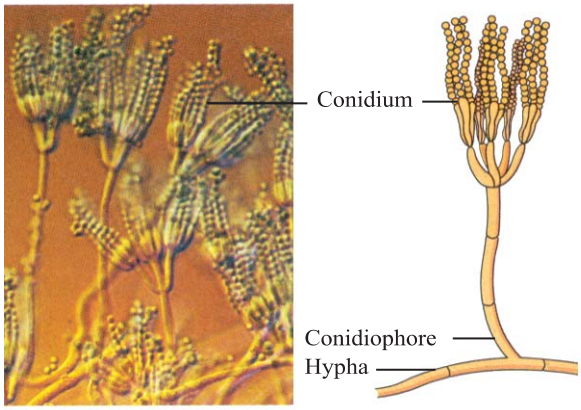
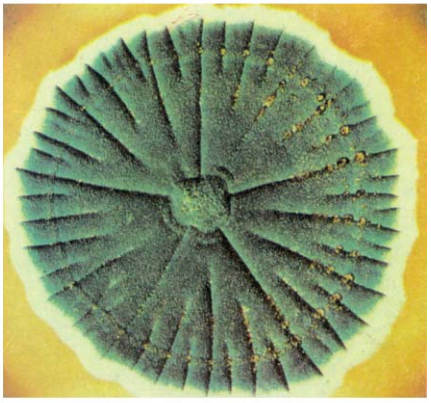


Fig. 7. 21(a) *Penicillium*



(b) *Penicillium* **Colony**

Science Titbits

Despite absence of sexual reproduction, imperfect fungi show special kind of genetic recombination, called parasexuality, in which portions of chromosomes of two nuclei lying in the same hypha are exchanged.

7.5 IMPORTANCE OF FUNGI

Fungi cause economic gains as well as losses. People eat them and grow them to make various chemicals. Fungi cause diseases in humans, other animals and plants. Their activities cost billions of dollars in agricultural damage yearly.

Importance of Yeast

The ability of yeasts to produce ethyl alcohol and carbon dioxide from sugars such as glucose by fermentation is utilized to make wine, beer and other fermented beverages and also to make bread.

Brewing: Wine is produced when yeasts ferment fruit sugars and beer results when yeasts ferment sugars derived from starch in grains (usually barley).

Baking: During the process of making bread, carbon dioxide produced by yeast becomes trapped in dough as bubbles, causing the dough to rise; this is what gives leavened bread its light texture. Both the carbon dioxide and the alcohol produced by the yeast evaporate during baking.

Genetic Research: Yeasts are used in biological research especially in the genetic research. For example yeasts have been used to study mutation, genetic recombination and laws of segregations and effect of many chemicals and medicine.

Often the first choice eukaryotic organisms for protein production is the yeast (*Saccharomyces cerevisiae*). Yeast cells can take up foreign DNA and integrate into their genomes. Yeasts also have **plasmids** that can be used as gene **vectors** and some time yeasts are better than bacteria at synthesizing and secreting eukaryotic protein. Yeast is currently used to produce a number of proteins. In some cases the same product, for example interferons used in cancer research can be made in either yeast or bacteria. In other cases such as hepatitis B vaccine, yeast alone is used.

Science, Technology and Society Connections

Describe how helpful fungi have been for us as source of antibiotics and other useful chemicals.

Table: 7.6 Antibiotics Obtained From Fungi			
Name of Fungus		Anitibiotics	
1	*Aspergillus fumigatus*	1	Fumigatin
2	*Cephalosporin acremonium*	2	Cephalosporin
3	*Penicillium chrysogenum*	3	Penicillin
4	*Penicillium nigricans*	4	Grisofulvin
5	*Tolypocladium inflatum*	5	Cyclosporins

MUTULISM: Lichen and Mycorrhizae

Mutualism is the association in which both the partners are benefitted. The two key **mutualistic symbiotic association** formed by the fungi are lichens and mycorrhizae.

Lichens

Lichens are an association between a fungus (mostly Ascomycotes and imperfect fungi and a few basidiomycotes), a cyanobacterium or green alga. The body of a lichen has three layers. The upper layer is thin and tough which consists of fungal hyphae. The middle layer consists of fungal hyphae interwoven with photosynthetic cell. Bottom layer consists of loosely packed fungal hyphae. Specialized fungal hyphae which penetrate or envelope the photosynthetic cells, transfer nutrients directly to the rest of the fungus.

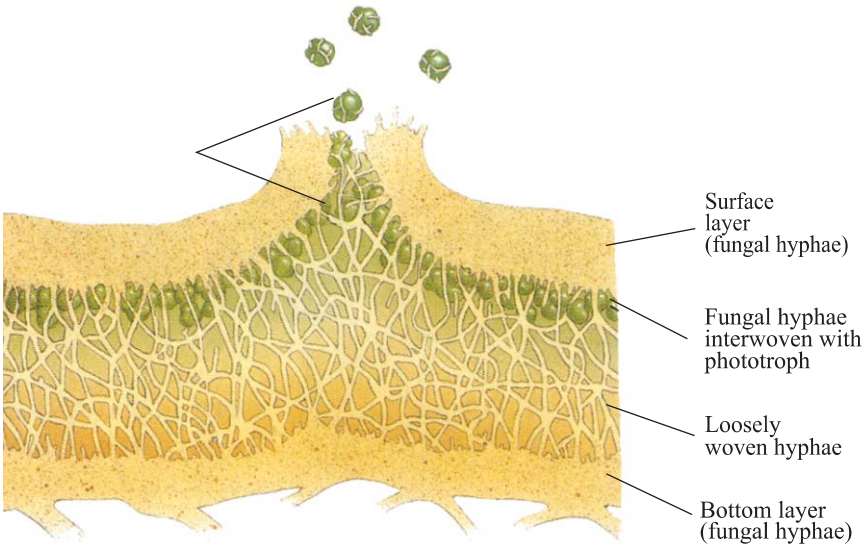


Fig: 7.22 A Cross Section of Lichen

In past lichens were assumed to have mutualistic relationships in which the fungus received nutrients from the algae cells and the algae cells were protected from dessication by the fungus. Actually lichens might involve a controlled form of parasitism of the algae cells by the fungus.

Mycorrhizae

Mycorrhizae are mutualistic relationships between soil fungi and the roots of most plants. This association occurs in 95% of all families of higher plants. Fungal hyphae increases the amount of soil contact and total surface area for absorption. The hyphae help in the direct absorption of phosphorous, zinc, copper and other nutrients from the soil into the roots. Plants whose roots are invaded by mycorrhizae grow more successfully than do plants without mycorrhizae. There are two main types of mycorrhizae in which mycelium extends far out into the soil.

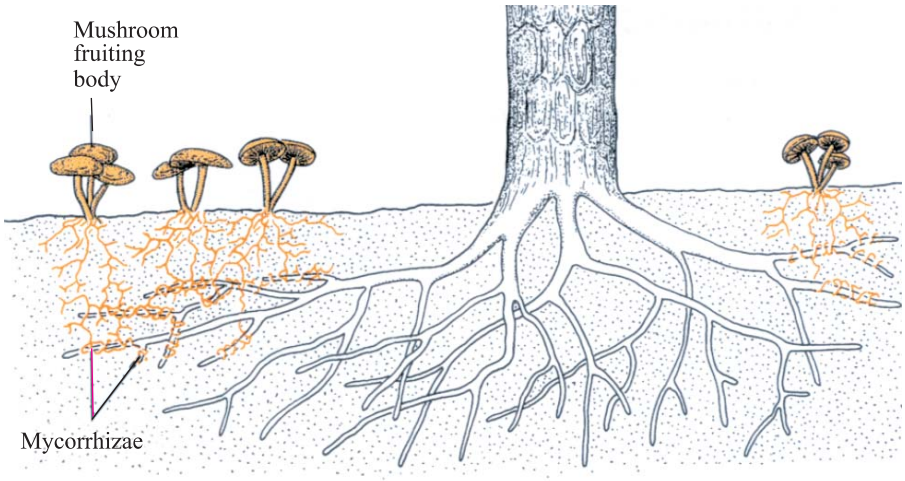


Fig: 7.23 Mycorrhizae

Endomycorrhizae

These penetrate only into the outer cells of plant root forming coils, swellings and minute branches and also extend out into surrounding soil.

Ectomycorrhizae

These form a mantle that is exterior to the root, and they grow between cell walls. These are mostly formed with pines, firs etc.

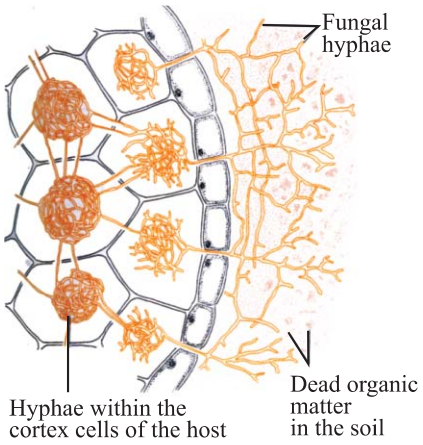


Fig: 7.24 Endomycorrhizae

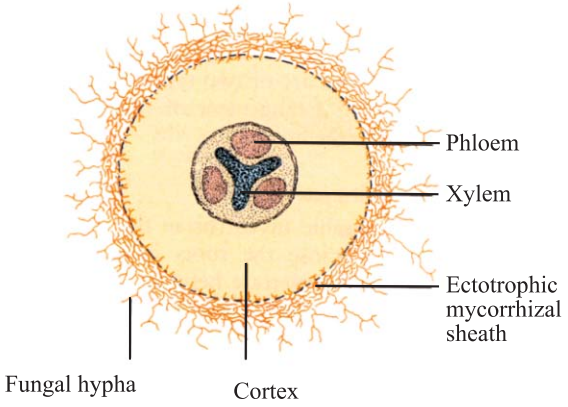


Fig: 7.25 Ectomycorrhizae

Edible Fungi

Aspergillus tamarii and other imperfect fungi are used in the Orient to produce soy sauce by fermenting soy beans. Among the basidiomyco tes, there are some 200 kinds of edible mushrooms (*Agaricus*) and about 70 species of **poisonous** ones, sometimes called **toadstools**. Some edible mushrooms are cultivated commercially. (*Morchella esculenta*), which superficially resemble mushrooms and **truffles**, which produce underground fruiting bodies, are ascomycotes.

Fig: 7. 26 Truffel Fungi

Edible and poisonous mushrooms can look very much alike and may even belong to the same genus. There is no simple way to tell them apart; they must he identified by an expert. Some of the most poisonous mushrooms belong to the genus **Amanita**. Toxic species of this genus have been appropriately called such names as “destroying angel” (*Amanita virosa*) and “death cap” (*Amanita phalloides*). Eating a single mushroom of either species can be fatal. Jack-o-lantern is a poisonous mushroom. Ingestion of certain species of mushrooms causes in toxication and hallucinations.

Fig: 7.27 Amanita

Fig: 7.28 Jack-o lantern

Ecological Impact of Fungi

Fungi make important contributions to the ecological balance of our world. Like bacteria, most fungi are saprotrophs, decomposes and absorb nutrients from organic wastes and dead organisms. In this way fungi help in maintaining the nutrient balance in nature. It is done in three ways.

Removal of organic debris: The organic waste is removed from the environment by the activity of saprotrophic fungi and bacteria. In the absence of it, the Earth would be covered by organic waste, which will make life difficult.

Liberation of Carbon dioxide: The fungi and bacteria liberate huge amounts of CO_2 in the air by decomposing dead bodies of animals and plants. The green plants for the synthesis of organic food use this carbon dioxide.

Humus: It is an important constituent of soil and essential for the proper growth of plants. It is found from the organic waste material through the activities of fungi and bacteria.

Pathogenic Role of Fungi

Fungi cause many important diseases in plants and also in animals including human beings.

Fungi Cause Plant Diseases

Fungi are responsible for many serious plant diseases, including epidemic diseases that spread rapidly and often result in complete crop failure. All plants are apparently susceptible to some fungal infection.

Some important plant diseases caused by **ascomycotes** are powdery mildews, chestnut blight, Dutch elm disease, apple scab, and brown rot, which attack cherries, peaches, plums, and apricots. Diseases casued by basidiomycotes include smuts and rusts that attack various plants - for example the cereal crops of corn, wheat, oats etc.

Fig: 7.29 Brown Rot of Peaches *(Monilinia fruticola* an ascomycote)

Fig: 7.30 Ergot Infection of rye, *(Claviceps purpurea,* sac fungi)

Rusts are called so because of numerous rusty and orange-yellow coloured disease spots on their host surface (mostly stem, leaves), later revealing brick/rust-red spores of the fungus. **Smuts** are called so because of their black, dusty spore masses that resemble soot or smut; these spore masses replace the grain kernels such as those of wheat, corn etc.

Rusts

Powdery mildews on grapes, roses and wheat, ergot of rye, red rot of sugar, potato wilt, cotton root rot, apple scab, brown rot of peaches, plums, apricots and cherries etc are common plant diseases caused by fungi.

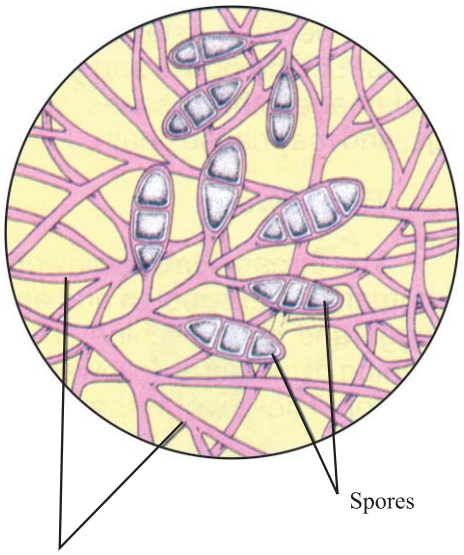


Fig: 7.31 Ringworm (*Microsporium audouni*)

Fig: 7.32 Athlete's foot

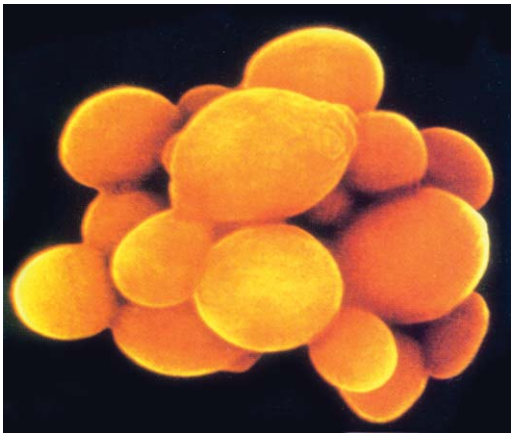


Fig: 7.33 *Candida* (Candidiasis)

Fungi Cause Animal Diseases

Some fungi cause superficial infections in which only the skin, hair, or nails are infected. Ringworm (*Microsporium audouni*) and athlete's foot (*Tinea pedis*) are examples of superficial fungal infections; both are caused by imperfect fungi. **Candidiasis**, a yeast infection of mucous membranes of the mouth or vagina, is among the most common fungal infections.

Other fungi cause systemic infections that infect internal tissues and organs and may spread through many regions of the body. **Histoplasmosis**, for example, is a serious infection of the lungs caused by inhaling spores of a soil fungus.

Aspergillus fumigatus causes **aspergillosis** which may cause death to persons with defective immune system. Some strains of *Aspergillus flavus* produce **aflatoxin**, a cancer causing mycotoxins in improperly stored grains of peanut, corn etc. **Ergotism** is caused by purple ergot rye. It causes nervous spasm, convulsion, psychotic delusion and even gangrene.

Exercise

SECTION I : MULTIPLE CHOICE QUESTIONS

Select the correct answer

1. Which of the following is true of both fungi and some types of bacteria?
   A) they both produce gametes
   B) they both engulf microscopic animals
   C) they both absorb materials across cell wall
   D) they both fix nitrogen
2. The cell wall consists of two over lapping shells in
   A) euglenoids B) diatoms
   C) dinoflagellates D) brown algae
3. Which of the following structure would you expect to find in the corn smut fungus?
   A) ascospores B) basidiospores
   C) zoospores D) zygosopres
4. The feeding stage of a slime mold is called
   A) hyphae B) plasmodium
   C) rhizoids D) mycelium
5. Which is found in slime molds but not in fungi?
   A) non-motile spores B) amoeboid adult
   C) zygote formation D) photosynthesis
6. Fungi resemble animals because they are
   A) saprotrophs B) autotrophs
   C) heterotrophs D) heterosporous

7. Fungi cell walls contain chitin, which is also found in exoskeleton of

   A) arthropods B) molluscs

   C) echinoderms D) chordates

8. Poisonous mushrooms are called

   A) toadstools B) morels

   C) truffles D) tuber

9. Which of the following is associated with asexual reproduction in fungi

   A) zygospores B) ascospores

   C) basidiospores D) conidia

10. Imperfect fungi are called imperfect because

   A) they have no zygospores

   B) they cause diseases

   C) they form conidiospores

   D) sexual reproduction has not been observed

SECTION II : SHORT QUESTIONS

1. Name the three eukaryotic kingdoms.
2. How do ciliates differ from other protozoans?
3. How do algae differ from plants?
4. What are diatoms?
5. Write two characteristics of:

   (a) Protozoa (b) Dianoflagelles (c) Diatoms

   (d) Slime mold (e) Oomycotes

6. How fungi resemble plants?
7. Define coenocytic hyphae.
8. How fungi get their nutrition?
9. Name the fungal mutualistic associations.

10. List the methods of asexual reproduction in fungi.
11. What is zygospore and how it is formed?
12. Where basidiospores are produced?
13. What do you mean by imperfect fungi. Why they are given this name?
14. What is histoplasmosis?
15. Write one difference between: (a) Fungi and Plants. (b) Fungi and Animals. (c) Zygomycota and Basidiomycota. (d) Sporangium and Conidium. (e) Ascus and Basidium. (f) Diakaryotic and Diploid. (g) Ascocarp, Ascus and Ascospores. (h) Basidiocarp, Basidium and Basidiosopres. (i) Endomycorrhizae and Ectomycorrhizae.
16. List some fungi that attack crops. In what division is each found?
17. List the differences between bacteria and fungi.
18. Why are fungi and plants are classified in different kingdom?
19. What ecological consequences would occur if all fungi on Earth were destroyed by human using a new and deadly fungisides?

SECTION III : EXTENSIVE QUESTIONS

1. What are the important features of protists.
2. Write the reasons for a separate kingdom, protista.
3. Explain the importance of protists.
4. Discuss general characteristics of algae.
5. Describe structure and reproduction of slime mold.
6. Write features that distinguish oomycotes from fungi.
7. Give some important features of Basidiomycotes.
8. Write general characteristics of fungi.
9. Discuss taxonomic status of fungi.
10. List the major divisions of fungi, describe the feature that gives each of its name, and give one example of each.

11. Give an account of beneficial fungi and harmful fungi.

12. Discuss pathogenic role of fungi.

13. Explain the term club fungi. Draw and explain a diagram of the life cycle of a typical mushroom.

ANSWER MCQS

1. C 2. B 3. B 4.B 5. B 6. C 7. A 8. A 9. D 10. D

SUPPLEMENTARY READING MATERIAL

1. Lewis, R. "A New Place for Fungi?" Bioscience 44:6, June 1994

USEFUL WEBSITES

1. www.prenhall.com/~audesirk
2. www.scigenics.com/index.html
3. www.newsscientist.com/
4. www.prairiepublic.org/features/healthworks/antibiotics/