CHAPTER 3

BIOLOGICAL CLASSIFICATION - PART 2

Topics Discussed

1. Introduction

There are several organisms surviving and growing on this planet. All these organisms are classified for the ease of their study and knowledge. Bacteria and prokaryotes are the most primitive organisms and are thus not completely developed. They are made of cells which are different from eukaryotes. They are included in Protista.

Similarly there are fungi and fungal spores. These organisms are little advanced than the Protists and thus need another classification kingdom. The fungi world has various organisms differing in size, form, colour and even different reproductive methods.

There are fungi and algae growing together as symbiont. They are helpful to each other and thus are growing together.

Viruses are still left without grouped under any kingdom. Scientist are still working on its classification as it is non-living as well as living.

Objectives of this Chapter

At the end of this chapter, you will be able to:

- Relate the different types of fungi to the kingdom Fungi.
- Describe various types of organisms under the Kingdom Protista.
- Distinguish virus as a different class altogether.

2. Kingdom Protista

- Unicellular
- Eukaryotes
- Free living. Exception with few organisms found in colonies
- Intermediate between Monera, plants and animals.

2.1 General Characteristic of Kingdom Protista

- Some Protists are colonial and lack higher cellular differentiation. Hence, there is no tissue organization in the members of this kingdom.
- Many protists are aquatic organisms in nature.
- Cell structure is eukaryotic in nature having membrane bound organelles of all the types along with the 80S cytoplasmic ribosomes.
- Some organisms have cellulosic cell wall.
- All the protists possess well-defined nucleus with varying number i.e. uninucleate, binucleate, multinucleate.
- Flagella and cilia have microtubule organization consisting of tubulin protein arranged in (9 + 2) pattern.
- Movement of the organisms are by pseudopodia, flagella and cilia where ciliary mode is the fastest among them giving speed of 2mm/s.
- Mode of nutrition among all the Protists range from photosynthetic (holophytic), holozoic (ingestive), saprobic to parasitic (absorptive). Some have mixed type of nutrition (photosynthetic and saprobic) like the one in *Euglena*.
- Reproduction takes place by both: asexual and sexual methods.
- Life cycle in Protists is of 2 types –major one showing zygotic meiosis and the minor one showing gametic meiosis.
- The Protists are decomposers, photosynthetic or parasitic in nature. Parasitic protists may cause diseases like dysentery, malaria, sleeping sickness etc. when encounter a host.

2.2 Photosynthetic Protists

They are also known by the name protistan algae, making the major portion of the phytoplankton.

2.2.1 Diatoms

Diatoms are photosynthetic Protists that are also called as Chrysophytes (including both diatoms and desmids). They grow in both aquatic and terrestrial environments.

Their important characters are:

- These are organisms that show diversity in colour having size in micrometers hence called as microscopic Protists.
- They are generally unicellular, however some diatoms may form pseudo filament and colonies. They lack flagella in their life except when in the reproductive stage.
- They may be free floating in underwater (phytoplanktonic) or floating on the surface of water when they have light weight lipids.
- The cells have the covering of cellulosic cell wall that is impregnated with silica to form transparent siliceous shell, known as frustule. Depending upon the symmetry, diatoms may be pennate type, having bilateral symmetry (e.g., *Navicula*) and centric type, having radial symmetry (e.g., *Melosira*).
- The cell wall is characteristic, made up of two halves; one half covering the other (epitheca over hypotheca) resembling a soap box.
- The cell wall enclose the peripheral layer of cytoplasm (primordial utricle) surrounding a large central vacuole.
- Nucleus lies in the central vacuole, suspended with the help of cytoplasmic strands.
- Mode of nutrition is holophytic (photoautotrophic), photosynthetic pigments are chlorophyll *a*, chlorophyll *c*, β carotene and special carotenoids containing fucoxanthin; xanthophylls like diatoxanthin, diadinoxanthin.
- The reserve food material is in the form of oil and a polysaccharide called leucosin (chrysolaminarin), even the cell shows presence of volutin granules.
- As the cells produce oils as food material they contribute almost 50% of the total organic matter and oils synthesized in the biosphere.
- Movement of diatoms is with the mucilage propulsion.
- The reproduction of diatoms is by asexual method, binary fission being most common mode.
- They reproduce sexually varying from isogamy to oogamy. Diatoms are diploid thus involving gametic meiosis (diplontic life cycle).
- During binary fission, the parent cell takes the first half of the cell wall and other is secreted afresh.
- Resting spores that have thick covering is formed within the diatoms are called statospores (centric diatoms).

Did You Know

- Silica shells of dead diatoms are so strong that it is indestructible. These shells get accumulated at the sea bed after their death. After a period of time, large deposits of hard shells of diatoms resemble huge rock. This rock constitutes the diatomaceous earth which is whitish powder called diatomite or kieselghur or diatomaceous earth after the mining of rock. Diatomite is rough and gritty which is the reason it is used in filtering industry, sugarcane refineries, for making insulating bricks, in polishes for metals, tooth pastes, houses and for making the latter sound proof, in insulation of refrigerators, in the manufacture of dynamite, water glass or sodium silicate and strong acids. This is added to paint to increase their night visibility.

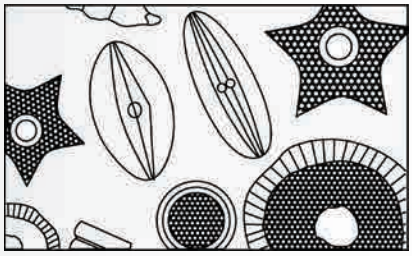

Figure 3.1: Diatoms in microscope

- They are very good indicators of water pollution. Common examples of diatoms are *Triceratium, Melosira, Navicula, and Cymbella*.

2.2.2 Dinoflagellates

Dinoflagellates are photosynthetic Protists having golden brown colour that belong to the class Dinophyceae (Pyrrophyta). They are mainly marine dwellers with few organisms growing in fresh water forms. They show red yellow, green, brown or blue appearance that occurs due to the pigment present in the cell.

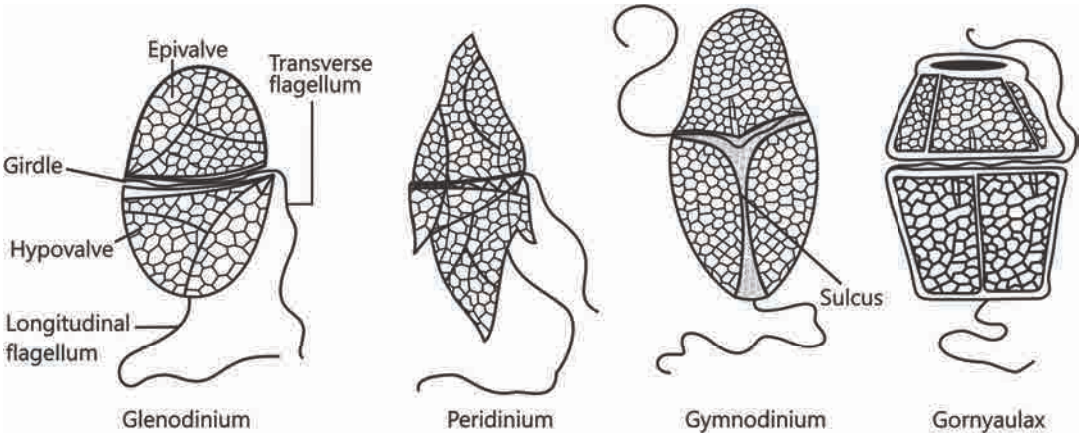

Figure 3.2: Diagrammatic view of Various Dinoflagellates

General characters of dinoflagellates are as follows

- They are motile, biflagellate showing golden brown photosynthetic Protists (some are non-motile, amoeboid, palmelloid or filamentous).
- They are mostly marine, and some of them are found in fresh water.
- The body has the rigid coating called the theca or lorica that consists of 2 and above articulated or sculptured plates of cellulose and pectin, hence are also called armoured dinoflagellates.

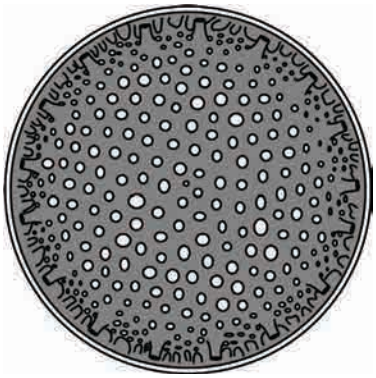

Figure 3.3: Microscopic view of various Dinoflagellates showing their body and shape

- Theca shows two grooves,the longitudinal one called as sulcus and the other transverse called as cingulum or annulus or girdle. Each of the grooves contain respective flagellum.
- There are two flagella in heterokont (different) position, one is longitudinal and the other is transverse outwards the cell. The flagella are across the pores in the lorica, lying in the grooves of the cell. The longitudinal flagellum is narrow, smooth directed posteriorly and the transverse flagellum is ribbon like.
- Both are oriented at right angle to each other producing spinning movements for the cell. Thus, Protists are also called as 'whirling whips'.
- Most of the species show brown, green or yellow colour as they have chromatophores with chlorophyll a, c, α -carotene, xanthophyll (e.g., *Peridinin*). Plastids have a 3-membrane envelope that contain 3-thylakoid lamellae. The species are photosynthetic (*Ceratium*) while few of them are saprobic or parasitic.

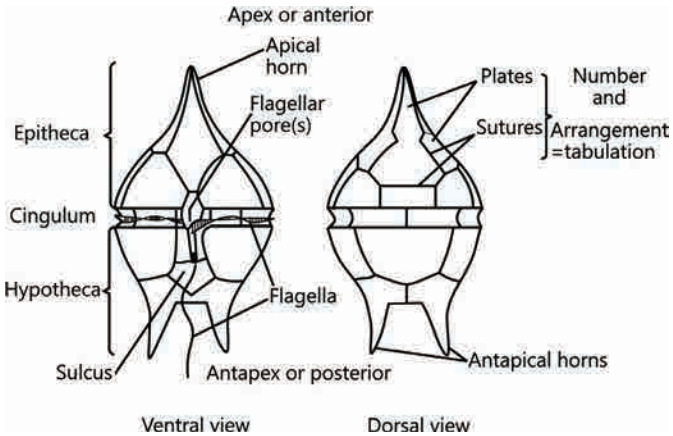

Figure 3.4: Diagrammatic view of Dinoflagellate with the flagella and base

- Reserve food is in the form of carbohydrate and oils.
- Nucleus is relatively larger in size with condensed chromosomes that lack histone. Nucleus envelop along with nucleus remain in the cell at all the stages of cell division.
- A non-contractile vacuole called as the pusule occur at the flagellar base. It may contain one or more vesicle and is involved in flotation and osmoregulation.
- Some dinoflagellates show presence of trichocysts and cnidoblasts similar to the coelenterates.
- Reproduction is asexual taking place through the usual cell division.
- Isogamous and anisogamous sexual reproduction is also observed in some dinoflagellates, e.g., *Ceratium.*
- Life cycle of dinoflagellates show zygotic meiosis (*Ceratium, Gymnodinium*). Gametic meiosis takes place in *Noctiluca*.

Did You Know

- Some marine dinoflagellates have bioluminescent property i.e., they emit light in darkness that glows the sea, e.g., *Noctiluca*, *Pyrodinium, Pyrocystis.*
- Some dinoflagellates like *Gonyaulax catenella* have the ability to produce a toxin. This toxin is called as saxitoxin released into the sea water which is highly poisonous to aquatic vertebrates. This toxin when enters the food chain, it affects all the levels from marine shell fish to man causing paralytic shell fish poisoning (PSP) that can be fatal.
- Some dinoflagellates proliferate extensively causing red tide of the sea, e.g., *Gonyaufax, Gymnodinium*.
- The organization of nucleus being always intact in the cell of the Dinoflagellates is called as Mesokaryon (Dodge, 1966).

2.2.3 Euglenoid (*Euglena*-Like)

The group of chlorophyllous and achlorophyllous flagellate Protists. Largest genera being *Euglena* amongst them.

General characteristics of Euglenoid

- Flagellate Protists found in aquatic region (fresh water organisms found in stagnant water) or damp soil.
- Body has spindle shape, blunt at the anterior part and pointed at the posterior end
- Cell wall is absent however the cell is covered by proteinaceous periplast or pellicle.
- Flagella causes locomotion.

- The cell bears pair of flagella arising at the anterior end. One of these is long tinsel type flagellum (stichonematic) and the other is reduced. The longer flagellum branches at the base in two that its own basal granule. The union of two flagella contains a photosensitive paraflagellar body.
- Euglenoids carry out creeping movement of contraction and expansion with the help of myonemes (strips in pellicle) which is called metaboly or Euglenoid movement.
- The apical end consists of an invagination having three distinct parts, i.e., mouth (cytostome), canal (gullet or cytopharynx) and reservoir. These help to take up the solid food particles.
- Stigma or an eye spot is present at the base of paraflagellar body attached to the membrane. The eye is assumed to be perceptive for light stimulus. It has photosensitive red-orange pigment which is called as the astaxanthin.

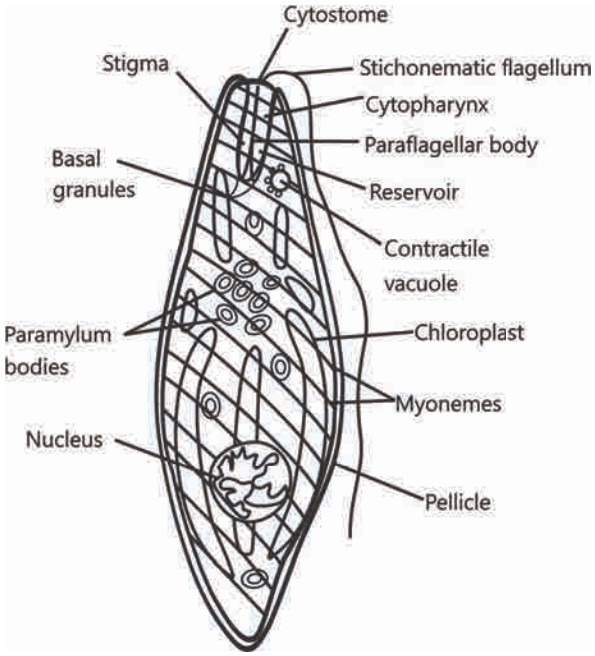

Figure 3.5: Diagrammatic view of *Euglenoid viridis*

- A contractive vacuole occurs in the anterior end of the cell just below the reservoir, meant for osmoregulation and exception.
- Single large nucleus is approximately at the center of the protoplast.
- Nutrition in *Euglena viridis* is photoautotrophic. However, when light is insufficient, it takes nourishment from dead and decaying organic matter present in the substrate as it can secrete digestive enzymes (saprophytic nutrition). This nutrition dual mode is termed as mixotrophic. Holozoic nutrition is absent in *Euglena* however some forms are holozoic (*Paranema*) or saprobic (*Rhabdomonas*).
- Photosynthetic pigments in the cell are chlorophyll *a*, chlorophyll *b*, xanthophyll and *β*-carotene giving it the colour.

- Reserve food material is called as paramylon. These paramylum granules are stored in cytoplasm. They are chemically β -1, 3-glucans.
- Longitudinal binary fission is the reproduction mode under favourable conditions. During unfavourable conditions, palmella stage cysts are produced by the cells for perennation. e.g., *Euglena* and *Paranema*.

Knowledge Builder

- *Euglena* is protist that is producer and decomposer.
- It is has characters of both plant and animal, thus is called as plant-animal.
- Characters of *Euglena* similar to plant:

  Presence of chloroplast, the photosynthetic pigment.

  Holophytic nutrition.
- Animal character of *Euglena*:

  Absence of cell wall.

  Presence of proteinaceous pellicle.

  Contains stigma and paraflagellar body.

  Has contractile vacuole.

  Reproduces by longitudinal binary fission.

2.3 Slime Molds or Consumer-Decomposer Protists

They were initially included in the class myxomycetes in the class fungi in the two-kingdom classification system of Plantae and Animalia. They were called as mycetozoa as they closely resemble animals, by DeBary. Slime molds are included in gymnomycota by Mycologists. As they are similar to fungi, they are called as Protistan fungi.

- They are free-living, similar to creeping over debris on fallen leaves and rotting woody logs.
- They lack cell wall and have a naked protoplast in vegetative stage of life cycle.
- They lack chlorophyll, thus have saprobic or phagotrophic nutrition mode.
- They are amoeboid and lack cellulosic wall during the life cycle, but spores show cellulosic wall. Their vegetative phase is similar with animals while reproductive phase is similar with plants.
- They have protozoa like amoeboid plasmodial stage and fungi like in spore formation.
- Spores are extremely strong and resistant to adverse conditions. They survive for many years and get dispersed by air currents.
- Reproduction is by both asexual and sexual methods.

- This group is represented by two separate types of organisms i.e. acellular and cellular.

2.3.1 Acellular or Plasmodial Slime Molds

General Characters

- Slimy mass that are found on decaying leaves and lumber are the acellular molds.
- Somatic body of the mold is free living, multinucleate, naked (no cell wall), diploid chromosome called as the Plasmodium.
- Pseudopodia causes movement.
- Plasmodium forms several fructifications or fruiting bodies called as the sporocarp.It contains a stalk which has a sporangium at the end. The wall of sporangium is called peridium.
- Sporangium shows an intricate network of cytoplasmic threads called capillitium.
- Diploid protoplast on meiotic division forms haploid spores.
- Spore wall is double layered, with spiny and sculptured outer wall.
- Spores produce biflagellate swarm cells called as non-motile myxamoebae on germination, which acts as gametes.
- The sexual reproduction is in the isogamous type.
- Diploid zygote directly produces the plasmodium that becomes multinucleate after repeated mitotic divisions of the diploid cellular nucleus.
- Saprotrophic is the mode of nutrition.
- Vegetative reproduction is common by fission.

  For e.g., *Physarum, Physarella, Fuligo, Dictydium, Lycogala* are the acellular slime molds.

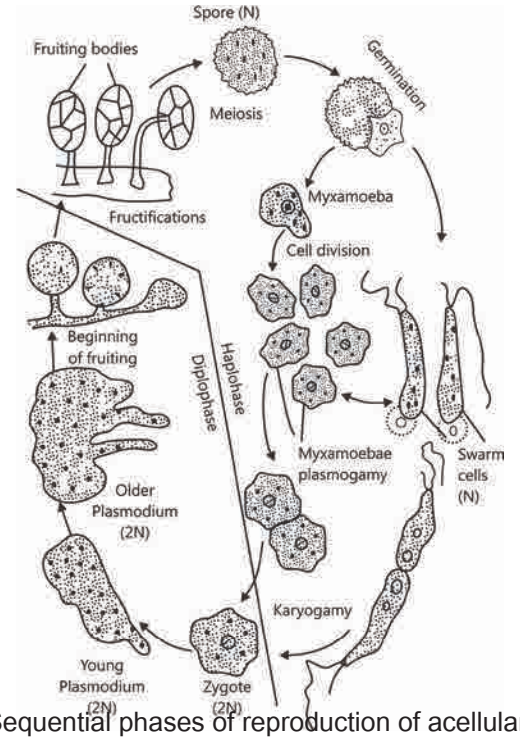

Figure 3.6: Sequential phases of reproduction of acellular slime mold

2.3.2 Cellular Slime Molds or Communal Slime Molds

General Character

- They lack cell wall, however spores show presence of cellulosic wall, are uninucleate and myxamoebae is present. They do not have flagellated cells during whole life cycle.
- The chemotactic movement of myxamoebae after the formation of pseudoplasmodium stage is due to the secretion of cAMP and acrasin.
- Sporangia are naked.

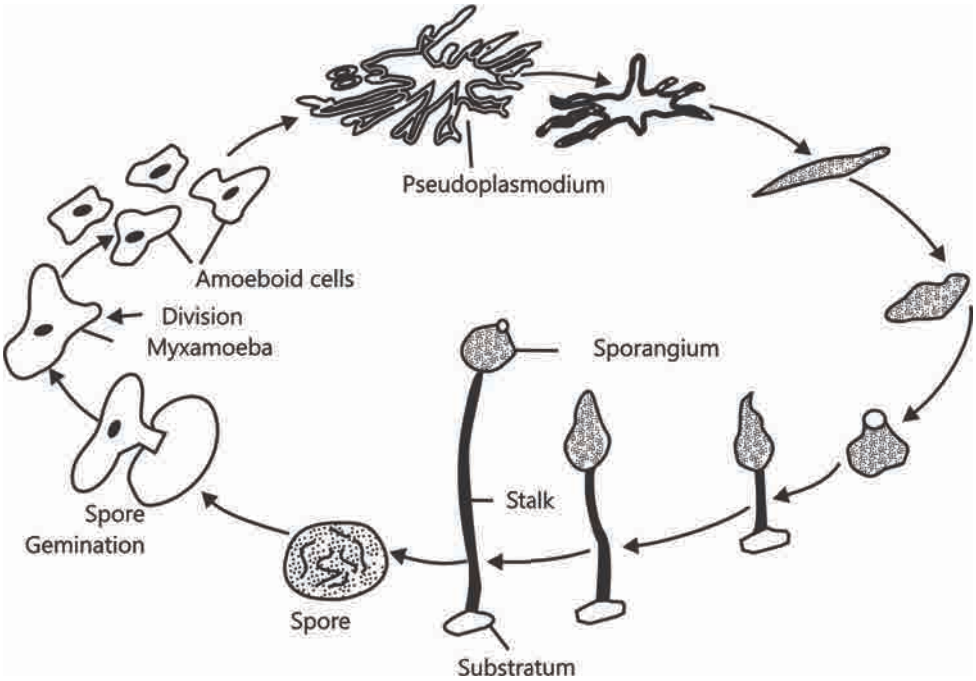

Figure 3.7: Sequential phases of reproduction of cellular slime mold

- *Dictyostelium*, is a common cellular slime mold, colonial in form which have hundreds of uninucleate, haploid amoeboid cells in aggregated form in a colony. The colonial mass of protoplasm shows the presence of single multinucleate called as the pseudoplasmodium.
- When the food supply is exhaustive and cells get stimulated by cAMP and chemical acrasin, they come close by chemotactic movement during the formation of pseudoplasmodium. Pseudoplasmodium has primitive multicellularity form and division of labour. Hence the name given communal slime molds. On these basis cellular slime moulds are considered as advanced Protists and primitive fungi.
- The myxamoebae form a cyst called microcyst for perennation and dispersal under unfavourable conditions.

- Pseudoplasmodium produces stalked sporocarp under dry conditions, which can be branched or unbranched. Each branch bears a single sporangium at the terminalend (monocentric). Sporangium does not have any cell wall.
- Within the sporangium, amoeboid cells acquire roundshape in order to secrete a spore wall around itself. When it encounters favourable conditions, spores are liberated free.
- Each spore germinates after the rupture of cellulosic wall to form myxamoebae. This myxamoebae is able to live independently, multiply with repeated mitotic divisions or aggregate to form pseudoplasmodium.
- Sexual reproduction is anisogamous type. A clump is formed from number of myxamoebae during sexual reproduction. One of the myxamoebae formed becomes larger enough to engulf the surrounding smaller myxamoebae.
- Then plasmogamy occurs.The fused protoplast produces a thick wall that forms a macrocyst. In the macrocyst, zygote is formed after karyogamy. It is followed by meiosis and several mitotic divisions to form a large number of haploid myxamoebae, which are released by rupture of macrocyst wall.

  e.g., *Dictyostelium, Polysphondylium*

TRY IT YOURSELF

1. Select correct statement
   (A) Some Protists are colonial without much cellular differentiation.
   (B) Pyrrophytes are exclusively marine forms.
   (C) Lorica or theca is absent in endozoic dinoflagellates.
   (D) Primordial utricle is present around a large central vacuole in diatoms.
   (E) In *Euglena*, paramylon as reserve food material is stored in chloroplast.

2. Fill in the blanks
   (A) Pennate diatoms have _____ symmetry.
   (B) Resting spores in centric diatoms are called _____.
   (C) A non-contractile vacuole called ____ is present neat flagellar base in dinoflagellates.
   (D) Vegetative stage of slime moulds resembles with ____ due to absence of cell wall.
   (E) *Euglena* does show ___ nutrition.

3. What is the type of meiosis in acellular slime molds respectively?

3. Kingdom Fungi (Mycota)

- Multicellular(except *Yeast* and *Synchytrium*).
- Decomposers (absorptive)
- Spore forming
- Eukaryotes

The study of fungi and its characteristics are called as **mycology**.

Did You Know

Pier Antonio Michele is considered as “father or mycology”. Mycologist H.A. DeBary is the “father of modern mycology”. The father of Indian mycology is E. J. Butler.

3.1 General Characters of Fungi

- Found in air, water, soil, on animals and plants.
- Omnipresent in various conditions.
- Mostly terrestrial.
- Love to grow in warm and humid places. Also they may grow on wood, burnt wood, tree bark, and keratinous material (e.g., hair, horns), are thus called as corticolous (bark), coprophilous (cow dung), epixylic (wood), xylophilous (burnt wood) and keratinophilous (keratin) respectively.
- The body is haploid (n) and thalloid, lacking proper root, stem and leaves. The fungal body shows thread like elongated tubular structures which is called as hyphae. These hyphae are in cris-cross pattern forming a network called as a mycelium.
- The hyphae show aseptate and multinucleate pattern termed as the coenocytic. The mycelium is septate in maximum species. The septum shows presence of a pore which is continuous to the cytoplasm of the adjacent cells.
- The septum either has a simple central pore as in ascomycetes ordolipore septum in higher fungi (class basidiomycetes). Also presence of a single nucleus (monokaryotic-feature of primary mycelium) or an intermediate phase of two nuclei (dikaryotic-feature of secondary mycelium) in the cell.
- The cell wall is made up of chitin or fungal cellulose (acetyl glucosamine) in the hyphae. Some fungi have the cellulosic cell wall (e.g., *Phytophthora, Pythia* and other oomycetes).
- Oil and glycogen is the reserve food material.
- Cells contain unicisternal Golgi bodies and not the usual one.
- Mitosis in somatic cells is Karyochorisis type (mitosis with intranuclear spindle formation).
- Heterotrophic and absorptive nutrition mode which involves saprophytes, parasites and symbionts pattern.

- The fungi have two distinct phases in their life cycle: the vegetative or assimilative phase and the reductive phase.
- During vegetative phase, the fungus acquires microscopic size attached to the substratum. The fungus in the vegetative phase attains maturity then enters the reproductive phase.
- In unicellular yeasts, the cell functions in both the assimilative and reproductive phases.
- The fungal bodies gets transformed into reproductive cells, they are then known as holocarpic.
- Fungal body is known as eucarpic when a part of the mycelium is involved in the developing process of reproductive structures.

Knowledge Builder

Modification of Mycelium

- Plectenchyma: Hyphae of a mycelium develop together in the form of plates and intertwine one another to assemble a thick woven thread, it is called plectenchyma. Plectenchyma has:

  Prosenchyma: Hyphae are loosely interwoven, are parallel to each other and are recognizable.

  Pseudoparenchyma: Hyphae have compact arrangement, have lost their usual appearance and gained isodiametric shape, is continuous. This is similar to the parenchyma of higher plants.
- Sclerotia (Singular Sclerotium): *Claviceps* have the mycelium that may be in dormant or resting stage with the formation of hard resting bodies that is resistant to unfavorable conditions. Each sclerotium is made up of central prosenchymatous from a pigmented hyphae ring.
- Rhizomorph: Hyphae aggregate together under the surface and form an organized unit similar to a root like strand having thick hard cortex. It shows a tip similar to a root tip, e.g., *Agaricus*.
- Appresorium: Hyphae show terminal swollen structure similar to that of a germ tube to help in the attachment and penetration.
- Haustoria: Hyphae have terminal swollen structure to absorb the food, e.g., *Albugo*.
- Snares/hyphal traps: Hyphae helps to catch nematodes in predaceous fungi, e.g., *Arthrobotrys* and *Dactylaria*.

3.2 Reproduction in Fungi

Fungi can reproduce by vegetative, asexual and sexual methods.

3.2.1 Vegetative Reproduction

- **Fragmentation**: The mycelium gets an injury or decay and the cell is broken into two or more fragments. Each fragment has the ability to develop into independent mycelium.
- **Fission**: Vegetative cells simply split by simple constriction into two daughter.
- **Budding:** Yeast have small outgrowths emerging from their vegetative body, called as buds. These buds mature into new individuals after they are separated from parent cell.

3.2.2 Asexual Reproduction

Spores bring about the reproduction. Spores have single cell that are specialized structures, get detached from the cell, disperse and germinate under favourable conditions to produce new mycelium. The spores are a result of mitotic division, thus termed as mitospores. The various means of asexual reproduction are as follows:

(i) Zoospore: Aquatic fungi produce such spores.

- It can be uniflagellate, e.g., *Synchytrium* or biflagellate, e.g., *Saprolegnia, Pythium*
- Naked uninucleate structures are formed in zoosporangia.
- They germinate to give rise to new mycelium.
- Biflagellate zoospores are of two kinds (e.g., *Saprolegnia*) pear shaped or pyriform with 2 flagella placed at anterior end (primary zoospore) and kidney shaped or bean shaped, bearing two laterally inserted flagella (secondary zoospore). This phenomenon of having two types of zoospores is called diplanetism.

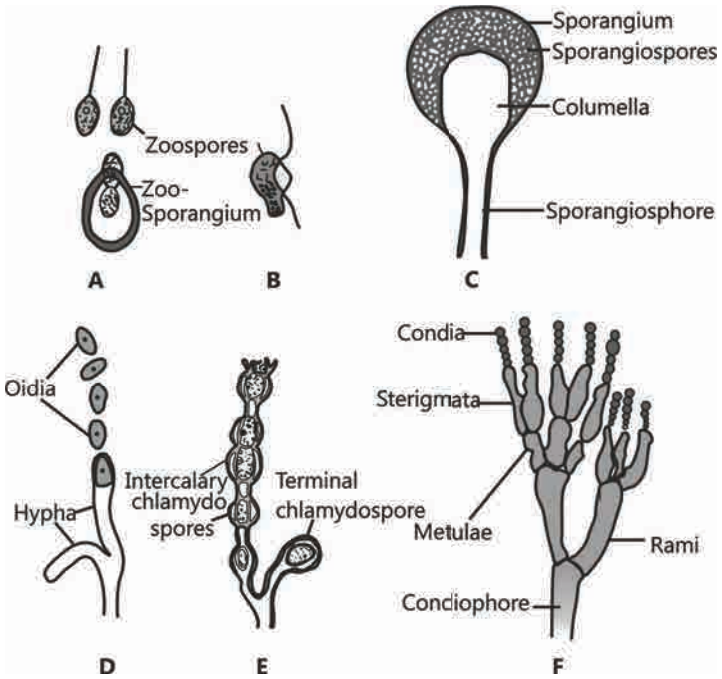

Figure 3.8: Diagrammatic view of various spores. **A.** Zoospore, **B.** Sporangium, **C.** Sporangiospore, **D.** Oidia, **E.** Chlamydospore and **F.** Condia

(ii) Sporangiospores: Sporangiospores are thin walled non-motile

- Endogenous spores formed in a sporangium during unfavourable conditions liberate and give rise to a new mycelium, e.g., *Rhizopus, Mucor*.

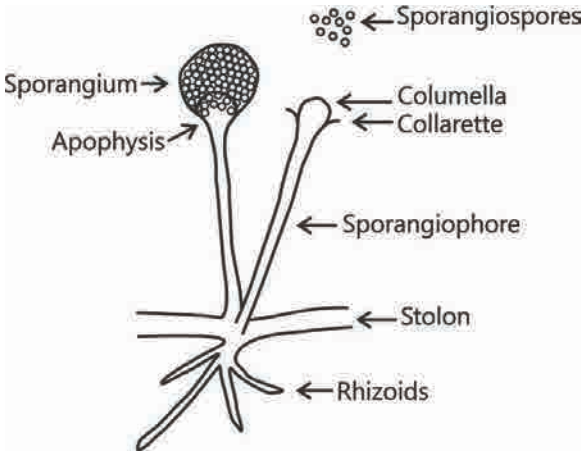

Figure 3.9: Diagrammatic view of: Sporangium, and Sporangiospore

(iii) Conidia: Non motile, thin walled exogenous spores.

- It is produced in the erect hyphae tips called conidiophore.
- Spores have chain arrangement upon the conidiophore, e.g., *Aspergillus* and *Penicillium*.

(iv) Chlamydospore: Thick walled resistant spores getting separated from each other.

- Terminal or intercalary spores in a cell.
- They have viability for several years.
- In favourable conditions new individuals germinate out.
- Thus, chlamydospores are structures for perennation also, e.g., *Rhizopus*.

(v) Oidia: Non-motile, thin walled spores.

- Develop when in excessive sugar in the medium. Their budding conditions is termed as the torula stage.

3.2.3 Sexual reproduction

Sexual reproduction takes place with the help of two fusing gametes. It includes 3 stages:

(i) Plasmogamy: Union of the two haploid protoplasts.

- The fusing nuclei of different parents thus comes close.
- In some fungi, karyogamy occurs just after plasmogamy.
- However, Ascomycetes and Basidiomycetes have an intermediate step where dikaryotic (n + n) condition takes place, the phase is called as dikaryophase.

(ii) Karyogamy: Two haploid nuclei fuse to form diploid zygote after their fusion.

- **Meiosis:** Zygote involves reduction division to divide the number of chromosomes to half. Plasmogamy occurs by the following methods:
- **Planogametic copulation/Gametic fusion:** The simplest form in sexual reproduction.
  - Fusion of two opposite sex or strains gamete occurs.
  - Fusing gamete or both of them are motile.
  - Production of a diploid zygote, e.g., Allomyces.
  - Different modes of plasmogamy in fungi
  - This process is usually of three types: Isogamy, Anisogamy, and Oogamy.

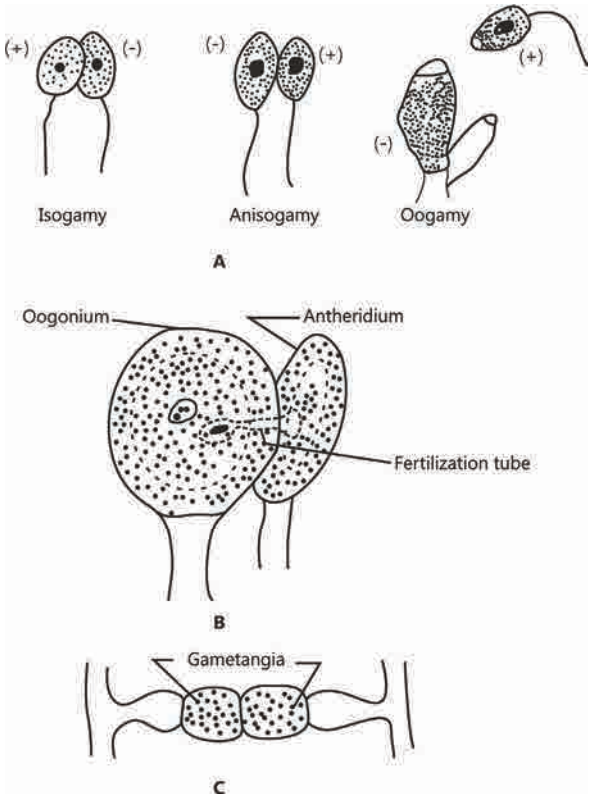

Figure 3.10: Diagrammatic view of various phases in mating in Plasmogamy.
A. Planogametic copulation, **B.** Gametangial contact, **C.** Gametangial copulation

- **Gametangial contact:** Two gametangia come close in contact.
  - The migration of complete male gametangium into the female gametangium is facilitated on development of a fertilisation tube.
  - Both the gametangia remain intact with their identity, e.g., *Pythium*, *Albugo* (Oomycetes).

- **Gametangial copulation:** Direct fusion of the two gametangia completely occurs.
  - It is due to the dissolution of their common walls forming a single cell.
  - The protoplasts of two gametangia fuse in the cell, e.g., *Mucor, Rhizopus* (Zygomycetes).
- **Spermatisation:**
  - Minute, spore like, single-celled structures are formed by few fungi called as the spermatia (non-motile male gametes) on spermatiophores (hyphae).
  - These spores are transferred through vectors to special female receptive hyphae (Basidiomycetes).
  - The contents enter into the receptive structure causing a dikaryotic condition, e.g., *Puccinia*.

(iii) Somatogamy: Most of the higher true fungi have this step.

- The formation of gametes does not occur.
- In such fungi, direct fusion of somatic hyphal cells occur to establish dikaryophase, e.g., *Agaricus.*

3.3 Classification of Fungi

There are various classifying systems for fungi. The major reasons for separation in this kingdom are Morphology of mycelium, mode of spore formation and fruiting bodies. The detailed description of the classes is as follows:

- **Oomycetes**
- **Zygomycetes**
- **Ascomycetes**
- **Basidiomycetes**
- **Deuteromycetes**

3.3.1 Class Oomycetes

Table 3.1: Characteristics of Class Oomycetes

Common name	Algal fungi
Mycelium type	Coenocytic (multinucleate and aseptate)
Cell wall made of	Cellulose and other glucans
Habitat	Aquatic, on decaying wood, moist and damp areas.
Asexual reproduction	Sporangia produce zoospores in water.
Sexual reproduction	planogametic fusion or gametangial contact oospore
Examples	*Albugo candida, Pythium debaryanum*

- Zoospores contain a pair of lateral flagella in the heterokont condition. One flagellum is smooth (whiplash) while the other is of tinsel type (having fine surface outgrowths called mastigonemes).

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Table 3.2: List of Diseases Caused by the Fungi

Organism Name	Disease Caused
Phytophthora infestens	Late blight of potato and even sometimes of tomato. Late blight of potato was the reason for Great Irish famine of 1845-1847.
Pythium debaryanum	Damping off disease in the seedlings of tomato, chilies, castor, and mustard.
Albugo candida (Cystopus candidus)	White rust of crucifers (have appearance of white blisters in irregular shape on the surface of leaves and stems).
Sclerospora graminicola	Downy mildew in cereals. *Pennisetum typhoides* (Bajra) gets the green ear disease.
Peronospora parasitica	Downy mildew among a range of plants, such as pea, mustard, spinach, onion etc.
Saprolegnia	Salmon disease of gills in fishes

3.3.2 Class Zygomycetes

Table 3.3: Characteristics of class Zygomycetes

Common name	Conjugation fungi
Mycelium type	Coenocytic (multinucleate and aseptate)
Cell wall made of	Cellulose and chitin
Habitat	Terrestrial
Asexual reproduction	Sporangia produce zoospores in water.
Sexual reproduction	Gametangial copulation or conjugation coenogametes
Examples	*Albugo candida, Pythium debaryanum*

- Mostly saprotrophic and rarely parasitic.
- Motile cells (zoospores or planogametes) are absent.
- Mitospores are also non-motile. The spores are formed inside the sporangia present at the tips of special hyphae called sporangiophores. Spores are called sporangiospores.
- Zygospore, a diploid spore is formed in the sexual reproduction. Thus the class is called as zygomycetes.
- Zygospore is the meiosis site and does not give rise to new mycelium directly. Instead it produces a new sporangium called germ sporangium. Germ sporangium forms meiospores called germ spores.

KNOWLEDGE BUILDER

Some of the common diseases caused by the class

- *Rhizopus stolonifer* (= *R. nigricans*) is popularly commonly called as black bread mould as it decays the bread.
- *M. mucedo* is called as the dung mold or pin mold.
- *Rhizopus* and *Mucor* species are the common saprotrophic fungi which attack many food stuffs. *Rhizopus* causes soft rot or leek disease of strawberry, apple, jack fruit, sweet potato etc. *Mucor pusillus* causes infection of internal organs in human beings.
- *Absidia corymbifera* causes bronchomycosis.

Ramysin (antibiotic) is produced by the fungi *Mucor ramannianus.*

Life cycle of *Rhizopus*

Rhizopus is a

- Saprophytic fungus feeding on dead organic matter to absorb carbohydrates.
- Mycelium consists of white narrow thread like hyphae spread on the surface of substratum.
- Four types of hyphae: Two vegetative hypha: Rhizoidal and Stoloniferous arises from hold fast/apparent nodes. Third is asexual in nature, called as the Sporangiophores and fourth type is sexual hypha called as the zygophore.
- The absorptive hyphae penetrate the substratum to take up nutrients, are called as the rhizoidal hyphae. The hyphae are in the stolon form that have appeared on the surface of substratum. Branched rhizoidal hyphae arise from stolon nodes that are under the surface. A group of aerial structures arise from hyphae that are called as sporangiophore (asexual hypha). The apical portion of each sporangiophore has a swollen structure having spores at the end which is called as sporangium.
    - The hyphae in *Rhizopus* are coenocytic, aseptate and branched having several nuclei, oil drops, glycogen bodies and vacuoles in its cytoplasm.
    - The reproduction mode in *Rhizopus* are vegetative, asexual and sexual.

Vegetative reproduction: Fragmentation of hyphae takes place.

Asexual reproduction: Asexual reproduction takes place after the formation of non-motile spores inside the sporangium.

- The tip of aerial hypha has cytoplasm that migrates with nuclei swells.
- The swollen tip contains nuclei that divide repeatedly.
- The contents of the young swollen tip differentiate into a central zone called columellaplasm mainly filled with vacuolated cytoplasm surrounded by a peripheral zone called sporangioplasm containing dense cytoplasm and many nuclei.

- Vacuoles ultimately form a continuous vacuolated layer by fusing laterally one after the other and ultimately develop into a dome shaped septum known as columella (sterile part).
- In the meantime, cleavage of sporangioplasm take place resulting into innumerable, small 2-10 nucleate portions which round up, become invested with spore membranes, and develop into nonflagellate spores, the sporangiospores.
- These are formed under most favourable conditions.
- Thus, the sporangium is large, globose and contains many spores. Spores are dispersed by bursting of the thin wall of the sporangium due to pressure that is set up in the columella.

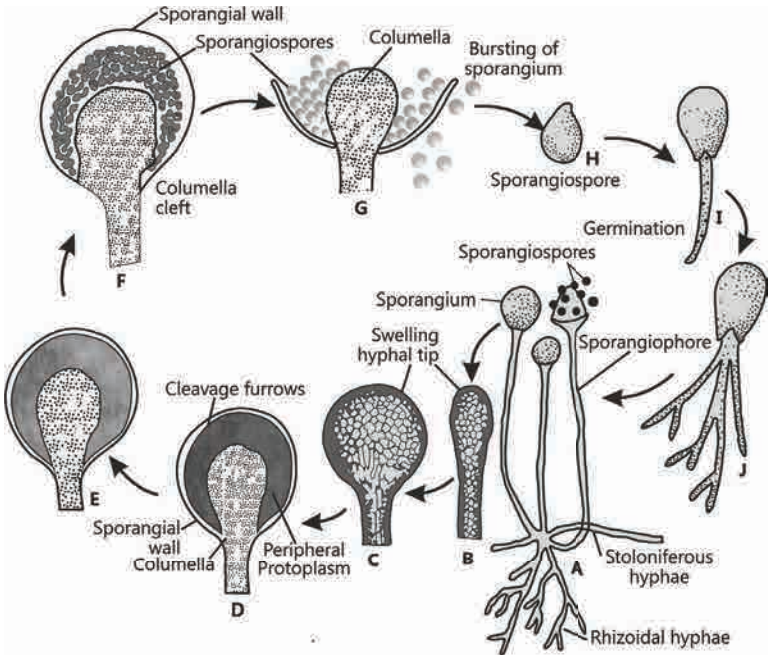


Figure 3.11: Diagrammatic view of various phases in mating in Sporangiospore formation

- Other two asexual spores are Oidia and chlamydospores (formed under unfavourable conditions). The spores on germination produce a germ tube giving rise to new mycelium.

Sexual Reproduction: Sexual reproduction in *Rhizopus* takes place by the formation of two multinucleate gametangia.

- Both the gametangia have differences in physiological factors i.e., they are of (+) and (-) type. This gametangia difference is called heterothallism (This was discovered by Blakesies in *Rhizopus stolonifer*). Another species of *Rhizopus* has similar gametangia sexually and thus is a homothallic species.
- The (+) gametangia is behaving as male and (-) gametangia is behaving as female. Both of them come close in presence of a chemical called trisporic acid. This chemical stimulates the formation of special sub-aerial hypha called zygophores. This hypha produces small outgrowths which is called as progametangia.

- Their apical ends are filled with multinucleate protoplasm and are thus swollen.
- The apical portion of these progametangia come closer and form gametangium.

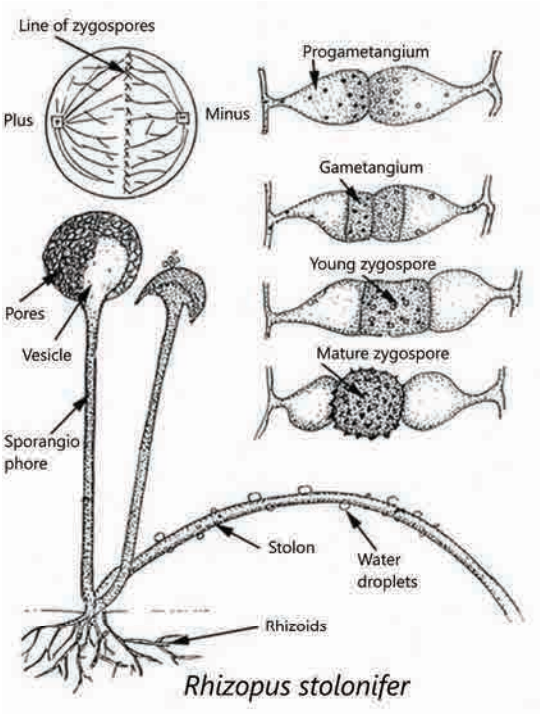


Figure 3.12: Diagrammatic view of various phases in spore formation in *Rhizopus*

- The progametangia is now left with small part and is called as the suspensor.
- The multinucleate undifferentiated protoplast present in the gametangium is termed as coenogamete.
- Gametangia mature, the separating wall dissolves in outward way from the middle.
- Two gametangia share their contents (Gametangial copulation).
- Nuclear pairs and fusion of one (+) and another (-) nuclei takes place. This fusion produces several diploid nuclei.
- The young zygospore present in the parent gametangial wall enlarges.
- It then secretes numerous thick wall layers (5 layered, 2 layered exosporium and 3 layered endosporium) around it.
- Zygospore breaks up the gametangial wall into small pieces on maturation. These small pieces then fall apart and expose the outer thick, spiny and black exosporium.

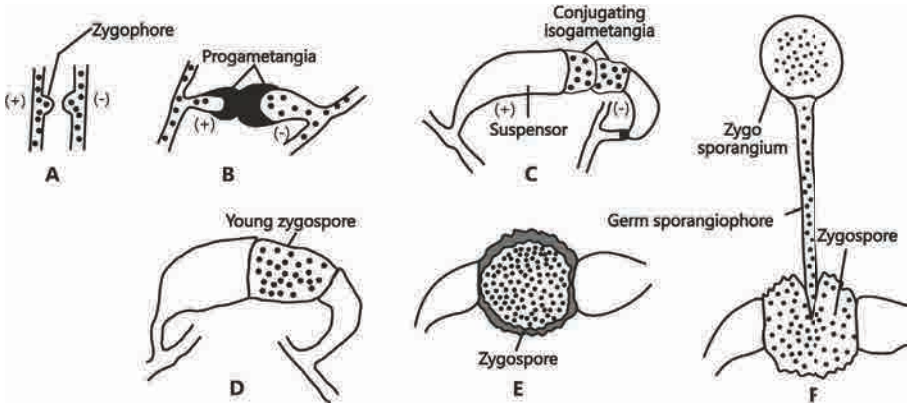


Figure 3.13: Diagrammatic view of various phases in formation of zygospore.

A. Zygophore, **B.** Progametangia, **C.** Conjugation, **D.** Zygospore formed, **E.** Zygospore and **F.** Mature zygospore

- Meiosis occurs at the time of germination of zygospore. The zygote after resting phase germinate.
- The exosporium cracks and endosporium produce a germ sporangiophore (promycelium) that terminally develops a germ sporangium (zygosporangium) which bears large number of spores.
- The meiosis produce 4 haploid nuclei where only one remain functional. This divides repeatedly to produce coenocytic mycelium with many haploid nuclei.
- Occasionally, failure of gametangial copulation results is parthenogenetic development of zygospore, which are called azygospores (parthenospores).

3.3.3 Ascomycetes: The Sac Fungi

Table 3.4: Characteristics of Class Ascomycetes

Common name	Sac fungi
Mycelium type	Septate hyphae
Cell wall made of	Chitin
Habitat	Terrestrial
Asexual reproduction	Sporangia produce zoospores in water.
Sexual reproduction	Gametangial copulation or conjugation coenogametes
Examples	*Pyronema, Peziza*

- The nutrition mode is saprophytic, decomposing, parasitic or coprophilous (growing on dung).
- The septa have central pores to communicate and transport nutrients among nearby cells called as the septal pores.

- Motile structures are not present in the life cycle.
- In majority of the ascomycetes, conidia is the common mode of asexual reproduction. Conidia are produced and stored on branched or unbranched hyphae called conidophores, e.g., *Penicillium, Aspergillus*.
- Female sex organ is present which is called as ascogonium.
- Plasmogamy occurs by means of-
  - Gametangial contact (e.g., *Pyronema*), Conjugation (e.g., *Yeast*), Spermatisation (e.g., *Ascobolus*), Somatogamy (e.g., *Peziza*) and Autogamy (e.g., *Morchella*).
- Karyogamy and plasmogamy have an intermediate phase of dikaryophase. The cells of dikaryophase are called as dikaryotic cells that have two different nuclei. This is a shorter phase of the life cycle as compared to others.
- A dikaryotic cell transfers the nucleus to other cells with the crozier method (method of dikaryotisation) in order to make them dikaryotic.
- Some dikaryotic cells function as ascus mother cells to convert them into asci (singular - ascus). Ascus is a sporangial sac which is specific to Ascomycetes. Ascus is where karyogamy and meiosis occurs. 4 to 8 haploid ascospores are endogenously produced in the ascus. The ascospores produced belong to both the mating type equally: 50% to one mating type (+) and 50% to the second mating type (-).
- Ascospores may have linear or improper arrangement.
- The asci may occur freely or get aggregated into specific fructifications called ascocarps. Ascocarps are: cup like (apothecium, e.g, *Peziza*), flask-shaped (perithecium, e.g., *Neurospora, Claviceps*), elongated with a slit (hysterothecium), closed (cleistothecium, e.g., *Penicillium*) cushion, like chambered (ascostroma, e.g., *Pleospora*). The fructification of some ascomycetes is used as food, e.g., morels, truffles.

Try It Yourself

1. Give one word for aggregated mass of fungal hyphae into root like strand with thick hard cortex.
2. Which of the following members are related with Phycomycetes, Ascomycetes or Basidiomycetes?

(a) *Penicillium*	(b) *Synchytrium*	(c) *Mucor*
(d) *Albugo*	(e) *Agaricus*	(f) *Saccharomyces*
(g) *Phytophthora*	(h) *Saprolegnia*	(i) *Rhizopus*

Knowledge Builder

Economic importance of the Fungi:

- **Morels:** Ascomycete member having edible ascocarps. They are fleshy sponge-like conical cap called as pileus held with a stalk like stipe, e.g., *Morchella esculenta* (verm. Guchhi). *M. Deliciosia.*
- **Truffles:** Subterranean ascocarps are tuber like edible fungi, e.g. *Tuber aestivum*.
- ***Claviceps purpurea*** infects mustard causing ergot of rye and *C. microcephalais* responsible for ergot in Bajra. The ears are filled with Sclerotia of the fungus. Consuming the infected cereals initiates the production of ergotism in the body. (It produces an alkaloid called as the ergotine that results in abortion. This is used as a drug to promote expulsion of foetus).
- ***Neurospora crassa*** (Pink bread mould), is common in experimental genetics, thus it is called as the *Drosophila* of plant kingdom.
- ***Erysiphe*:** The fungus produces powdery mildew (fungal disease in which pathogen results in a powdery coating of spores on the surface of the host), e.g., *Erysiphe graminicola.*
- ***Penicillium chrysogenum*** is used in commercial production of the antibiotic penicillin. The later was the first commercial antibiotic. It was discovered from *P. notatum.* The fungus is employed in ripening of cheese, e.g., *P. roqueforti* and *P. comemberti.*
- ***Aspergillus*:** The common green smoky mould affecting all the laboratory work by contaminating other laboratory cultures (hence called weed of laboratory) and also infecting various food stuffs including bread, butter etc. *Aspergillus flavus* is highly poisonous as it produces aflatoxins. *A. oryzae* produces diastase enzyme causing ear and lung diseases in humans.
- **Brewing Industry:** Yeasts use sugar as their energy source and convert it into ethanol which is edible alcohol. Under anaerobic conditions, sugary solution are inoculated with specific strains of yeasts e.g., beer, wine, cider, toddy. The two common yeasts used for alcohol production in brewing industry are *Saccharomyces cerevisiae* (Beer or Baker's yeast) and *S. ellipsoidens* (Wine yeast)
- **Gibberellins:** The natural plant growth hormone first discovered in the extracts of fungi *Gibberella fujikuroi* that grew on rice (bakanae disease of rice).

Life Cycle events of Yeast and *Penicillium* are described below:

(i) Yeast

- Non-mycelial or else pseudomycelial ascomycetes.
- Reproduce asexually

- Asci are not developed into ascocarps.
- Facultative aerobes.
- Yeasts are classified on their mode of asexual reproduction, as follows – budding yeast (e.g. *Saccharomyces*), fission yeast (e.g., *Schizosaccharomyces*) and helobial yeast (both budding and fission, e.g. *Saccharomycoides*).
- Yeasts having ascus formation are named as true yeasts.
- Yeasts that lack ascus formation are called as false yeasts, e.g., *Candida, Mycoderma*, *Geotrichum*, and *Cryptococcus* (false yeasts belong to Deuteromycetes).

Life Cycle of Yeasts

A saprophytic fungus growing on substratum which has high sugar amounts, e.g. sugarcane juice, fruits (banana, plum, grapes), milk etc.

Structure

- Circular or elliptical, colourless fungi, unicellular, lacks typical mycelium.
- Cell wall is made of mannans, glucans, lipids, proteins and chitin.
- Protoplasm has two distinct regions. Outer region is called as ectoplasm in the form of a thin layer and inner region is called as endoplasm which is granular.
- The protoplasm contains stored food as glycogen bodies, volutin granules and fats.
- Mitochondria and ribosomes are present in the cytoplasm.

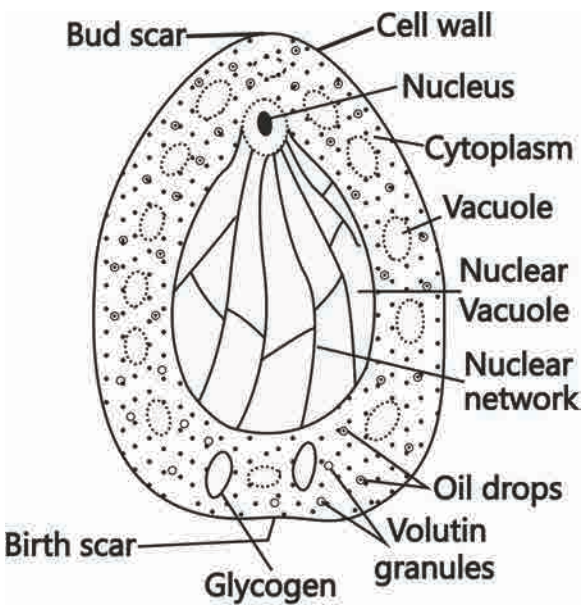


Figure 3.14: Diagrammatic view of Yeast cell

Vegetative Reproduction: Yeast reproduces vegetatively either by fission or by budding. Depending on this character, they are grouped as fission yeast (*Schizosaccharomyces*) and budding yeast (*Saccharomyces*)

a. By Fission

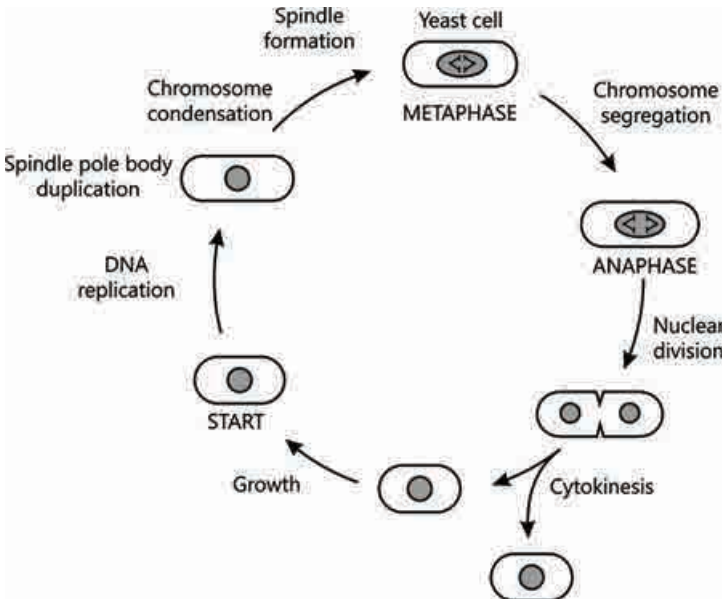


Figure 3.15: Phases of yeast cell reproduction

b. By Budding: Commonly Found in Yeasts

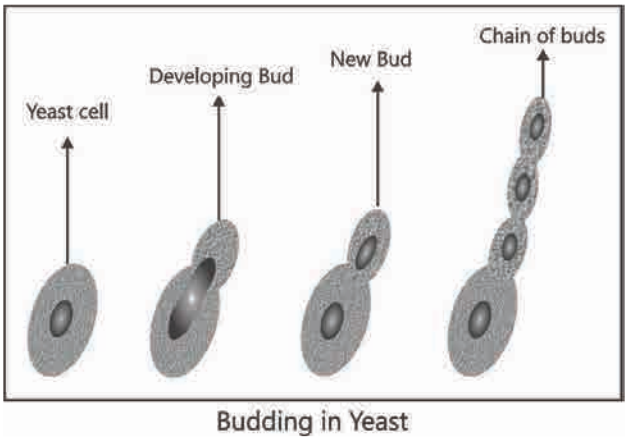


Figure 3.16: Phases of bud formation in yeast reproduction

When yeasts multiply rapidly, the daughter cell starts budding even when it is attached to the mother cell. This can be a continuous process producing several chains of yeast cells. Branched or unbranched pseudo mycelium is produced. The cells are in loose contact in chains of pseudo mycelium. The chains break to form individual cells.

Sexual Reproduction: Union of two similar sized chromosome occurs. The pair of cells involved may be vegetative or ascospores. Yeasts can be homothallic or heterothallic. The fusing stages are different.

a. **Haplontic Life Cycle:** This is exhibited by homothallic *Schizosaccharomyces octosporus* (fission yeast). In this type of life cycle, haploid stage (haplophase) is larger than the diploid stage (diplophase).

Events at sexual reproduction:

- Two cells come close to make a contact.
- The point of contact in conjugating cell shows a beak-like protuberance developing.
- Nuclei migrate through a continuous passage which is developed from the intervening walls of cells at the point of contact.
- Karyogamy occurs to form the zygote.
- The ascus is a result of zygote development.
- The diploid zygotic nucleus divides several times. It forms eight haploid nuclei from the first meiotic division and then mitotic division.
- Ascospore develops from each nucleus with cytoplasm, giving eight ascospores.
- The ascospores break down to liberate ascus that are somatic cells.

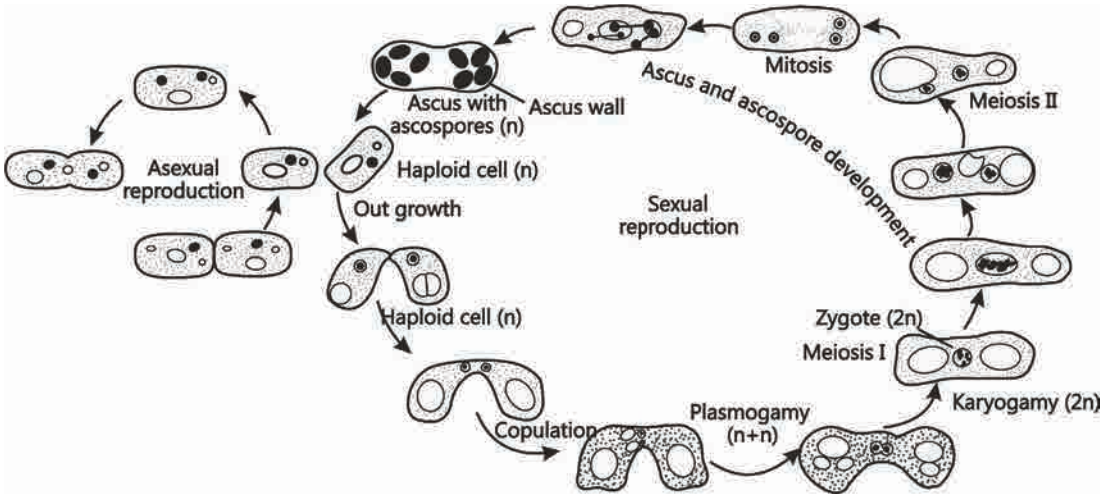


Figure 3.17: Phases of yeast cell reproduction asexual and sexual

Diplontic Life Cycle: This is observed in *Saccharomycoides ludwigii* (Helobial yeast).

- The diploid somatic stage is longer than the shorter haploid stage.
- The diploid somatic cells produce buds that enlarge to form asci.
- The diploid nucleus forms two diploid cells after meiotic division.
- Each diploid cell is germinated from a germ tube and forms a tube.
- This is pushed out through the ascus wall.
- This tubular structure forms bud from the diploid cells.
- Thus, ascospores represent the haploid stage

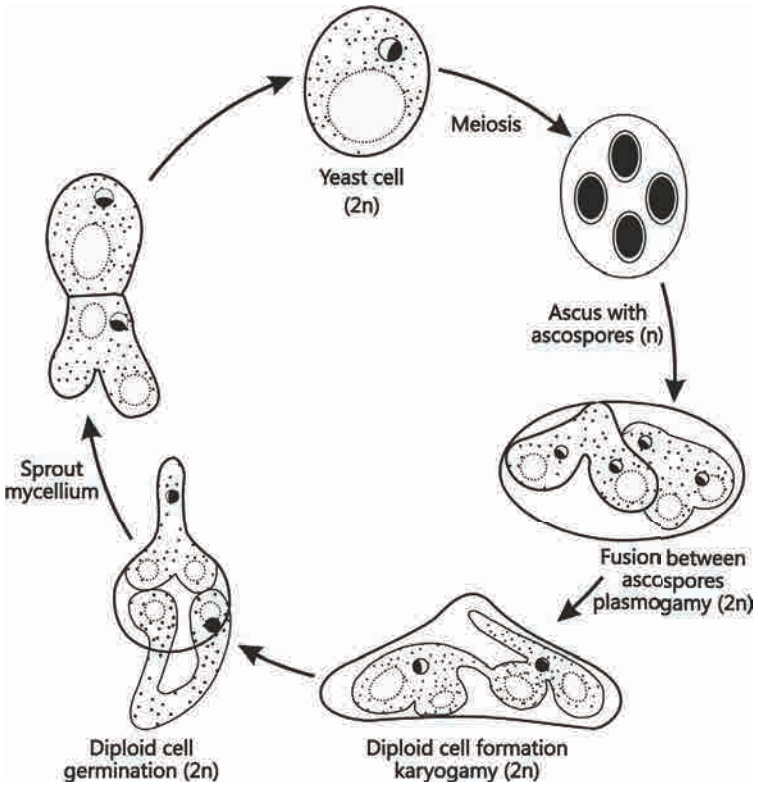


Figure 3.18: Phases of yeast cell reproduction in diplointic cycle

Diplohaplontic Life Cycle – *Saccharomyces cerevisiae* (Budding yeast) reproduces by this method.

- Both haploid and diploid phases occur and alter the generations.
- A diploid cell is formed from two haploid cells by copulation.
- The diploid cells enlarge the population by budding.
- Each diploid cell acts as an ascus that has four ascospores.
- The ascospores from ascus are liberated free and multiply by budding to produce haploid cells.

- The diploid stage and the haploid stage occur in the yeasts in alternate cyclic order.
- The haploid or diploid vegetative cells reproduce asexually with budding.

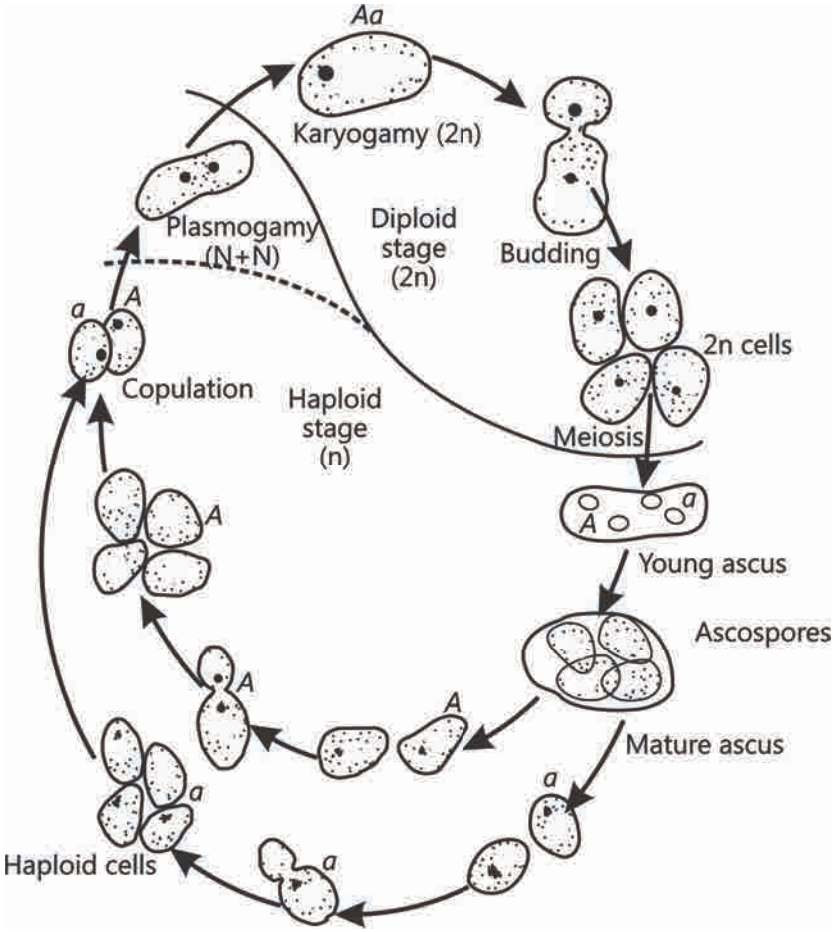


Figure 3.19: Phases of Yeast cell reproduction in haplodiplontic cycle

Did You Know

Yeasts also multiply

a. **Adephogamy:** The two adjoining daughter cells copulate (mate sexually). This is an isogamous process. The fusion cells remain united and form short chains.

b. **Pedogamy:** The copulation between mother and the daughter cell formed after budding. The daughter is in contact with the mother while the nucleus of the bud travels into the mother cell.

Knowledge Builder

Table 3.5: Uses of Yeasts in Industries

Saccharomyces cerevisiae	Brewer's/Beer or Baker's yeast
S.ellipsoidens	Wine yeast
Torulopsis utilis and Endomyces vermalis	Proteins content is higher
Rhodotorula	High vitamin
Ashbya gossypii	Rich in vitamin B_2
Yeasts	Curing cocoa beans

Table 3.6: Some Diseases caused by Yeasts

Candidiasis/moniliasis	*Candida albicans*
Blastomycosis	*Blastomyces dermamtidis*
Histoplasmosis	*Histoplasma capsulatus*
Cryptococcosis	*Cryptococcus neoformans*

Some yeasts reduce the yield of silk industry by attacking silkworms.

Species of *Nematospora* attack cotton, tomato and beans

Penicillium

Specific to this fungi

- Facultative parasite and saprophytic fungi.
- Branched septate myceliumhaving simple septal pore.
- Cell can be uninucleate or multinucleate in the species.
- Conidia forms to reproduce asexually. Conidiophores produced are branched. Rami is the first branch level and metulae is the second or ultimate branch possessing bottle shaped sterigmata. Sterigmata produce chain of conidia which have basipetal order. Conidium is uninucleate, non-motile, double layered, spread by air that germinates to produce new mycelium.
- Sexual reproduction: Fungi consists of dikaryophase and forms ascocarp. The ascocarp has cleistothecium pattern. Each ascus produces eight ascospores that germinates and produces new mycelium.

Try It Yourself

1. *Penicillium* is multicellular and saprophytic fungi (True/False)

2. Select the correct sequence of sexual reproduction events in sac fungi w.r.t. *Penicillium*.

(A) Meiosis (B) Dikaryophase (C) Development of sex organs

(D) Plasmogamy (E) Karyogamy (F) Ascospore.

3.3.4 Basidiomycetes

Table 3.7: Characteristics of Class Basidiomycetes

Common name	Club fungi
Mycelium type	Primary with oidia and secondary with septate hyphae
Cell wall made of	Chitin
Habitat	Terrestrial
Asexual reproduction	Sporangia produce zoospores in water.
Sexual reproduction	Basidiospores and monokaryotic spores
Examples	Mushrooms, toadstools, puff balls, bracket fungi etc.

- Basidiomycetes have the best decomposing ability and enzymes for wood (cellulose and lignin).
- Lignin is a sugar that is undigested by many fungi and even bacteria. *Ganoderma* species decay wood when it is on standing trees.
- Motile structures or cells are lacking. Mycelia are primary and secondary. Primary mycelium is made of monokaryotic cells which has short life. Secondary mycelium is dominant phase with long life, called as dikaryophase. It contains branched septate hyphae.
- Monokaryotic phase divide oidia, conidia-like spores and pycniospores.
- Septa possess dolipores or central pores that has outgrowths in barrel-shape (except rusts and smuts).
- Secondary mycelium is sclerotia or rhizomorph that has penetrating ability in the soil or wood.
- Dikaryophase or secondary mycelium form different types of spores for their division– Chlamydospore, aeciospores, uredospores, teleutospores etc.
- There are two mating types (+) and (-) in thallus. Sexual reproduction is without sex organs. Fusion occurs either between basidiospores and other monokaryotic spores, between a spore or spermatium and a hypha or between two hyphal cells of primary mycelia. Karyogamy and meiosis takes place in a club-shaped structure called as basidia (singular – basidium) which gives the class its name.
- A basidium contains four exogenous meiospores or basidiospores located at the tips of fine outgrowths called sterigmata or directly on the surface of basidium.
- The fungi may contain fructifications called basidiocarps which may vary from microscopic size to large macroscopic structures. Some fungi may have 50 cm diameter of the fruit body.

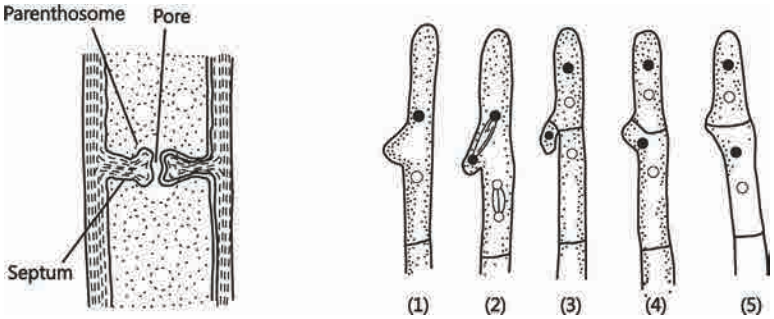


Figure 3.20: Phases of fungus reproduction and hyphae growth

Knowledge Builder

Examples of Fungi

Smuts: Smut spores are resting thick-walled, black-colored spores unique to smuts. Smuts are covered and loose. The sorus contains the spore mass in the membrane of the covered smuts, e.g., *Ustilago hordei* (covered smut of barley), *Ustilago maydis* (smut of corn). The spores are exposed while remain attached to the host in loose smut, e.g., *Ustilago nuda tritici* (loose smut of wheat), *U. avenae* (loose smut of oat).

Mushrooms: Around 30 000 species of mushrooms are found that are edible and non-edible Agaricales. They have umbrella like basidiocarps. Edible mushrooms are *Agaricus campestris*, *A. bisporous, Volvariella volvacea* (Paddy straw mushroom), *Pleurotus ostreatus* etc.

Toadstools: The poisonous mushrooms producing white spores. *Amanita caesarea* (Caeser's mushroom) poisoned Roman emperor Caesar. The other toadstools examples are *Amanita phalloides* (Death cup), *A muscaria* (Fly agaric) and *Gynomitra esculenta* (heat labile carcinogenic toxin).

Rusts: They form rusty pustules that have the spores and is a special feature of rusts. Examples of diseases that they cause:

Puccinia graminis tritici – Black rust of wheat.

Puccinia glumarum or *P. striformis* – Yellow rust of wheat.

P. recondite – Brown rust of wheat.

Hallucinogens: *Psilocybe Mexicana* (Sacred mushroom) is similar to LSD in hallucinating properties. Mexican Indians use it in certain religious ceremonies.

Armillariella (Largest Fungi)**:** *A. mellea* (Honey mushroom) is edible mushroom growing on both hardwoods and conifers which makes it a serious root parasite. The fungus develop rhizomorph into the phloem cells which blocks its food supply in the host.

Puffballs: The basidiocarp has a stalked round structure that releases puffs of spores on ripening. The fructification has growth above or below the substratum, e.g., *Lycoperdon oblongisporum, L. giganteum.*

Bracket fungi (Shelf Fungi)**:** The basidiocarps or fructifications grow on tree trunks, logs, lumber etc. similar to brackets or shelves, e.g. *Fomes applanatus. Polyporus sulphurous, Ganoderma.*

Predator fungi: e.g. *Dactylaria, Arthrobotrys*.

Stinkhorn: e.g. *Phallus impudicus* (Dead man's finger). Spore creates a stinking odour that attract flies.

Life Story of a Mushroom

Agaricus campestris is the common edible basidiocarp used for farming.

- Saprotrophic nutrition.
- The subterranean is vegetative or assimilative part of mycelium.
- Moist humus rich soil of open fields, grassland, piles of straw or wooden rotting logs are common places for mushroom.
- Fragmentation is mode of mycelium multiplication. Occasionally, spores like oidia and chlamydospores are also formed.

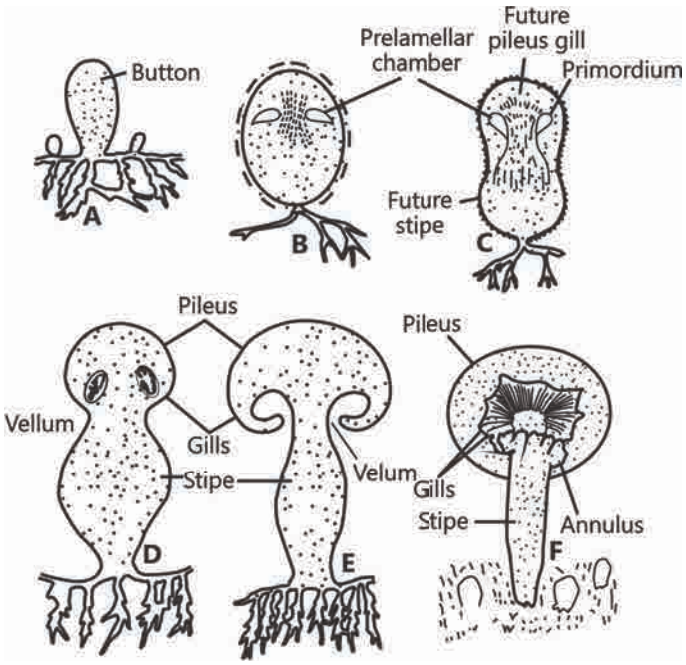


Figure 3.21: Different phases of mushroom

- Mushroom contains two types of mycelia, primary and secondary.
- Sex organs are the same.
- Primary mycelium has septate hyphae with monokaryotic cells with short life. It consists of septate hyphae having monokaryotic cells.
- The mycelia have heterothallic type with two mating types (+) and (-).
- The hyphae of two mating types come in contact and show Somatogamy.
- However, only plasmogamy is functional at this time. A dikaryotic cell is produced that grows, divides and forms a long-lived, extensive dikaryotic or secondary mycelium.
- The secondary mycelium hyphae form clamp connections and dolipore septa. The cells possess two haploid nuclei and not the usual single diploid nucleus.

- Hyphae of secondary mycelium gets collected at a place giving rise to round or pyriform compact hyphae called buttons.
- The buttons enlarge to produce aerial bodies called as fructifications or basidiocarps. Common name is mushroom. Spawn is a different mushroom which develops from secondary mycelium.
- The basidiocarps or mushrooms have ring arrangement.
- Each basidiocarps or mushroom has cream to pinkish brown colour.
- The mushroom has two parts, stipe and pileus where the stipe or stalk is fleshy and swollen at the base. Pileus is umbrella-like capon the stipe of the mushroom.
- The pileus and stipe are connected with a membrane called veil or velum.
- It ruptures when pileus grows and has scar on the upper part of stipe as annulus. The pileus has circular outline.
- Pileus has convex upper surface and flat or concave lower surface. Lower surface has 300-600 radiating rows of vertical plates named gills (lamellae)

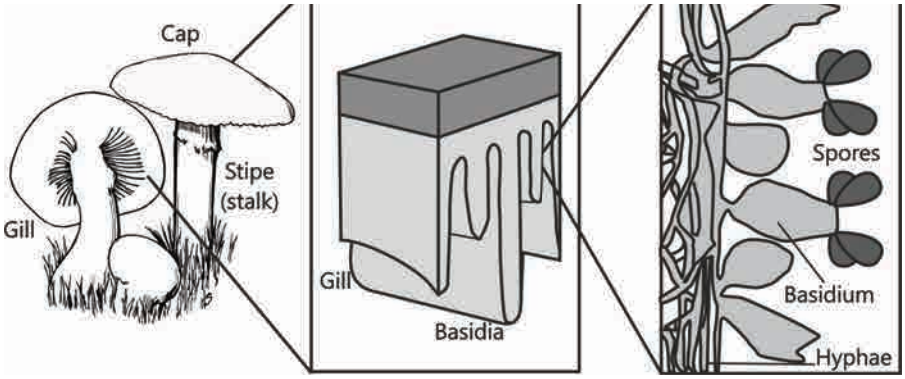


Figure 3.22: Mushroom a fruiting body of a fungus

- The two sides of vertically placed gills contain thousands of club-shaped basidia and sterile paraphyses.
- They together make up the fertile layer or hymenium of the gill in mushroom.
- Hymenium is subtended by compactly arranged sub hymenium.
- The centre includes interwoven hyphae called trama.
- Each basidium is the site for karyogamy as well as meiosis.
- The two nuclei then fuse to form a short-lived diploid synkaryon.
- The synkaryon then divides meiotically to form four haploid nuclei, two of (+) strain and two of (-) strain.
- Sterigmata is a four peg-like outgrowths formed from the free end of the basidium.
- Each sterigmata contains ovoid pinkish-purple meiospores that is called as basidiospores.
- A droplet is made at the sterigmata tip creating tension and air currents carry hanging basidiospores away.
- The basidiospores are produced and set free for many days successively. On contact with suitable substratum, basidiospores germinate and produce monokaryotic primary mycelium.

3.3.6 Life Cycle of *Puccinia graminis tritici*

P. graminis tritici is a

- Macrocyclic (producing many dikaryotic spores at a time),
- Heteroecious (need for more than one host i.e. primary host – e.g. wheat, secondary or alternate host – barberry) fungi.
- It induces growth of uredospores and teliospores on the wheat plant, Basidiospores in the soil and, pucniospores and aeciospores on barberry.
- It infects wheat causing black or stem rust.

Details of various life cycle phases of *Puccinia* is:

Stage of Life Cycle on Wheat (Primary Host)

Uredia and Uredospores – The dikaryotic aeciospores form dikaryotic mycelium and germinate on the leaves and stem surfaces.

The germ tube protrudes out which swells up to form an elongated Appresorium near the stomata. A peg like outgrowth now arises from the Appresorium and penetrates the stomata. It ramifies repeatedly to form a mass of mycelium this mycelium forms the uredospore. As a result, some pressure is exerted on the epidermis which bursts exposing the uredospore. These clusters of uredospores have been variously referred to as uredosori or urediopustules. A uredospore is reddish-brown, unicelled. Oval or globose, stalked, dikaryotic spore. Its wall is three layered, the outer being somewhat spiny. The uredial stage multiplies through the uredospores which germinate on fresh wheat plants (due to the red colour of spores this stage is called red rust stage).

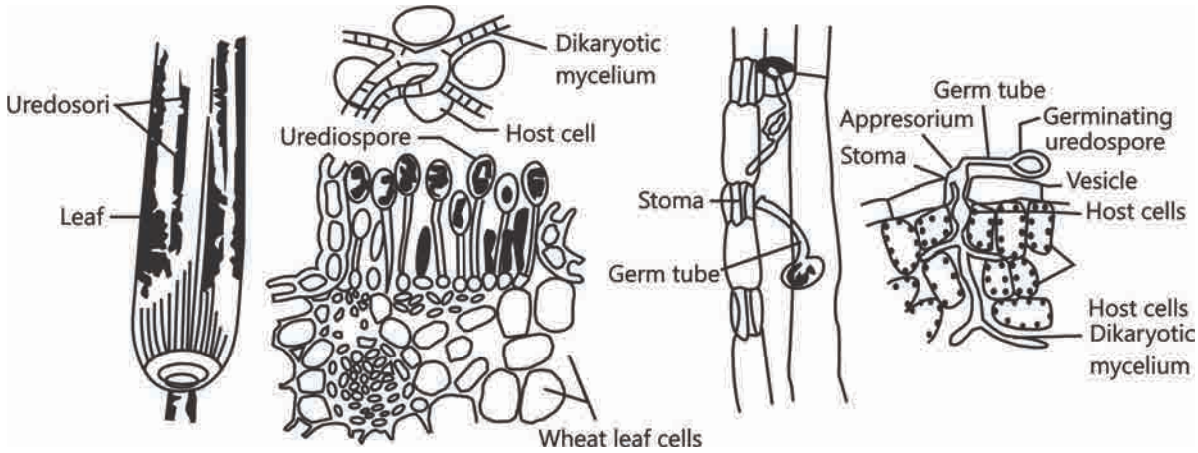


Figure 3.23: *Puccinia* showing: infected wheat leaf showing uredia, Dikaryotic mycelium, V.S. through uredosorus and germination of uredospores and aeciospores on wheat leaf along with passage of germtube

Telia and teliospores (Black Rust Stage) – Towards the end of the season, the dikaryotic mycelium of the uredosorus begins to produce teliospores (or teleutospores) in the same sorus. They are dark brown or black, stalked, thick walled, bi-celled spores. The upper cell is pointed, both the cells are binucleate. The pustules containing telispores are called as telia or teleutosori. The teliospores also exert pressure on the epidermis which bursts open, exposing the spores. It is at this stage the symptoms develop in stem also, so the disease in named black stem rust of wheat. Karyogamy occurs inside each cell of teliospore and as a result they become diploid. The teliospores cannot infect fresh wheat plants. They germinate in soil to form the basidiospores.

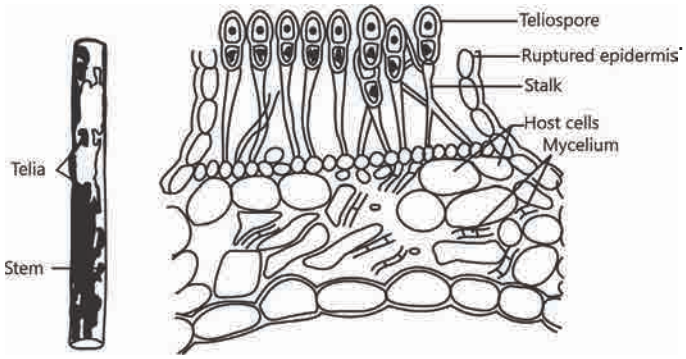


Figure 3.24: *Puccinia* showing: Teleutosorus on wheat stem and T.S of host through teleutosorus.

Basidia and basidiospores – The two cells of the teliospores now act as hypobasidium. They germinate in soil and form a tube called promycelium. The diploid nucleus migrates into epibasidium and then undergoes meiosis to form four haploid nuclei each of them develops as a basidiospore on the stengmata. Of these, two basidiospores belong to +ve strain and two to –ve strain. These spores are not capable to infect a wheat plant. Each spore is unicelled, monokaryotic and unstalked. These can infect the barberry plant (*Berbens vulgaris*) which is the secondary or alternate host occurring on the hills in India.

Stage of Life Cycle on Barberry

Spermatia or pycniospores – The basidiospores of both the strain (+ and -) can germinate on upper surface of barberry leaf. They produce haplophase or primary mycelium of the respective strain which grows ghrough the intercellular spaces. Soon the mycelium forms a palisade like mat which organises like a flask shaped structure near the upper epidermis called as spermogonia or pycnidium. They open by a single pore called ostiole. The spermatiophores are pinched off a large number of uninucleate cells called pycniospores or spermatia. Besides, some sterile hyphae also arises which grow out through the ostiole. They are called as periphyses. In addition to these, some thin walled hyphae are also given out which become more elongated. They are called as flexuous hypae or receptive hyphae.

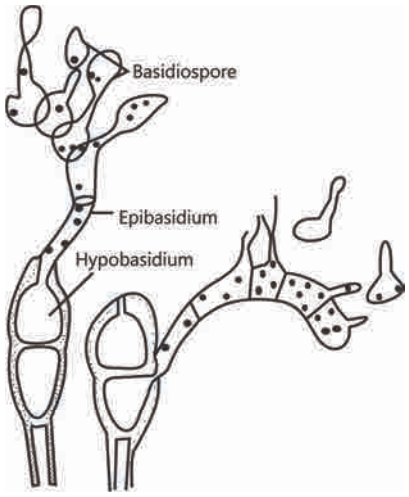


Figure 3.23: *Basidia* showing basidiospores

While the spermatia function as the male cells, the flexuous hyphae behave as the female hypha. The pycniospores or spermatia protrude out of the ostiole in a nectar. The insects feeding on this nectar transfer the spermatia from one spermogonium to the other. Spermatisation is brought about when spermatia of one strain come in contact with the trichogyne of flexuous hyphae of the other strain.

The nucleus of pycniospore or spermatium passes into the flexuous hyphae, thus bringing about dikaryotisation.

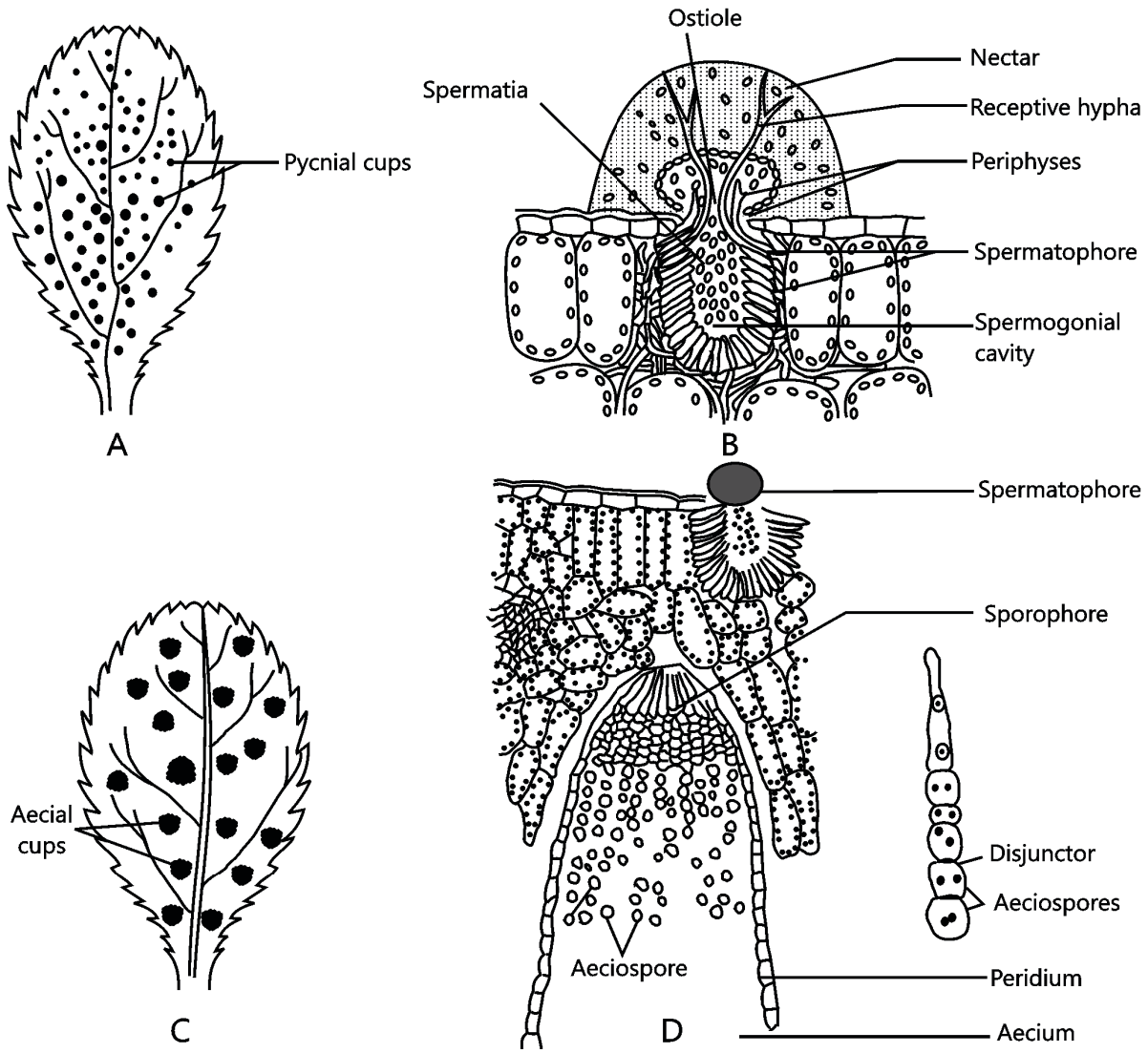


Figure 3.25: *Puccinia* infecting *Barberry* leaf (A - D) showing pycnial cups, T.S. through spermogonium.

Aecia and aeciospore – An aecium or aeciosorus is produced on the lower surface of barberry leaves. It arises just beneath pycnium. The dikaryotized mycelium aggregates sub-epidermally. This gives rise to a group of elongated dikaryotized cells which function as aecial mother cell. The mother cells differentiate a row of binucleate cells. The alternate binucleate cells enlarge and they are identified as aeciospores. The alternate cell remaining small is disjunctor or sterile cell. The sterile wall of the aecial cup called peridium or pseudoperianth presses the lower epidermis which eventually bursts open. Thus, the aeciospores are set free.

The aeciospores are polyhedral or ovate, binucleate, unicelled and double layered. The outer thick wall is called exine and the inner as intine. They are set free in spring. They cannot infect the barberry bushes. These are carried from hills to the plants where they infect wheat plants. They germinate on the leaf surface from a germ tube which enters the host through stomata.

3.3.5 Deuteromycetes

Table 3.8: Characteristics of Class Deuteromycetes

Common name	The Fungi Imperfecti
Mycelium type	Septate and branched hyphae
Cell wall made of	Chitin
Habitat	Terrestrial
Asexual reproduction	Conidia
Sexual reproduction	Gametangial copulation or conjugation Coenogametes
Examples	*Pyronema, Peziza*

- Deuteromycetes lacks actual forms of fungus and is an artificial class (form class) of fungi. This is to accumulate all the fungi where sexual stage (or perfect stage) is not known yet (absent or not reported).
- As the members included in this class are in research, as and when the perfect (sexual) stages of members of Deuteromycetes are known they are moved to Ascomycetes and basidiomycetes.
- They are decomposers of litter and thus help in recycling mineral while some members are saprophytes or parasites.

Knowledge Builder

Table 3.9: Diseases Caused by Some Fungi with their Effects

Organisms Name	Disease Caused	Effects / Comments
Helminthosporium oryzae	Leaf spot disease of rice	Bengal famine in 1942-43
Alternaria solani	Early blight of potato	Small oval brown spots with concentric rings on leaves
Cercospora personata	Tikka disease	Circular necrotic dark brown or blackish leaf spots develop in groundnut
Colletotrichum falcatum	Red rot of sugarcane	Sour alcoholic odour
Fusarium especially F. oxysporum, F. udum	Wilting economically important plants	Blockage of tracheary elements by growth of fungus
Trichophytoninterdigitate.	Ringworm of foot/Athlete's foot	

Table 3.10: Common names in fungi

Fungus/Group	Common names
Rhizopus	Black/Bread mould
Morchella	Morels (sponge mushroom)
Saccharomyces	Yeasts (Sugar fungus)
Phallus	Stink horns
Hydrum	Tooth fungi (Hedge hog fungi)
Agaricus	*Gill fungi (Mushroom)*
Ganoderma, Polyporus	*Wood/Bracket/shelf fungi*
Aspergillus and Penicillium	*Pigmented moulds*
Aspergillus	*Laboratory mould*
Aspergillus flavus	*Guinea pig of plant kingdom*
Mucor mucedo	*Dung mould*
Penicillium	*Blue/green mould*
Peziza	*Cup fungi*
Lycoperdon, Clavatia	*Puff balls*
Cyathus	*Bird's nest fungus*

Clavaria	Coral fungi
Amanita	Toad stool
Tremella	Jelly fungi/Trembling fungi
Pleurotus ostreatus	Oyster mushroom
Agaricus bisporus	Button mushroom
Neurospora crassa	Drosophila of plant kingdom

Did You Know

Annual Recurrence of Rust in India

Prof. K.C. Mehta studied the rusts and concluded the annual recurrence of the rust on wheat occurs through uredospores in India. The alternate host *Berberis vulgaris* does not have enough role in our country. According to Mehta, if wheat cropping is avoided on hills, the intensity of this infection in the plains can be effectively reduced.

He also suggested that even when the wheat is not grown, the fungus doesn't disappear and is on certain collateral hosts like *Briza minor*, *Bromus* and *Thalictrum* for multiplication of uredospores.

Did You Know

Common Fungicides and their composition

Bordeaux mixture

- ($CuSO_4$: $Ca(OH)_2$: H_2O). First fungicide discovered by RMA Millardet
- Commonly known as holy water of plant pathology

Burgandy mixture (Soda Bordeaux)

- Mixture of $CuSO_4 + Na_2CO_3 + H_2O$

Chestnut mixture

- Ammonium carbonate + copper sulphate

3.4 Mycorrhiza (Fungal Roots)

- There are associations of fungus with several hosts where in it takes the food and in return helps the hosts in some or other way. This is called as Mutualistic Symbiotic Association.
- Mycorrhizal association is symbiotic, beneficial to both the partners.
- The mutually beneficial set of a fungus and the roots of higher plants are termed as mycorrhiza.
- Mycorrhizal roots have shape diversity, with no root hairs and root cap, however with a woolly covering on them.
- The association gives nourishment and shelter to the fungal partner from the cortical cells of the root.
- The root cells excrete sugars along with other soluble gradients useful for growth of fungal hyphae that spread in intercellular spaces.
- The nourishment from the cells can also be taken by sending small projections from hyphae into root cortical cells.
- The fungus plays essential role for the plant growth.

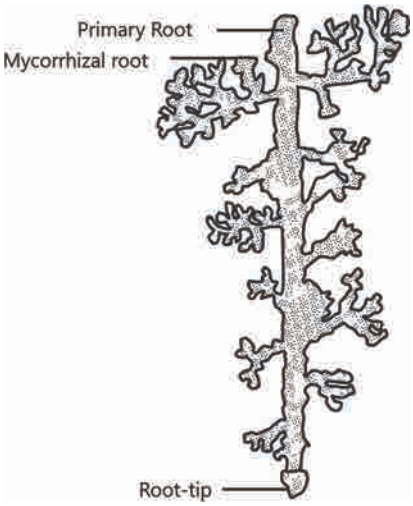


Figure 3.26: Mycorrhizal relationship between roots and fungus.

- The fungal hyphae spread in soil that increases the surface area of absorption by roots that enhances the supply of water, nitrogen, phosphorus and other minerals to the plant from the soil.
- The association of a fungus can be with many plant roots and that plant may have several fungi growing on it.
- The mycorrhiza is of two types: ectomycorrhiza (outside root) and endomycorrhiza (inside roots).
- Ectomycorrhizal association, the fungus forms network of mycelium known as Hartig net, on the external surface of roots. Mycelium network is in the intercellular cortex spaces. Fungal partner in this group is commonly basidiomycetes. e.g., *Pinus roots*.

- In endomycorrhiza, the fungal hyphae spread in intercellular and intracellular spaces after they enter the tissue of the root system. The fungus breaks the cell wall of root cells to an extent of the cortical region of the root. Some hyphae in fungi let small projections enter into cortical cells keeping the cells safe. Such fungi are termed VAM (Vesicular Arbuscular Mycorrhiza), e.g. Orchid roots.

4. Lichens

- Lichens are a permanent association of a fungal partner or mycobiont and an algal partner or phycobiont.
- Mycobiont is dominant partner belonging to ascomycetes (Ascolichens -, e.g., *Graphis*, *Cladonia*, *Parmelia*, *Usnea*, etc.) or basidiomycetes (Basidolichens – e.g., *Corella, Cora* etc.).
- Phycobiont is mostly a member of Chlorophyceae (e.g., *Chlorella*, *Trebouxia*, *Protococcus*, *Palmella*, etc.) or can be a BGA (e.g., *Nostoc*, *Chlorococcus*, *Scytonema*, etc.)
- Lichens are found in uninhabited or inhospitable places like barren rocks (sexicolous), soil (terricolous), tundra ice or alpines, sand dunes, roots, walls, wood (lignicolous), tree bark (corticolous) leaves, etc.
- Humid and exposed conditions are common however the lichens can tolerate extreme desiccation. Lichens do not grow in air pollution, and in high sulphur dioxide content (so are considered indicators of SO_2 pollution).
- Lichens are greyish, yellowish greenish, orange, and dark brown or blackish in colour growing throughout the year.
- The fungal partner called mycobiont makes the bulk of lichen body. It includes the surface, medulla (or interior) and rhizines (attaching devices) in lichens.
- The algal partner or phycobiont contributes only 5% of the lichens body and is restricted only to a narrow zone (algal zone) that is below the surface.

Structure: Lichens have different morphology, the major ones are of three types:

- Crustose: They form crust like shape that is attached to the substratum at several places, e.g., *Graphis*, *Lecanora*, and *Rhizocarpon*.
- Foliose: The lichen is flat, broad, lobed and leaf-like, attached at one or few places of substratum. The attachment is with a rhizoid like structure called rhizine, e.g., *Parmelia*, *Peltigera*.
- Fruticose: The lichen remains attached to the substratum with the disc while it is branched like a bush. e.g. *Cladonia*, *Usnea*, *Evernia*, *Bryonia*.

Relationship: The fungus in lichen helps in following functions:

- Body structure and covering
- Anchoring
- Absorption of water and minerals.
- Water is absorbed from wet air (atmosphere), dew and rain and minerals are taken from substratum and atmosphere. Minerals from substratum are absorbed after they are dissolved with chemicals from fungi.

- Fungal sex organs and fructifications are dominant.
- Food is produced by photosynthesis in algae.
- The cyanobacterial alga also fixes nitrogen.
- The algae takes water and mineral salts from the fungus and gives food to the fungus. Therefore, mutual benefit (mutualism) popularly called as symbiosis is assigned to lichens.
- Fungus at times is found to
  - Send Haustoria into algal cells
  - Induce alga cells that secrete organic substances and
  - Prevent alga to develop pectic covering.

Reproduction: Lichens multiply by four methods:

- Progressive death and decay resulting in the separation of a lichen thallus into two or more parts.
- Fragmentation caused by mechanical injury, due to wind or animal bites.
- Isidia are superficial outgrowths of the lichens which are primarily meant for increasing surface area and photosynthetic activity. At time, they are broken off. Each isidium is capable of forming a new lichen because it has a core of a few algal cells surrounded by a sheath of fungal hyphae.
- Soredia: These are most efficient means of asexual reproduction. They are microscopic lichen propagules which are produced in large numbers inside sori called pustules. Soredia are dispersed by air currents. After falling on a suitable substratum each soredium gives rise to a lichen, because it has a few algal cells surrounded incompletely by a weft of fungus.

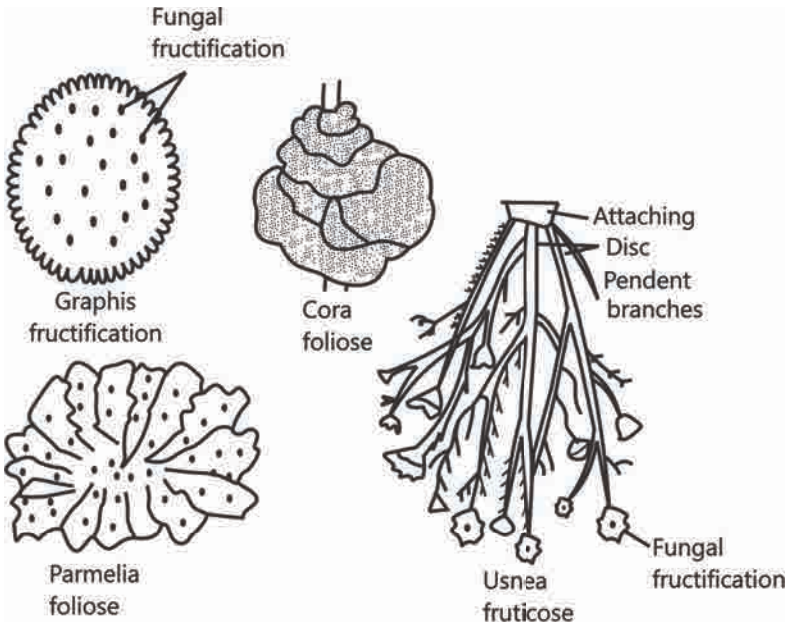


Figure 3.27: Image of various fungal bodies

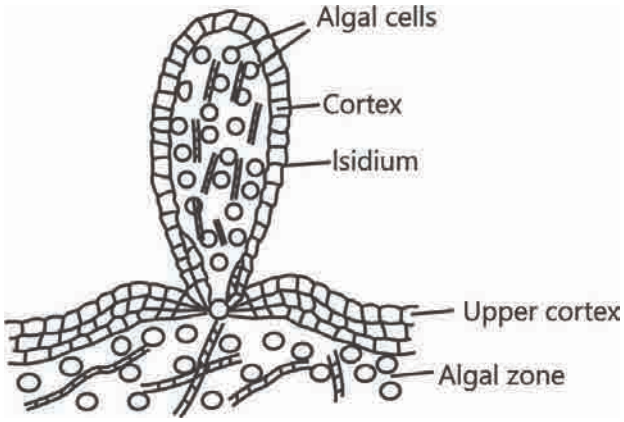


Figure 3.28: Algal and fungal relationship in sorediai

Did You Know

The term lichen was coined by Theophrastus (370 – 285 B.C), also called as the Father of Botany.

Special structures in the thallus of lichen:

Cyphellae: Present in lower cortex and help in exchange of gases.

Cephalodia: It help to retain moisture while the algal partner fixes nitrogen.

Breathing pores : Present in upper cortex of thallus to respire.

Knowledge Builder

Uses of Lichens

- Early colonizers: Lichens have shown early or pioneer life as colonizers of barren rocks, cliffs, mountains and new terrains. Lichens secrete acids that help them to adhere the rocks and cliffs. It produces minute crevices where organic matter accumulates. It paves the way for growth of mosses.
- Food: lichens are high in sugar and thus in tundra, *Cladonia rangifera* (Reindeer Moss) is used as the staple food of reindeer, Caribou, musk ox, etc. *Cetraria islandica* (Iceland moss) is eaten by man in Iceland.
- Dyes: Orchil is obtained from *Rocella tinctoria*, the organism which was used as a litmus paper earlier till the invention of synthetic litmus. Litmus is a pH indicator.
- Perfumes: Species of *ramalina* and *evernia* give scented incense.
- Medicines: *Usnea* (Old Man's Beard) and *Cladonia* produce usnic acid that has antibiotic properties and hence used in ointment for burns and wounds.
- Air pollution: Lichen population decrease as SO_2 pollution increase indicating air pollution.
- Fires: Usnea may produce forest fires in high temperatures.

Try It Yourself

Fill in the blanks:

a. In ectomycorrhiza, fungal partner commonly belongs to _____

b. _____ are mutually useful association between algae and _____

c. _____ are superficial outgrowths of the lichens which are primarily meant for increasing surface area and photosynthetic activity.

d. In tundra_____ constitutes the staple food of reindeer, caribou etc.

e. _____ are most efficient means of asexual reproduction in lichens.

5. Viruses

Pasteur coined the virus term.

Viruses are obligate intracellular parasites. The main reason of their kingdom or class not decided is that the viruses are both living and non-living entities.

5.1 Viruses Show Non-Living Nature

- Lacking protoplast.
- Capability to crystallize, e.g., TMV poliomyelitis virus.
- Lack functional autonomy and cannot live independently outside.
- High specific gravity common in non-living objects.
- Absence of respiration.
- Energy storing system is not there at all.
- Growth and division is not observed.

5.2 Living Nature of Viruses

- Organic macromolecules make the structure.
- Presence of genetic material.
- Genes that give ability to multiply.
- Have mutating properties.
- Include certain enzymes like, neuraminidase (first discovered), transcriptase and lysozyme in body of viruses.
- Infectivity and host specificity.
- Viruses can be ''killed'' by autoclaving and ultraviolet rays.
- The multiplication is through biosynthetic machinery of the host cell that produce chemicals required for viruses.
- Viruses cause a number of infectious diseases like common cold, epidemic influenza, chicken pox, mumps, poliomyelitis, rabies, herpes, AIDS, SARS etc.

5.3 Structural Components of Viruses

- Viruses are ultramicroscopic structures having size in nanometres smaller than smallest bacteria.
- The outer covering of virus is a thin layer of protein (virus), lipids and carbohydrates (both from host) called as envelope. It includes smaller subunits that are called as peplomers, e.g., Herpes virus, HIV, vaccine virus etc.When the envelope is not present the virus is said to be naked.
- Capsid:The outer protein coat is made up of subunits that is called as capsomeres, and their number is virus specific. These protein possess antigenic properties for the virus.
- Nucleoid: Viruses contain either DNA or RNA. There is yet no virus with both DNA and RNA as genetic material.
- Viruses that have DNA as their genetic materials are called as the deoxyviruses. These are of two types:
    - Double stranded DNA (dsDNA) virus, e.g., Pox virus, Cauliflower mosaic virus.
    - Single stranded DNA (ssDNA) virus, e.g., *Coli phage* ϕ *x 174, M 13 phage*.

- RNA is the genetic material then viruses are known as riboviruses. They are of two types:
  - Double stranded RNA (ds RNA) virus, e.g., Reo virus, Would Tumour virus.
  - Single stranded RNA (ssRNA) virus, e.g., TMV, influenza virus, Foot and Mouth disease virus, Retroviruses (HIV).

DID YOU KNOW

- Mayer gave details of Tobacco mosaic disease in 1886.
- Iwanowsky discovered viruses in 1892. TMV was the first virus discovered.
- Beijerinck called virus as ''Contagium vivum fluidum'' meaning living infectious fluid.
- In 1935, Stanley crystallised TMV.
- Twart and d'Herelle discovered bacteriophage.
- L'woff and Wolman discovered temperature viruses.
- Shafferman and Morris discovered cyanophage, e.g. LPP-1.
- Bawd+en and Pirie studied the chemical nature (nucleoproteins) of TMV
- Sinshelmer discovered single stranded DNA in bacteriophage θ x 174
- Isaac and Lindeman discovered interferon which is like antibiotic for viruses.
- Delbruck (1938), found that viruses undergo mutations.
- Reverse transcription in Retroviruses was discovered by Temin and Baltimore, so the phenomenon is called teminism. The enzyme reverse transcriptase is RNA dependent DNA polymerase

5.4 Classification of Virus

Holmes (1948) has divided viruses into three groups on the basis of specific hosts.

- Phytophagineae viruses specific for plant infections. They have ssRNA, e.g., TMV, Potato mosaic virus, Yellow vein mosaic virus, cauliflower mosaic virus.
- Zoophagineae viruses are animal specific. They have ssRNA or dsRNA or dsDNA. e.g., Poliomyelitis virus, influenza viruses, Small pox virus, Mumps virus, Rabies virus.
- Phagineae attack lower organisms.
  - Bacteriophages are bacterial viruses and they usually possess dsDNA, e.g. T_2, T_4, lambda (λ) phage.
  - Coliphages are viruses of *E.coli*, e.g., Coliphages fd.
  - Cyanophage attack blue green algae, e.g., LPP-1, SM – 1

- Phycophages attack algae.
- Mycophages attack fungi
- Zymophages attack yeast.

5.5 Reproduction

Viruses reproduce mainly by two types: Phagic and Pinocytic

- **Phagic Reproduction:** It is further of two types:
  - **Lytic cycle:** Occurs in virulent phages, e.g., T_4 bacteriophages.
  - **Lysogenic cycle:** Occurs in temperate viruses such as phage.
- **Pinocytic Reproduction:** It is found in viruses like TMV, HIV, Hepatitis B etc., in which whole of virus particle enters host cell except envelope (if present).

5.6 Structural Details of Some Viruses

- Tobacco Mosaic Virus (TMV)
  - Elongated rod like with 3000 Å length, 180 Å diameter,and 39.4 x 10^6 Dalton molecular weight.
  - 2130 capsomeres form capsid with helical arrangement.
  - RNA strand is helically shaped.
  - RNA contains 6400 nucleotides.
  - Thus, the ratio of nucleotides: capsomeres = 3: 1

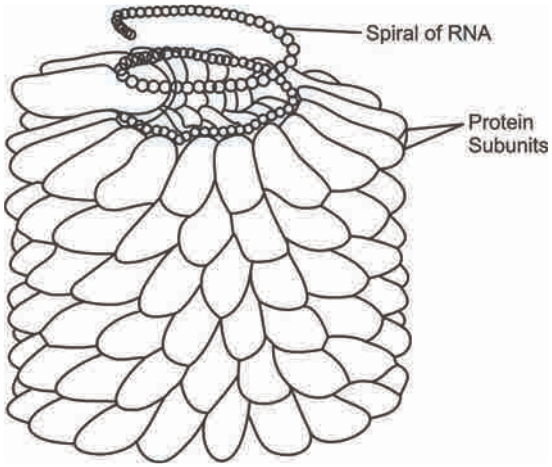


Figure 3.29: TMV virus in diagrammatic way

- Pox virus/Variola is the causal agent of small pox.
  - Largest animal viruses
  - Rectangular (brick) shaped 300 x 230 nm in size.
  - Genome is dumbbell shaped with central core of dsDNA.
  - The core shows two enzymes RNA polymerase and ATP phosphohydrolase.
- AIDS virus
  - It has 2 copies of ssRNA.
  - Outer envelope has 5 layers, 1- outer most glycoprotein, 2, 3 - lipid layer and 4, 5 - the innermost protein layers.
  - It has reverse transcriptase enzyme.
- T_4 Bacteriophage
  - Tadpole like structure that has polyhedral head connected to helical tail (binal).
  - The head hasprotein coat or capsid on the nucleic acid.
  - Nucleic acid is dsDNA.
  - Proteinaceous tube-like core with sheath cover is the tail.
  - Tube is joined to the head by thin collar and then connected to the hexagonal base plate with six small tail pins and six fibres.The fibresattach the phage to the host cell.

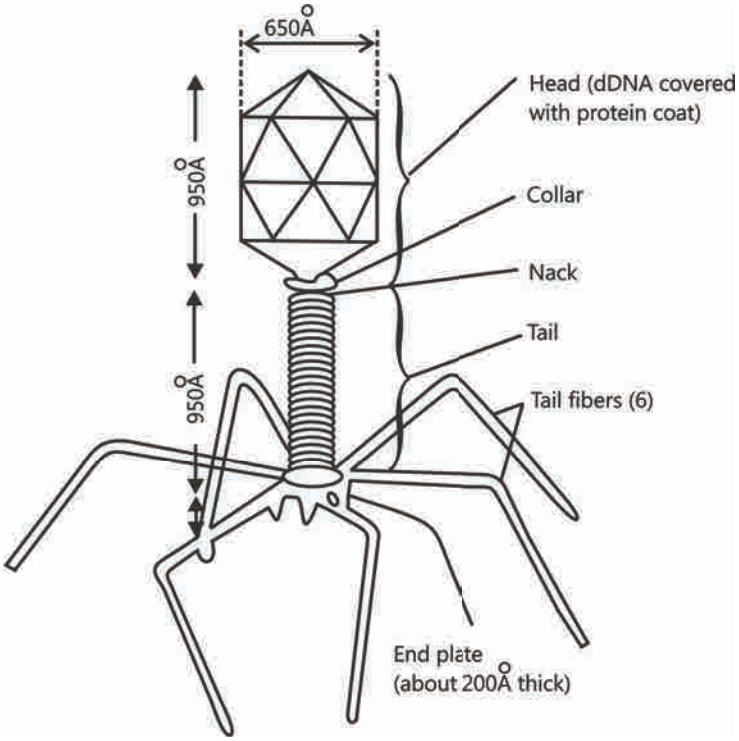


Figure 3.30: Bacteriophage diagram

5.7 Special Characters Who are Similar Yet Different from Viruses

- Viroids (L. virus – poison, eidos – diminutive)

  Diener (1971) was working on viruses when he found some organisms smaller than them which could pass the filter for virus. They are the smallest self-replicating particles which were discovered by Viroids are infectious RNA particles which are devoid of protein coat. They are obligate parasites. Molecular weight of a viroid is low. The RNA is tightly folded to form circular or linear structures. Viroids are known to cause diseases (some 20) in plants only, e.g., Potato spindle tuber disease (PSTD), Chrysanthemum stunt and Citrus exocortis.

- Prions (Discovered by Alper *et al*.)

  Proteinaceous infectious particles, causing certain diseases like

  - Kuru disease (laughing death disease in humans)
  - Bovine spongiform encephalopathy (BSE or Mad cow disease)
  - Scrapie disease in sheep
  - Creutz Feldt Jakob disease

KNOWLEDGE BUILDER

Table 3.11: Common Diseases caused by Viruses in Plants and Animals

Disease	Causal agent
Tobacco mosaic	Tobacco Mosaic virus
Cucumber mosaic	Cucumber mosaic virus
Potato mild mosaic	Potato virus X
Potato rugose mosaic	Potato virus Y
Potato leaf roll	Potato leaf roll virus
Rosette of groundnut	Groundnut mosaic virus
Bunchy top of Banana	Banana bunchy top virus
Sugarcane mosaic	Sugarcane (or Saccharin) Virus I
Common cold	Rhinoviruses
Influenza	Influenza virus
German measles (Rubella)	Rubella virus
Measles	Measles virus
Poliomyelitis	Polio virus
Small pox	Variola virus
Yellow fever	Arbovirus

Did You Know

Nomenclature of viruses:

International committee of virus nomenclature has given a system of naming the virus. The system consists of two parts. First part is common name of the virus and second part has the coded information about the virus. This is called as Cryptogram.

In a cryptogram

- First pair → Represents type of nucleic acid / no. of strands in nucleic acid.
- Second pair → Represents molecular weight of nucleic acid / amount of nucleic acid expressed as percentage.
- Third pair → Denotes shape of virus / shape of nucleoprotein.
- Fourth pair → Denotes type of host / carrier used in the transmission of virus.

Cryptogram of TMV Tobacco mosaic Virus

R/1 : 2/5 : E/E : S/A

It can be explained as

- First pair → Nucleic acid RNA ® is single stranded (1)
- Second pair → Mol. Wt. of nucleic acid is two (2) hundred thousand / amount of nucleic acid (5%).
- Third pair → Shape of virus – elongated € / shape of nucleoprotein enlongated (E)
- Fourth pair → Host is seed plants or spermatophytes (S) / carrier of transmission air (A) or sap (S)

Cryptogram of Polio virus

R/1, 2.5 / 30, S/S, V/O [O means no vector is needed]

Cryptogram of T^4 bacteriophage

D/2, 130 / 40, X/X, B/O [X means complex shape and B for bacteria]

Try It Yourself

1. What type of nucleic acid is present in most of the plant viruses?
2. Fill in the blanks
   i. Reproduction in temperate viruses occurs by ……. Cycle
   ii. Number of capsomeres and nucleotides in TMV is respectively …….. and ……..
   iii. Nucleic acid in Reo virus is ……
   iv. Shape of virus is represented in …… pair of cryptogram.
   v. The chemical nature of infectious particle causing kuru disease is …….
3. Bunchy top of banana is a viral disease (true/false)

Summary

- Biological classification of plants and animals was first proposed by Aristotle on the basis of simple morphological characters.
- Linnaeus later classified all living organisms into two kingdoms – Plantae and Animalia
- Whittaker proposed an elaborate five kingdom classification – Monera, Protista, Fungi, Plantae and Animalia. The main criteria of the five kingdom classification were cell structure. Body organization, mode of nutrition, reproduction and phylogenetic relationship out of which mode of nutrition was most important.
- In the five kingdom classification, bacteria are included in Kingdom Monera.
- Bacteria are cosmopolitan in distribution.
- These organisms show the most extensive metabolic diversity. Although they have a simple structure.
- Bacteria may be autotrophic or heterotrophic in their nutrition.
- Kingdom Protista includes all single-celled eukaryotes such as Chrysophytes, Dinoflagellates. Euglenoids, Slime moulds and Protozoans.
- Protists have defined nucleus and other membrane bound organelles. They reproduce both asexually and sexually.
- Members of Kingdom Fungi show a great diversity in structures and habitat.
- Most fungi are saprophytic in their mode of nutrition.
- They show asexual and sexual reproduction.

- Phycomycetes, Ascomycetes, Basidiomycetes and Deuteromycetes are the four classes under this kingdom.
- The plantae includes all eukaryotic chlorophyll containing organisms Algae, Bryophytes, Pteridophytes, Gymnosperms and Angiosperms are included in this group.
- The life cycle of plants exhibit alternation of generations-gametophytic and sporophytic generations.
- The heterotrophic eukaryotic, multicellular organisms lacking a cell wall are included in the Kingdom Animalia. The mode of nutrition of these organisms is holozoic.
- They reproduce mostly by the sexual mode.
- Some acellular organisms like viruses and viroids as well as the lichens are not included in the five kingdom system of classification.

EXERCISE

Objective Questions

Q.1 *Chrysophytes* are

(A) Diatoms and desmids
(B) Diatoms and dinoflagellates
(C) Slime moulds and desmids
(D) Slime moulds and diatoms

Q.2 Red tide is caused by rapid multiplication of

(A) BGA
(B) Desmids
(C) Diatoms
(D) Dinoflagellates

Q.3 Which of the following option for diatoms is correct?

(A) Pecto-cellulosic cell wall
(B) Silicified cell wall
(C) Multicellular eukaryotes
(D) Produce saxitioxin

Q.4 Acellular slime moulds show

(A) Haploid uninucleate
(B) Naked sporangia
(C) Autotrophic nutrition
(D) Isogamous type reproduction

Q.5 Mark the odd one (w.r.t. fungi)

(A) Unicisternal Golgi bodies
(B) Show a great diversity in morphology and habitat
(C) Most of the members are aquatic
(D) Reserve food material is stored in the form of oil and glycogen

Q.6 Fungi with cellulosic wall belong to the class

(A) Oomycetes
(B) Zygomycetes
(C) Ascomycetes
(D) Basidiomycetes

Q.7 Select incorrectly matched pair

(A) *Rhizopus* - Sporangiospore
(B) *Penicillium* - Ascocarp
(C) *Mucor* - Dikaryophase
(D) *Aspergilus* - Conidia

Q.8 Which one of the following organism performs plasmogamy by gametangial contact?

(A) *Puccinia* (B) *Albugo* (C) *Rhizopus* (D) *Agaricus*

Q.9 Coenocytic dimorphic vegetative mycelium is found in

(A) *Neurospora* (B) *Rhizopus* (C) *Pencillium* (D) *Ustilago*

Q.10 Choose incorrect match w.r.t. different classes of fungi

(A) Oomycetes-zoospore-gametic copulation

(B) Zygomycetes-sporangiospore-zygophore

(C) Ascomycetes-conidia-monokaryotic aseptate-coenocytic mycelium

(D) Phycomycetes-algal and conjugation fungi-coenocytic mycelium

Q.11 Fungi often employed in experimental genetics is the member of

(A) Egg fungi (B) Conjugation fungi (C) Sac fungi (D) Club fungi

Q.12 Select correct match

S. No.	Column – I	S. No.	Column - II
(a)	Soft rot of apple	(i)	*Absidia*
(b)	Bronchomycosis	(ii)	*Rhizopus*
(c)	White rust disease	(iii)	*Pythium*
(d)	Damping off disease	(iv)	*Albugo*

(A) a(ii), b(i), c(iv), d(iii) (B) a(i), b(ii), c(iv), d(iii)

(C) a(iv), b(iii), c(ii), d(i) (D) a(ii), b(i), c(iii), d(iv)

Q.13 In which of the following yeast ascus contains eight ascospores?

(A) *Saccharomyces* (B) *Saccharomycoides*

(C) *Schizosaccharomyces* (D) *Morels*

Q.14 Acsci are not organised into ascocarps in

(A) True yeast (B) Drosophila of plant kingdom

(C) Pigmented mould (D) Morels

Q.15 Mark the odd one (w.r.t. *Penicillium*)

(A) Asexual reproduction by conidia (B) Obligate parasite

(C) Sac fungi (D) 8 ascospores is each ascus

Q.16 Ultimate branches of conidiophore in *Penicillium* is

(A) Rami (B) Phialide (C) Sterigmata (D) Metulae

Q.17 Ascospore in sac fungi is a _____ that is formed _____.

(A) Meiospore, exogenously (B) Meiospore, endogenously

(C) Mitospore, endogenously (D) Mitospore, exogenously

Q.18 The common type of asexual spore in sac fungi is

(A) Uninucleate and motile (B) Unilayered and non-motile

(C) Two layered and non-motile (D) Multinucleate, two layered and motile

Q.19 Fungi which is best decomposers of wood are

(A) Ascomycetes (B) Basidiomycetes

(C) Deutromycetes (D) Zygomycetes

Q.20 Secondary mycelium is long lived and dominant phase of life cycle in

(A) Club fungi (B) Sac fungi

(C) Ray fungi (D) More than one option is correct

Q.21 The name of the class is based on sexual structure as the site of karyogamy and meiosis in

(A) Phycomycetes and Actinomycetes (B) Deuteromycetes and Zygomycetes

(C) Ascomycetes and Basidiomycetes (D) Basidiomycetes and Actinomycytes

Q.22 In *Agaricus*, clamp connections and dolipore septa are shown by the hyphae of

(A) primary mycelium (B) Secondary mycelium

(C) Monokaryotic mycelium (D) Coenocytic mycelium

Q.23 In the life cycle of wheat rust fungi, spermatisation occurs on the

(A) Upper surface of leaf of primary host (B) Lower surface of leaf of alternate host

(C) Upper surface of leaf of secondary host (D) Lower surface of leaf of primary host

Q.24 Bengal famine disease was caused by a pathogen which belongs to the class

(A) Ascomycetes (B) Basidiomycetes

(C) Deuteromycetes (D) Phyocomycetes

Q.25 Lichens growing on tree bark are called

(A) Lignicolous (B) Terricolous (C) Corticolous (D) Saxicolous

Q.26 Common mycobionts and phycobionts of lichen body are respectively

(A) Ascomycetes, Chlorophyceae (B) Ascomycetes, Cynophyceae
(C) Basidiomycetes, Chlorophyceae (D) Basidiomycetes, Cyanophyceae

Q.27 Foliose lichens are attached to the substratum at one or few places with the help of

(A) Branched, multicellular rhizoids (B) Holdfast
(C) Rhizines (D) Rhizomorph

Q.28 Specialised structure in the thallus of lichen for nitrogen fixation and retaining moisture is

(A) Cyphellae (B) Isidia (C) Cephalodia (D) Soredia

Q.29 Select the statement w.r.t. mycorrhizal roots

(A) They do not in shape from normal roots (B) Often show a wooly covering
(C) Possess root cap but lack root hairs (D) fungal partner is commonly a member of Ascomycetes

Q.30 Which of the following feature is not related with virus?

(A) Infectively and host specificity (B) Presence of genetic material
(C) Occurrence of certain enzymes (D) Presence of respiration

Q.31 Most of the viruses are/have

(A) Enveloped nucleo-protein structure (B) Non-enveloped nucleo-protein structure
(C) Infectious protein particles (D) Double standard DNA as well as dsRNA

Q.32 Infectious RNA particles without protein coat

(A) have high molecular weight (B) were discovered by Apler
(C) known to cause disease in plants only (D) more than one option is correct

Q.33 Select incorrect statement w.r.t. T_4 bacteriophages

(A) Have polygonal prismatic head (B) Contractile tail without tail-sheath
(C) Six tail fibres (D) ds-DNA as the genetic material

Q.34 TMV is

(A) ds Ribovirus
(B) ds Deoxyvirus
(C) ss Ribovirrus
(D) Ribovirus with 6400 capsomeres

Q.35 The photosynthetic protists are

(A) Diatoms, euglenoids and slime moulds
(B) Sacrodines, dinoflagellates and diatoms
(C) Euglenoids, diatoms and dinoflagellates
(D) Ciliates, zooflagellates and dinoflagellates

Q.36 Sea water glows during night mainly due to occurrence of

(A) *Gonyaulax*
(B) *Noctiluca*
(C) *Euglena*
(D) *Cyclotella*

Q.37 Bivalved siliceous shell or frustule occur in

(A) Diatoms
(B) Radiolarians
(C) Zooflagellates
(D) Archaebacteria

Q.38 Rejuvenescent spore of diatom is

(A) Haploid and exospore
(B) Diploid and statospore
(C) Haploid and statospore
(D) Diploid and auxospore

Q.39 Diatomaceous earth is due to

(A) Silicon
(B) Zinc
(C) Phosphorus
(D) Calcium

Q.40 Leucosin (Chrysolaminarin) is a carbohydrate which is stored as reserve food in case of

(A) *Diatom*
(B) *Euglena*
(C) *Dinoflagellates*
(D) *Paramecium*

Q.41 Reserve food in *Euglena* is

(A) Paramylum
(B) Starch
(C) Glycogen
(D) Mannitol

Q.42 Flagellation in *Euglena* is

(A) Uniflagellation and stichonematic
(B) Isokont and whiplash type
(C) Heterokont and whiplash type
(D) Heterokont and stichonematic

Q.43 Special type of red pigment present in the eye-spot *Euglena* and *Crustacea* is called

(A) Phycoerythrin (B) Astaxanthin (C) Carotene (D) Xanthorphyll

Q.44 Mixotrophic nutrition occurs in

(A) *Paramecium* (B) *Euglena* (C) *Plasmodium* (D) *Amoeba*

Q.45 Paraflagellar body of *Euglena* helps in

(A) Locomotion (B) Photoreception
(C) Reproduction (D) Osmoregulation

Q.46 The structure formed in the life cycle of cellular slime-mould due to chemotactic movement is

(A) Pseudoplasmodium (B) Swarm cells
(C) Macrocyst (D) Capillitia

Q.47 Myxamoeba are formed in the life cycle of

(A) *Physarum* (B) *Amoeba* (C) *Entamoeba* (D) *Diatoms*

Q.48 De Bary considered slime moulds to be closely related to animals and called them

(A) Protozoa (B) Metazoa (C) Mycetozoa (D) Mycotina

Q.49 Difference between a red sea and red tide is

(A) Red tide takes place in red sea
(B) Associated with a cyanobacteria and protest respectively
(C) One is by virus and other by bacteria
(D) Associated with Rhodophyceae and diatoms respectively

Q.50 De Bary was a leading

(A) Phycologist (B) Mycologist (C) Meiospores (D) Pteridologist

Q.51 Asexual spores of fungi (thillophytes) are commonly known as

(A) Oospores (B) Mitospores (C) Meiospores (D) Zygospores

Q.52 Oidia resemble yeasts in

(A) Fermentation (B) Budding
(C) Unicellular nature (D) All of these

Q.53 Which one of the following shows haplodiplontic life cycle with four ascospores in the ascus?

(A) Budding yeast (B) Fission yeast

(C) Helobial yeast (D) False yeast

Q.54 Gametangial copulation (conjugation) is common in

(A) Ascomycetes (B) Zygomycetes (C) Basidio (D) Deuteromycetes

Q.55 Motile sperms (or motile sperm cells) are absent in

(A) *Rhizopus* (B) *Funaria* (C) *Fem* (D) *Cycas*

Q.56 If the thallus of an organism like a fungus is entirely converted into one or more reproductive structures it is called as

(A) Eucarpic (B) Holocarpic (C) Holozoic (D) Homothallic

Q.57 Subterranean masses of hyphae which pass the unfavourable periods in dormant stage are known as

(A) Sclerotia (B) Mycelium (C) Rhizomorph (D) Puff balls

Q.58 Asexual reproduction by aplanospore formation is the feature of

(A) Sac fungi (B) Fungi imperfecti

(C) Conjugating fungi (D) Club fungi

Q.59 Find the correct match

S. No.	Column – I	S. No.	Column - II
(a)	Gill fungi	(i)	Salmon disease
(b)	Cup fungi	(ii)	Trama
(c)	Black mould	(iii)	Penicillin
(d)	Blue/green mould	(iv)	Zygophore
		(v)	Apothecium

(A) a(ii), b(iii), c(i), d(v) (B) a(ii), b(v), c(iv), d(i)

(C) a(ii), b(v), c(iv), d(iii) (D) a(ii), b(iii), c(i), d(iv)

Q.60 Haploid sexual spore produced exogenously is

(A) Ascospore (B) Oospore (C) Basidiospore (D) Zygospore

Q.61 Select incorrectly matched pair

(A) *Mucor mucedo* - Coprophilous

(B) *Albugo candida* - Facultative parasite

(C) *Agaricus bisporus* - Edible basidiocarp

(D) *Puccinia graminis* - Heteroecious fungi

Q.62 White rust of crucifers is caused by

(A) *Albugo candida* (B) *Sclerospora*

(C) *Phytophthora infestans* (D) *Pythium debaryanum*

Q.63 Coenocytic mycelium occurs in

(A) Zygomycetes (B) Phycomycetes

(C) Both (A) and (B) (D) Deuteromycetes

Q.64 Ascomycetes are known as

(A) Club fungi (B) Sac fungi (C) Fungi imperfecti (D) Fission fungi

Q.65 One of the following is helobial yeast

(A) *Saccharomyces* (B) *Schizosaccharomyces*

(C) *Saccharomycoides* (D) *Schizomycetes*

Q.66 One of the following is a true yeast

(A) *Candida* (B) *Mycodema* (C) *Cryptococcus* (D) *Saccharomyces*

Q.67 Fungi differs from bacteria in

(A) Mode of nutrition (B) Having NAG in cell wall

(C) Flagella structure (D) Reserve food material as glycogen

Q.68 Penicillin is obtained from

(A) *Penicillium griseofulvum* (B) *Penicillium chrysogenum*

(C) *Penicillium camemberti* (D) *Penicillium roqueforti*

Q.69 Branched conidophores are found in

(A) *Penicillium* (B) *Rhizopus* (C) *Ustilago* (D) *Saccharomyces*

Q.70 Fruiting body in *Aspergillus* (or *Penicillium*) is known as

(A) Cleistothecium (B) Apothecium (C) Perithecium (D) Hysterothecium

Q.71 A mushroom having hallucinating properties similar to L.S.D. is

(A) *Morchella* (B) *Psaliota* (C) *Psilocybe* (D) *Armillaria*

Q.72 Powdery mildew of cereals is due to

(A) *Puccinia graminis* (B) *Claviceps purpurea*

(C) *Ustilago tritici* (D) *Erysiphe graminicola*

Q.73 Ergot is a product of

(A) *Rhizopus* (B) *Claviceps* purpurea

(C) *Aspergillus* (D) *Sclerospora*

Q.74 The famous Irish famine is related to a disease of potato known as

(A) Late blight of potato (B) Early blight of potato

(C) Dry rot of potato (D) Potato scab

Q.75 A fungus, which grows on rotting wood, is

(A) *Rhizopus* (B) *Pythium* (C) *Peziza* (D) *Aspergillus*

Q.76 A dolipore septum is a characteristic feature of

(A) Phycomycetes (B) Ascomycetes

(C) Basidiomycetes (D) Zygomycetes

Q.77 Fertile layer of gill fungi is known as

(A) Hymenium (B) Trama (C) Paraphyses (D) Basidia

Q.78 An edible part of mushroom is

(A) Primary mycelium (B) Secondary mycelium

(C) Rhizomorph (D) Basidocarp

Q.79 When two host species are required for completion of a parasitic fungus life cycle, this condition is described as

(A) Autoecious (B) Heteroecious (C) Autotrophic (D) Heterokaryotic

Q.80 Pioneer work on wheat rust was done by

(A) Mundkur (B) Tulsane (C) K.C. Mehta (D) Subramaniam

Q.81 The soredium is reproductive structure of

(A) Ascomycetes (B) Zygomycetes (C) Basidomycetes (D) Lichens

Q.82 The most common chlorophycobiont in a lichen is

(A) *Chlorella* (B) *Trebouxia* (C) *Gonium* (D) *Chlamydomonas*

Q.83 Symptom not seen in plants due to viruses is

(A) Mosaic formation (B) Leaf rolling and curling

(C) Yellowing, vein clearing (D) Root knot

Q.84 Viroids were discovered by

(A) Alper (B) Randle (C) Diener (D) Ivanowsky

Q.85 Viruses possess all the following properties, except

(A) They are non-cellular organisms (B) Possess both DNA and RNA

(C) Capsid protects nuclei acid (D) Have inert crystalline structure outside living cells

Q.86 Consider the following statements and select set of features w.r.t. the life cycle of *Physarum*

a. Haploid vegetative stage as myxamoebae

b. Diploid vegetative stage as plasmodium

c. Holocarpic and polycentric

d. Holocarpic and monocentric

e. Sporeic meiosis

g. Isogamous sexual reproduction

g. Anisogamous sexual reproduction with zygotic meiosis

(A) a, c, g (B) b, c, g (C) b, d, e, f (D) b, c, e, f

Q.87 Mycelium with compact mass of hyphae as pseudoparenchymatous structure can be observed in the

(A) Fructification stage of slime moulds (B) Gill of mushroom

(C) Asexual stage of bread mould (D) Uredia stage of rust fungi

Q.88 Which one of the following combination of characters is correct for the given fungal group?

(A) Algal fungi : Coenocytic, cellulosic wall, zoospore, zygospore, dikaryophase present

(B) Conjugating fungi : Septate mycelium, chintinous wall, sporangiospore, shorter (n + n) phase

(C) Sac fungi : Septate mycelium, Ascogonium, Crozier stage, meiospores as ascospores, shorter dikaryophase

(D) Club fungi: Shorter primary mycelium stage, No sex organs, dominant dikaryophase, zygosporic meiosis.

Q.89 Read the statements carefully

a. Hartig net is the network of intracellular mycelium of boletus

b. Ectomycorrhiza forms ten percent of total mycorrhiza

c. Fungal partner of VAM belongs to zygomycetes or ohycomycetes

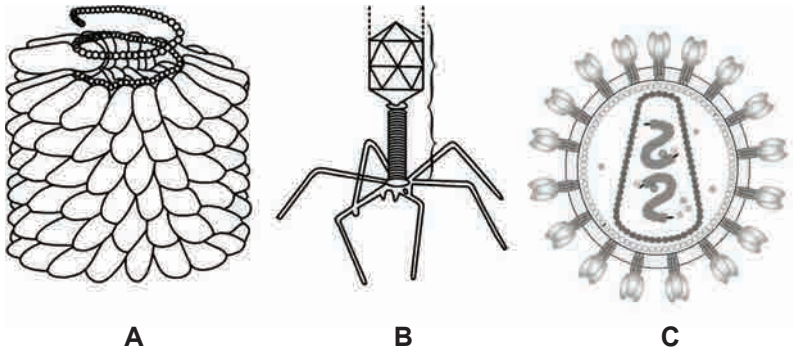
(A) Only a & c are correct

(B) Only b & c are correct

(C) Only c is correct

(D) All are correct

Q.90 Identify A, B and C given below



(A)

A - DNA virus – Cauliflower mosaic virus

B – RNA virus – Pox virus

C – Reterovirus – HIV

(B)

A – RNA virus – T.M.V

B – DNA virus – T4 bacteriophage

C – Retro virus – HIV

(C)

A – RNA virus – Hepatitis B virus

B – Reterovirus – T.M.V

C – DNA virus - ϕ 174

(D)

A – Retrovirus – Hepatitis B virus

B – RNA virus - T_4 bacteriophage

C – DNA virus – Pox virus

Q. 91. Read the following statements carefully and identify correct statements w.r.t. Lichens

a. The association cannot tolerate air pollution, especially due to sulphur dioxide

b. Lichens are annuals and their growth is slow

c. The fungal partner shows controlled parasitism

d. Soredia are most efficient means of asexual reproduction

e. Orchids seldom occur without this association

f. Foliose lichen are pioneers of succession on bare rock

(A) c, d, f (B) a, c, d, f (C) a, b, e (D) a, c, d

Previous Years' Questions

Q.1 Tikka disease occurs in ***(Orissa 2006)***

(A) Rice (B) Wheat (C) Ground nut (D) Sugarcane

Q.2 Which of the following environmental conditions are essential for optimum growth of Mucor on a piece of bread ? ***(CBSE 2006)***

i. Temperature of about 25°C

ii. Temperature of about 5°C

iii. Relative humidity of about 5%

iv. Relative humidity of about 95%

v. A shady place

vi. A brightly illuminated place

Choose the answer from following option

(A) B, D and E only (B) B, C and F only

(C) A, C and E only (D) A, D and E only

Q.3 Ergot of Rye is caused by a species of ***(CBSE 2007)***

(A) *Ustilago* (B) *Claviceps* (C) *Erysiphe* (D) *Phytophithora*

Q.4 Mycorrhiza is found in ***(DPMT 2007)***

(A) Oligotrophic soil (B) Eutrophic soil

(C) Both A and B (D) None

Q.5 Which one is the wrong pairing for the disease and its causal organism?

(CBSE PMT Prelims 2009)

(A) Loose smut of wheat – *Ustilago nuda*

(B) Root – knot of vegetables – *Meloidogyne* sp.

(C) Late blight of potato – *Alternaria solani*

(D) Black rust of wheat – *Puccinia graminis*

Q.6 Black (stem) rust of wheat is caused by ***(CBSE Main PMT 2010)***

(A) *Alternaria solani* (B) *Ustilago nuda*

(C) *Puccinia graminis* (D) *Xanthomonas oryzae*

Q.7 A plant disease in which the pathogen is seen as a cottony growth on the surface of the host is called ***(AMU Medical 2011)***

(A) Downy mildew (B) Damping off

(C) Smut (D) Rust

Q.8 Match column I and Column II and select the correct option. ***(Kerala PMT 2011)***

Column I (Kingdom)	**Column II (Class)**
a. Morels	1. Deuteromycetes
b. Smut	2. Ascomycetes
c. Bread mould	3. Basidiomycetes
d. Imperfect fungi	4. Zygomycetes

(A) a – 3, b – 4, c – 1, d - 2 (B) a – 2, b – 3, c – 4, d – 1

(C) a – 3, b – 4, c – 2, d – 1 (D) a – 2, b – 1, c – 4, d – 3

Q.9 Which one single organism or the pair of organisms is correctly assigned to its or their ganisms is correctly assigned to its or their named taxonomic group ? ***(CBSE PMT Prelims 2012)***

(A) Lichen is a composite organism formed from the symbiotic association of an algae and a protozoan

(B) Yeast used in making bread and beer is a fungus

(C) *Nostoc* and *Anabaena* are examples of Protista

(D) *Paramecium* and *Plasmodium* belong to the same kingdom as that of *Penicililum*

Q.10 Sexual reproductive structures in lichens are produced by ***(Chandigarh CET 2012)***

(A) Algae (B) Fungi

(C) Both algae and fungi (D) Lichens remain vegetative and do not reproduce

Q.11 Wonder drug is extracted from ***(HP PMT 2012)***

(A) *Aspergillus* (B) *Claviceps* (C) *Penicillium* (D) *Albugo*

Q.12 Coenocytic mycelium is a characteristic feature of ***(HP PMT 2012)***

(A) *Phycomycetes* (B) *Ascomycetes*

(C) *Basidiomycetes* (D) *Deuteromycetes*

Q.13 Which of the organism is used as food ? ***(HP PMT 2012)***

(A) *Bracket fungi* (B) *Agaricus*

(C) *Claviceps* (D) *Moulds*

Q.14 Lichens are composite organisms consisting of an alga and …… ***(HP PMT 2012)***

(A) Mosses (B) Fungus (C) Protozoa (D) Bacterium

Q.15 Which one of the following fungi contains hallucinogens ? ***(AIPMT 2014)***

(A) *Ustilago sp.* (B) *Morchella esculenta*

(C) *Amanita muscaria* (D) *Neurospora sp.*

Q.16 Bacteriophage release lysozyme during ***(UP CPMT 2007)***

(A) Penetration phase (B) Eclipse phase

(C) Absorption phase (D) Maturation phase

Q.17 Dog distemper is a disease carried by a ***(Karnataka CET 2011)***

(A) Bacterium (B) Viroid (C) Prion (D) Virus

Q.18 A virus differs from a bacterium as it contains ***(J & K CET 2011)***

(A) A cell wall (B) Cytosol

(C) DNA as genetic material (D) DNA or RNA as genetic material with no ribosome

ANSWER KEY

Objectives Questions

Q.1. A	**Q.2.** D	**Q.3.** B	**Q.4.** D	**Q.5.** C	**Q.6.** A
Q.7. C	**Q.8.** B	**Q.9.** B	**Q.10.** C	**Q.11.** C	**Q.12.** A
Q.13. C	**Q.14.** A	**Q.15.** B	**Q.16.** D	**Q.17.** B	**Q.18.** C
Q.19. B	**Q.20.** A	**Q.21.** C	**Q.22.** B	**Q.23.** C	**Q.24.** C
Q.25. C	**Q.26.** A	**Q.27.** C	**Q.28.** C	**Q.29.** B	**Q.30.** D
Q.31. B	**Q.32.** C	**Q.33.** B	**Q.34.** C	**Q.35** C	**Q.36.** B
Q.37. A	**Q.38.** D	**Q.39.** A	**Q.40.** A	**Q.41.** A	**Q.42.** D
Q.43. B	**Q.44.** B	**Q.45.** B	**Q.46.** A	**Q.47.** A	**Q.48.** C
Q.49. B	**Q.50.** B	**Q.51.** B	**Q.52.** D	**Q.53.** A	**Q.54.** B
Q.55. A	**Q.56.** A	**Q.57.** C	**Q.58.** C	**Q.59.** C	**Q.60.** C
Q.61. B	**Q.62.** A	**Q.63.** C	**Q.64.** C	**Q.65.** B	**Q.66.** C
Q.67. D	**Q.68.** C	**Q.69.** B	**Q.70.** A	**Q.71.** A	**Q.72.** C
Q.73. D	**Q.74.** B	**Q.75.** A	**Q.76.** C	**Q.77.** C	**Q.78.** A
Q.79. D	**Q.80.** B	**Q.81.** C	**Q.82.** D	**Q.83.** B	**Q.84.** D
Q.85. C	**Q.86.** B	**Q.87.** B	**Q.88.** D	**Q.89.** B	**Q.90.** C
Q.91. B					

Previous Years' Questions

Q.1. C	**Q.2.** D	**Q.3.** B	**Q.4.** A	**Q.5.** C	**Q.6.** C
Q.7. A	**Q.8.** B	**Q.9.** B	**Q.10.** B	**Q.11.** C	**Q.12.** A
Q.13. B	**Q.14.** B	**Q.15.** C	**Q.16.** A	**Q.17.** D	**Q.18.** D