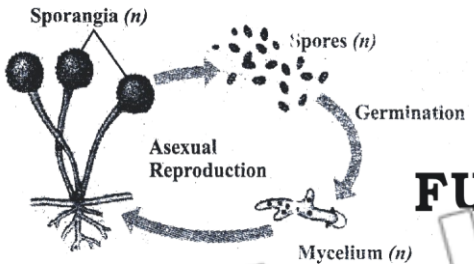


Chapter 8

FUNGI The Kingdom of Recyclers

8.1 INTRODUCTION

Approximately ***100,000 species*** of organisms called "fungi" are known and many more are estimated to be present.

VARIETY AMONG FUNGI

Members of this kingdom are of diverse nature i.e,

(i) Pathogenic Fungi

This group includes notorious pathogens such as disastrous rusts, smuts of wheat and corn, and molds found growing on important crops and foodstuff.

(ii) Edible Fungi

Some members are delicacies such as mushrooms, truffles and morels.

(iii) Commercially important Fungi

Some of the organisms are of commercial use such as;

- ***Penicillium*** – the source of antibiotic penicillin.
- ***Yeasts*** – used in bakeries and breweries.

(iv) Ecologically important Fungi

Ecological role of fungi as decomposers is paralleled ***only by bacteria***.

TAXONOMIC STATUS OF FUNGI

Taxonomic status of fungi has changed from that of 'a group of Plant kingdom' to a separate kingdom "Fungi".

Comparison between Plants and Fungi

Similarities	Dissimilarities
i) Like plants, fungi also have cell wall.	**i)** Chitin is present in cell wall of fungi, while cellulose in cell wall of plants.
ii) Both plants and fungi don't have centrioles.	**ii)** Fungi are heterotroph while plants are autotroph.
iii) Plants and fungi both are non- motile.	

Comparison between Animals and Fungi

Similarities	Dissimilarities
i) Like animals, fungi are also heterotroph.	**i)** Fungi have cell wall while animals don't have cell wall.
ii) Both animals and fungi lack cellulose.	**ii)** Fungi are absorptive heterotrophs while animals are ingestive heterotrophs.
iii) Fungi contain chitin; the chemical found in exoskeleton of arthropods.	**iii)** Fungi are non- motile while animals are motile.

For this reason, some ***mycologists*** (scientists who study fungi) think that fungi and animals probably arose from a common ancestor.

Conclusion

So fungi are neither plants nor animals, their DNA studies also confirm that they are different from all other organisms.

- They show a characteristic type of mitosis, called ***'nuclear mitosis'***.

During nuclear mitosis, nuclear envelope does not break; instead the mitotic spindle forms within the nucleus and the nuclear membrane constricts between the two clusters of daughter chromosomes (In some fungi nuclear envelope dismantles late). Because fungi are distinct from plants, animals and protists in many ways, they are assigned to a separate kingdom 'Fungi'.

QUESTION RELATED TO ABOVE ARTICLE

Give detail of taxonomic status of fungi. (LHR 2021)

8.2 THE BODY OF FUNGUS

MYCELIUM

The ***body of a fungus*** is called mycelium.

HYPHAE

Mycelium consists of long, slender branched tubular thread like filaments ***called the hyphae*** (singular hypha).

Characteristics of Hyphae

- Hyphae spread extensively over the surface of substratum.
- Chitin in their wall is more resistant to decay than are cellulose and lignin which makeup plant cell wall.
- Hyphae may be septate or non-septate.
- ***Septate*** hyphae are divided by cross-walls called septa (singular septum) into individual cells containing one or more nuclei.
- ***Non-septate*** hyphae lack septa and are not divided into individual cells; instead these are in the form of an elongated multinucleated large cell. Such hyphae are called ***coenocytic*** hyphae, in which cytoplasm moves effectively, distributing the materials throughout.

Role of Hyphae in Growth

Septa of many septate fungi have a pore through which cytoplasm flows from cell to cell, carrying the materials to growing tips and enabling the hyphae to grow rapidly when food and water are abundant and temperature is favourable. All parts of fungus growing through the substrate are metabolically active. Extensive spreading system of hyphae provides enormous surface area for absorption.

Role of Hyphae in Reproductive Structure

Hyphae may be packed together and organized to form complex reproductive structures such as mushrooms, puff balls morels etc. which can expand rapidly.

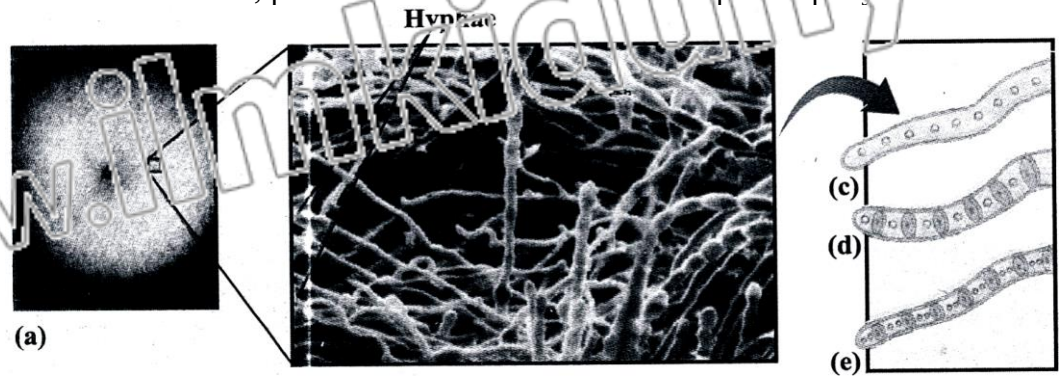


Fig. 8.1 The fungus body plan: (a) Fungus mycelium growing on agar plate (b) Hyphae of mycelium (c) A coencytic hypha (d) A septate hypha with porous septa and monokaryotic cells (e) A septate hypha with dikaryotic cell.

Non - Hyphal Fungi

Yeasts *are non-hyphal unicellular fungi.*

> A single mycelium may produce upto a kilometer of new hyphae in only one day. A circular clone of ***Armillaria***, a pathogenic fungus afflicting conifers, growing out from a central focus, has been measured upto 15 hectares (1 hectare = 10000 m^2) could it be the world's largest organism?

Fungi are Haploid

All fungal nuclei are **haploid** except for transient **diploid zygote** that forms during sexual reproduction.

QUESTION RELATED TO ABOVE ARTICLE

What is mycelium and hyphae? Explain the structure of fungi.

8.3 NUTRITION IN FUNGI

Introduction

All Fungi lack chlorophyll and are ***heterotrophs*** (obtaining carbon and energy from organic matter). They obtain their food by direct absorption from the immediate environment and are thus fungi are ***absorptive heterotrophs.***

Modes of Nutrition

Various modes of nutrition are found in fungi. Some of them are;

i) Saprotrophic Nutrition
ii) Parasitic Nutrition
iii) Predation
iv) Mutualistic Nutrition

1) Saprotrophic Nutrition

Most fungi are saprotrophs (or saprobes), ***decomposers*** that obtain their food (energy, carbon and nitrogen) directly from dead organic matter.

Saprobic fungi, alongwith bacteria, are the major decomposers of the biosphere, contributing to the recycling of the elements ***(C, N, P, O, H etc.)*** used by living things.

Characteristics of Saprobes

- Saprobic fungi anchor to the substrate by modified hyphae, the ***rhizoids***.
- Fungi are the principal decomposers of cellulose and lignin, the main components of plant cell walls (most bacteria cannot break them).
- Extensive system of fast growing hyphae provides enormous surface for absorptive mode of nutrition.

Mechanism of Saprotrophic Nutrition

- They secrete out digestive enzymes which digest dead organic matter.
- The organic molecules thus produced are absorbed back into the fungus.

2) Parasitic Nutrition

Parasitic fungi absorb nutrients directly from the living host cytoplasm with the help of special hyphal tips called ***haustoria***.

Types of Parasitic Fungi

There are two types of parasitic fungi i.e,

- Obligate Parasites
- Facultative Parasites

Obligate Parasites; can grow only on their living host and cannot be grown on available defined growth culture medium.

Examples

Various mildews and most rust species are obligate parasites.

Facultative Parasites can grow parasitically on their host as well as by themselves on artificial growth media.

3) Predation

Some fungi are active predators (which can capture a living prey). Other predators have other adaptations, such as secretion of sticky substances.

Examples

The oyster mushroom **(*Pleurotus ostreatus*)** is a carnivorous (predatory) fungus. Some species of ***Arthrobotrys*** trap soil nematodes by forming constricting ring, their hyphae invading and digesting the unlucky victim.

Mechanism of Predation

It paralyses the nematodes. (That feed on this fungus), penetrate them, and absorb their nutritional contents, primarily to fulfill its nitrogen requirements.

- It fulfills its glucose requirements by breaking the wood.

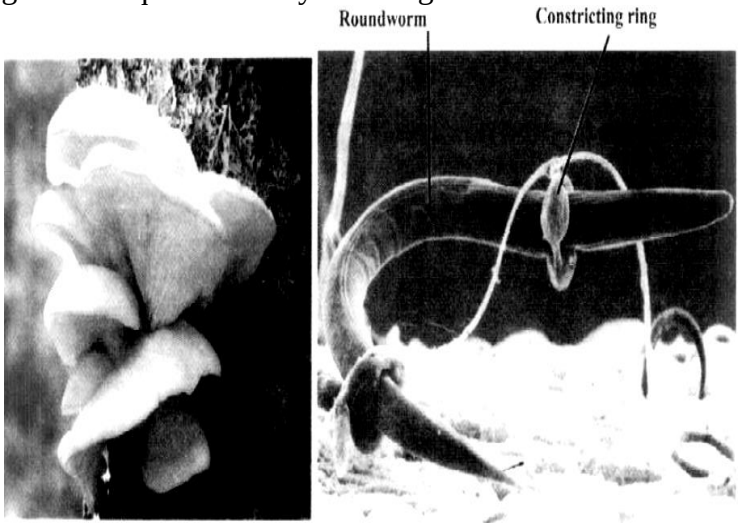


Fig 8.2 Carnivorous fungi (a) The oyster mushroom decomposes wood, and also uses nematodes as a source of nitrogen (b) A nematode is trapped in constricting ring of a soil-dwelling carnivourous fungus (Arthrobotry sp)

4) Mutualistic Nutrition

Fungi form two key mutualistic symbiotic associations (associations of benefit to both partners).

These are ***lichens*** and ***mycorrhizae***.

Lichens

Lichens mutualistic symbiotic associations between certain fungi (mostly Ascomycetes and imperfect fungi, and few Basidiomycetes – about 20 out of 15000 species of lichens) and certain photoautotrophs either green algae or a cyanobacterium, or sometimes both.

- Most of the visible part of lichen consists of fungus, and algal components are present within the hyphae.
- Fungus protects the algal partner from strong light and desiccation and itself gets food through the courtesy of alga.
- Lichens can grow at such places where nether of the components alone can, even at harsh places such as bare rocks etc. lichens vary in colour, shape, overall appearance, growth form.
- They are ecologically very important as ***bioindicators*** of air pollution.

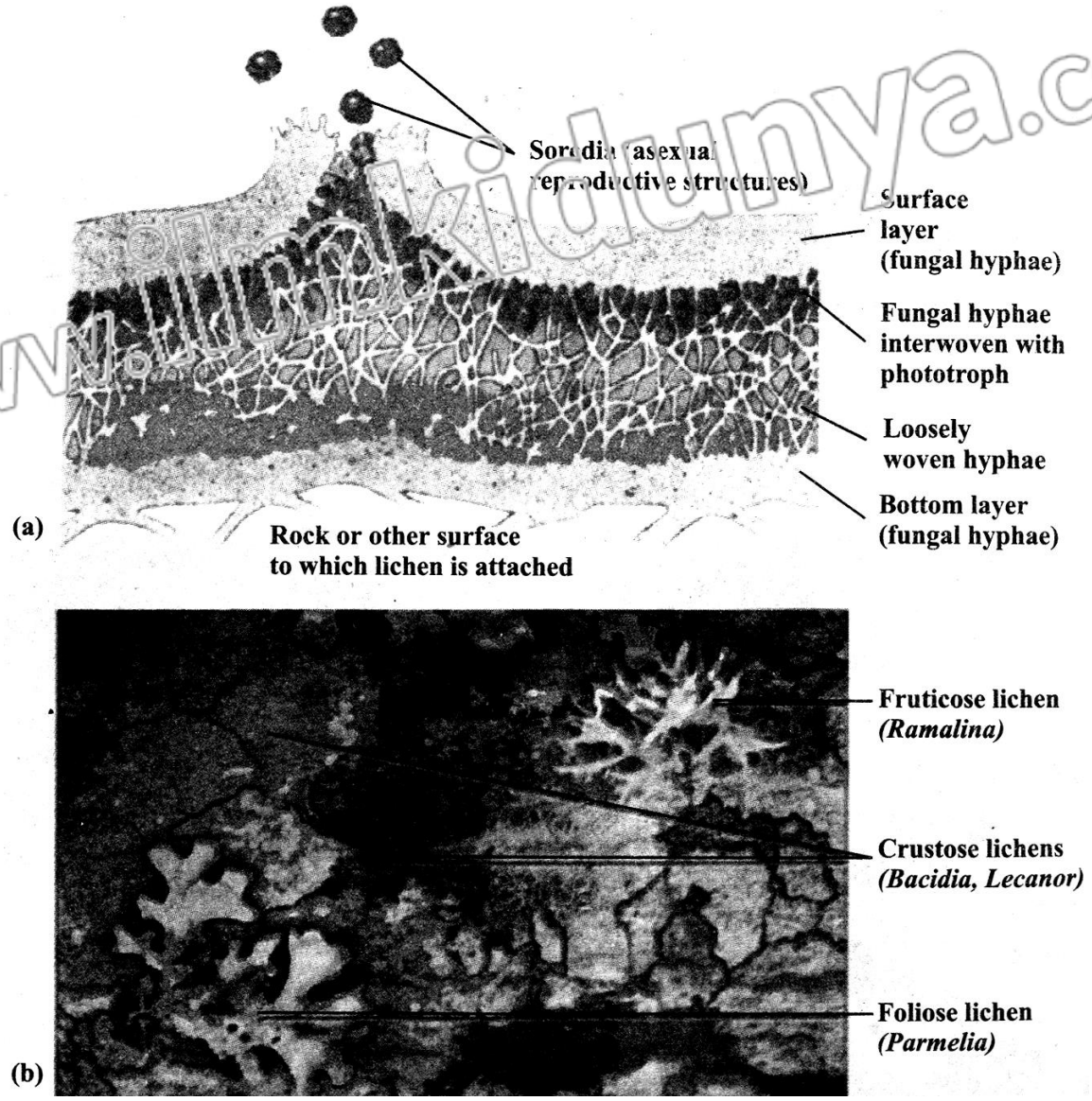


Fig 8.3 Lichens (a) Cross section of a typical lichen showing different layers. (b) Different types of lichens varying in size, colour and appearance. Three growth forms-crustose grow tightly attached to rocks, tree trunks etc; foliose are leaf-like, fruticose are branching.

Mycorrhizae

Mycorrhizae are mutualistic association between certain fungi and roots of vascular plants (about 95% of all kinds of vascular plants).

- The fungal hyphae dramatically increase the amount of soil contact and total surface area for absorption and help in the direct absorption of phosphorus, zinc, copper and other nutrients from the soil into the roots.
- Such plants show better growth than those without this association. The plant, on the other hand, supplies organic carbon to fungal hyphae.

Types of Mycorrhizae

There are two main types of mycorrhizae:

- **Endomycorrhizae;** in which the fungal hyphae penetrate the outer cells of the plant root, forming coils, swellings, and minute branches, and also extend out into surrounding soil.

- **Ectomycorrhizae;** in which the hyphae surround and extend between the cells but do not penetrate the cell walls of the roots. These are mostly formed with pines, firs etc. However, the mycelium extends far out into the soil in both kinds of mycorrhizae.

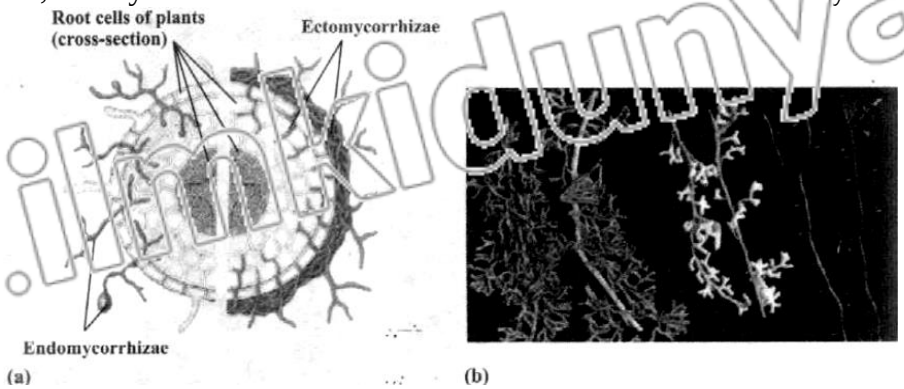


Fig. 8.4 Endomycorrhizae and ectomycorrhizae. (a) In endomycorrhiza (left side) of figure), Fungal hyphae penetrate and branch out in a root cells. In ectomycorrhiza (right side of figure), fungal hyphae simply grow around but do not penetrate cell (b) Ectomycorrhizae on roots of pines.

Characteristics of Fungi

- Fungi grow best in moist habitats, but are found wherever organic matter is resent.
- They survive dry conditions in some resting stage or by producing resistant spores.
- They can also tolerate a wide range of ***pH from 2 – 9***, a wide temperature range, and high osmotic pressure such as in concentrated salt/sugar solutions as in jelly, jam etc. These features also help them in their survival on land.
- Fungi store surplus food usually as lipid droplets or glycogen in the mycelium.

QUESTION RELATED TO ABOVE ARTICLE

Write down the different modes of nutrition in fungi.
What is mycorrhizae? Explain its types.
Discuss various methods of Nutrition in fungi. (BWP 2019)
Write a detail note on mycorrhizae. (RWP 2021)
What are key symbiotic associations formed by fungi. (MTN 2022)
Describe nutrition in fungi and explain mycorrhizal association. (SWL 2022)

8.4 REPRODUCTION

Most fungi can reproduce asexually as well as sexually) except imperfect fungi in which sexual reproduction has not been observed.

8.4.1 Asexual Reproduction

Asexual reproduction in fungi takes place by;

i) Spores
ii) Conidia
iii) Fragmentation
iv) Budding

1) Spores

Spores are produced inside the reproductive structures called sporangia, which are cut off from the hyphae by complete septa. Spores may be produced by ***sexual or asexual*** process**,** are haploid, non-motile and not needing water for their dispersal, and are small, produced in very large number and dispersed by wind to great distances and cause wide distribution of many kinds of fungi, including many plant pathogens. When spores land in a suitable place, they germinate, giving rise to new fungal hyphae. Spores may also be dispersed by insects and other small animals and by rain splashes. Spores are a ***common means of reproduction*** in fungi.

2) Conidia

Conidia (singular conidium) are non-motile, ***asexual spores*** which are cut off at the end of modified hyphae called conidiophores and not inside the sporangia, usually in chains or clusters. These may be produced in a very large number, can survive for weeks and cause rapid colonization of new food.

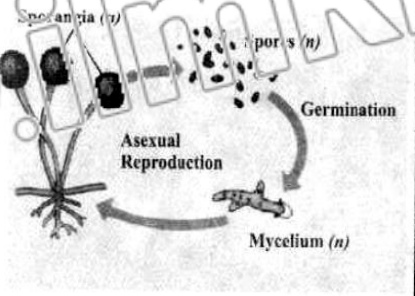


Fig. 8.5 Spores are released from sporangia germinate to produce new hyphae.

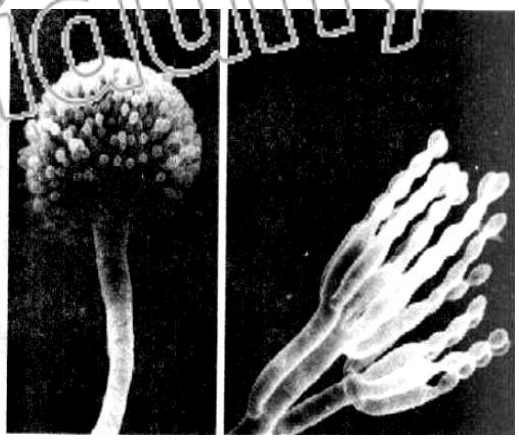


Fig. 8.6 Conidia cut off at the tip of conidiophores and In clusters chains

3) Fragmentation

Fragmentation is simple ***breaking of mycelium*** of some hyphal fungi, each broken fragment giving rise to a new mycelium.

4) Budding

Unicellular yeasts reproduce by budding (an ***asymmetric division*** in which tiny outgrowth or bud is produced which may separate and grow), or by simple, relatively ***equal cell division.***

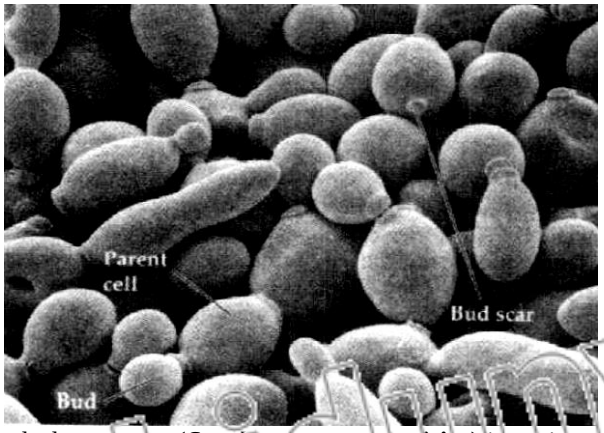


Fig. 8.7 Micrograph shows yeast (***Saccharomyces cerevisiae***) in various stage of budding.

8.4.2 Sexual Reproduction

Details of sexual reproduction vary in different groups of fungi but fusion of haploid nuclei and meiosis are common to all.

Mechanism of Sexual Reproduction

When fungi reproduce sexually, hyphae of two genetically different but compatible mating types come together, their cytoplasm fuse followed by nuclear fusion.

i) Sexual Reproduction in Zygomycetes

Sexual reproduction in zygomycetes is carried out by fusion of two genetically different but compatible mating types of hyphae, plasmogamy is followed by karyogamy. There is no lengthy dikaryotic phase found in zygomycetes.

ii) Sexual Reproduction in Basidiomycetes and Ascomyucetes

- In two of the three main groups of fungi (Basidiomycetes, Ascomycetes), fusion of nuclei **(**karyogamy**)** does not take place immediately after the fusion of cytoplasm **(**plasmogamy**)**
- Lengthy dikaryotic phase is present in both Basidiomycetes and Ascomycetes.
- The two genetic types of haploid nuclei from two individuals may coexist and divide in the same hyphae for most of the life of the fungus. Such a fungal hypha/cell having 2 nuclei of different genetic types is called dikaryotic (also heterokaryotic**)** hypha/cell.

➢ Different groups of fungi produce different types of haploid sexual spores, such as ***basidiospores*** and ***ascospores***, subsequent upon meiosis in zygote. These spores may be produced by their characteristic structure/fruiting bodies such as ***basidia/basidiocarps*** and ***asci/ascocarps.***

iii) Sexual Reproduction in Deuteromycetes

Sexual reproduction in Deuteromycetes has not been observed yet. Members of this phylum (group) reproduce only through asexual reproduction by formation of conidia.

QUESTION RELATED TO ABOVE ARTICLE

Describe asexual reproduction in fungi.
Describe different methods/ asexual reproduction found in fungi. (LHR 2017)
Discuss asexual reproduction in fungi. (LHR 2019)
Describe sexual reproduction in fungi. (DGK 2019)
What are various methods of asexual reproduction met within fungi? (DGK 2021)
Describe different method of asexual reproduction in fungi. (FSD 2022)
Write down different methods of a sexual reproduction in fungi. (SGD 2022)

8.5 CLASSIFICATION OF FUNGI

Classification of fungi into four main groups is based primarily on the type of their sexual reproductive structures and methods of reproduction.

➢ However, these groups also differ in the type of hyphae and some other characters.

Table 8.1 Classification of Fungi

Phylum (group)	Typical Examples	Sexual Reproduction	Asexual Reproduction	Hyphae
Zygomycota (Zygomycetes)	*Rhizopus* (Black bread mold), *Pilobolus* (spitting fungus)	Zygospores	Non-motile spores form in sporangia	Non-septate, multinucleate
Ascomycota (Ascomycetes or sac-fungi)	Yeasts, morels, truffles, powdery mildews, molds	Ascospores inside sac-like asci	Conidia cut off from tips of conidiophores	Septate, lengthy dikaryotic phase.
Basidiomycota (Basidiomycetes or club-fungi)	Mushrooms, rusts, smuts, puff balls, bracket fungi	Basidiospores borne on club shaped basidia	Uncommon	Septate, lengthy dikaryotic phase
Deuteromycota (Deuteromycetes imperfect fungi)	*Aspergillus*, *Penicillium*, *Alternaria*	Sexual phase has not been observed	Conidia	Septate, branched

QUESTION RELATED TO ABOVE ARTICLE

Summaries and differentiating/ distinguishing characteristics of four groups of fungi and give two common examples of each group. (Exercise Question ii)

8.5.1 Zygomycota (Zygomycetes or Conjugating Fungi)

Sexual Reproduction

- During their sexual reproduction, zygote formed directly by the fusion of hyphae forms temporary, dormant, thick walled resistant structure called ***zygospore*** hence the name Zygomycetes.
- Meiosis takes place when zygospore germinates and haploid spores are produced.
- Spores on germination produce new mycelium.

Asexual Reproduction

- Asexual reproduction by ***spores*** is common.
- Hyphae are coenocytic.

Example

Rhizopus, found growing on spoiling moist bread, fruit etc.

QUESTION RELATED TO ABOVE ARTICLE

Describe the life cycle of Rhizopus.

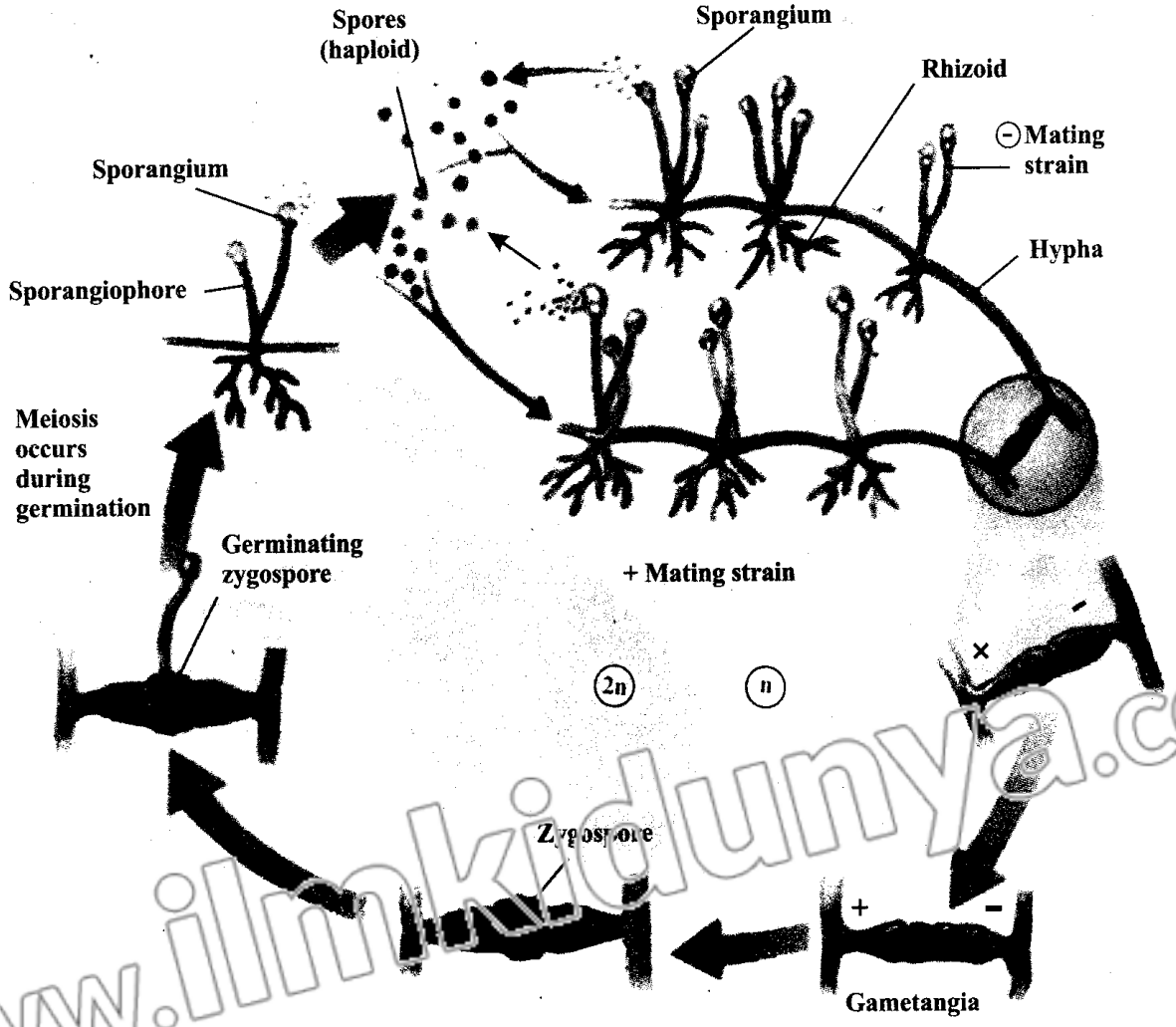


Fig. 8.8 Life cycle of *Rhizopus* (black bread mold), a Zygomycete. Zygote formed by fusion of gametangia directly develops into a resting zygospore.

QUESTION RELATED TO ABOVE ARTICLE

Explain and sketch the life cycle of *Rhizopus*. **(GRW 2018)**
Describe and sketch life cycle of *Rhizopus*. **(BWP 2022)**

8.5.2 Ascomycota (Ascomycetes or Sac – Fungi)

Introduction

- It is the largest group of fungi, including over ***60,000 species,*** 50% or so occurring in lichens and some, such as morels, are mycorrhizal.
- Most are terrestrial, though some are marine or fresh water.
- The group shows diversity from unicellular yeasts to large cup fungi and morels.
- Their hyphae are septate.

Sexual Reproduction

- They produce haploid sexual spores called ***ascospores*** by meiosis inside their characteristic sac like structures called asci (sing.ascus).
- Meiosis follows nuclear fusion inside the ascus, commonly ***8 ascospores*** are produced inside each ascus. Most sac – fungi have asci inside macroscopic fruiting bodies called ***ascocarps*** – the visible morels etc.
- ➢ They have ***lengthy dikaryotic phase*** that forms ascocarps.

Asexual Reproduction

- They reproduce asexually by ***conidia*** that are often dispersed by wind.

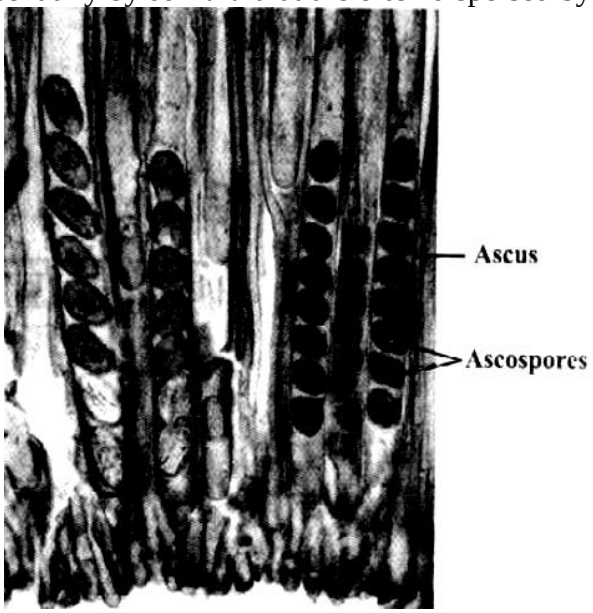


Fig. 8.9 Asci and Ascospores. Each ascus contains eight haploid ascospores

YEASTS

Yeasts are unicellular microscopic fungi derived from all the three different groups of fungi but mostly ascomycetes. Yeasts mostly asexually reproduce ***by budding.*** Yeasts reproduce sexually ***by forming asci/ascospores or basidia/basidiospores.*** They ferment carbohydrate (glucose) to ethanol and carbondioxide. Because of this feature and many other reasons, these are of great economic importance (see economic importance off fungi).

Example

Saccharomyces cerevisiae is the most commonly exploited yeast.

QUESTION RELATED TO ABOVE ARTICLE

Write a note on ascomycetes. Also give importance of yeast. (LHR 2021)
Write down a note on sac fungal. (GRW 2021)
Write a note on Ascomycota. (LHR 2018, SGD 2019, FSD 2021)
Write down the characteriscts of ascomycetes and importance of yeasts. (GRW 2022, RWP 2022)

8.5.3 Basidiomycota (Basidiomycetes or Club – Fungi)

Introduction

These are among the ***most familiar fungi*;** edible ***mushrooms***, devastating plant pathogens ***rusts*** and ***smuts***, *Puccinia* species are most common rust fungi, and *Ustilago* species most common smut fungi. ***puffballs***, and ***bracket/shelf fungi*** are all club fungi club fungi).

During most part of their life cycles the hyphae are septate; the cells are uninucleate during the remaining, lengthy phase.

Sexual Reproduction

Sexual reproduction is carried out by reproductive structure, the ***basidium*** (plural basidia). Their characteristic fruiting bodies, or visible mushrooms, are formed entirely of dikaryotic mycelium.

- Nuclear fusion in the basidium is followed by meiosis.
- Four haploid sexual spores, called the ***basidiospores,*** are born on, inside, each basidium.
- On germination the basidiospores give rise to mycelium.

Asexual Reproduction

Asexual reproduction in Basidiomycetes is uncommon.

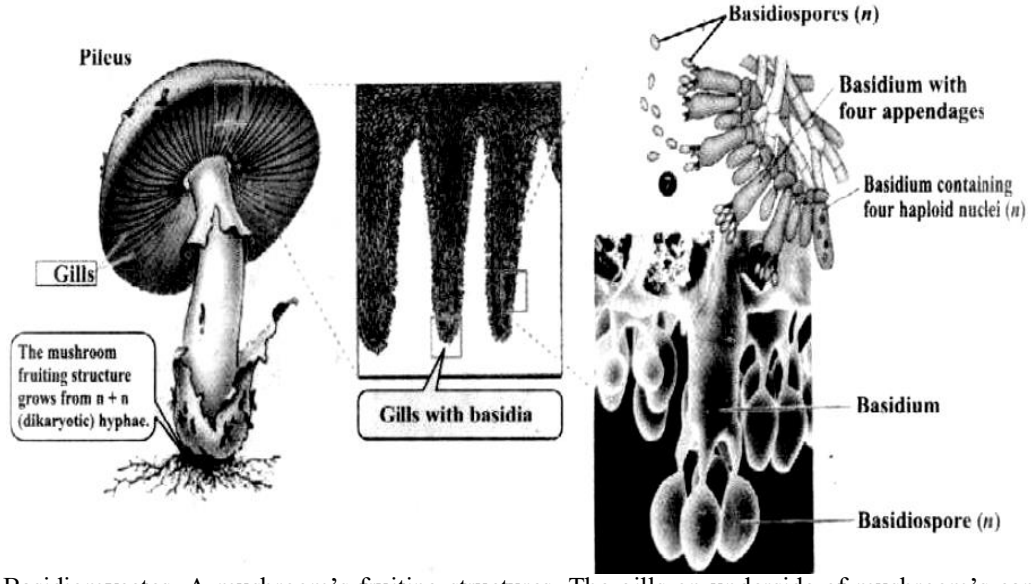


Fig. 8.10 Basidiomycetes. A mushroom's fruiting structures. The gills on underside of mushroom's cap are lined with basidia, on which basidiospores are produced.

Rusts; are called so because of numerous rusty, orange – yellow coloured disease spots on their host surface (mostly stem, leaves) later revealing brick/rust-red spores of the fungus.

Smuts; are called so because of their black, dusty spore masses that resemble soot or smut; these spore masses replace the grain kernels such as those of wheat, corn etc.

Disease Cycle of Smut

Spores (teliospores) of *Ustilago tritici* (loose smut of wheat) are carried by wind from infected wheat ears to healthy flowers, where they germinate.

- The resulting hyphae penetrate flower ovaries.
- Inside the ovary mycelium spreads and becomes dormant and remains so in the seed (grain).
- When such infected seeds are sown next season, the hyphae also grow within the growing plant and form smut spores inside the kernel, thus destroying them completely.
- The covering of the grain breaks exposing the black spores mass, that may be dispersed by wind.

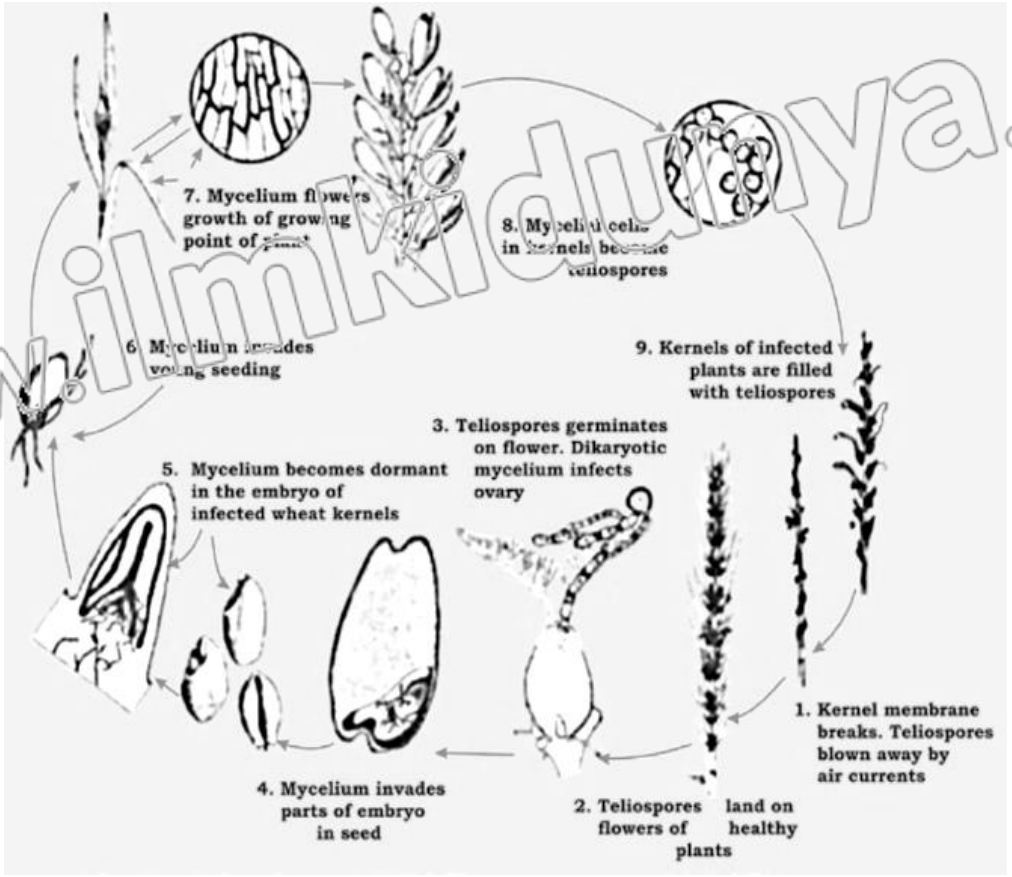


Fig 8.11 Disease cycle of loose smut of wheat caused by a club-fungus (*Ustilago tritici*)

QUESTION RELATED TO ABOVE ARTICLE

Describe the life cycle of disease loose smut of wheat. (GRW 2017)
Describe loose smut of wheat in detail. (FSD 20219)
Describe characteristics of Basidiomycota. (MTN 2019)
Describe in detail Basidiomycota. (GRW 2021)

8.5.4 Deuteromycota (Deuteromycetes or Imperfect Fungi)

Introduction

This ***heterogenous group*** includes all such fungi in which sexual phase has not been observed. Most of them are related to their sexually reproducing relatives of ascomycetes;

- However some are related to other two phyla (Zygomycota, Basidiomycota) as well.
- If sexual structures are found on an imperfect fungus, it is then reassigned to the appropriate phylum.
- Biologists now can classify most imperfect fungi on the basis of DNA sequences, though sexual structures may not be found.

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

Examples

Penicillium (blue, green molds), ***Aspergillus*** (brown molds), ***Alternaria***, ***Fusarium***, ***Helminthosporium*** are some of the economically important genera of Deuteromycetes (See economic importance of fungi).

Penicillium; a common Deuteromycote

- *Penicillium* sp. (blue, green molds) are wide spread saprotrophic species common on decaying fruit, bread etc.
- Its hyphae are septate.
- *Penicillium* reproduces **asexually** by means of naked spores called **conidia**. These are found in chains at the tips of special hyphae called **conidiophores**, which are branched.
- Brush-like arrangement of its conidia is characteristic of ***Penicillium***.
- These conidia give colour to the mycelial colony, which is circular.
- Mature conidia are easily and readily dispersed.

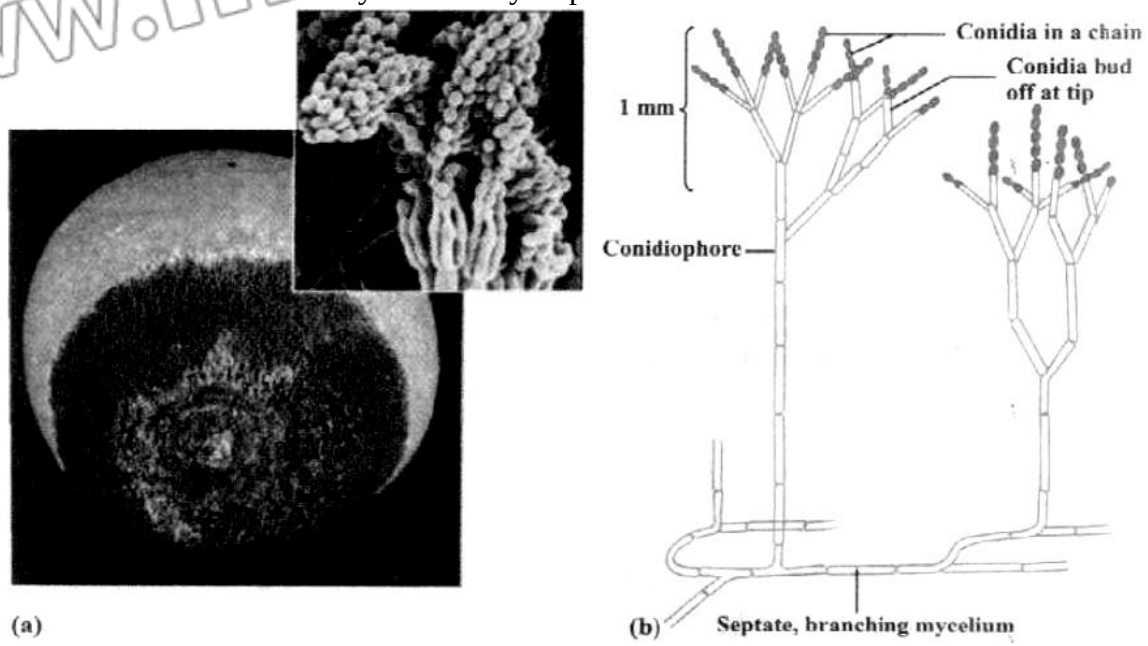


Fig. 8.12 *Penicillium* (a) A moldy orange; the blue mold is caused by saprobic species of *Penicillium.* (b) *Penicillium* showing asexual reproduction, characteristic brush like arrangement of conidia.

QUESTION RELATED TO ABOVE ARTICLE

Write note on Diatomicity and Basidiomycota.

Give the disease cycle of loose smut of wheat caused by *Ustilago tritici.*

8.6 LAND ADAPTATIONS OF FUNGI

Fungi; although grow best in moist habitats, are found wherever organic matter is present. They are a successful group of land organisms, and possess several features in their body and reproduction that adapt them to their habit and terrestrial mode of life.

i) ***Extensive system of fast spreading hyphae***, penetrate the substrate and enormously increase the contact and surface area for absorption. Cytoplasmic flow throughout the hyphae is responsible for their rapid growth and spread.

ii) ***Chitin*** in their thickened hyphal wall is more resistant to decay than are cellulose and lignin found in plant cell wall.

iii) They can even break down the lignin (in addition to cellulose) to obtain their nutrients.

iv) In saprobes, certain modified hyphae called ***rhizoids*** anchor the fungus to the substrate and also digest and then absorb the food.

v) These are very well adapted to live on land due to lack of flagellated cells, non-motile ***spores*** and conidia efficient dispersal by wind, thick-walled zygote and other resistant structures.

vi) Hyphae may be modified in such a way as to enable them to reproduce themselves without dependence on external water.

vii) Many fungi are more ***tolerant*** than are bacteria to damage in hyperosmotic surroundings. Many can tolerate temperature extremes – 5°C below freezing and 50°C or more.

QUESTION RELATED TO ABOVE ARTICLE

Give important land adaptations of fungi in details.

Why molds (e.g. Penicillium) can grow on oranges and jelly kept in a refrigerator, while generally bacteria cannot?

Explain land adaptations in Fungi. (SWL 2019)

Fungi are well adapted to live on land. Give reasons. (RWP 2019, SGD 2021)

State various features of fungi that adapt them to terrestrial mode of life.

(Exercise Question iii)

8.7 IMPORTANCE OF FUNGI

8.7.1 Ecological Importance

Fungi have great ecological impact. They are very important as ***decomposers*** and ***symbionts***.

- Fungi, along with saprobic bacteria, play vital role in the recycling of inorganic nutrients in the ecosystem. Without their activity all the essential nutrients would soon become locked up in the mounds of dead animals, plants would be unavailable for use by organisms, and life would cease.
- ***Mycorrhizal fungi*** improve the growth of plant with which they are associated. 95% of all kinds of vascular plants have this association.
- ***Lichens*** growing on rocks break them, setting stage for other organisms during the course of ecological succession.
- Lichens are very good bioindicators of air quality as they are very sensitive to pollution.
- Some fungi are also used for bioremediation (degrading/removing environmental poisons/pollutants by organisms).

QUESTION RELATED TO ABOVE ARTICLE

What is ecological importance of saprotrophic fungi, lichen and mycorrhizae?

(Exercise Question iii)

8.7.2 Commercial Importance

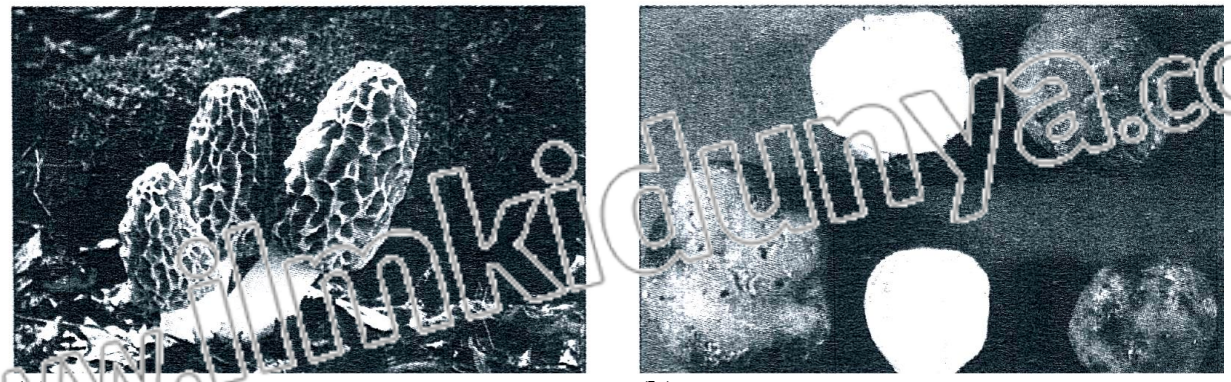
Fungi cause economic gains as well as losses.

8.7.2. a) Economic Gains due to Fungi

1. Certain fungi are ***edible***.

- About 200 species of mushrooms (e.g. *Agaricus* sp), morels (e.g. *Morchella esculenta*), and truffles (underground fruiting bodies of some. Ascomycetes, e.g. *Tuber* spp.) are common ***edible*** fungi.

➢ Beware of poisonous mushrooms called the ***toadstools***, such as death cap/death angel **(*Amanita*)** and jack-O' latern mushroom.



(a) (b)

Fig. 8.13 Edible fungi (a) A common morel (*Morchella esculenta).* (b) The truffles (*Tuber* species) are underground fruiting bodies that people find with the help of trained dogs or pigs.

2. Certain fungi are used in ***food industry*.** Because of their fermenting ability;

- **Yeasts** (***Saccharomyces cerevisiae***) are used in the production of bread and liquor.
- ***Penicillium*** species are used for giving flavour, aroma and characteristic colour to some cheese.
- Some species of ***Aspergillus*** are used for fermenting/producing soya sauce and soya paste from soya bean. Citric acid is also obtained from some ***Aspergillus*** species.

(a) (b)

Fig. 8.14 a: Poisonous mushroom Jack-O'-lantern (*Omphalotus Olearius*) whose gills glow in the dark. B: *Amanita*, another common poisonous mushrooms

3. Some fungi are ***source of antibiotics*** and some other drugs.

- ***Penicillin***, first antibiotic to be ever discovered (by A. Fleming-1928) is obtained from *Penicillium notatum*.
- ***Lovastatin*** is used for lowering blood cholesterol.
- ***Cyclosporine*** obtained from a soil fungus is used in organ transplantation for preventing transplant rejection;
- ***Ergotine*** to relieve one kind of headache migraine.
- ***Griseofulvin*** is used to inhibit fungal growth.

4. Some ***natural dyes*** obtained from lichens are used in textile industry**.**

5. Yeasts are heavily used in ***genetic/molecular biological research*** because of their.

- Rapid generation and rapidly increasing pool of genetic and biochemical information.
- Yeasts were the first eukaryotes to be used by genetic engineers.
- In 1983, a functional artificial chromosome was made in ***Saccharomyces cerevisiae***. The same yeast was the first eukaryote whose genomic sequence was completely studied in 1996.
- Yeasts are also being investigated for production of some hormones**.**

➢ Pink bread mold ***Neurospora*** has also been used for genetic research.

QUESTION RELATED TO ABOVE ARTICLE

Describe, giving examples, different ways in which fungi are useful to humans.
Describe, giving examples, different ways in which fungi are useful to human. **(LHR 2019)**
Discuss the importance of fungi in genetic research, food and pharmaceutical industry. **(SWL 2021)**
Describe economic gains due to fungi. **(LHR 2017, GRW 2019, LHR 2022)**

8.7.2. b) Economic Losses due to Fungi

1. Fungi are responsible for many serious ***plant diseases*** because they produce several enzymes that can breakdown cellulose, lignin and even cutin. All plants are susceptible to them.

- Extensive damages due to rusts and smut diseases of wheat corn and rice prompted mass displacement, and starvation to death of many people.
- Powdery mildews (on grapes, rose, wheat etc), ergot of rye, red rot of sugar cane, potato wilt, cotton root rot, apple scab, and brown rot of peaches, plums, apricots and cherries are some other common plant diseases caused by fungi.

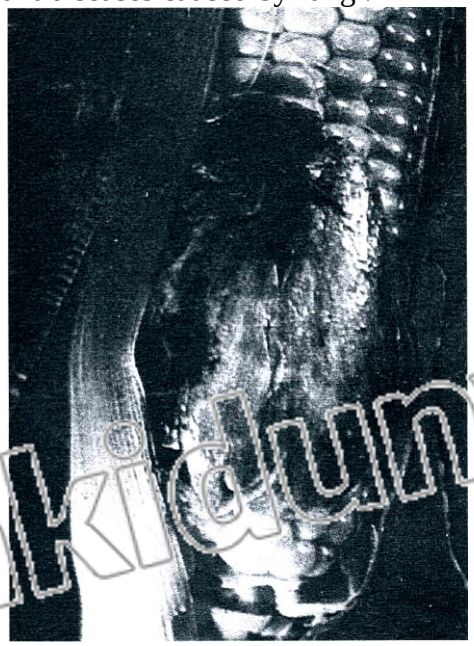


Fig. 8.15: Plant Pathogenic fungus. Corn smut on an ear of sweet corn is caused by ***Ustilago maydis***.

2. Fungi also cause certain ***animal diseases.***

- ***Ringworm*** and ***athlete's foot*** are superficial fungal infections caused by ***certain imperfect fungi***.
- *Candida albicans*, yeast, causes oral and vaginal thrush (***candidiasis*** or candidosis).

- ***Histoplasmosis*** is a serious infection of lungs caused by inhaling spores of a fungus, which is common in soil contaminated with bird's feces. If infection spreads into blood stream and then to other organs (which is very occasional), it can be serious and even fatal.
- ***Aspergillus fumigatus*** causes ***aspergillosis,*** but only in persons with defective immune system such as AIDS**,** and may cause death. Some strains of *Aspergillus* produce one of the most carcinogenic (cancer-causing) mycotoxins (toxins produced by fungi), called aflatoxins**.** ***Aspergillus*** contaminates improperly stored grains such as peanuts and corn etc. milk, eggs and meat may also have all traces of ***aflatoxins***.
- ➢ Any moldy human food or animal forage product should be discarded.
- ***Ergotism*** is caused by eating bread made from purple ergot-contaminated rye flour. The poisonous material in the ergot causes nervous spasm, convulsion, psychotic delusion and even gangrene.

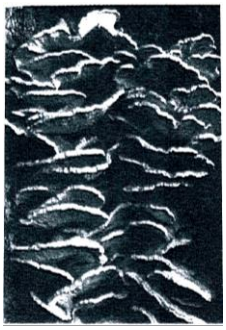


Fig. 8.16: This shelf fungus is parasitizing a tree. These are important decomposers of wood

3. Saprobic fungi are not only useful recyclers but also cause incalculable damage to food, wood, fiber, and leather by decomposing them.

- 15-50% of world's fruit is lost each year due to fungal attack.
- Wood-rotting fungi destroy not only living trees but also structural timber.
- Bracket/shelf fungi cause lot of damage to stored cut lumber as well as stands of timber of living trees.
- ➢ Pink yeast (***Rhodotorula***) grows on shower curtains and other moist surfaces.

QUESTION RELATED TO ABOVE ARTICLE

What are the economic gains due to fungi?
Give at least three benefits of fungi.
Give an account of animal diseases caused by Fungi. (MTN 2019)
Explain different economic losses due to fungi.
(LHR 2018, DGK 2021, MTN 2021, BWP 2021, DGK 2022)
Name any four important fungal diseases of plants and four fungal diseases of humans and briefly describe any one of the plant diseases and any one of the diseases of humans. (Exercise Question v)
Discuss taxonomic status of fungi. (Exercise Question i)

KEY POINTS

Bioindicators:

Fungi and algae are more sensitive to change in environment. They are affected by pollutant. The population of fungi is reduced dramatically due to certain specific pollutant. So we can get idea about the level of pollution from the population of fungi.

For Example: The population of Penicillium is very sensitive to change in concentration of CO_2. Its population decreases, if concentration of CO_2 is increased in environment.

Bioremediation:

There are certain bacteria and fungi which directly act on certain pollutants and break them into certain simple compound. For example: Industrial waste is successfully treated with certain bacteria during process of bio-remediation.

Mushrooms:

A fungi with flattened head and a stalk is generally called mushroom.

Molds:

Fury (fur like) growth of fungus on bread and fruits is called molds e.g. break mold.

Mildew:

The fungi which form white coating on its host like grapes are called mildew.

Conidia:

It is cut off at the tip of a hyphae. It is not produced inside the sporangium like spores.

Truffles:

These are underground fungi which are used as food e.g: Agaricus sp.

Rust:

Rust means rust of iron. So its colour is brown like rust of iron e.g: *Puccinia*

Smut:

Smut means coal. So its colour is back e.g: *Ustilago*

Haustoria:

These are special hyphae produced in parasitic fungi. These hyphae penetrate into to the host tissue (plant) and absorb food.

Ecological Succession:

The establishment of new vegetation on a barren land or rock is called ecological succession.

EXERCISE

Q.1. Each Question Has Four Options. Encircle Correct Answer.

i) Which statement about fungi nutrition is not true?
(a) Some fungi are active predators
(b) Some fungi are mutualists
(c) Facultative parasitic fungi can grow only on their specific host
(d) All fungi require mineral nutrients

ii) The absorptive nutrition of fungi is aided by:
(a) Spore formation
(b) Their large surface area-volume ratio
(c) They are all parasites
(d) They form fruiting bodies

iii) The Zygomycetes:
(a) Have hyphae without regularly occurring cross walls
(b) Produce motile gametes
(c) Are haploid throughout their life
(d) Answers a and c are both correct

iv) Which of the following cells/structures are associated with asexual reproduction in fungi:
(a) Ascospores
(b) Conidia
(c) Zygospores
(d) Basidiospores

v) The closest relatives of fungi are probably:
(a) Animals
(b) Slime molds
(c) Brown algae
(d) Vascular plants

vi) *E. Coli* of fungi are the:
(a) Rusts
(b) Brown mold
(c) Green mold
(d) Yeasts

vii) An ascus is to ascomycetes as is a _____ to basidiomycetes.
(a) Basidiospore
(b) Basidiocarp
(c) Basidium
(d) Haustorium

viii) Which statement is not true about Deuteromycetes?
(a) They are also called imperfect fungi
(b) Their asexual spores are called conidia
(c) It is a heterogenous polyphyletic group
(d) They have both sexual and asexual reproduction

Answers Key:

i	**c**	**iv**	**b**	**vii**	**c**
ii	**b**	**v**	**a**	**viii**	**d**
iii	**d**	**vi**	**d**		

Q.2. Short Questions

i) What is a hypha? What is the advantage of having incomplete septa?
Ans: Thread like filaments of fungi are called hyphae. Advantage of incomplete septa is that cytoplasm moves effectively, distributing the materials throughout.

ii) What is the composition of fungal cell wall and how this composition is advantageous to fungi?
Ans: Cell wall of fungi is made up of chitin. Chitin is more resistant to decay as compared to cellulose and lignin.

iii) To which phylum does the yeast belong? How do they differ from other fungi?
Ans: Yeasts belongs to Ascomycota. They are the only occurring unicellular fungi.

iv) Name sexual and asexual spores of Ascomycetes.
Ans: Sexual spores are ascospores and asexual spores are conidia.

v) What are mycorrhizae?
Ans: Mycorrhizae are mutualistic association between certain fungi and roots of vascular plants.

vi) By what means can individual s in imperfect fungi be classified?

Ans: Most of the imperfect fungi can be classified on the basis of DNA sequence.

vii) Give a single characteristic that differentiates Zygomycota from Basidiomycota.

Ans: In Zygomycota, sexual reproduction is through zygospores while in Basidiomycota, sexual reproduction is through basidiospores.

viii) Why is green mold more likely to contaminate an orange kept in refrigerator than are bacteria?

Ans: They are more tolerant than bacteria. Many can tolerate temperature extremes –5ºC below freezing point and 50ºC or more. This is the reason due to which green molds (e.g. Penicillium) can grow on oranges and jelly kept in a refrigerator.

ix) What is a fungus?

Ans: A fungus is eukaryotic, mostly multicellular, heterotrophic organism with absorptive mode of nutrition.

x) State two parallel characteristics of Ascomycetes and Basidiomycetes.

Ans:

- In both hyphae are septate.
- In both hyphae are with lengthy dikaryotic phase

Q.3. Extensive Questions.

i) Discuss taxonomic status of fungi.

Ans: (See article 8.1)

ii) Summaries and distinguishing characteristics of four groups of fungi and give two common examples of each group.

Ans: (See article 8.5)

i) State various features of fungi that adapt them to terrestrial mode of life

Ans: (See article 8.6)

ii) What is ecological importance of saprotrophic fungi, lichen and mycorrhizae?

Ans: (See article 8.7.1)

iii) Some enzymes of fungi are useful on Wone hand and harmful on other hand. Discuss.

Ans: They are useful as they are involved in decaying dead material and harmful because that also cause spoilage of food etc.

iv) Name any four important fungal diseases of plants and four fungal diseases of humans and briefly describe any one of the plant diseases and any one of the diseases of humans.

Ans: (See article 8.7.2b)

v) Describe, giving examples, different ways in which fungi are useful to humans.

Ans: (See article 8.7.2a)

vi) Differentiate between the members of each of the following pairs.

1. Spore/conidia
2. Ascus/basidium
3. Dikaryotic/Diploid
4. Ascocarp/Ascus
5. Obligate parasite/Facultative parasite
6. Endomycorrhizae/Ectomycorrhiza
7. Plasm gamy/Karyogamy

Ans: (For answer to short questions consult **KIPS** Objective Type Series)