# **KINGDOM FUNGI (MYCOTA)**

# **INTRODUCTION:**

- The term **fungus** is derived from a **Latin word 'Fungour'** which means **'to flourish'**. Term fungus was used by Gaspard Bauhin. The study of fungi is called **Mycology**.
- Pier Antonio micheli described fungi in his book 'Nova Plantarum genera'. He is called 'Father of Mycology.' E.J. Butler is known as 'Father of Inidan Mycology'.
- R.H. Whittaker (1969) established it as kingdom Fungi.

# **General Characters:**

- (1) Fungi are eukaryotic, achlorophyllous, heterotrophic, non vascular, non flowering, gametophytic, haploid (n), multicellular organisms.
- (2) Habitat: Fungi are cosmopolitan and occur in air, water, soil and on animals and plants.
  - They prefer to grow in warm and humid places.
- (3) Nutrition in fungi: The fungi constitute a unique kingdom of heterotrophic (saprophytic/absorptive nutrition) organisms. Type of heterotrophic nutrition in fungi
  - (i) **Saprophytes:** Most fungi are heterotrophic and absorb soluble organic matter from dead substrates and hence are called saprophytes.
    - e.g. You must have seen fungi on a moist bread and rotten fruits.
  - (ii) **Parasites:** Derive nutrition from living plants and animals.

e.g. White spots seen on mustard leaves are due to a parasitic fungus.

Many fungi cause diseases in plants and animals;

Wheat rust-causing *Puccinia* is an important example.

- (iii) Symbionts: They can also live as symbionts In association with algae as lichens and with roots of higher plants as mycorrhiza.
- (iv) Predacious:

e.g. Arthrobotrys (Nematophagus Fungi)

## (4) Thallus organization:

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• The main body is thallus that is called **mycelium** which is composed of interwoven mass of thread like **hyphae**. Hyphae may be aseptate or septate.

## Note:

In most of fungi there are two distinct phases vegetative / assimilative phase (below soil, inconspicuous) and reproductive phase (Conspicuous and aerial).

- Mycelium is of following types.
- (a) Aseptate mycelium: Septa absent in hyphae so mycelium is coenocytic or multinucleated.e.g. Phycomycetes Albugo, Rhizopus.
- (b) Septate mycelium: Septa present in hyphae so mycelium may be uninucleated (primary mycelium) or multinucleated (secondary mycelium) e.g. Class *Ascomycetes*, Basidiomycetes and Deuteromycetes.

Note - dolipore septa (collar like septa) are found in basidiomycetes only.



- Thallus of fungi may be of two type
  - (i) Homothallic fungi / Monoecious fungi: Bisexual, Reproduce sexually by itself (self fertile). e.g. Chaetomium and Albugo.
  - (ii) Heterothallic fungi / Heterocious fungi: Reproduce sexually by the help of two compatible Thallus (self sterile). e.g. Most of fungi are heterothallic like Saccharomyces, Aspergillus, Penicillum, Neurospora, Rhizopus, Mucor, Puccinia etc.
- (5) Stored Food: Reserve food material is glycogen and oil.
- (6) Cell wall: Cell wall is composed of chitin or fungal cellulose (C<sub>22</sub>H<sub>54</sub>N<sub>4</sub>O<sub>21</sub>), which is nitrogen containing homopolysaccharide of NAG (N-acetyl glucosamine).

#### Note:

- (i) Exceptionally in **oomycetes**, **cell wall** is composed of **cellulose**. **e.g.** *Phytopthora*.
- (ii) Lomasomes are special outgrowths of cell membrane in between cell wall and cell membrane for the synthesis of cell wall.

#### (7) Reproduction:

- (A) Vegetative Reproduction (B) Asexual Reproduction (C) Sexual Reproduction
- (A) Vegetative Reproduction: It takes place through -
- (a) Fragmentation e.g. Filamentus fungi.
- (b) Budding Non mycelial fungi like Yeast.

**Note -** Pseudomycelium formation occur in yeast during favourable condition and abundent food supply.

- (c) Fission Non mycelial fungi like Yeast.
- (d) Perenating structures like rhizomorphs, sclerotia.
- (B) Asexual Reproduction: It occurs by asexual spores, which are of following types-
- (a) By Zoospore: They are naked, motile, biflagellated/heterokont spores formed inside zoosporangium (endogenous). e.g. Phycomycetes (oomycetes)
- (b) Conidia: They are non motile spores that are formed exogenously at the tip or lateral side of special hyphal branches called conidiophores. They are borne singly or in chains. e.g. Ascomycetes and Deuteromycetes.
- (c) Sporangiospores: Non-motile spores that are formed inside (endogenous) sporangium e.g. Zygomycetes *Rhizopus*, *Mucor*.

## (C) Sexual Reproduction:

- There is progessive degeneration of sexual organ from lower to higher fungi, i.e., sexual reproduction is developed in lower fungi and absent in higher fungi.
- Sexual reproduction takes place during unfavourable conditions.
- The sexual cycle involves the following three steps:
  - (i) **Plasmogamy:** Fusion of protoplasms between two motile or non-motile gametes.

When a fungus reproduces sexually, two haploid hyphae of compatible mating types come together and fuse.

(ii) Karyogamy: Fusion of two nuclei to form diploid nucleus called as synkaryon.

In class Phycomycetes of fungi, the fusion of two haploid cells immediately results in diploid cells/zygospore (2n).

However, in other fungi (ascomycetes and basidiomycetes), an intervening dikaryotic stage (n + n, i.e., two nuclei per cell) occurs; such a condition is called a dikaryon and the phase is called dikaryophase of fungus. Later, the parental nuclei fuse and the cells become diploid.

- Note: Longest dikaryotic phase occur in basidiomycetes.
- (iii) Meiosis: Meiosis in zygote resulting in haploid spores. The fungi form fruiting bodies in which reduction division occurs, leading to formation of haploid spores. The various spores (asexual and sexual spores) are produced in distinct structures called **fruiting bodies**.

## Note:

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Sexual reproduction is by sexual spores – zygospore (Zygomycetes), **oospores** (Oomycetes), ascospores (Endogenus origin e.g. Ascomycetes) and basidiospores (Exogenus origin e.g. Basidiomycetes).



# Classification of fungi:

**Basis of classification:** The morphology of the mycelium (Structure of mycelium), mode of spore formation and fruiting bodies (sexual reproduction)

Modern scientists have been classified true fungi or Eumycota into 4 classes. (NCERT)

- (1) Phycomycetes (including Oomycetes & Zygomycetes)
- (2) Ascomycetes
- (3) Basidiomycetes
- (4) Deuteromycetes

## (1) Phycomycetes (Algal fungi / Lower fungi):

- A Members of phycomycetes are found in aquatic habitats and on decaying wood in moist and damp places or as obligate parasites on plants.
- The mycelium is aseptate and coenocytic.
- Asexual reproduction takes place by zoospores (motile) or by aplanospores (non-motile). These spores are endogenously produced in sporangium.
- A zygospore / diploid zygote is formed by fusion of two gametes. These gametes are similar in morphology (isogamous) or dissimilar (anisogamous or oogamous).
- > Phycomycetes further classified into oomycetes and zygomycetes.

	Oomycetes (Egg fungi)		Zygomycetes (Conjugation fungi)
1.25	Cellulosic cell wall	1.	Chitinous cell wall
2.	Asexual spores – Motile zoospore and Conidia	2.	Asexual spores – non-motile Applanospore
3.	Sexual reproduction	3.	Isogamy
	– Anisogamy / Oogamy		Gametangial copulation / Conjugation
	<ul> <li>– Gametangial contact</li> </ul>		Zygospore formed.
	<ul> <li>Oospore formed</li> </ul>		
4.2	e.g. Phytopthera infestans,	4.	e.g. Rhizopus (Bread mould), Mucor,
	Sclerospora, Albugo.		Pilobolus - dung loving / coprophylous / hat
			thrower / fungal shotgun.



S.No.	Name of disease	Causal organism
1 25.	Green ear disease of Bajra (Pearl millet)	Sclerospora graminicola
	Downy mildew of cereal	
222	Late blight of potato	Phytophthora infestans
3৯	White rust of crucifers	Albugo candida
4	Damping off of seedlings	Pythium debaryanum
5	Black wart disease of potato	Synchytrium endobioticum

#### Table: Disease caused by the members of oomycetes

# (2) Ascomycetes (Sac fungi):

Moulds, Powdery mildews, Yeast, Morels, Truffles and Buffles.

## **General characters:**

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- (i) Mostly multicellular, e.g., *Penicillium*, or rarely unicellular, e.g., yeast (Saccharomyces).
  - (ii) They are saprophytic, decomposers, parasitic or coprophilous (growing on dung).
    - (iii) Mycelium is branched and septate. Septa possess central pores called **septal pores / simple septa** that help in exchange between adjacent cells (pore do not allow nucleus to pass).
- (iv) The asexual spores are conidia produced exogenously on the special mycelium called conidiophores (branched or unbranched).
  - (v) Sexual spores are called **ascospores** which are produced **endogenously** in sac like asci (singular ascus). These asci are arranged in different types of fruiting bodies called ascocarps.
    - (vi) There is gap between **plasmogamy and karyogamy**. At this time a new transitional phase appears in the life cycle that is called **dikaryophase**. The latter has two types nuclei (n + n).
    - (vii) Some dikaryotic cells act as ascus mother cells in which karyogamy and meiosis occur. Now they are converted into sac like structures called asci (singular-ascus).
    - (viii) Each ascus has 4–8 (sometimes meiosis is followed by one mitosis) endogenously formed ascospores that arrange either in linear sequence e.g. *Neurospora* or unorderly e.g. Yeast. Out of them half of the ascospores are of one type and the remaining half to the second type.
    - (ix) Asci are aggregated into fruiting bodies or fructifications called ascocarps.

# Economic importance:

- 1. Aspergillus (Black or green smoky mould):
  - (i) Facultative parasite, that contaminates cultures in the laboratory hence called "weed of laboratory".
  - (ii) It causes pulmonary disease-Aspergillosis in human beings.
  - (iii) Aspergillus flavus (formerly called Guinea Pig of plant Kingdom) produces a carcinogenic toxin called aflatoxin.
  - (iv) Aspergillus niger produces citric acid & oxalic acid while gallic acid by Aspergillus gallomyces.
  - (v) Fumingallin and flavicin or aspergillic acid antbiotics are extracted form Aspergillus *fumigatus*.
- Claviceps: Ergot of rye is due to Claviceps purpurea while ergot of bajra is due to C. microcephalla. Sclerotia produces ergot. Lysergic acid obtains from it and gives a hallucinogen LSD (lysergic acid diethylamide).

# **BIOLOGY FOR NEET**

- Neurospora (Pink bread mould) : Neurospora crassa (Drosophila of Plant kingdom) is used extensively in biochemical and genetic work.
- **4. Morels and Truffles:** Many members like morels (*Morchella esculenta*) and truffles (*Tuber aestivum*) are edible and are considered delicacies.
- **5.** *Penicillium* (blue-green mould):
  - (i) A. Fleming (1929) discovered (serendipity i.e. accidental discovery) antibiotic penicillin from *Penicillium notatum*. Penicillin is commercially extracted from *P. chrysogenum*.
  - (ii) Griseofulvin (antifungal antibiotic) is obtained from *P. griseofulvum* while Brefeldin antibiotic from *P. brefeldianum*.
  - (iii) Ripening of Camembert and Roquefort cheese is performed by *P. camemberti* and *P. roqueforti* respectively.
  - 6. Brewing Industry: Beer yeast-Saccharomyces cerevisiae and wine Yeast Saccharomyces ellipsoidens perform alcoholic fermentation.
  - 7. Erysiphe graminicola-It causes powdery mildew disease of cereals like wheat, barley.



## (3) Basidiomycetes (Club Fungi): Mushrooms, Puff ball, Toad stools, Bracket fungi.

#### **General characters:**

- (i) They grow in **soil, on logs and tree stumps** and in living plant bodies as **parasites**, e.g., rusts and smuts.
  - (ii) These are most advanced fungi and best decomposers of wood. Their fruiting bodies are large and visible.
  - (iii) Mycelium is septate and branched. Septa has dolipore except in rusts and smuts. Mycelium is of two types –

Primary mycelium is monokaryotic, short lived, haploid and formed by basidiospores.

**Secondary mycelium** is dikaryotic, long lived (longest in all type of fungi) and containing binucleated cells (n + n) formed from primary mycelium by somatogamy.

- (iv) Flagella are absent.
- **a** (v) Asexual reproduction is generally absent but vegetative reproduction by fragmentation is common.
- (vi) The sex organs are absent, but plasmogamy is brought about by fusion of two vegetative or somatic cells of different strains or genotypes or mating type (+ / –).
- (vii) The resultant structure is dikaryotic (formed by clamp connection) which ultimately gives rise to basidium.
- **(viii)** Karyogamy and meiosis take place in the basidium producing four basidiospores.
- (ix) The basidiospores (4) are exogenously produced (on sterigmata) on the basidium (pl.: basidia). The basidia (club shaped) are arranged in fruiting bodies called basidiocarps.



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# **Economic importance:**

- 1. Puccinia : Rust fungi.
- Disease "Black rust of wheat" is caused by *Puccinia graminis tritici.* 
  - It is heterocious fungi which complete its life cycle in Wheat (primary infection through aeciospores and secondary infection through Uredospore) and Barbery.
    - It is polymorphic fungi.
    - The collateral hosts of *Puccinia* are Briza, Bromus, Hordeum.
- The life cycle of puccinia was studied by K.C. Mehta (1931) in Indian plains.

#### Spores produce by puccinia.

S.No.	Spore	Formed on	Cell	Nucleus
1	Uredospore	Wheat	Unicelled	Dikaryotic
2	Telio or Telutospores	Wheat	Bicelled	Dikaryotic
3	Basidiospores	Soil	Unicelled	Monkaryotic
4	Pycniospores or Pycnidiospores or Spermatiospores	Upper surface of Barberry leaf	Unicelled	Monokaryotic
5	Aeciospores	Lower surface of Barberry leaf	Unicelled	Dikaryotic

#### 2. Ustilago: Smut fungi

- They are pathogenic fungi and cause **smut diseases**.
- They bear thick walled black coloured resting spores called **chlamydospores**, **smut spores**.

Smuts are of two types.

- (a) Loose smut: In this type spores are exposed from the beginning
  - e.g. Loose smut of wheat (caused by Ustilago tritici), Note: Spread by flower and seeds. Loose smut of oat (caused by Ustilago avenae).
- (b) covered smut: The spore mass remains with the sorus till before liberation
  - e.g. Smut of corn (caused by Ustilago maydis).
    - Covered smut of barley (caused by Ustilago jensenii).
- Agaricus: Agaricus bisporus is edible mushroom. Also called as gill fungi / fairy rings because its fruiting body is ring shaped and have gills for dispersal of spores.

Note: Poisonous mushrooms are commonly called as toad stool.

Amanita muscaria - It is poisonous mushroom (Hallucinogenic).

- 4. Puff balls: Fruiting body is large and burst to release basidiospores e.g. Lycoperdon.
- 5. Bracket fungi (Shelf fungi) : e.g. Polyporus.
- 6. Nidularia and Cyathus: Commonly called as bird nest fungi.

# (4) Deuteromycetes (fungi imperfecti):

## **General characters:**

(i) The perfect stage or sexual stage is either absent or not reported therefore these are called fungi imperfecti.

Note: Parasexual cycle / mitotic recombination occurs to produce variations.

- (ii) It is considered as artificial group without any common relationship. Vegetative phase of some fungi were classified under deuteromycetes but later on when linkage was established between vegetative phase and sexual phase of these fungi, then they were classified under ascomycetes and basidiomycetes.
- (iii) Mycelium is septate and branched.
- (iv) The deuteromycetes reproduce only by asexual spores known as conidia. Vegetative propagation also found.
- (v) Some members are saprophytes or parasites while a large number of them are decomposers of litter and help in mineral cycling.
- **e.g.** Alternaria (Early blight of potato), Colletotrichum (Red rot of sugarcane) and Trichoderma (biocontrol agents against fungal disease of plants).

S.No.	Name of disease	Causal organism
1.	Early Blight of potato	Alternaria solani
2.	Red rot of Sugarcane	Colletorichum falcatum
3.25	Brown leaf spot of rice	Helminthosporium oryzae
4.	Tikka disease of Groundnut	Cercospora arachidicola, C.personatum.
5.	Ringworm of Foot / Athlete's foot	Trichophyton interdigitate / Tinia pedis.
6.	Ringworm of Scalp / Head	Microsporum lanosum

#### **Resonate the Concept**

- 1. Irish Famine (1845-1847): Phytophthora infestans causes Late Blight of potato. The former destroyed potato crop in Ireland during1845 that was called Irish Famine.
- 2. Bengal Famine (1942–1943): *Helminthosporium oryzae* is responsible for Sesame or Brown leaf spot of Rice that destroyed Rice crop of Bengal in 1942–1943 which was called bengal famine.
- 3. Autoecious & Heteroecious: A fungus that requires only one host to complete its life cycle is called autoecious fungus e.g. *Albugo*, Hemileia. A fungus that requires two hosts to complete its life cycle is called heteroecious fungus e.g. *Puccinia*.
- 4. Septa : The septa in fungi are of two types, namely simple pore septa and dolipore septa. In dolipore septa, the wall around the pores become swollen in a collar like manner so two pores are formed. These pores are covered by a perforated cap of ER called parenthosome.
- 5. Plectenchyma: Fungal hyphae form loose or compact network called as plectenchyma. Plectenchyma is two type, Prosenchyma (loosely packed) and pseudoparenchyma (closely packed)]
- **6.** Ascocarps are of following types
  - (a) **Perithecium –** Flask shaped ascocarp **e.g.** *Claviceps*.
  - (b) Apothecium Cup shaped ascocarp e.g. Peziza, Ascobolus.
  - (c) Cleistothecium Spherical Ascocarp closed from all sides e.g. Penicillium, Aspergillus
  - (d) Ascostroma Cushion like e.g. Pleospora.
- **7.** Nuclear division is intranuclear in which spindle is formed inside the nucleus and nuclear membrane persists. It is called **karyochorisis**.

8. Clamp connections or Hook shaped outgrowths are found on the side of septa. These connections are used for proper distribution of dikaryons at the time of cell division.



Fig: - Agaricus :Clamp connections

- 9. Some common Fungicides:
  - (i) Bordeaux mixture: It was first fungicide discoverd by RMA millardet of Brodeaux university (France). Its composition 4:4:50 (4 lbs CuSO<sub>4</sub> + 4 lbs Ca (OH)<sub>2</sub> + 50 gallon water) or (40g + 40g + 5 litre).
  - (ii) Burgandy mixture (Soda Bordeaux) : It was discovered by Mass. It is mixture of CuSO<sub>4</sub> + Na<sub>2</sub>CO<sub>3</sub> + H<sub>2</sub>O.
- **10.** False yeast: There are some unicellular fungi in which sexual reproduciton in not reported are called false yeast. There placed in class deuteromycetes e.g. Candida, Torula.

# Lichens:

These are formed by **symbiotic** (mutualistic) **association** between **algae** – **Phycobiont or photobiont** and **fungi** – **mycobiont**.

Algae : Blue green algae (20% lichen)	Fungi : Mostly ascomycetes like Parmelia,
Green algae (80% lichen)	Graphis, Cladonia, Usnea – called <u>ascolichen</u> , <b>Some times basidiomycetes</b> like Corella – called <u>Basidiolichens</u>

- Algae prepare food for fungi and fungi provide shelter and absorb mineral nutrients and water for its partner (Algae).
- Lichens are very good pollution indicators (**indicators of SO**<sub>2</sub> **pollution**) they do not grow in polluted areas (because pollutants accumulates in body of lichen).
- Lichen are perrenial organisms in which 95% body is found by fungi and 5% by algae.
- On the basis of shape or external appearance **Hue (1899)** described its types.
  - (i) Crustose Lichens: These are crust like closely attached to the substratum at many points. e.g. *Graphis, Rhizocarpon*.



- (ii) Foliose Lichens: These are flat, Leaf like, and attached to the substratum by rhizoid like structures called rhizines e.g. *Parmelia*.
- (iii) Fruticose Lichens: These are much branched giving a bushy appearance. They are either erect and filamentous or pendent. e.g. *Cladonia, Usnea.*
- Some special structures of thallus are as follows.
  - (i) Cyphellae: Small concave pits in the lower cortex that open into medulla and help in gaseous exchange.
    - (ii) Cephalodia: Gall like / warty dark swellings that is found on the upper side of thallus enclosing algal cells mixed with fungal hyphae. They help to retain moisture and its algal partner fix nitrogen also.

## **Reproduction in Lichens:**

(i) Vegetative reproduction: It is performed by fragmentation, Soredia, Isidia etc.

- **Fragmentation** the accidental fragmentation of older parts causes separation of lichen into two or more fragments, each growing into mature lichen.
- **Soredia :** These are powdery bodies in which both algal and fungal components present and formed on the upper surface of the thallus. Each Soredium is surrounded incompletely by loose fungal hyphae. They get disseminated by wind or other agencies and each of them gives rise to lichen after falling on suitable substrate.



- **Isidia:** Each Isidium contains core of many algal cells surrounded by cortex of fungal hyphae they increase surface area for more photosynthesis. At times they are broken off and may grow into new thallus.
  - (ii) Sexual Reproduction: Only fungal part of lichen performs sexual reproduction.

## **Economic Importance of Lichens:**

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- (i) These are firstly established on barren rocks thus these are pioneers of xerarch type of ecological succession where they form soil by corroding rocks through secreting carbonic acid and oxalic acid.
  - (ii) Reindeer moss or Cladonia rangiferina is used as food by Reindeer, Caribou. Iceland moss or *Cetraria islandica* is used as food in iceland.
  - (iii) Blue dye orchil is obtained from *Rocella tinctoria* and *Lecanora*. Litmus is composed from Rocella tinctroria and Lasallia pustulata.
  - (iv) Usnic acid is obtained from Usnea (old man's beard) and used as antibiotic. Peltigera is used in the treatment of hydrophobia, Cladonia for whooping cough, Cetraria in diabetes, Lobaria in the treatment of lung cancer and Tuberculosis.
  - (v) Some lichens are used in making perfumes such as *Evernia prunastri* yields excellent perfume. Scented essence is obtained from Ramalina and Evernia.
  - (vi) Lichens are good absorbers of radioactivity.

#### Resonate the Concept

- **1. Helotism:** According to **Crombie (1885)**, the relationship between Algal partner and fungal partner in lichen is actually master and slave relationship that is called **Helotism.** In this fungal partner dominates over the algal partner and the latter lives as prisoner or subordinate. According to Ahmadjian (1963) described fungal partner as a controlled parasite over the alga.
- 2. Trebouxia is most common unicellular green algae in Lichens.
- 3. Schwendener established dual nature of lichens.

#### Mycorrhiza:

- Let is a symbiotic (mutualistic) relationship between a saprophytic fungus and roots of higher plants. Mycorrhizal association is not very specific.
- Usually mycorrhizae are commonly found in **oligotrophic soils** (Nutrient poor soil).
- Mycorrhizae help in absorption of minerals specially phosphorus.
- Mycorrhizae also help in absorption of water and allow plant to grow better. In contrast, mycorrhizae obtain shelter and nutrients (simple carbohydrates and vitamins) from roots of host plant.
- Mycorrhizae are of two types.

#### (i) Ectomycorrhizae (ii) Endomycorrhizae

(i) Ectomycorrhizae: Fungal hyphae mainly lie on the outside as thick wooly sheath or **mantle** and some part lie between the intercellular spaces of cells of cortex.

It never enters into the cells. Fungal partner is usually member of **basidiomycetes**. **e.g.** *Pinus, Eucalyptus, Ficus*, **Oak**.

(ii) Endomycorrhizae: In this type, tips of fungal hyphae pass into cortical cells forming swollen vesicles or finely branched masses called arbuscules therefore, it is also called VAM (vesicular-arbuscular mycorrhiza).

The fungal partner belongs to mainly Zygomycetes / Phycomycetes (like Glomus).

Vesicles store phosphorus while Arbuscules function as haustoria that help in transfer nutrients from fungus to roots. **e.g. Orchids, Black papper, Cardamom, Walnut**.