**Fungi Definition**

Fungi (singular: fungus) is a heterotrophic multicellular eukaryotic organism that plays an important role in the nutrient cycling of the ecosystem. The biology where we study fungi is known as mycology. Fungi follow both sexually and asexually methods for reproduction sometimes they appear in symbiotic associations with plants and bacteria.

## General Characteristic of Fungi

## It is estimated that there are about 1.5 million fungi on earth. There are about 300 species of fungi which are infectious to humans.

* They contain a true nucleus, which means the nucleus is membrane-bounded.
* They are heterotrophs in nature means they don’t produce their food by themselves.
* They lack the vascular system (Xylem and Phloem absent) means fungi are non-vascular organisms.
* Chlorophyll pigment is absent in fungi because they are achlorophyllous.
* They contain a cell wall that is made up of chitin.
* Fungi lack the embryonic stage.
* They reproduce by the formation of both asexual and sexual spores. Some examples of sexual spores are Oospores, Zygospores, Ascospores, Basidiospores, etc.and some examples of asexual spores are Sporangiospores, Aplanospores, Zoospores, Conidia, etc.
* Fungi conduct biosynthesis of chitin.
* Some fungi contain small nuclei with repetitive DNA.
* Fungi are non-motile in nature, they can’t move.
* In fungi, the nuclear envelope is not dissolved during the mitosis.
* They show alternation of generation, containing both haploid and diploid stages.
* The vegetative body of the fungi is made of microscopic threads known as hyphae. Yeast don’t produce any hyphae, they are unicellular.
* Fungi form a hyphal network known as mycelium.
* The physical structure of both the plant and fungi is similar but chemically they are different. The fungal cell wall is made up of chitin
* The fungal cell membrane is made up of unique sterol and ergosterol.
* Most fungi grow in acidic environments (tolerate acidic pH).
* Fungi contain several exoenzymes such as Hydrolases, Lyases, Oxidoreductase, Transferase, etc. which helps in food digestion.
* They store their food in the form of starch.
* The fungi can be saprophytes (gets energy from dead and decaying matters), or parasites (lives in a host, attack and kill) or symbionts (mutually beneficial).
* The saprophytic fungi has an optimum temperature of 20-30°C while 30-37°C for parasitic fungi.
* As compared to bacteria the fungi have a slower growth rate.
* They follow both sexual(Teliomorph) and asexual reproduction (Axamorph). The Asexual reproduction is accomplished by the fragmentation, somatic budding, fission, asexual spore formation. The sexual reproduction is accomplished by gametic copulation, gamate-gametangium copulation, gametangium copulation, somatic copulation and Spermatization.
* Mold or mushrooms are macroscopic fungi, they can be seen in naked eye.

## Occurrence of Fungi

They are cosmopolitan means they can be found in air, water soil, and on plants and animals. The warm and humid places are preferred as the optimum environment for their growth.The term fungus adopted from the Latin word fungus which means mushroom. The word mycology comes from the Greek word *mykes* which means”mushroom” and *logos* means “discourse”.

**Example:**

Some examples of fungi are yeasts, rusts, smuts, mildews, molds, and mushrooms.

**Cell structure of Fungi**

* The cell wall of a fungal cell is made up of chitin (fungal cellulose, C22H54N4O21).
* In case of primitive fungi, the true cellulose with or without chitin can be found.
* Occasional Plasma-lemma appears, coiled ingrowths called lomasomes which lie below the cell wall.
* The cytoplasm of fungal cells contain different organelles such as Endoplasmic reticulum, mitochondria, ribosome, Golgi bodies etc. and inclusions such as stored foods, pigments and secretory granules.
* At the hyphal tip, the cytoplasm contains Golgi vesicles known as the chitosomes which filled with cell wall materials.
* Nucleus and mitochondria are found in connect with ER.
* During the karyochoresis, the nucleus divides. The nuclear envelope remain intact during nuclear division and a new internal spindle formed.
* They store their food in the form of glycogen and oil.

## Heterothallism and Homothallism

In 1904 A. F. Blakeslee discovered mating types or genetically distinct strains in Mucor. He named those fungi with different mating types are known as heterothallic, and those without mating types are known as homothallic. If both male and female gametes produce in the same individual can fertilize each other homothallic. On the other hand if the gametes can only be fertilized by gametes from another individual of the same species are known as heterothallic. Heterothallism is responsible for the variations in the species.

## Thallus organization of Fungi

## The thallus structure of fungi is different in higher and lower groug of fungi. In the primitive group Slime molds the thallus is naked amoeboid mass of protoplasm which may be a plasmodium (single large multinucleate protoplast) or pseudoplasmodium (an aggregation of many small uninucleateprotoplast retaining their individuality).

## In the members of higher fungi Eumycota the thallus is well develop with reproductive structure. In some members eg. Yeast the thallus is unicellular which behaves as both vegetative and reproductive cell. In other form the thallus contains a network of much branched thin filaments called hyphae which tangled into mycelium. The hyphae may be aseptate or septate (having septum). Variations in the structure of septa are numerous in the fungi. Some fungi have sievelike septa called pseudosepta, whereas fungi in other groups have septa with one to few pores that are small enough in size to prevent the movement of nuclei to [adjacent](https://www.merriam-webster.com/dictionary/adjacent) cells. Basidiomycota have a septal structure called a dolipore septum that is composed of a pore cap surrounding a septal swelling and septal pore. This organization permits cytoplasm and small organelles to pass through but restricts the movement of nuclei to varying degrees.

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There are present two types of thallus in fungi such as 1. Unicellular Thallus

2. Filamentous Thallus.

### Unicellular Thallus

* The thallus of some lower fungi for example Chytrids is more or less a spherical, single-celled structure (A).
* In holocarpic fungi the thallus becomes a reproductive unit during the time of reproduction, latter it develops the asexual or sexual cells.
* The vegetative and reproductive stages do not occur in thallus of holocarpic fungi.
* The vegetative form of Plasmodiophora is made of a naked, multinucleate, amoeboid mass of protoplasm (D), is known as Plasmodium.
* In diploid Plasmodium the protoplast is differentiating to form the resting spores.
* The filamentous forms of yeast contain a unicellular thallus (B).
* The mycelium is absent in unicellular holocarpic forms.

### Filamentous Thallus

* The Fungal cell also contains Filamentous Thallus, which is developed through the germination of spores. When spores land on a suitable substratum where other favorable conditions of life are present, they start to germinate.
* The fungal spores give rise to a fluffy thallus consisting of a cottony mass of fine, branched filaments.
* The long, fine filaments are known as hyphae. Later these hyphae extend into the air and bear the reproductive bodies. And the remaining are continued the normal activities by spreading over or within the substratum.
* The interwoven mass of thread-like hyphae is known as mycelium, hence hyphae is the structural unit of the mycelium.
* The mycelium grows upon a medium known as substratum.
* In the life cycle, mycelium functions as the food procuring structure. It carries on the general activities of a plant cell for example absorption, digestion, respiration, excretion and growth but not photosynthesis.
* The mycelium branch consists of hyphae. It forms a loose and ramifying network by spreading in all directions within or over the substratum.
* Those hyphae embedded within the substratum are usually colorless, but in some fungi, the aerial hyphae is colored. Black, orange, yellow, red, blue and brown are the usual tints.

## Mycelium of Fungi

There are present three types of Mycelium in fungi such as;

### 1. Plectenchyma (fungal tissue)

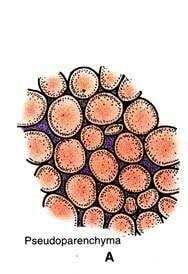
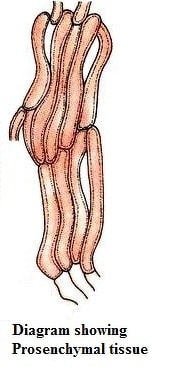
The hyphae in fungal cells are organized loosely or compactly woven to form a tissue called plectenchyma. There are two types of plectenchyma  such as;

* **Prosenchyma or Prosoplectenchyma**

In this type the hyphae are loosely interwoven lying more or less parallel to each other.

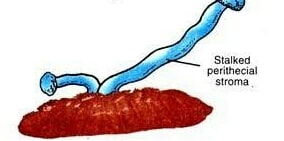
* **Pseudoparenchyma or paraplectenchyma**

In this type the hyphae are compactly interwoven looking like a parenchyma in cross-section.



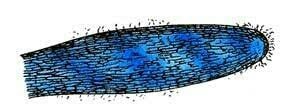
### 2. Sclerotia (Gr. Skleros=haid)

Sclerotia is a hard dormant body made of compact hyphae which is protected by external thickened hyphae. Under favourable conditions they germinate within a mycelium e.g., Penicillium.



### 3. Rhizomorphs

Rhizomorphs are the root-like compactly interwoven hyphae which contains distinct growing tips. These are helpful in absorption and perennation (to tide over the unfavourable periods), e.g., Armillaria mellea.



## Nutrition of Fungi

Fungi don’t produce their food by own because they lack chlorophyll. Based on the type of source fungi are classified into different groups such as;

### a. Saprotrophs (= saprobes)

Saprotrophs get their nutrition from dead and decaying organic matter by releasing digestive enzymes which digest the substratum and then absorb nutrients.

Example: Mucor, Agarious. Rhizopus (bread mould) etc.

### b. Parasitic

* Parasitic fungi get their nutrients from living cells.
* They can be facultative or obligate.
* The facultative parasites are found in a variety of tissues and often cause ‘soft rot’ of the tissue, e.g., Ustilago.
* There are present another type of parasite such as ectoparasites or ectophytic parasites. They grow on the host cell surface and absorb nutrients through haustoria. Example: Mucor, Erisphae.
* Some parasites grow inside the host cell, they are known as the endoparasites or endophytic. Such as Pythium, Puccinia.

### c. Predacious

Predacious is a soil fungi, it forms a ring-like nose to trap annelids, nematodes etc. Example: Arthrobotrys, Zoophagus, Dactylella etc.

### d. Symbiotic

* Fungi can be found in a mutualistic relationship with another organism, where both organisms are benefited. Example: lichens and mycorrhiza.
* The symbiotic association of fungi and algae is known as the Lichens. In this symbiotic relation fungi(ascomycetes or basidiomycetes) provides water and nutrients whereas the algae (green algae or cyanobacteria) produces food by photosynthesis.
* The symbiotic relationship between the soil fungi and plant roots is known as the mycorrhizae. In this relationship, fungi provide minerals, nutrients, water, vitamins to the plants, Whereas the plant provides food to fungi. Example: ectomycorrhizas (ECM) and endomycorrhizas.

Affinities of fungi with plants and animals

**Affinities with Plants:-**

Origins:- Both plants and fungi evolved from eukaryotic single-celled organisms called "protists," which make up the kingdom Protista. Plants, animals and fungi are all made up of eukaryotic cells. With the exception of yeasts, most fungi are multi-cellular organisms, and all plants are also multi-cellular. (Algae and phytoplankton are photosynthetic protists.)

Cell Structure:-Since plants and fungi are both derived from protists, they share similar cell structures. Both plant and fungal cells are enclosed by a cell wall. As eukaryotes, both fungi and plants have membrane-bound nuclei, which contain DNA condensed with the help of histone proteins. They both also have organelles, including mitochondria, endoplasmic reticula and Golgi apparatuses, inside their cells.

Relationships:-Both plants and fungi engage in relationships with other organisms; some of these interactions are beneficial to both organisms, while others are parasitic. In parasitic relationships, plants or fungi steal resources from other organisms. The fungi Armillaria can feed off of living trees, causing the wood to decay. Other relationships are mutually beneficial. The symbiotic relationship called "mycorrhiza" involves fungi living on plant roots; the fungi protect the plant and help it take up nutrients from the soil, and in return the fungi receive sugar from the plant.

Mobility :- On the outside, plants and fungi look similar. The flowering bodies of both types of organisms don’t move. Fungi can grow in a variety of places, including soil, animal bodies, water or plants. When most people think of fungi they think of common mushrooms, which look similar to plants growing out of the soil. In addition, fungal "hyphae," which are long, thread-like structures, resemble the roots of plants.

**Affinities with Animals**

Both Fungi and animals are without Chlorophyll

Both are having heterotrophic mode of nutrition.

Both stores Carbohydrate as Glycogen (reserve food).

Generally both are multicellular with an exception Yeast.

Both are eukaryotic with cell organelles like mitochondria, endoplasmic reticulum, golgi bodies etc.

Both are having Chitin, cell wall of fungi is primarily made up of chitin, whereas in some animals chitin is present in the exoskeletal structure of insects, spider and crustaceans.

**TAXONOMICAL / SYSTEMIC CLASSIFICATION OF FUNGI**

Fungi are placed in phylum *Thallophyta*. This classification of fungi is based on the sexual spore formation. There are four classes of fungi as follows :

1. Phycomycetes/Zygomycetes
2. Ascomycetes
3. Basidiomycetes
4. Deuteromycetes/Hyphomycetes/Fungi imperfecti

**Zygomycetes**

* The division Zygomycota contains the fungi called Zygomycetes.
* These are lower fungi that have non-septate Hyphae and produce endogenous asexual spores, called Sporangiospores, contained within swollen sac-like structures called Sporangia.
* The Hyphae of Zygomycetes known as Coenocytic, with many haploid nucleoids.
* Zygomycetes also produce sexual spores known as oospores in some fungi and Zygospores in others.
* Zygospores are tough thick walled zygotes called Zygospores that can remain dormant when the environment is too harsh for the growth of the fungus.
* They usually reproduce asexually but if food becomes starve or environmental condition unfavorable it begins sexual reproduction.
* The Zygomycetes also contributes to human welfare for e.g. – Rhizopus is used in Indonesia to produce food; another Zygomycetes is used with soybean to make a curd called Sufu.

**Ascomycetes**

* The division Ascomycota contains the fungi called Ascomycetes are commonly known as sac fungi.
* They have septate Hyphae ad form exogenous asexual spores called conidia.
* It forms sexual spores (Ascospores) are present within a sac or Ascus.
* Asexual reproduction is common in the Ascomycetes and takes place by means of Conidiospores.
* It includes both yeasts and filamentous fungi. Many yeast genera are classified specifically within Ascomycetes because of their sexual reproduction.
* Many species are quite familiar and economically important for example – most of the Red, Brown and blue-green moulds that cause food spoilage are Ascomycetes.

**Basidiomycota**

* The division Basidiomycota contains the Basidiomycetes commonly known as the club fungi.
* It forms sexual spores called Basidiospores on a basidium or base. A basidium is produced at the tip of Hyphae and normally in club shape.
* The Basidiomycetes affects humans in many ways; many mushrooms are used as food throughout the world.
* For e.g. – Basidiomycetes includes Smuts, Jelly fungi, Mushrooms & Bird net fungi.

**Deuteromycota**

* When a fungus lacks the sexual phase (perfect stage) or if this phase has not been observed it is placed within the division Deuteromycota, commonly called as Deuteromycetes or Fungi imperfecti.
* Most Deuteromycetes reproduce by means of Conidia.
* Most fungi imperfecti are terrestrial; with only a few being reported from freshwater and marine habitats.
* Many Deuteromycetes directly affects human welfare and causing numerous diseases such as Ringworm.
* The chemical activities of many fungi are important to industries such as some species of Penicillium used in the synthesis of antibiotics.

**Cell Wall composition**

### Glucans

Glucan is the most important structural polysaccharide of the fungal cell wall and represents 50–60% of the dry weight of this structure. Most polymers of glucan are composed of 1,3 linkage glucose units (65–90%), although there are also glucans with β-1,6 (in *Candida* but not in *Aspergillus*) The α-1,3-glucan is also a fundamental component of the fungal cell wall and is synthetized by α-glucan synthase

### Chitin

The chitin content of the fungal wall varies according to the morphological phase of the fungus. It represents 1–2% of the dry weight of yeast cell wall while in filamentous fungi, it can reach up to 10–20%.

### Glycoproteins

Proteins compose 30–50% of the dry weight of fungal wall in yeast and 20–30% of the dry weight of the wall of the filamentous fungi. Most proteins are associated to carbohydrates by O or N linkages resulting in glycoproteins.

### Melanin

Melanin is a pigment of high molecular weight that is negatively charged, hydrophobic and insoluble in aqueous solutions and protects fungi against stressors facilitating survival in the host.