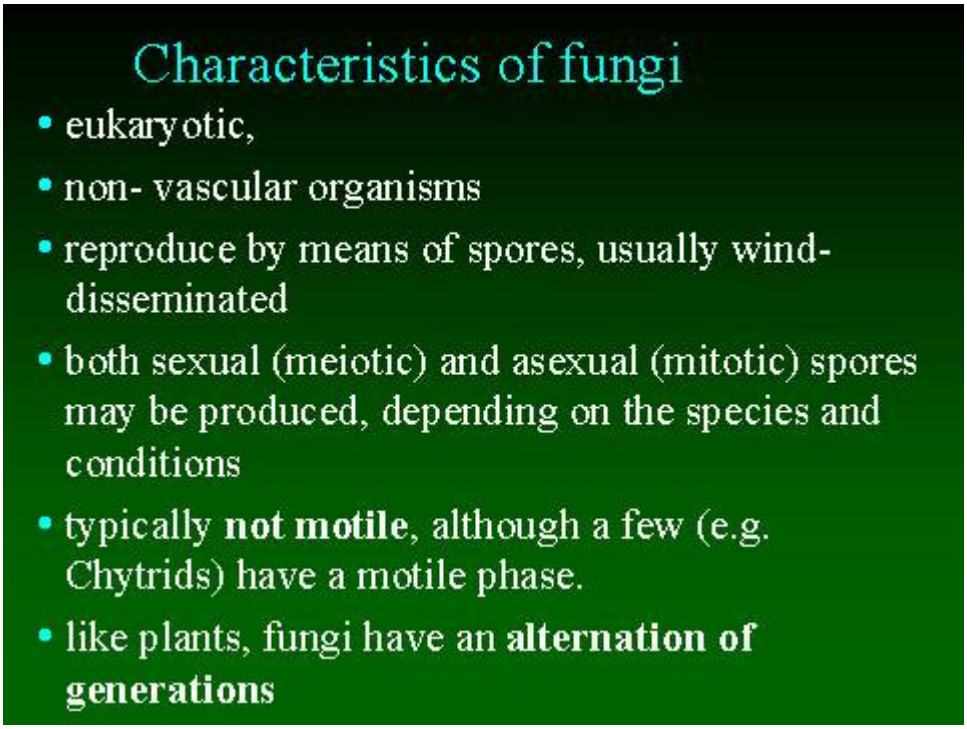
Introduction to Fungi
1. General characteristics

Fungus is a (taxonomic) group that includes heterotrophic eukaryotes that are usually filamentous, devoid of chlorophyll, with chitinous cell wall, and produces spores.

Most species of **fungi** live as multicellular filaments called hyphae, which form a mycelium while other species live as unicellular. They reproduce by means of spores. Fungi that reproduce through asexual spores and sexually-produced spores are called **perfect fungi** whereas fungi that reproduce only by asexual spores are called **imperfect fungi** (deuteromycetes). They do not have chlorophyll, hence, they are heterotrophic organisms, absorbing foods into their hyphae. Examples of **fungi** are yeasts, rusts, puffballs, truffles, molds, mildews and mushrooms. **This fungal group is distinct from the structurally similar myxomycetes (slime molds) and Oomycetes (water molds).**



Note that: Each generation of Fungi Kingdom is opposite of its parents generation. A generation of fungal cells cans either diploid, with two copies of each chromosome, or haploid, with only one copy of each chromosome. Most fungi that you would recognize as fungi, for example mushrooms (club fungi), the fruiting bodies of sac fungi and molds that appear above ground, are diploid. On the other hand, haploid fungi make up the hyphae cells and underground mycelium before the mycelium undergoes sexual reproduction. For the most part, the underground hyphae-roots which often sustain fungi that grow above the ground are of a haploid generation while fungi that grow above the soil or on the sides of trees are of a diploid generation. Each of the two generations of fungi undergoes a different type of reproduction. Haploids sexually reproduce, joining the two nuclei of two different strands of hyphae cells to produce a new strand of diploid hyphae cells which will the sprout into an above-earth mushroom (etc.) Diploids, on the other hand, produce special haploid cells using Mitosis to be released as spores into the ground. The children of diploids become haploid mycelium that will produce more diploids.

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- vegetative body may be unicellular (yeasts) or composed of microscopic threads called hyphae
- **cell walls** similar in structure to plants' but differ in chemical composition--fungi cell walls are composed of mostly of chitin--plant cell walls are composed mostly of cellulose (plus lignin in secondary walls)
- **cytoplasmic ultrastructure** broadly similar to plants cells, but differ significantly in kinds of organelles and their structures.

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- fungi are heterotrophic ("other feeding," must feed on preformed organic material), not autotrophic ("self feeding," make their own food by photosynthesis).
- Unlike animals (also heterotrophic), which ***ingest then digest***, fungi ***digest then ingest***.
- Fungi produce exoenzymes to accomplish this
- most fungi store their food as glycogen (like animals)--plants store food as starch

Economic importance of fungi

Many fungi are very useful to humans:

- yeasts-- baking and brewing
- antibiotics--- e.g. penicillin & cephalosporin
- other drugs-- e.g. cyclosporin
- many organic acids are commercially produced with fungi-- e.g. citric acid in Coke is produced by an *Aspergillus*
- steroids and hormones--- e.g. the pill
- certain "stinky" cheeses-- e.g. blue cheese, Roquefort and Camembert

Many fungi are harmful to human interests:

- can cause human disease, either directly or through their toxins
- can cause diseases of plants and animals that humans are intersted in (e.g. crops, etc.)
- cause rot and contamination of foods
- can destroy almost every kind of manufactured good-- with the exception of plastics and some pesticides

List, source, and uses of enzymes derived from fungi for food manufacture		
Enzyme	**Source**	**Use**
α -Amylase, amyloglucosidase	*Aspergillus niger* *A. oryzae* *Rhizopus spp.*	Hydrolysis of starch in production of beer, bread; manufacture of high-fructose syrups
Catalase	*Aspergillus niger* *Penicillium vitale*	Remove excess hydrogen peroxide formed during cake baking or that may be added during pasteurization of milk and cheese
Cellulase	*Aspergillus niger* *Trichoderma viride*	Improve palatability of low-quality vegetables, accelerate drying of vegetables, alter texture of foods, increase flavor of commercial mushrooms
Hemicellulase	*Aspergillus niger* *Trichoderma viride*	Manufacture of instant coffee
Lactase	*Aspergillus niger* *A. oryzae*	Hydrolysis of lactose in milk products, enabling their use by lactose-intolerant individuals; production of syrups for use as sweetening agents

2. Morphology of fungi

2. 1 Microscopic structures

Most fungi grow as hyphae, which are cylindrical, thread-like structures 2–10 µm in diameter and up to several centimeters in length. Hyphae can be either **septate** or **coenocytic:** septate hyphae are divided into compartments separated by cross walls (internal cell walls, called septa, that are formed at right angles to the cell wall giving the hypha its shape), with each compartment containing one or more nuclei; **coenocytic** hyphae are not compartmentalized. Septa have **pores** that allow cytoplasm, organelles, and sometimes nuclei to pass through; an example is the dolipore septum in the fungi of the phylum Basidiomycota. Coenocytic hyphae are essentially multinucleate super cells.

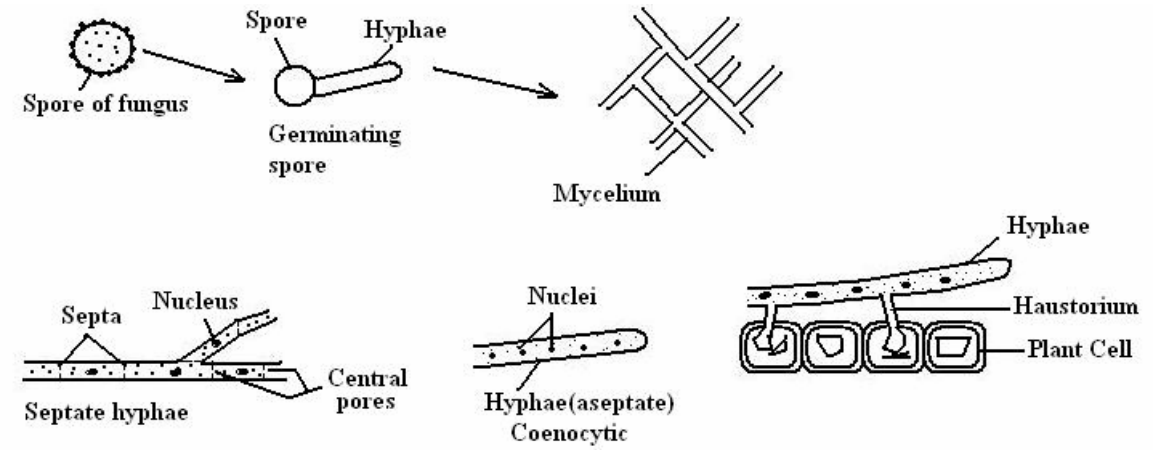
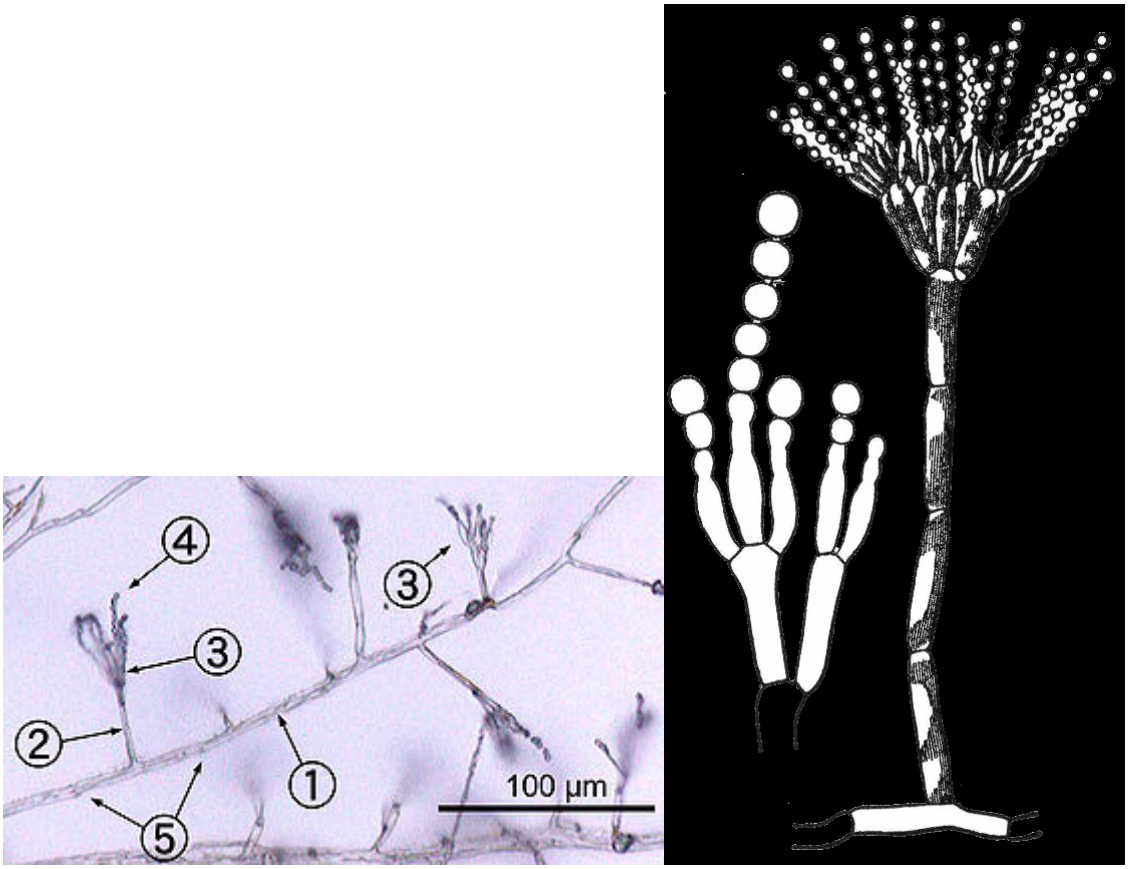


Fig.1 Thallus organisation (structure)



An environmental isolate of *Penicillium*
1. hypha 2. conidiophore 3. phialide 4. conidia 5. septa

Mycelium (plural **mycelia**) is the vegetative part of a fungus, consisting of a mass of branching, thread-like hyphae. The mass of hyphae is sometimes called **shiro**,

especially within the fairy ring fungi. Fungal colonies composed of mycelia are found in soil and on or within many other substrates. A typical single spore germinates into a **homokaryotic** mycelium, which cannot reproduce sexually; when two compatible homokaryotic mycelia join and form a **dikaryotic** mycelium, that mycelium may form fruiting bodies such as mushrooms. A mycelium may be minute, forming a colony that is too small to see, or it may be extensive.

In fungi, the **sporocarp** (also known as **fruiting body** or **fruit body**) is a multicellular structure on which spore-producing structures, such as basidia or asci, are borne.

Conidiophore: A specialized hypha upon which conidia develop.

Conidium (pl. conidia): An asexual reproductive propagule formed in any manner that does not involve cytoplasmic cleavage. Conidia function as organs of dissemination.

Phialide: A specialized conidiogenous cell that produces conidia in basipetal succession without increasing in length.

Homokaryotic (adj.) refers to multinucleate cells (multiple nuclei share one common cytoplasm as it is found in hyphal cells or mycelium of filamentous fungi) where all nuclei are genetically identical. It is the antonym of **heterokaryotic.**

Dimorhphic: A fungus able to grow either in yeast form or in mycelial form. Several pathogens of humans exhibit dimorphism
Q *Candida albicans*

Q *Histoplasma capsulatum,* mold at 25°C, yeast at 37°C

Eucarpic: a fungus in which the thallus is differentiated into vegetative and reproductive regions. eg *Rhizopus stolonifer*

Holocarpic: a fungus in which the entire thallus is differentiated into a reproductive sporangium when mature. Eg. *Synchytrium endobioticum*

Many species have developed specialized hyphal structures for nutrient uptake from living hosts; examples include **haustoria** in plant-parasitic species of most fungal phyla.

Homothallic: A fungus capable of sexual reproduction on a single thallus. eg. *Pythium debaryanum*

Heterothallic: A fungus that requires mating between two compatible strains for sexual reproduction to occur. eg. *Rhizopus stolonifer.*

2. 2 Macroscopic structures

Armillaria solidipes

Fungal mycelia can become visible to the naked eye, for example, on various surfaces and substrates, such as damp walls and on spoiled food, where they are commonly called **molds.** Mycelia grown on solid agar media in laboratory petri dishes are usually referred to as **colonies.** These colonies can exhibit growth shapes and colors (due to spores or pigmentation) that can be used as diagnostic features in the identification of species or groups. The **apothecium**—a specialized structure important in sexual reproduction in the ascomycetes—is a cup-shaped fruiting body that holds the hymenium, a layer of tissue containing the spore-

bearing cells. The fruiting bodies of the basidiomycetes (basidiocarps) and some ascomycetes can sometimes grow very large, and many are well-known as **mushrooms.**