

INTRODUCTORY BIOLOGY AND MICROBIOLOGY

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Introduction on Fungi

- Fungus is a member of a large group of eukaryotic organisms that includes microorganisms such as yeasts and molds as well as mushrooms.
- These organisms are classified as a kingdom, Fungi, which is separate from plants, animals, protists and bacteria.
- One major difference is that fungal cells have cell walls that contain chitin, unlike the cell walls of plants and some protists, which contain cellulose, and unlike the cell walls of bacteria.

- These and other differences show that the fungi form a single group of related organisms, named the Eumycota (true fungi or Eumycetes), that share a common ancestor (is a monophyletic group).
- This fungal group is distinct from the structurally similar myxomycetes (slime molds) and oomycetes (water molds).
- The discipline of biology devoted to the study of fungi is known as mycology.

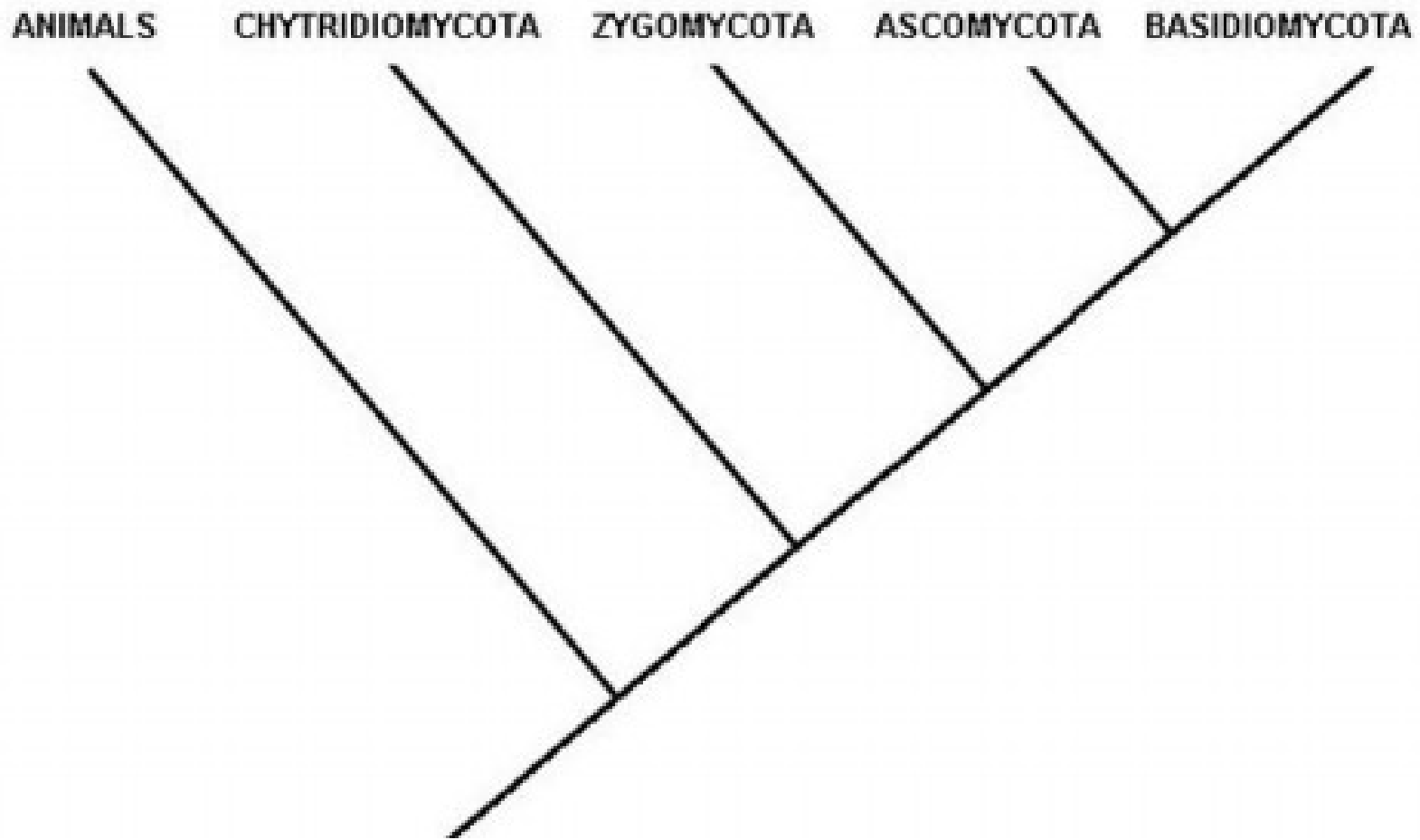
- Fungi feed by absorption of nutrients from the environment around them. They accomplish this by growing through and within the substrate on which they are feeding.
- Numerous hyphae network through the wood, cheese, soil, or flesh from which they are growing. The hyphae secrete digestive enzymes which break down the substrate, making it easier for the fungus to absorb the nutrients which the substrate contains.

- This filamentous growth means that the fungus is in intimate contact with its surroundings; it has a very large surface area compared to its volume.
- While this makes diffusion of nutrients into the hyphae easier, it also makes the fungus susceptible to dehydration and ion imbalance.
- Most fungi are saprophytes, feeding on dead or decaying material.

- Nutrients absorbed by the fungus then become available for other organisms which may eat fungi. A very few fungi actively capture prey, such as *Arthrobotrys* which snares nematodes on which it feeds.
- Many fungi are parasitic, feeding on living organisms without killing them. Ergot, corn smut, Dutch elm disease, and ringworm are all diseases caused by parasitic fungi.

Classification and Taxonomy of Fungi

- The kingdom Fungi, or Eumycota, is composed of four phyla, to which about 56 000 known species belong. The estimated number of extant fungal species, however, lies between 1 and 1.5 millions.



Phylogenetic relationship among fungi with the animal kingdom

Systematic Classification

- Fungi are usually classified according to biological taxonomy based upon the type of hypha, spore, and reproduction. There are four Phyla of fungi :
 - Phylum Chytridiomycota
 - Phylum Zygomycota
 - Phylum Ascomycota
 - Phylum Basidiomycota

Phylum Chytridiomycota

- The Chytridiomycota, often called chytrids, are unique among all fungi in having motile stages in their life cycles; no other fungi have this trait.
- These motile stages take the form of zoospores, single cells with a single posterior (at the rear) flagellum.
- Obviously these sperm-like cells require water and it is thus not surprising that chytrids live in permanently or temporarily aquatic habitats.

- Most chytrids are structurally fairly simple. They are spherical and are usually attached to their substrates using thread-like structures called rhizoids.
- The rhizoids are also responsible for nutrient absorption from the substrate.
- Usually the interior of the chytrid appears granular when the cell prepares itself into a sporangium filled with zoospores.



- During asexual reproduction the zoospores simply swim away in search of new substrates where they will attach and form new chytrids.
- They usually grow on pine pollen as their substrates. During spring season when masses of pine pollen fall into a water body, the entire mass will become colonized by chytrids within a short time.
- This can happen because a single chytrid can produce enough spores to colonize several new grains, and each of these will go on to colonize even more

- As the pollen season draws to an end the chytrids, if they are confined to consuming pollen, have a long wait for their next feast.
- What is needed is a resting stage, and this usually involves sexual reproduction. Sexual reproduction in a simple chytrid like *Rhizophidium* varies from species to species.
- In some the sporangium produces structures similar to the asexual zoospores, but these are able to locate and fuse with one from another sporangium to form a diploid zygote.

- The zygote becomes thick-walled and is able to withstand long periods of dormancy. In some cases one of the chytrids remains attached to its substrate and only one of the two mating individuals is motile.
- The fertilized individual becomes thick-walled and is again resistant to off-season stresses.
- Other chytrid habitats include algae e.g. *Achlya* a variety of invertebrate animals and protozoans. One of the most remarkable of these is *Haptoglossa mirabilis*; a chytrid that colonizes cuticle of its invertebrates.

- Chytrids are also active as parasites on plants. Members of the genus *Olpidium* are common in the roots of many plants where they may cause major distortions of the tissue and ultimately serious damage to the plant.
- They have also been shown to be important vectors of plant viruses.
- Although chytrids are generally seen in ponds and streams they may also occur in some rather unusual places. Perhaps the most unlikely of these are the chytrids living within the stomachs of certain animals

- Chytrids are also common in soil and other moist terrestrial habitats and are also present in the sea.

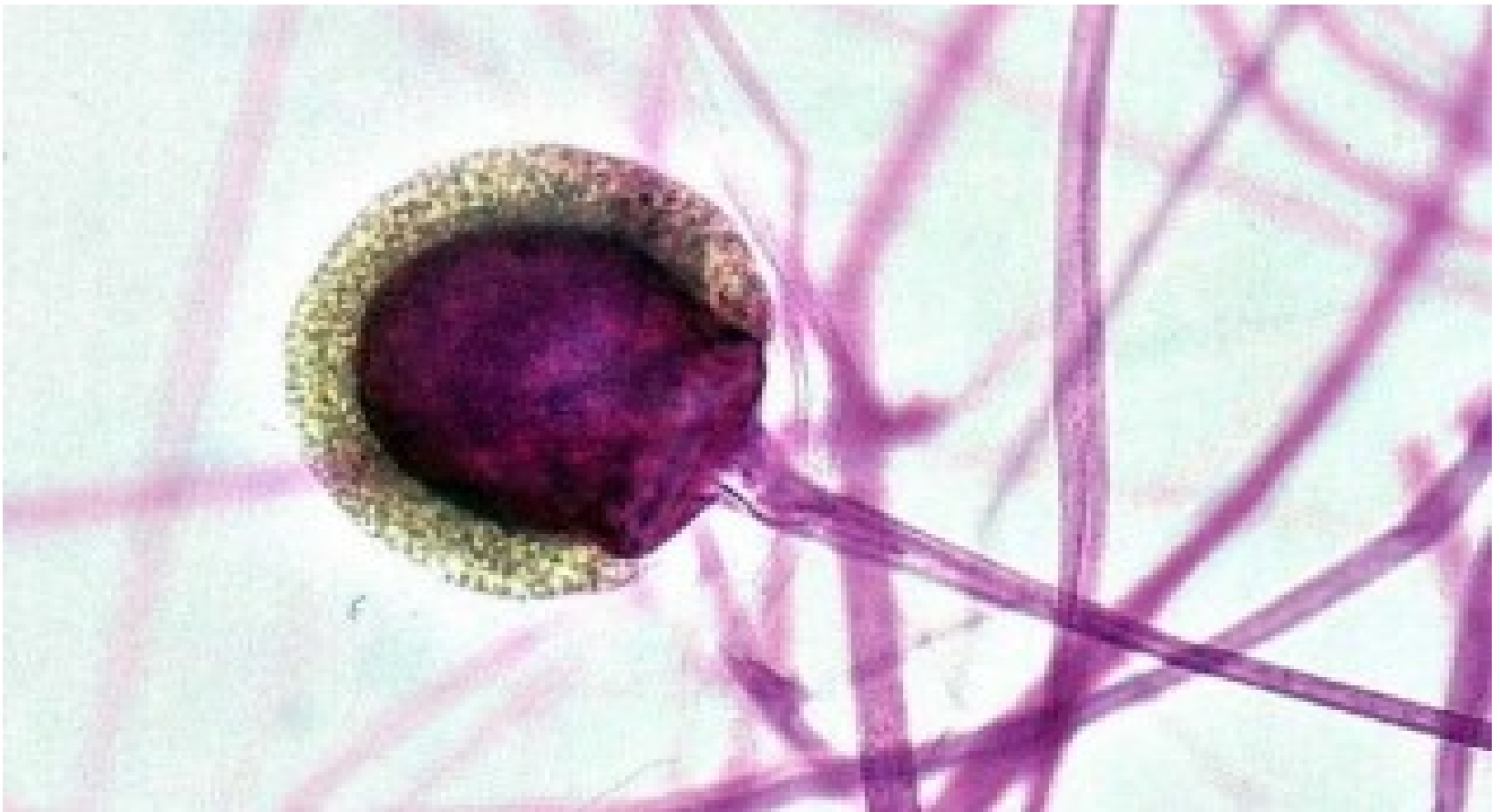
- Members of the Phylum Zygomycota - including about 170 genera and more than 1 000 species - produce zygospores, i.e., thick-walled, diploid sexual resting spores, within zygosporangia, formed by the fusion of two gametangia, produced from the same (homothallic) or different mycelia (heterothallic).
- Asexual haploid sporangiospores are produced within sporangia; some species produce chlamydospores (i.e., resistant thick-walled mitospore, intercalary or terminal, formed by modification of a single hyphal segment).

- Zygomycota are filamentous, coenocytic, i.e., with multinucleate hyphae lacking septa, and without flagella; they produce zygospores, i.e., thick-walled, diploid sexual resting spores, within zygosporangia, and produce asexual haploid sporangiospores within sporangia.
- The class Zygomycetes includes the very common saprobic 'sugar fungi' in the Mucorales, symbionts of higher plants in the Glomales, which form arbuscular endomycorrhizae (AM), and Endogonales, which form ectomycorrhizae.

- Insect parasites are included in the **Entomophthorales**, and obligate fungicolous parasites or predators in the Zoopagales.
- The class Trichomycetes includes **endosymbionts**, living in the gut of insects and other arthropods.



- Zygosporangium of Rhizopus (Mucorales, Zygomycota), which contains a single zygospore, diploid diploid sexual spore formed by fusion of gametocytes.



- Sporangium of *Rhizopus* (Mucorales, Zygomycota), which contains sporangiospores, haploid asexual spores, surrounding the enlarged columella at the tip of a long stalk.

Phylum Ascomycota

- Ascomycota, characterized by the presence of the ascus (a sac-like cell, which produces ascospores), can be either single-celled (yeasts), or filamentous with septate hyphae, or both (dimorphic).
- The class Archiascomycetes includes fungi with yeast-like growth (at least in culture), lacking ascomata, as *Taphrina deformans*, the agent of peach leaf curl disease

- The class Saccharomycetes includes yeasts, such as *Saccharomyces cerevisiae*, the yeast used in baking, brewing and wine production.
- Ascomycetes are filamentous fungi with septate mycelium, characterized by fruiting bodies or ascomata having different shapes and organizations.
- They include pathogens of man, such as *Arthroderma* spp. (which cause dermatophytoses, such as tinea and ring worm disease of the skin),

- pathogens of plants, such as *Ophiostoma ulmi* and *O. novo ulmi* (causing Dutch elm disease), and ectomycorrhizal symbionts of plant roots, such as *Tuber* spp. (truffles).
- Conidial or mitosporic fungi consist of fungi producing spores mitotically, for which, in some cases, a connection with a sexual state has been established, mostly with ascomycetes

Phylum Basidiomycota

- Basidiomycota include the plant pathogen rusts, smuts, and bunt fungi as well as the fungi popularly called mushrooms, toadstools, puffballs, shelf fungi, stinkhorns, bird's nest fungi, and jelly fungi.
- Many of these are saprobes, some are ectomycorrhizal symbionts of plant roots, while others are parasites.
- *Puccinia graminis*, the agent of black stem rust, is representative of Urediniomycetes, and *Ustilago maydis*, which causes the common corn smut, of Ustilaginomycetes.

- The class Hymenomycetes includes aphylophoralean orders, fruiting bodies which are known as shelf and bracket fungi, pore fungi, tooth fungi, coral fungi, and club fungi; it also includes agaricoid orders, many of which are ectomycorrhizal fungi with fleshy and stalked fruiting bodies, as in the genera *Russula*, *Lactarius*, and *Amanita*.
- *Amanita virosa* is the poisonous 'destroying angel', *A. phalloides* is commonly called death cup, and *A. caesarea* is the edible 'Caesar's mushroom'; in the gasteromycetous orders puffballs, earthstars, bird nest's fungi, and stinkhorns, as *Phallus impudicus*, are included.

- **Class Phycomycetes**

- The algal fungi: bread molds and leaf molds. The only known mycosis (fungal disease) caused by fungi of this class is mucormycosis, a very rare fungal growth of the upper respiratory tract bronchial mucosa, and lungs.
- It occurs largely as a complication of a chronic, debilitating disease, such as uncontrolled diabetes.

Morphology and Characteristics of Fungi

Introduction

- Fungi vary widely in size and shape, from unicellular, microscopic organisms to multicellular forms easily seen with the naked eye.
- Individual cells range from 1 μ to 30 μ . Microscopic fungi exist as either molds or yeasts or both. Internally, fungal cells are fairly typical eucaryotic cells.

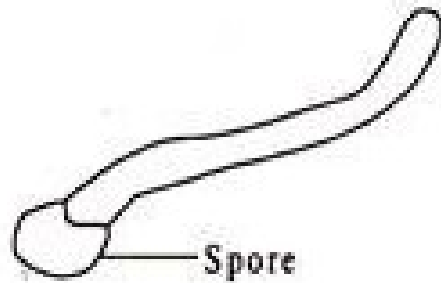
Molds

- The molds form large multicellular aggregates of long branching filaments, called hyphae. There are vegetative hyphae and reproductive hyphae. Spores are borne on the reproductive hyphae.
- Fungal spores should not be confused with bacterial spores that are resistant bodies formed for bacterial survival rather than reproductive purposes.)

- Spore size, shape and structure are used in the classification and identification of fungi.
- The tube-like hyphae are responsible for the fluffy appearance of the macroscopic mold colony. The hyphae and other structures combine to form an elaborate network called a mycelium.

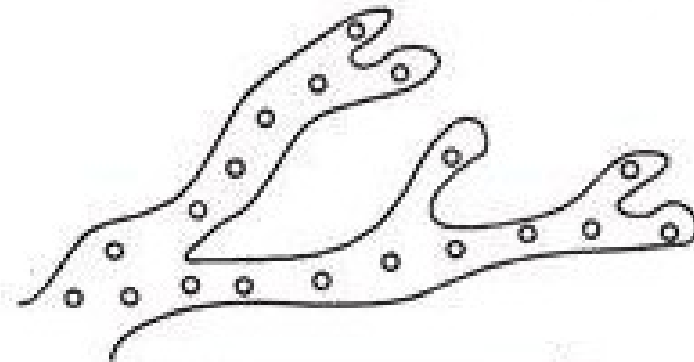
Yeasts.

- These are large (5 to 8 μ), single-celled organisms that rarely form filaments.
- Most yeasts reproduce by the asexual process of budding. Yeast colonies are usually characterized by a smooth surface similar to that of many bacteria.

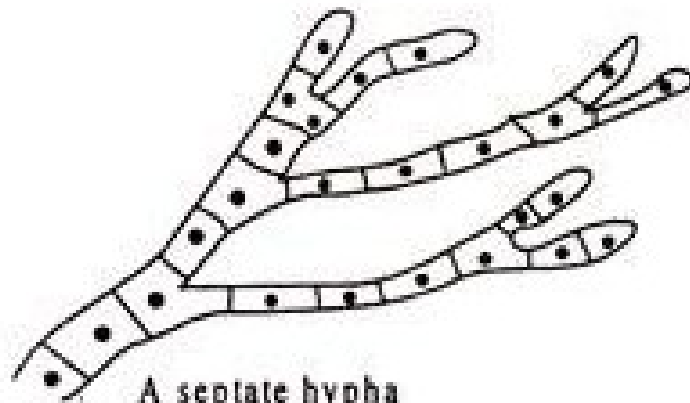


Spore

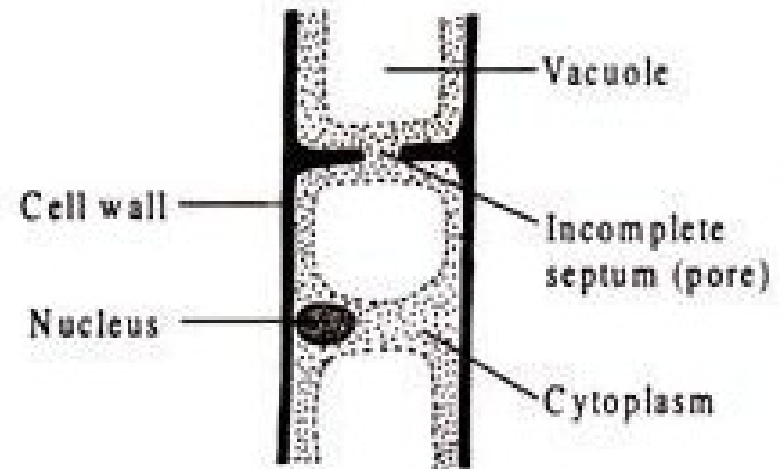
A germinating spore
producing a hypha



An aseptate coenocytic
hypha of a lower fungus



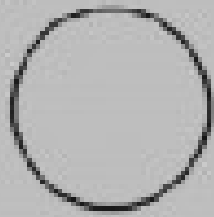
A septate hypha
of a higher fungus



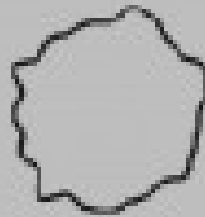
Colony Morphology

- Colony morphology is a method that scientists use to describe the characteristics of an individual colony of fungi growing on agar in a Petri dish. It can be used to help to identify them.

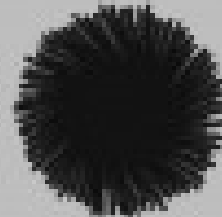
FORM



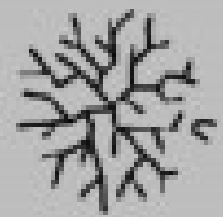
Circular



Irregular

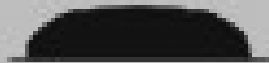


Filamentous



Rhizoid

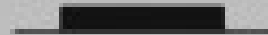
ELEVATION



Raised



Convex



Flat

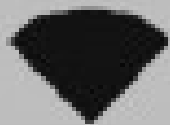


Nubonate

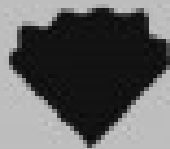


Crateriform

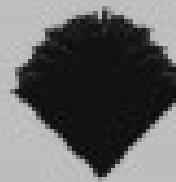
MARGIN



Entire



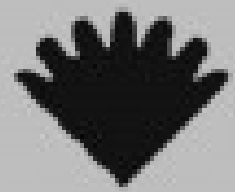
Undulate



Filiform



Curled



Lobate

- Different types of fungi will produce different-looking colonies, some colonies may be coloured, some colonies are circular in shape, and others are irregular. A specific terminology is used to describe common colony types.

These are:

- Form - What is the basic shape of the colony? For example, circular, filamentous, etc
- Size - The diameter of the colony. Tiny colonies are referred to as punctiform

- Elevation - This describes the side view of a colony.
Turn the Petri dish on end.
- Margin/border - The edge of a colony. What is the magnified shape of the edge of the colony?
- Surface - How does the surface of the colony appear?
For example, smooth, glistening, rough, wrinkled, or dull.
- Opacity - For example, transparent (clear), opaque, translucent (like looking through frosted glass), etc.

- Colour - (pigmentation) - For example, white, buff, red, purple, etc. Yeast colonies are very similar to bacterial colonies. Moulds often have fuzzy edges. They usually turn into a different colour, from the centre outwards

Other Characteristics

- **Fungal Nutrition**

- Most fungi contain complex enzymes and other chemical substances which, when diffused into the host, break down the complex substances available – wood, vegetation, leather, bread, and so forth – into simpler substances that can be used for food.
- The chemical products of digestion are, therefore, completed outside of the organism, and the fungus absorbs the end products.

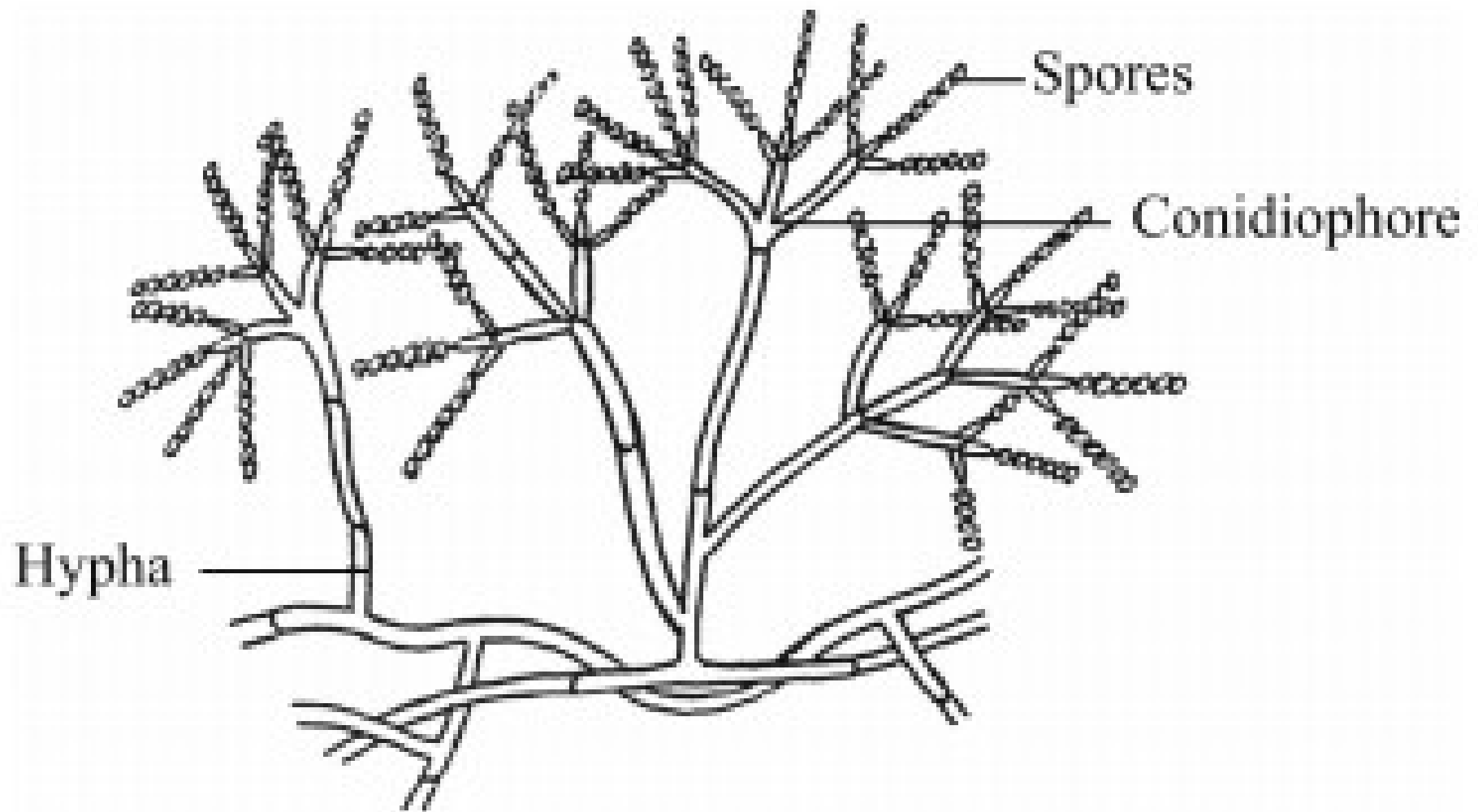
Growth and Reproduction

- Fungal Growth
 - Fungi grow well under the same conditions that favor the growth of bacteria – warmth and moisture. It is for this reason that fungal infections pose a serious problem to troops in the tropics.
 - As the temperature decreases, fungal activity also decreases; however, the spores are very resistant to cold, some surviving freezing temperatures for long periods of time. On the other hand, fungi are easily killed at high temperatures.

- **Fungal Reproduction**

- Fungi reproduce sexually or asexually, or both, depending upon the species and the environmental conditions. As the name implies, sexual reproduction is the result of the union of two spores. Most fungi reproduce both sexually and asexually. Those that produce only asexual spores are known as Deuteromycetes Fungi imperfecti.

- This group is important because it contains most of the pathogenic fungi. The yeasts reproduce both by spores and by a process known as budding, which is similar to binary fission.
- The yeast cell forms a small knoblike protrusion, or bud, that separates from the mother cell and grows until it reaches full size, at which time the process is repeated.



Economic Importance of Fungi

- Some species of fungi for example *Pythium* inhabit cultivated soils where they pose serious problems for various agronomically important crops. *Pythium* species are the most important causes of pre and post emergence damping off diseases of seedlings.
- Some fungal species cause diseases to plants for example *Phytophthora* spp. causes late blight of potato and tomato; damping off, root rot fruit rot of many plants.

- It also causes black shank of tobacco; bud rot of coconut; leaf blight of sesame etc.
- Some species of Ascomycetes attack leaves and shoots of angiospermous plants and induce various plant diseases.
- Some of the terrestrial Phycomycetes are the most destructive parasites of crop plants and certain insects. Again others often cause spoilage of foodstuff, various fruits and vegetables.
- Some others are utilized in industrial fermentations for example *Saccharomyces cerevisiae* is used in the production of beers, Vinegars, malt tonics, etc.

- Production of antibiotics like Penicillin is also done with the aid of the fungus like the *Penicillium notatum* and *Penicillium chrysogenum*. The *Aspergillus* species are also widely used in the preparation of the antibiotics.
- The *Penicillium roqueforti* and *Penicillium camemberti* are used for flavoring the cheese.
- Some *Penicillium* species are used in the production of the citric acid, oxalic acid, fumaric acid and gluconic acids etc.

- Yeast is widely used in the baking industries and genetic research.
- Some of the species of yeast are responsible for the spoilage of the food items like cheese, tomato products etc.
- *Nematospora* species causes various diseases in tomato, beans and cotton.
- *Aspergillus* species cause spoilage of food stuffs and deterioration of leather goods and fabrics.
- *Penicillium expansum* causes spoilage of apples, grapes and peas in storage.

- The powdery mildew of peas is caused by *Erysiphe polygoni*.
- The ergot of cereals is caused by the fungal species *Claviceps purpurea*.
- *Candida* species causes candidiasis in human beings.

END