Chapter VI

Concepts of Mycology and Virology

1. Mycology

1.1. Definition

Mycology (from the Greek "***mukes***" = mushroom and "***logos***" = study, science) is the branch of biology that studies fungi, particularly microscopic fungi (yeasts and molds).

Fungi are eukaryotic organisms, either unicellular or multicellular. They include both macroscopic species (*macromycetes*) and microscopic species (*micromycetes*), with either a filamentous or yeast-like appearance.

The number of known fungal species is estimated at around 95,000, although the actual number is likely much higher.

The vast majority of fungi are saprophytes, living in the soil or on dead or living plants. Many species are plant parasites, and a smaller number are opportunistic pathogens that can infect humans and animals. They are generally strict aerobes (facultative aerobes for certain yeasts), mesophilic (optimal growth temperature between 25°C and 35°C), tolerant of a wider range of pH values than bacteria. They are chemo-heterotrophic and non-photosynthetic (non-chlorophyllous).

Microscopic fungi are divided into two main groups: **yeasts** and **molds**.

1.2. Morphology and cellular structure of microscopic fungi

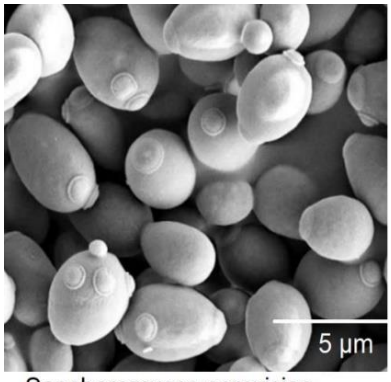
The cellular organization of fungi is referred to as the ***thallus***. In microscopic fungi, the thallus can be either **unicellular** (yeasts) or **filamentous** (molds).

The plasma membrane, rich in ergosterol, is protected by a rigid and thick cell wall composed mainly of polysaccharides, typically **chitin**.

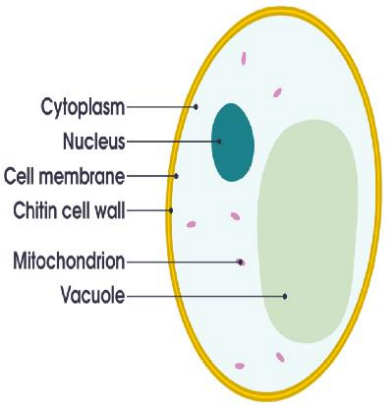
1.2.1. Yeasts

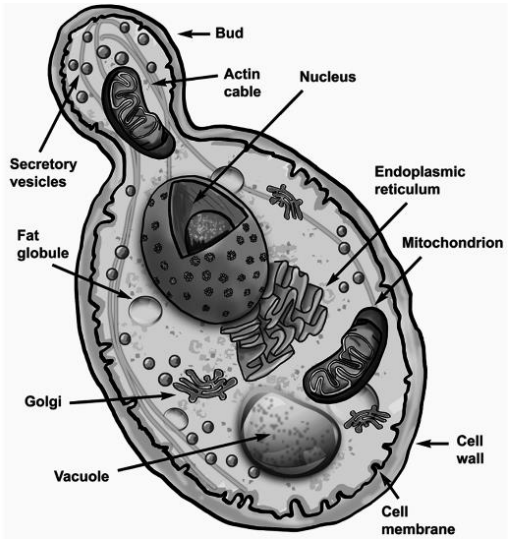
Yeasts are **unicellular** fungi, generally measuring between 10 and 50 µm. Their shape can be spherical, ovoid, elongated, or cylindrical. Their thallus is referred to as *yeast-like*.

The cytoplasm contains organelles (endoplasmic reticulum, Golgi apparatus, mitochondria, vacuoles, and ribosomes) as well as a true nucleus containing chromosomes (16 chromosomes in *Saccharomyces cerevisiae*).



Saccharomyces cerevisiae

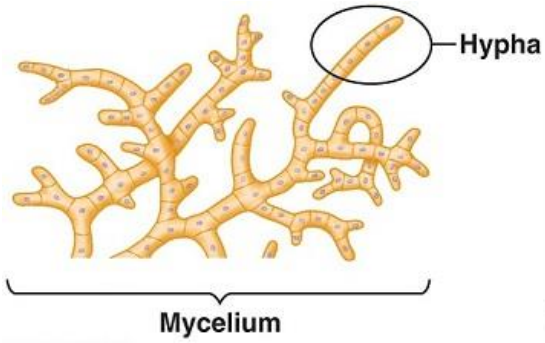


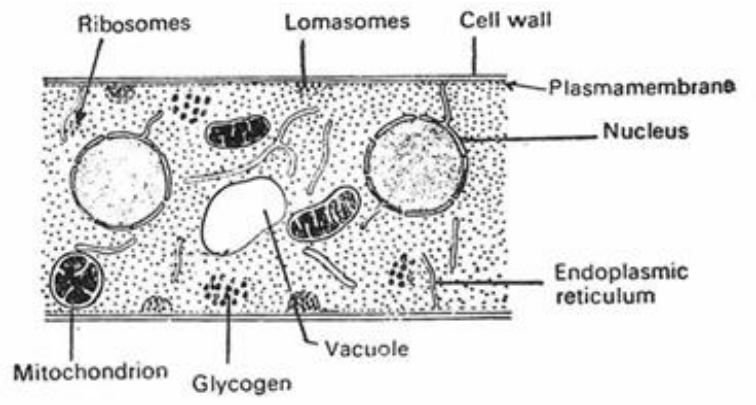


1.2.2. Molds

Molds are **multicellular** fungi whose thallus consists of filaments, more or less branched, called ***hyphae***.

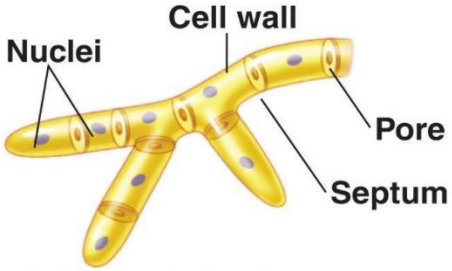
The network of hyphae forms the ***mycelium***, which constitutes the vegetative part of the fungus.





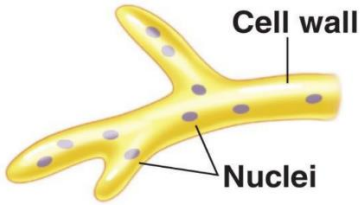
Depending on the organization of their thalli, molds can be classified as:

a. Fungi with septate hyphae (e.g., *Ascomycetes*, *Basidiomycetes*), whose thallus is divided by cross-walls (septa). Perforations (pores) allow communication between cells;



(a) Septate hypha

b. Fungi with coenocytic hyphae (e.g., *Zygomycetes*), whose thallus is not divided by transverse walls, forming a continuous multinucleate structure.



(b) Coenocytic hypha

1.3. Nutrition and modes of life

Fungi exhibit an **osmotrophic** mode of nutrition: they absorb nutrients by first releasing hydrolytic enzymes into the external environment, thereby digesting food outside the cell. Nutrients are then absorbed in a soluble form.

These organisms lack chlorophyll and are strictly heterotrophic. They interact with other organisms in various ways:

a) **Saprophytic** lifestyle: The majority of fungal species are saprophytes, obtaining their nutrients by degrading dead organic matter.

b) **Commensalism**: Some fungi live in a commensal relationship, benefiting from their host without causing harm or providing any advantage in return.

c) **Parasitism**: Other fungi are parasites, feeding on living organic material. They can cause mycoses in animals (including humans) as well as diseases in plants.

d) **Symbiosis**: some fungi establish symbiotic relationships with plants, forming mutualistic associations where both partners benefit. Such relationships can lead to the formation of new biological entities such as lichens or mycorrhizae.

1.4. Reproduction

Fungal reproduction is a complex process that involves the formation of specialized cells known collectively as *spores*. A spore is a unicellular reproductive structure that can develop into a new individual. Spores are very light and can be dispersed through the air, facilitating the spread of fungi in nature.

Reproduction can occur through two mechanisms: sexual or asexual. Some fungi can even alternate between these two types of reproduction.

1.4.1. Asexual reproduction (Anamorph)

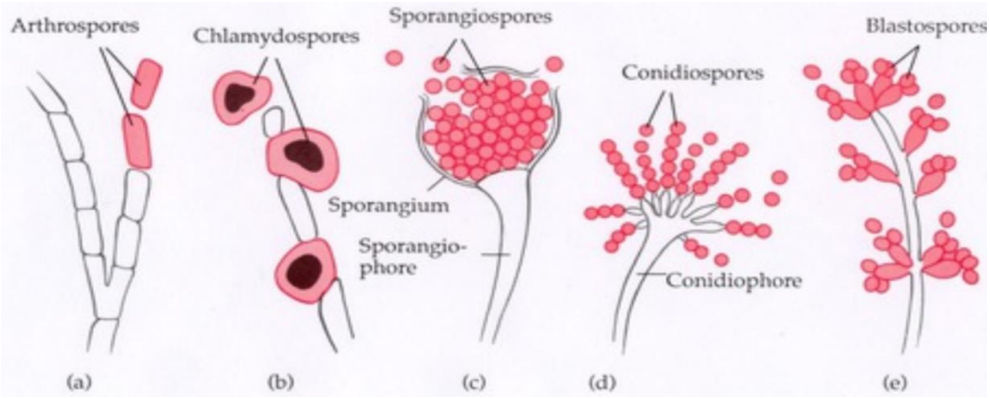
In asexual reproduction, spores are diploid and result from successive mitotic divisions. They are classified into three types :

A. Thallospores: Exospores formed from the thallus by the transformation of pre-existing elements. Thallospores are subdivided into:

- **Arthrospores**: Formed by the fragmentation of the tip of a hypha (through cleavage of the cell wall or septum); each fragment becomes a spore.
- **Chlamydospores**: Large, thick-walled spores that can be terminal or intercalary; they may occur singly or in chains.
- **Blastospores**: Formed by budding, an unequal division of the cytoplasm resulting in a smaller daughter cell and a larger parent cell.

B. Sporangiospores: Spores formed inside a sporangium (a sac-like structure) located at the tip of a hypha.

C. Conidiospores: Spores formed without an enclosing sac, typically produced in specialized structures called conidia.



1.4.2. Sexual reproduction (Teleomorph)

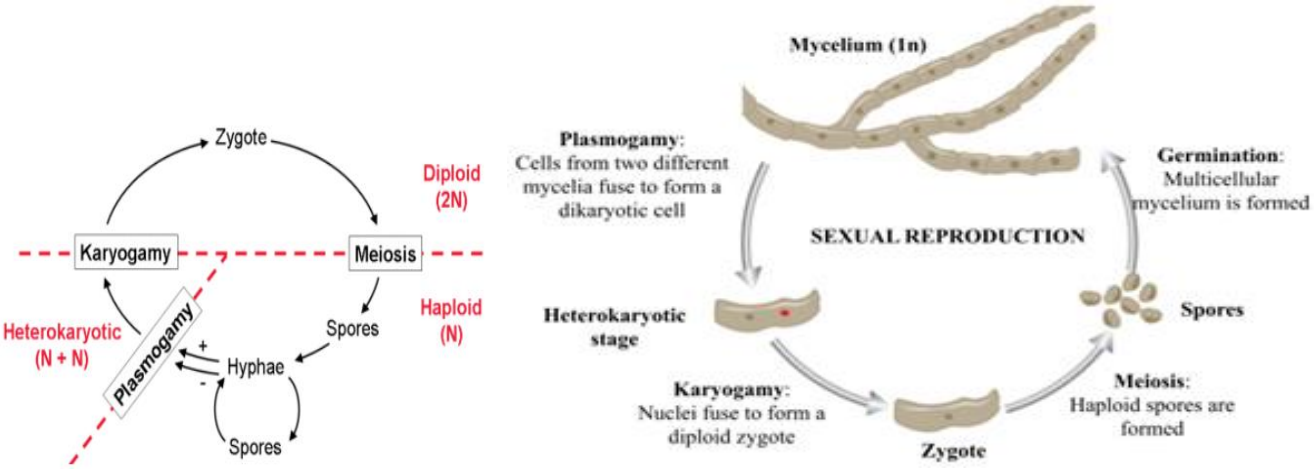
Sexual reproduction involves the fusion of two haploid cells (cells with *n* chromosomes) acting as gametes, leading to the formation of a diploid zygote (cell with *2n* chromosomes).

A (+) structure carrying *n* chromosomes encounters a (–) structure, and the fusion of their cytoplasms gives rise to a new mycelium with *2n* chromosomes.

- Some species are self-fertile (*homothallic*), producing sexually compatible gametes on the same mycelium.
- In other species, mating between different individuals (*heterothallic*) is necessary.

The process of sexual reproduction includes the following stages:

- **Plasmogamy**: the fusion of the cytoplasm of two specialized filaments, either from the same thallus (*homothallic*) or different thalli (*heterothallic*), without immediate nuclear fusion.
- **Karyogamy**: the fusion of the two haploid nuclei, resulting in diploid (2n) cells.
- **Meiosis**: a reduction division that restores the haploid (n) state, producing haploid spores of both (+) and (–) types.



These events are followed by the formation of sexual spores, the type of which varies according to fungal groups:

A. **Ascospores**: Haploid spores formed inside a sac-like structure called an ***ascus***.

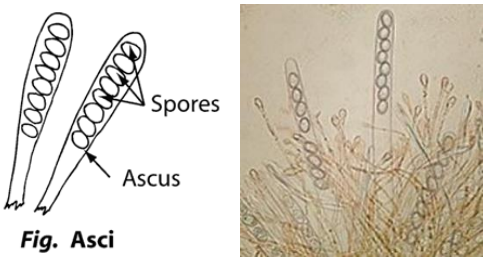


Fig. **Asci**

B. **Zygospores**: are formed by the fusion of two sporangia (sporocysts) from opposite mating types.

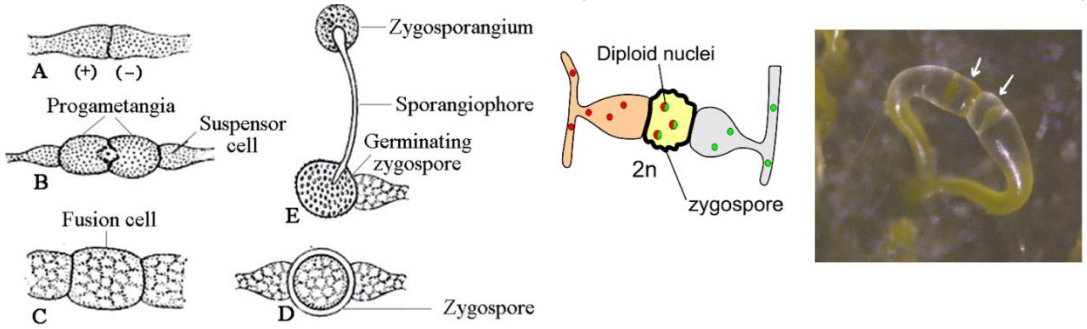
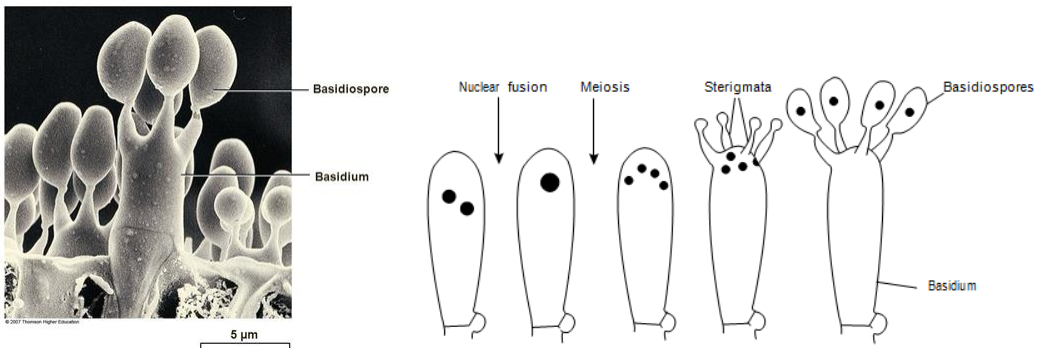


Fig: ***Mucor spp.*** Development of zygospore and its germination.

C. Basidiospores: they are formed through the transformation of a cell into a *basidium*. A diploid (2n) cell undergoes two successive meiotic divisions, resulting in a basidium bearing four haploid (n) basidospores.



1.5. Classification

Microscopic fungi belong to the kingdom *Mycetes* (Fungi) within the domain *Eucarya*. Their classification is based on physiological criteria and morphological characteristics observed during sexual reproduction. Thus, they are divided into the following groups :

- **Zygomycota**: This group includes microscopic fungi such as the black bread molds (*Rhizopus stolonifer*) and fungi of the genus *Mucor*. They are characterized by the presence of zygospores, which are resistant reproductive structures. Their thallus is usually non-septate (coenocytic), and the hyphae are multinucleated.
- **Ascomycota (Ascomycetes)**: These fungi produce a specialized structure called an *ascus* (Latin for "sac") during sexual reproduction. The ascus contains ascospores, which, upon maturation, are forcibly ejected into the environment through the opening of the ascus.
- **Basidiomycota (Basidiomycetes)**: This group includes microscopic fungi characterized by specialized reproductive structures called *basidia*, which are cells bearing *basidiospores*. These basidiospores are produced at the tips of projections known as *basidiocarps* and are dispersed by the wind upon maturation.
- **Anamorphic fungi**: These are fungi for which no sexual stage is known, or which reproduce only through asexual means.