

Chapter 1 : Mycology

1- Definition

Fungi (mycetes) are eukaryotic organisms, unicellular (yeast) or filamentous (molds), non-photosynthetic, and possessing a heterotrophic metabolism. Their basic cellular unit is called a hypha (Fig. 1). It is a tubular cell encased in a rigid chitinous wall. Hyphae multiply at their tips, forming a tangled mass called mycelium (Fig. 2).

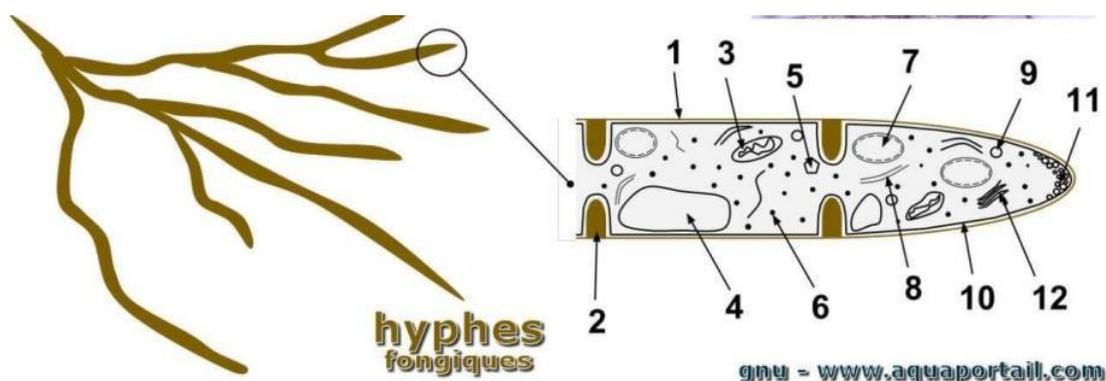


Figure 1 : Structure of a fungal hypha

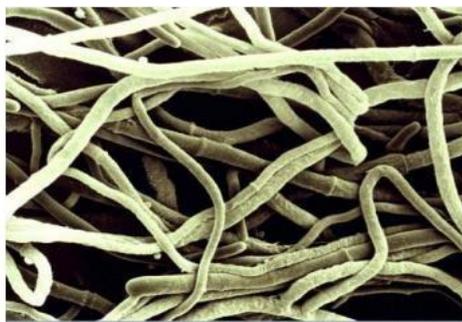


Figure 2: Mycelium

Fungi feed by absorption. This method of nutrition involves absorbing small organic molecules from their environment. Fungi digest their food outside their bodies by hydrolyzing it with powerful enzymes. These enzymes break down complex molecules into simpler compounds that the fungi can then absorb and use. They also synthesize their own nutrients from water and other nutrients.

and minerals that they obtain from their environment. These organisms are very important and live in relation to other organisms in several ways:

- **Saprophytes** They extract their nutrients from decomposing organic matter. They are very important as decomposers and recyclers of dead matter.
- **Parasites** Their nutrients come from living matter. * Mycoses (in animals), * Fungal diseases (in plants: phytopathogens) production of mycotoxins.
- **Symbiotes** These fungi obtain their nutrients from another organism, receiving certain benefits in return. This type of association is essential for plants; 90% of plants are thought to live in symbiosis with these fungi. These fungi are called mycorrhizae. Other fungi live in association with algae. They cannot survive without each other. These are lichens.

2- General characteristics of mushrooms

2-1- Chemical composition and cell structure

The cellular organization of fungi is called the thallus. In microscopic fungi, the thallus can be unicellular (yeasts) or filamentous (molds). Some yeasts, however, are capable of forming filamentous structures (pseudomycelium) under certain conditions (Figure 3).

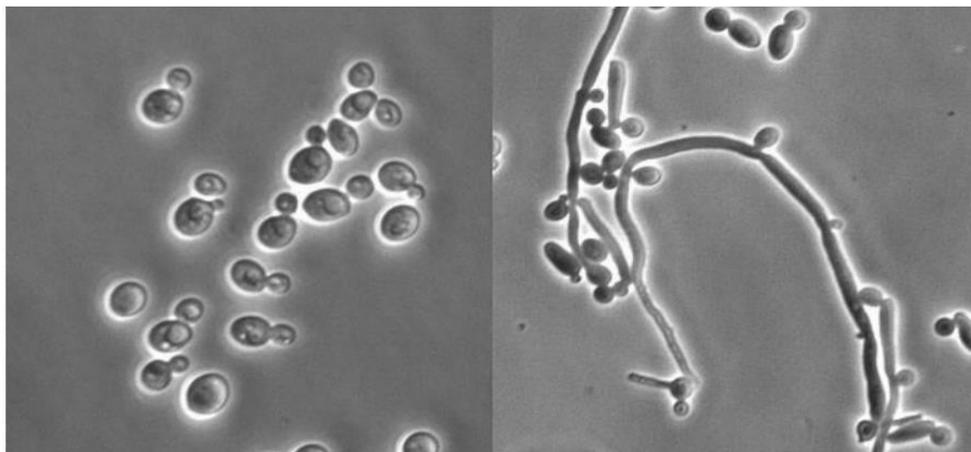


Figure 3: Dimorphisms in a yeast

The collection of hyphae constitutes the mycelium. In Phycomycetes, the cells are not separated by transverse septa: the thallus is said to be coenocytic (or "siphonous"). In Septomycetes, the thallus is septate (or "septate"). As a general rule, Septomycetes have thin hyphae (5 to 7 μm wide) while in Siphomycetes, the hyphae are much wider (10 to 15 μm) (Figure 4).

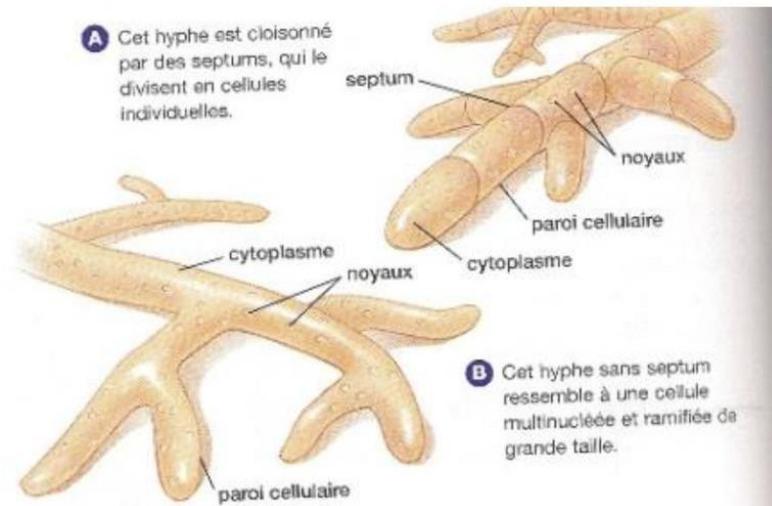


Figure 4: Structure of a hypha and its development towards the formation of a mycelium: (A), coenocytic hypha; (B), septate hypha

- ✓ **Molds:** They have a cell wall formed by several layers arranged one on top of the other. It contains 80 to 90% polysaccharides, the remainder being proteins and lipids. Chitin is a specific component of the fungal cell wall, where it is the major component. However, in some species, chitin can be partially or totally replaced by cellulose (e.g., Oomycetes are completely devoid of it).
- ✓ **Yeasts:** Their cell wall represents 30% of the cell's dry weight. The main difference with molds is that chitin is not the major component of the yeast cell wall; it represents only 1 to 6% of the cell wall mass.

3- Growth and reproduction

3-1- Growth of fungi

3-1- 1- Thallus growth:

In fungi, this growth occurs only at the tips of the filaments. It is called "apical growth." This type of growth is the opposite of intercalary growth.

Apical growth requires lysis of the cell wall and synthesis of new cell wall material.

The apex is often rich in vesicles containing cell wall precursors. Apical elongation results from cytoplasmic flow directed by these vesicles, then the membrane of these cells anastomoses with the plasma membrane, the vesicles release their contents outside the cytoplasm. The newly synthesized wall is initially fluid and then becomes plastic.

If there are too many vesicles to be used all at the apex, lateral branches appear a few tens or hundreds of microns from the apex (Figure 5). These branches develop more when nutrients are abundant; they are subject to apical dominance.

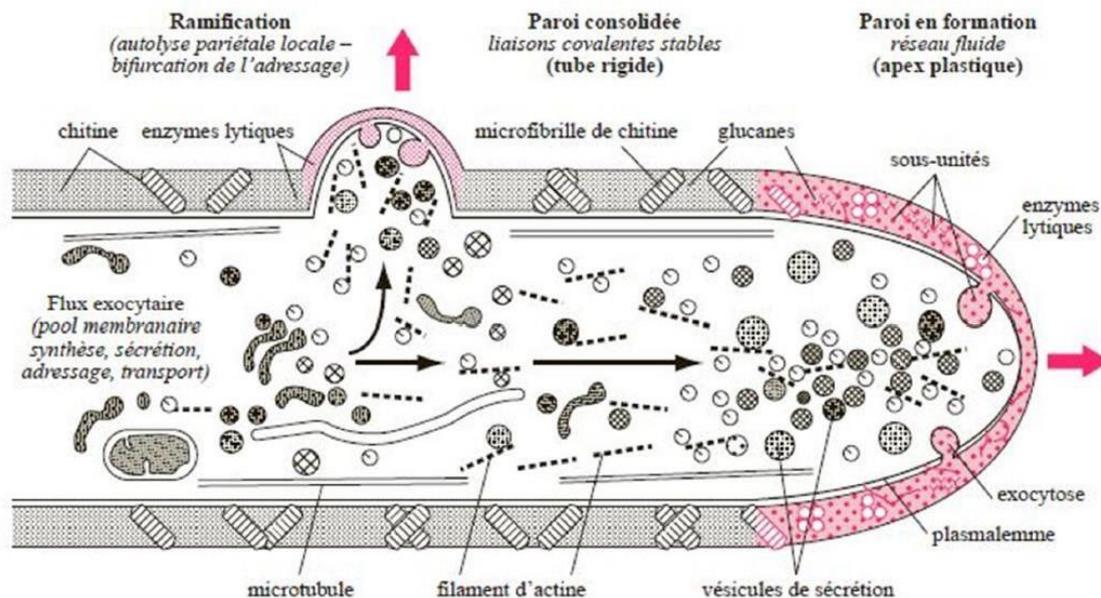


Figure 5: Apical cytoplasmic flow

3-1-2- Hyphal growth mechanism

Growth is generally apical.

- The apex is structurally and functionally very different from the rest of the hypha.
- denser cytoplasm
- The thickness of the apex wall is less important
- Accumulation of "APICAL VESICULAR CLUSTERS"
- = vesicles that play an essential role in growth.

Role of strokes

- Also called spitzenkörper
- If the hypha stops growing – strokes disappear
- If the hyphae regrows – strokes reappear
- The position of the stroke is related to the direction of growth.

• The vesicles contain:

- Cell wall precursors (e.g., N-acetylglucosamine, chitin subunits).
- Cell wall lytic enzymes (e.g., chitinase, glucanase) to break down and separate cell wall components.
- Cell wall synthesis enzymes (e.g., chitin synthase, glucan synthase) to assemble new cell wall components and thus increase cell wall size.

3-2- Reproduction of fungi

Fungal reproduction is complex; it can be sexual or asexual, although some fungi alternate between the two types of reproduction.

3-2-1-Asexual reproduction "anamorphic"

This is a mode of reproduction common to almost all fungi, and can occur through budding, binary fission, fragmentation, or spore formation.

* Budding and binary fission

Budding and binary fission are the simplest forms of asexual reproduction. Budding is an unequal division of the cytoplasm, resulting in a parent cell and a daughter cell, the latter being smaller than the parent cell. Binary fission, on the other hand, results in two identical cells.

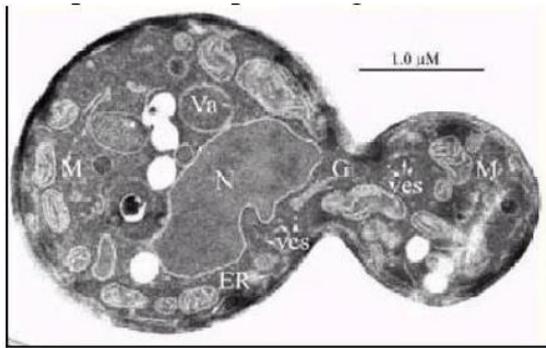


Figure 6.Reproduction by budding



Figure 7.Reproduction by fission

- **Fragmentation and sporulation**

Fragmentation is a form of asexual reproduction where a new organism develops from a parent fragment. In many molds, hyphal fragmentation can give rise to new individuals. The isolation of cells by cleavage of the cell wall allows the formation of arthrospores.

***Sporulation** This is the most important form of asexual reproduction in fungi. It occurs through asexual spores, formed during the asexual phase of the fungal life cycle. Following mitosis, these spores transform into reproductive cells called mitospores, which, after dispersal, develop into new organisms.

The colonization of environments by fungi is ensured by the production of dispersal spores:

- **Sporangiospores:** They form inside a sporangium or sporocyst. During sporogenesis (spore formation), a mycelial filament (sporocystophore) arises from the vegetative mycelium, and its tip swells to form the sporocyst. A large number of spores are typically produced within the sporocyst after its cytoplasm divides and are released after the sporocyst wall ruptures. These endospores germinate, directly giving rise to a mycelium.
- **Conidiospores:** Exogenous spores produced at the tip or on the sides of aerial hyphae. They are borne by a conidiophore.
- **Arthrospores:** resulting from the fragmentation of the hyphae. A filament, which ceases to grow, repeatedly and in alignment partitions to individualize the conidia.
- **Blastospores** Produced by budding from a vegetative cell. Each conidium buds in turn, leading to the formation of chains of conidia, the oldest being at the base of the chain.

- **Chlamydospores**Chlamys: mantle. A type of thick-walled, resistant spore found in all fungi. They are formed terminally or intercalarily, singly or in chains.

There are fundamentally two modes of asexual spore formation:

- o **Endogenous mode:** where the endospores are formed and contained within an envelope borne by a mycelial filament called a sporocyst (Zygomycetes),
- o **Exogenous mode:** where the external spores or conidia are formed and successively released outside the mycelium that gave rise to them (Ascomycetes and Basidiomycetes). Direct spore production.

3-2-2- Sexual Reproduction "teleomorphic"

Sexual reproduction (or teleomorphism) involves the meeting of specialized filaments (plasmogamy), the conjugation of nuclei (karyogamy), and finally a reduction in cell size (meiosis) followed by one or more mitoses. These events are followed by the formation of four types of spores: ascospores, basidiospores, and zygospores, the process of which varies according to the different classes of fungi.

Sexual reproduction involves the fusion of two haploid cells acting as gametes, resulting in the formation of a diploid zygote.

In fungi, there is often a delay between the fusion of cytoplasm (plasmogamy) and the fusion of nuclei (karyogamy). Therefore, there is a dikaryotic stage, in which cells contain two separate haploid nuclei, one from each parent.

- **Ascospores** They are formed in specialized structures called "asci." Once mature, the ascospores position themselves at the tips of the asci and are released by the contraction of the asci. This mode of reproduction is characteristic of Ascomycetes.

- **Basidiospores** These are cells formed outside the basidia and borne on thin filaments called sterigmata. After maturation, the sterigmata break down (due to rain, frost, wind, the weight of the spores, etc.) and release the basidiospores. These cells are characteristic of Basidiomycetes.

- **The oospores** In plasmodial thalli, they are formed by the fusion of two sporangia of opposite sexes (the oogonium and the spermatocyst). Fertilization occurs inside the oospore. This form of reproduction is found in Oomycetes.

- **Zygospor**es: They are also formed by the fusion of two sporocysts of opposite sexes. They are found in siphonous thallus molds (Zygomycetes). The zygospor

es are borne on sporophores that differentiate into "suspensors."
As with the oospore, fusion takes place inside.

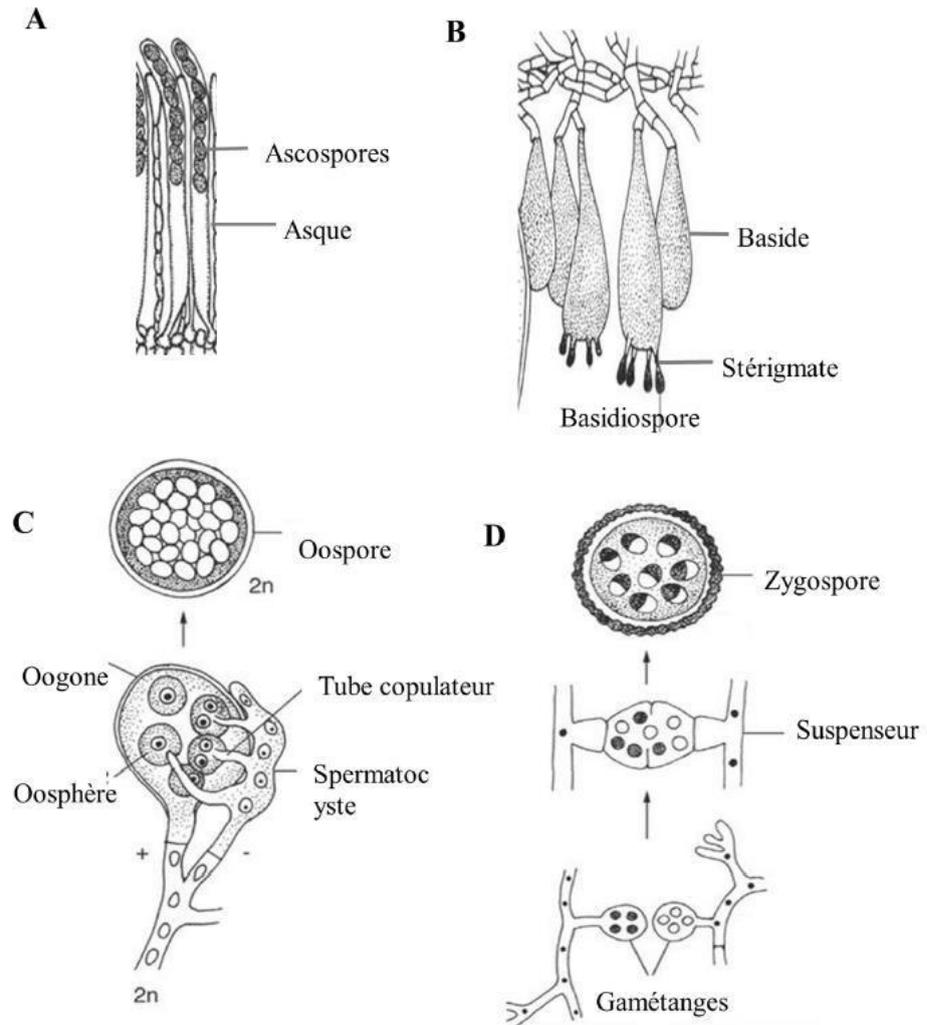


Figure 8: Sexually reproducing cells
 A: Ascospores, B: Basidiospores, C: Oospore formation, D:
 Formation of the zygospore.

4- Stages of fungal development

Three phases occur during mold development: germination, growth, and sporulation. In 2001, Osherov and May studied and described the different phases of the asexual life cycle of an ascomycete (Figure 9). Conidia are produced by a specialized structure, the conidiophore. After dispersal and contact with a suitable environment, the conidia germinate and give rise to a hypha. The development of this structure forms a branched mycelium from which an aerial hypha bearing conidiophores emerges.

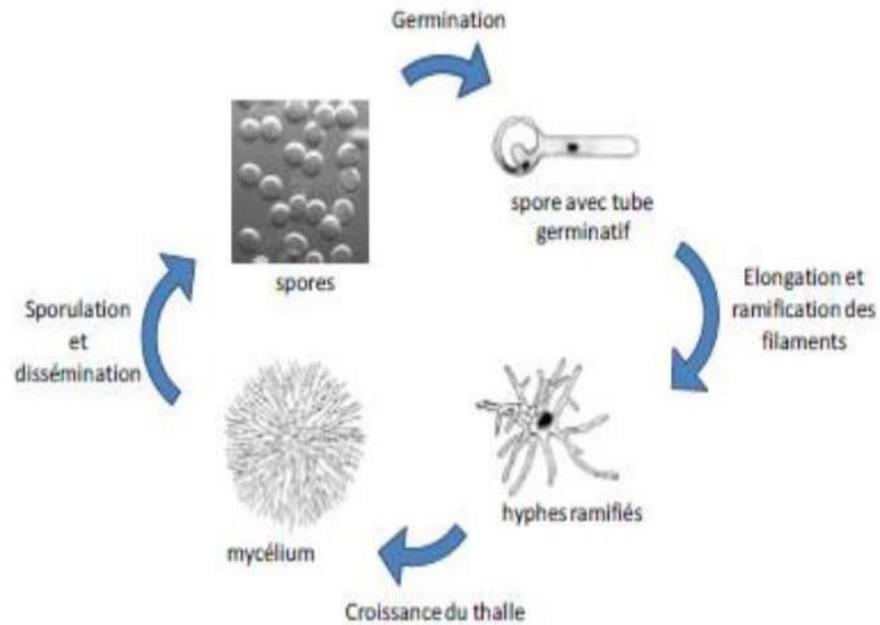


Figure 09:Mold life cycle

a) Germination

This stage has two phases. First, the spore swells (it hydrates), increasing its diameter and biomass. During this spherical growth, new layers are formed and uniformly cover the inner surface of the spore. Surface properties are modified, and spore-to-spore and spore-substrate adhesion increases. The emergence of a hypha from the hydrated spore corresponds to the second phase of germination.

b) Growth

In 1994, Carlile and Watkinson precisely described this stage. The hypha, having emerged from the spore, grows exponentially after a few hours until it reaches a maximum elongation rate on the order of mm/h, and then elongates at a linear rate.

At the rear of the apex, branches form, lengthen and divide in turn, constituting a tangle of hyphae called mycelium.

c) Sporulation and dissemination

The final phase of fungal development, sporulation, consists of the formation of particles of size essentially between 3 and 30 μm , enveloped in a thick wall before separation (chlamydospores), enclosed in "sacs" at the end of the hypha (sporangiospores), produced on the ends or sides of the hypha (conidiospores), or generated by budding from a vegetative mother cell (blastospores).