Structure, Growth, Nutrition, and Reproduction in Fungi

Structure of Fungi

Fungi grow as Unicellular budding yeast or as multicellular filamentous colonies-the molds and mushrooms.

Fungi contain cytoplasm and nucleus.

Fungi comprise a thallus which contains a vegetative and a reproductive system.

The vegetative system is made up of Hyphae or mycelium, that contain the cytoplasm and nuclei.

Hyphae:- Elongation of apical cell produces a tubular, thread-like structure, 2-10 u in diameter called hypha

Mycelium: A tangled mass of hyphae is called mycelium. Fungi-producing mycelia are called molds or filamentous fungi.

Hyphae is the main element of a vegetative or growing form of the mold and is a branching tubular structure. Hyphae become intertwined to form a mycelium.

Hyphae may be septate or non-septate (Coenocytic). Some fungi have hyphae divided into cells by **septa**, with pores allowing cell-to-cell movement of organelles

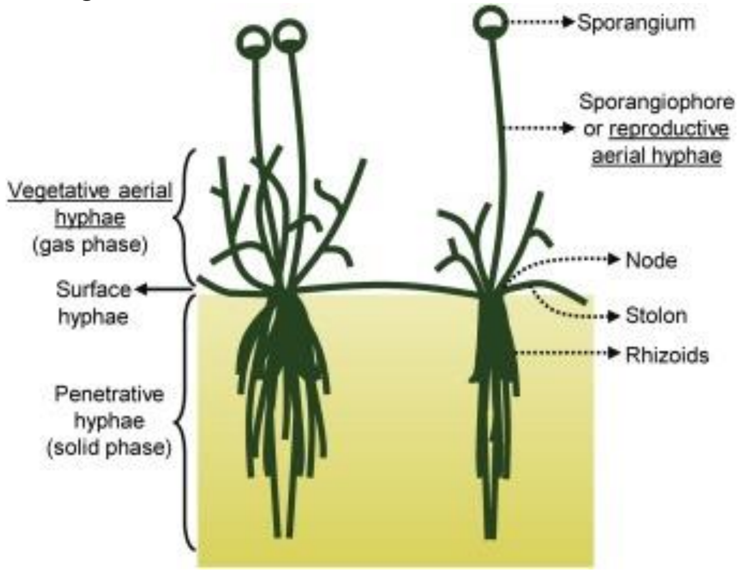
Coenocytic fungi lack septa.

(a) Septate hypha

(b) Coenocytic hypha

The vegetative mycelium consists of the surface hyphae, hyphae that arise above the surface are referred as the aerial mycelium.

Under certain conditions the hyphae of the aerial mycelium produce reproductive cells or spores- collectively known as fruiting bodies.



The morphology of multicellular fungi enhances their ability to absorb nutrients.

Cell Wall of Fungi

The fungal cell wall is located outside the plasma membrane and is the cell compartment that mediates all the relationships of the cell with the environment. It protects the contents of the cell, gives rigidity and defines the cellular structure. The cell wall is a skeleton with high plasticity that protects the cell from different stresses, among which osmotic changes stand out. The cell wall allows interaction with the external environment since some of its proteins are adhesins and receptors. Since, some components have a high immunogenic capacity, certain wall components can drive the host's immune response to promote fungus growth and dissemination. The cell wall is a characteristic structure of fungi.

The major constituents of the fungal cell wall are **chitin, glucans, and glycoproteins**. Chitin is a structurally important component of the fungal cell wall located closest to the plasma membrane. The composition of the outer layer varies, depending on the fungal species, morphotype, and growth stage

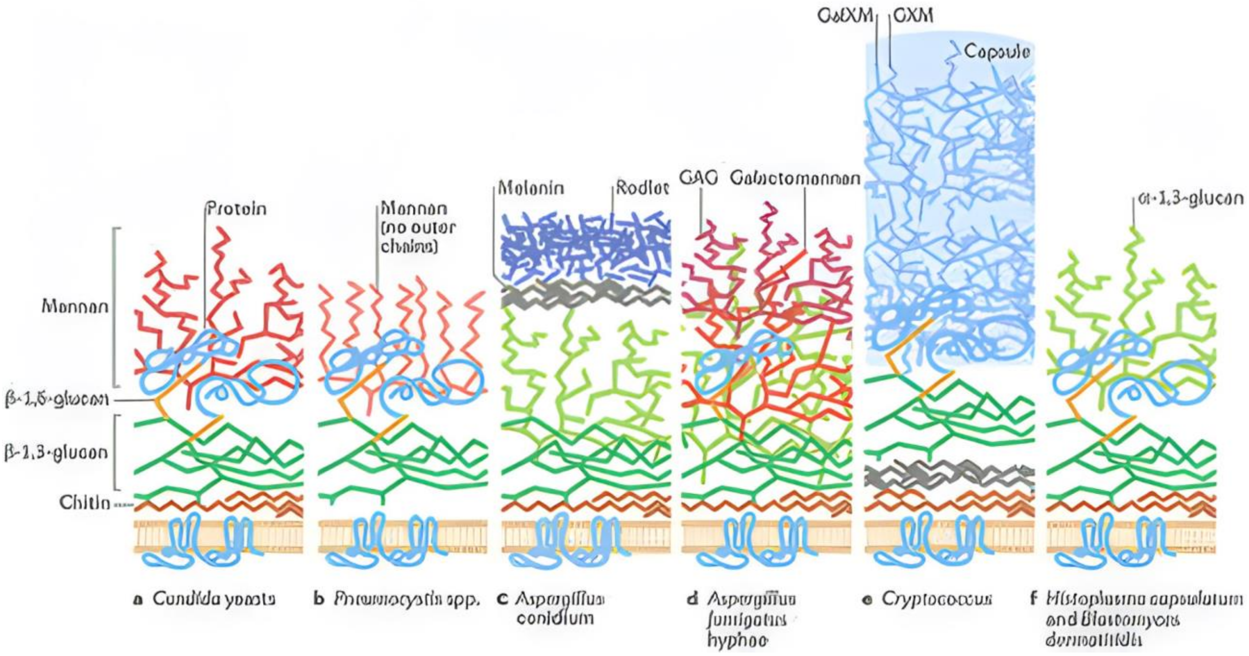


Figure: Structural organization of the cell walls of fungal pathogens

The graphical representation shows the major components of the wall and current hypotheses about their interconnections. Most fungi have a common alkali-insoluble core of branched β-(1,3) glucan, β-(1,6) glucan, and chitin but differ substantially in the components that are attached to this.

In *Candida albicans*, the outer wall is heavily enriched with highly mannosylated proteins that are mostly attached via glycosylphosphatidylinositol remnants to β-(1,6) glucan and to the β-(1,3) glucan-chitin core. In *A. fumigatus*, typical of many filamentous fungi, mannan chains are of lower molecular weight and are modified with β-(1,5) galactofuran. These mannans are not components of glycoproteins but are attached directly to the cell wall core. The cell wall core polysaccharides of *A. fumigatus* are β-(1,3)-β-(1,4) glucans and are attached to an outer layer of alkali-soluble linear α-(1,3)(1,4) glucan.

Conidial walls of *Aspergillus* have an outer hydrophobin rodlet layer of highly hydrophobic portions (hydrophobins) and a melanin layer; hyphae of *Aspergillus* have α-(1,3) glucan GM, and galactosaminoglycan (GAG) in the outer cell wall and limited glycosylated proteins. In *C. neoformans*, an outer capsule is composed of glucuronoxylomannan (GXM) and lesser amounts of galactoxylomannan (GalXM). The capsule is attached to α-(1,3) glucan in the underlying wall, although peptides or other glycans may also be required for anchoring the capsule to the cell wall. The inner wall has a β-(1,3) glucan-β-(1,6) glucan-chitin core, but most of the chitin is deacetylated to chitosan, and some of the chitosan/chitin may be located further from the membrane. *C. neoformans* also has a layer of melanin whose precise location is not known, but it may be incorporated into several cell wall polysaccharides and may assemble close to the chitin/chitosan layer. *Pneumocystis* cell walls may lack chitin and the outer chain *N*-mannans but retain core *N*-mannan and *O*-mannan modified proteins. Hyphae of *H. capsulatum* and *Blastomyces dermatitidis* have an outer cell wall layer of α-(1,3) glucan that prevents efficient immune recognition of β-(1,3) glucan in the inner cell wall.

Growth of fungi

Fungi are usually aerobic (Particularly Molds), some yeast, however, are facultatively anaerobic and can obtain energy by fermentation.
Obligate or strict anaerobic fungi are found in the rumen of the cattle.
Fungi grow in wide range of temperature between 10°C and 40 °C. Some fungi can grow at temperature of 50°C or even in freezing temperature.
Optimum temperature is 22 to 30°C (Saprophytic fungi) and for parasitic fungi 30 - 37°C.
Mostly fungi prefer an acidic pH for their growth. The optimum pH range is between 3.8 to 5.6.

Sabouraud Dextrose Agar or SDA generally used agar medium was formulaed by **Raymond Sabouraud** in 1892. Sabouraud Dextrose Agar is used for the cultivation of fungi (yeasts**,** molds).

Sabouraud Dextrose Agar contains digests of animal tissues (**peptones**) which provide a nutritious source of amino acids and **nitrogenous** compounds for the growth of fungi and yeasts. **Dextrose** is added as the energy and carbon source. **Agar** is the solidifying agent. The **pH is adjusted to approximately 5.6** in order to enhance the growth of fungi, especially dermatophytes, and to slightly inhibit bacterial growth in clinical specimens. High dextrose concentration and low pH favor fungal growth and inhibit contaminating bacteria from test samples.

Composition of Sabouraud Dextrose Agar (SDA)

Ingradients	Gms/Litre
Dextrose	40.0
Peptone Agar	10.0
Agar	15.0
Final pH (at 25°C) 5.6±0.2	

*65 Gms of above add to 1 Litre of distilled water, autoclave, dispense and use for cultivation of fungi.
Chloramphenicol and/or **tetracycline** may be added as broad-spectrum antimicrobials to inhibit the growth of a wide range of gram-positive and gram-negative bacteria. Gentamicin is added to further inhibit the growth of gram-negative bacteria.

Nutritional Aspects of Fungi

Fungi are achlorophyllous (Lacking chlorophyll-heterotropic), heterotrophic eukaryotic thallophytes. The nutrition requirements of the fungi are discussed below:

Nutritional Requirements:

❖ The fungi utilize both organic compounds and inorganic materials as the source of their nutrient supply *i.e*., organic and inorganic compounds constitute their food.

❖ No fungus is able to make any increase in its dry weight in the absence of organic food materials, because lacking chlorophyll the fungi are unable to photosynthesize or use carbon dioxide to build up organic food materials/cannot synthesize their own food.

❖ Fungi are heterotrophic for carbon (organic) food compounds which they in their natural habitats obtain by living as saprophytes or parasites from dead or living plants, animals or microorganisms or their wastes.

Essential Elements:

The constituent elements of the organic and inorganic substances that fungi make use of are C, O, H, N, P, K, Mg, S, P, Mn, Cu, Mo, Fe, and Zn. Calcium is required by some fungi but not all.

These elements which fungi require as food are termed the essential elements. Some of these, the fungi need in extremely small trace amounts, and the others in comparatively larger amounts.

Reproduction in fungi

Fungal reproduction is complex, reflecting the differences in lifestyles and genetic makeup within this diverse kingdom of organisms. Fungal sexual reproduction differs from sexual reproduction in animals or plants in many aspects.

Differences between fungal groups are used to discriminate species using morphological differences in sexual structures and reproductive strategies.

Most fungi reproduce by forming spores that can survive extreme conditions such as cold and lack of water. **Both sexual meiotic and asexual mitotic spores may be produced, depending on the species and conditions**. Most fungi life cycles consist of both a diploid and a haploid stage.

Sexually reproducing fungi may combine by fusing their hyphae together into an interconnected network called anastomosis. Sexual reproduction begins when the haploid hyphae from two fungal organisms meet and join. Although the cytoplasm from each fuse together, the nuclei remain separate. The hyphae produced by this union, called a **dikaryon**, have two distinct nuclei. The dikaryon forms sexual sporangia, or spore cases, in which the nuclei fuse into one. The cell then undergoes meiosis to form haploid spores and the cycle is repeated. Some fungi have no diploid phase except for the sexual sporangium, whereas others have completely lost the ability for sexual reproduction.

Some reproduce by asexual fission or by fragmentation, with each fragment forming a separate organism. Asexual reproduction occurs either with vegetative spores or through mycelia fragmentation where the fungal mycelium separates into pieces and each piece then grows into a separate mycelium.

Fungi *imperfecti* and *deuteromycota* lack an observable sexual cycle.

Yeasts are unicellular fungi that have the ability to ferment sugars. Although they can produce spores, they usually multiply as single cells that divide by budding. Most yeasts form structures called asci that contain up to eight haploid ascospores that then fuse with adjoining haploids and multiply. Yeast cell size can vary from 2 µm to 50 µm in length and can exhibit great diversity with respect to color and shape.

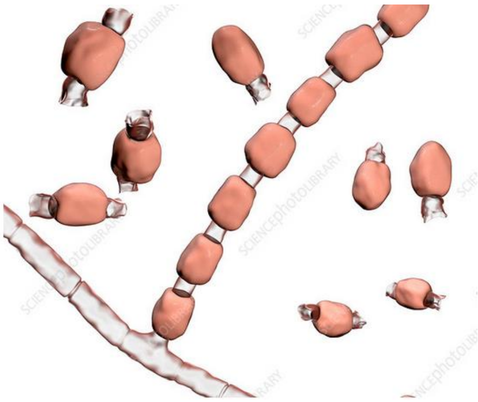
Reproduction in fungi
Sexual - formation of zygospores, ascospores or basidiospores
Asexual reproduction – budding or fission
Asexual spores are formed on or in specialized structures.
Vary in size, shape & colour but these characteristics are constant for a particular species.

Vegetative Structures of Fungi

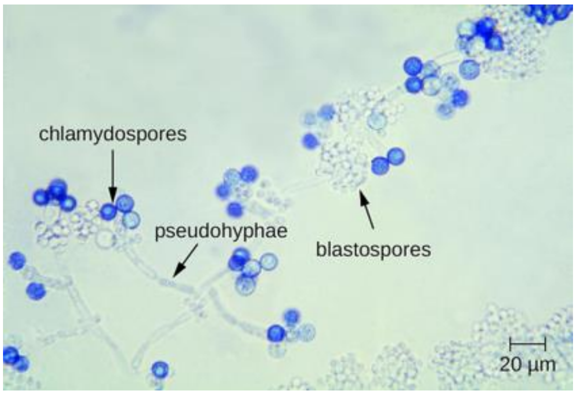
Arthrospores – formed by segmentation & condensation of hyphae

Chlamydospores – thick-walled resting spores

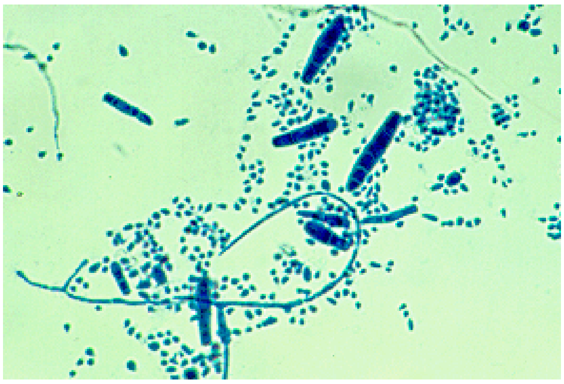
Macroconidia are large, hyaline, multiseptate, with thick rough cell walls, and are clavate, fusiform or spindle-shaped. **Microconidia** are small single-celled, hyaline, smooth-walled, and are predominantly clavate in shape.



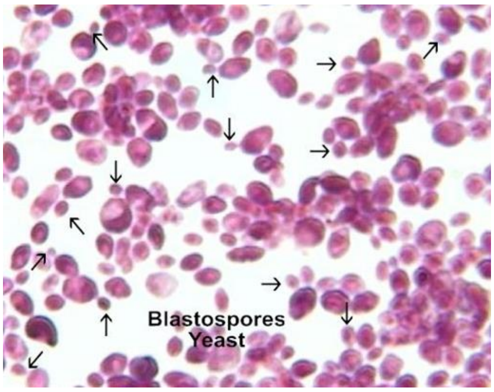
Arthrospores – formed by segmentation and condensation of hyphae



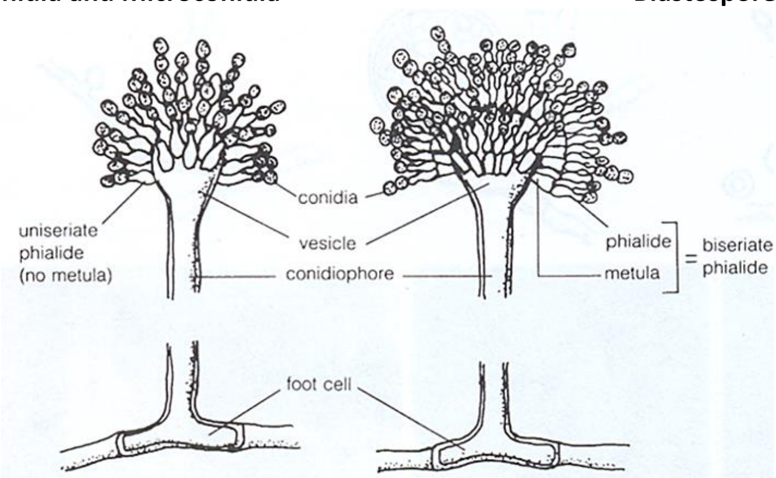
Chlamydospores – thick walled resting spores



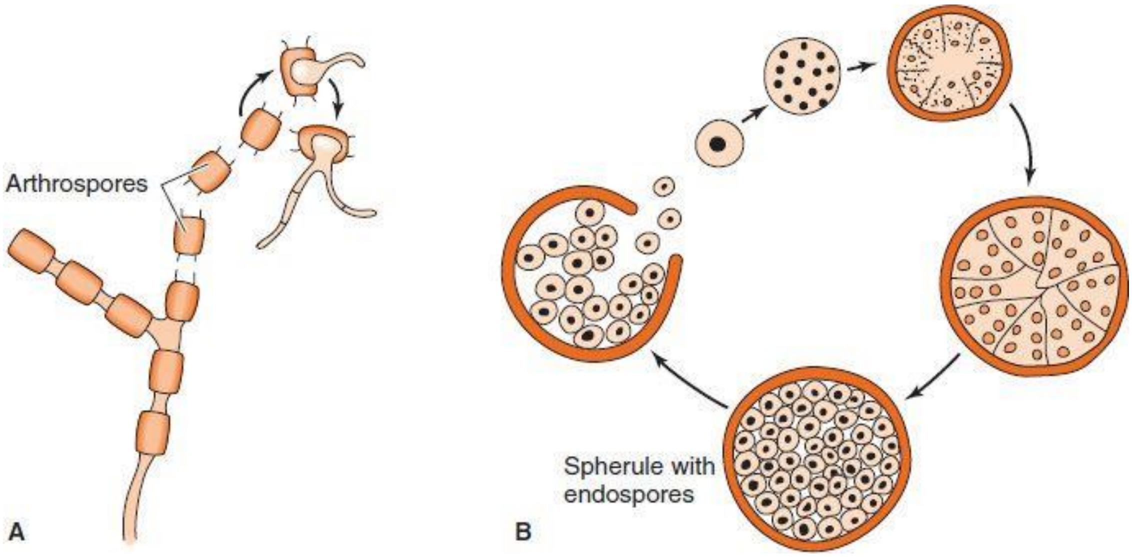
Macroconidia and Microconidia



Blastospores



Conidia and conidiophores



Stages of *Coccidioides immitis:* A: Arthrospores form at the ends of hyphae in the soil. They germinate in the soil to form new hyphae. If inhaled, the arthrospores differentiate into spherules. **B:** Endospores form within spherules in tissue. When spherules rupture, endospores disseminate and form new spherules. (Source: https://basicmedicalkey.com/systemic-mycoses/)

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