FUNGAL CELL WALL

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 and is composed mainly of glucans, chitin and glycoproteins. As the components of the fungal cell wall are not present in humans, this structure is an excellent target for antifungal therapy.

The cell wall is a specific and complex cellular organelle composed of glucans, chitin, chitosan, and glycosylated proteins. Proteins are generally associated with polysaccharides resulting in glycoproteins. Together, these components contribute to the cell wall rigidity. The synthesis and maintenance of cell wall involves a large number of biosynthetic and signaling pathways.

The wall components are as follows:

Glucans

Glucan is the most important structural polysaccharide of the fungal cell wall and represents 50–60% of the dry weight of this structure. Most polymers of glucan are composed of 1,3 linkage glucose units (65–90%), although there are also glucans with β-1,6 (in Candida), β-1,4, α-1,3 and α-1,4 links. The β-1,3-D-glucan is the most important structural component of the wall, to which other components of this structure are covalently linked. The β-1,3-D-glucan is synthesized by a complex of enzymes located in the plasma membrane called glucan synthases. The genes encoding β-1,3-D-glucans, FKS1 and FKS2, were initially identified in *Saccharomyces cerevisiae*. Disruption of one of these genes affects cell growth but elimination of both causes cell.

Chitin

The chitin content of the fungal wall varies according to the morphological phase of the fungus. It represents 1–2% of the dry weight of yeast cell wall while in filamentous fungi, it can reach up to 10–20%. Chitin is synthesized from n-acetylglucosamine by the enzyme chitin synthase, which deposits chitin polymers in the extracellular space next to the cytoplasmic membrane.

Glycoproteins

Proteins compose 30–50% of the dry weight of fungal wall in yeast and 20–30% of the dry weight of the wall of the filamentous fungi. Most proteins are associated to carbohydrates by O or N linkages resulting in glycoproteins. Cell wall proteins have different functions including participation in the maintenance of the cellular shape, adhesion processes, cellular protection against different substances, absorption of molecules, signal transmission, and synthesis and reorganization of wall components.

Melanin

Melanin is a pigment of high molecular weight that is negatively charged, hydrophobic and insoluble in aqueous solutions and protects fungi against stressors facilitating survival in the host. The fungi produce melanin by two routes, from 1, 8-dihydroxynaphthalene (DHN) intermediate and from L-3, 4-dihydroxyphenylalanine (L-dopa). Melanin production contributes to fungal virulence, improves resistance to environmental damage such as extreme temperature, UV light and toxins, and is important for invasion and dissemination. For example, *C. neoformans* melanin has been linked with dissemination of yeast cells from the lungs to other organs, is known to influence the immune response of the host and inhibit phagocytosis. In *Aspergillus*, melanin inhibits macrophage apoptosis that have phagocytosed melanized conidia (Volling et al., 2011).

HYPHAL GROWTH

A hypha is a long, branching, filamentous structure of a fungus. In most fungi, hyphae are the main mode of vegetative growth, and are collectively called a mycelium. A hypha consists of one or more cells surrounded by a tubular cell wall. In most fungi, hyphae are divided into cells by internal cross-walls called "septa" (singular septum). Septa are usually perforated by pores large enough for ribosomes, mitochondria, and sometimes nuclei to flow between cells. The major structural polymer in fungal cell walls is typically chitin, in contrast to plants and oomycetes that have cellulosic cell walls. Some fungi have aseptate hyphae, meaning their hyphae are not partitioned by septa.

The direction of hyphal growth can be controlled by environmental stimuli, such as the application of an electric field. Hyphae can also sense reproductive units from some distance, and grow towards them. Hyphae can weave through a permeable surface to penetrate it. Hyphae may be modified in many different ways to serve specific functions. Some parasitic fungi form haustoria that function in absorption within the host cells. The arbuscules of mutualistic mycorrhizal fungi serve a similar function in nutrient exchange, so are important in assisting nutrient and water absorption by plants.

Hyphae grow at their tips. During tip growth, cell walls are extended by the external assembly and polymerization of cell wall components, and the internal production of new cell membrane. The **spitzenkörper** is an intracellular organelle associated with tip growth. It is composed of an aggregation of membrane-bound vesicles containing cell wall components. The spitzenkörper is part of the endomembrane system of fungi, holding and releasing vesicles it receives from the Golgi apparatus. These vesicles travel to the cell membrane via the cytoskeleton and release their contents (including various cysteine-rich proteins including cerato-platanins and hydrophobins)[4][5] outside the cell by the process of exocytosis, where it can then be transported to where it is needed. Vesicle membranes contribute to growth of the cell membrane while their contents form new cell wall. The spitzenkörper moves along the apex of the hyphal strand and generates apical growth and branching; the apical growth rate of the hyphal strand parallels and is regulated by the movement of the spitzenkörper. As a hypha extends, septa may be formed behind the growing tip to partition each hypha into individual cells. Hyphae can branch through the bifurcation of a growing tip, or by the emergence of a new tip from an established hypha.