

AN INTRODUCTION TO MEDICAL MYCOLOGY

Definition of fungi

The living world is divided into the five kingdoms of Planta, Animalia, Fungi, Protista and Monera. It is important to recognize that the fungi are not related to bacteria (Monera). To define the exact limits of the groups in a few words is virtually impossible, however generally speaking fungi are eukaryotica, heterotrophic, unicellular to filamentous, rigid cell wall and spore-bearing organisms that usually reproduce by both sexual and asexual means. Further they are insensitive to antibacterial antibiotics.

- a. Eukaryotic cells contain membrane bound cell organelles including nuclei, mitochondria, golgi apparatus, endoplasmic reticulum, lysosomes etc. Eukaryotes also exhibit mitosis. These features separate fungi from bacterial which are prokaryotic cells lacking the above structures.
- b. Heterotrophic - fungi lack chlorophyll and are therefore not autotrophic (photosynthetic) like plants and algae; rather they are heterotrophic absorptive organisms that are either saprophytes (living on dead organic matter) or parasites (utilizing living tissue).
- c. Like plants, fungi have rigid cell walls and are therefore non-motile, a feature which separates them from animals.

Structure of Fungi

Fungi occur in two basic growth forms or stages:

- a) A unicellular or yeast form which is defined morphologically, as a single-celled fungus that reproduces by simple budding to form blastoconidia. Colonies are usually moist or mucoid. Yeast-like fungi may be basidiomycetes, such as *Cryptococcus neoformans* or ascomycetes such as *Candida albicans*.
- b) A filamentous or mould form which is a vegetative growth of filaments. Structures such as mushrooms consist simply of a number of filaments packed tightly together, and reproduction is by spores or conidia. Moulds produce a great variety of conidia which are borne on specialized hyphae or conidiophores. Many moulds can be identified by the morphology of these spores and by their arrangement on the hyphae. Fungal filaments are known as hyphae and a mass of hyphae collectively make up the mycelium. The terms "hyphae" and "mycelium" are used interchangeably. There are two kinds of hyphae; non-septate (coenocytic) and septate. The septa divide the hyphae into compartments but not into cells. In some groups nuclei and/or cytoplasm can flow through a hole or pore in the centre of these septa.

Fungi with non-septate hyphae typically belong to the Zygomycetes. Non-septate hyphae are considered to be more primitive because if a hyphal strand is damaged the entire strand dies.

Septate hyphae are typically found in the Basidiomycetes and Ascomycetes, the latter also includes the hyphomycetes or conidial fungi. When a septate hyphal strand is damaged, the pores between adjacent compartments can be plugged, thus preventing death of the whole hyphal strand.

Two basic types of reproductive structures are found in the fungi:

- a) Sexual structures are produced by the fusion of two nuclei that then generally undergo meiosis. Sexual methods of reproduction involve plasmogamy (cytoplasmic fusion of two cells), karyogamy (fusion of two nuclei), genetic recombination and meiosis. The resulting haploid spore is said to be a sexual spore, e.g. zygospores, ascospores and basidiospores. If a sexual spore is produced only by fusion of a nucleus of one mating type with a nucleus of another mating type (+ and - strains), the fungus is said to be heterothallic. In contrast, homothallic moulds produce sexual spores following the fusion of two nuclei from the same strain.
- b) Asexual structures are termed either spores or conidia depending on their mode of production, and which arise following mitosis of a parent nucleus. Conidia arise either by budding off conidiogenous hyphae or by differentiation of preformed hyphae. Asexual spores are commonly formed by consecutive cleavages of a sporangium. Asexual forms of reproduction represent the major method for the maintenance and dissemination of many fungi.

Classification of Fungi

Separation of taxa is still primarily based on the method of spore production of the perfect or sexual state (teleomorph) and three major subdivisions, the Zygomycota, Ascomycotina and Basidiomycotina are generally recognized. However for convenience mycologists often recognize an additional artificial subdivision called the Deuteromycotina to accommodate those fungi without a perfect state, but which may represent the asexual states (anamorphs) of either Basidiomycotina or Ascomycotina.

ZYGOMYCETES (bread or pin moulds)

1. Fast growing, terrestrial, largely saprobic fungi with non motile cells; cosmopolitan (665 species). Hyphae coenocytic and mostly aseptate. Asexual spores include chlamydoconidia, conidia and sporangiospores contained in sporangia borne on simple or branched sporangiophores. Sexual reproduction is isogamous producing a thick-walled sexual resting spore called a zygospore. However, most isolates are heterothallic, *i.e.* zygospores are absent, therefore identification is based primarily on sporangial morphology. eg. *Rhizopus*, *Mucor* and *Absidia*

BASIDIOMYCETES (mushrooms and toadstools)

Saprophytes and parasites (esp. of plants), terrestrial; cosmopolitan (16,000 species). Hyphae septate with complex septal pores called dolipores which allow cytoplasmic but not nuclear migration. Hyphae are dikaryotic and can often be distinguished by the presence of clamp connections over the septa. Sexual reproduction is by the formation of exogenous

basidiospores, typically four, on a basidium. Occasional species produce conidia but most are sterile. Four classes may be distinguished: Hymenomycetes (mushrooms), Gasteromycetes (puff balls), Urediniomycetes (rusts) and Ustilaginomycetes (smuts).

ASCOMYCETES (common moulds)

Saprophytes, parasites (esp. of plants), or lichen forming, mostly terrestrial; cosmopolitan (28,650 species). Hyphae septate with simple septal pores, cytoplasmic and nuclear migration not inhibited. Asexual reproduction is by conidia. Sexual reproduction is by the formation of endogenous ascospores, typically eight, in an ascus. Asci are often housed in a fruiting body or ascocarp e.g. cleistothecia or perithecia. No classes are now recognized; although in the past they have often been grouped on how the asci were arranged (Hemiascomycetes, Plectomycetes, Pyrenomycetes, Discomycetes, Laboulbeniomycetes and Loculoascomycetes).

HYPHOMYCETES (conidial moulds)

A class of mycelial moulds which reproduce asexually by conidia on hyphae or aggregations of hyphae but not within discrete conidiomata. No sexual state is present; cosmopolitan (17,000 species). Hyphae are septate, having simple ascomycetous septal pores. This class contains the majority of medically important fungi.

Dematiaceous Hyphomycetes are those conidial fungi that produce dark brown, green-black, or black colonies and are the causative agents of phaeohyphomycosis. Hyaline Hyphomycetes include those conidial fungi which are not darkly pigmented, colonies may be colourless or brightly coloured. These include the agents of hyalohyphomycosis, aspergillosis, dermatophytosis and the dimorphic pathogens, like *Histoplasma capsulatum*. Identification of the hyphomycetes is primarily based on microscopic morphology of the conidia, their arrangement, and on what type of cell produces them. Culture characteristics, although less reliable may also be useful. These include surface texture, topography and pigmentation, reverse pigmentation and growth at 37°C.