

## MEDICAL MYCOLOGY

### Stephen Davis

*Mycology Unit, S. A. Pathology, Women's and Children's Hospital Campus, Adelaide, South Australia*

**Keywords:** Yeast, mould, fungi, teleomorph, anamorph, Basidiomycetes, Zygomycetes, Ascomycetes, deuteromycetes, Blastomycetes, Coelomycetes, Hyphomycetes, Tinea, Thrush, Aspergillosis, Cryptococcosis, Candidiasis, Histoplasmosis, Blastomycosis, Coccidiomycosis

### Contents

1. Introduction
  2. Classes of fungi that are of Medical Interest
  3. Clinical groupings of fungal infections
  4. Subcutaneous infections
  5. Systemic infections
  6. Miscellaneous fungal or fungal-like diseases
  7. Antifungal Therapy
  8. Identification of fungi- The Classical Approach to Fungal Identification
  9. Serological testing
- Glossary  
Bibliography  
Biographical Sketch

### Summary

In conclusion, Medical Mycology is a science that has increased in importance over the years. This is due mainly to an increase in the medical use of immunosuppressive drugs which in turn has led to an increase in the incidence of opportunistic fungal infection. Thus the focus of Medical Mycology has shifted from a science that deals almost exclusively with medical dermatological conditions to one that also deals with systemic diseases leading to life or death situations. However, since it has been estimated by Professor John Rippon (an eminent American Mycologist who wrote the original 'Medical Mycology') that 70% of the world's population will have some sort of tinea during the course of their lives, the relevance of Medical Mycology to most people is not to be underestimated.

### 1. Introduction

In simple terms, Medical Mycology is the study of fungi that impact on human health in some way. Surprisingly to many people, the causative relationship of fungi to human health was known before the pioneering work of Pasteur and Koch with pathogenic bacteria. Schoenlein and Gruby studied fungal scalp infections caused by *Trichophyton schoenleinii* in 1839, and Gruby produced the disease in a healthy individual by inoculation of the causative fungus, thus fulfilling Koch's postulate before it was formulated.

During the early years, Medical Mycology was really the study of dermatophytes (tinea and ringworm fungi), with Raimond Sabouraud (1864-1938) being the most famous name in the field. Sabouraud's agar to this day remains the most well known agar formulation for growing fungi.

Over the years, knowledge of fungi has increased, and confusion in fungal taxonomy and nomenclature was brought into order by Norman Constant and Chester Emmons. With the advent of immunosuppressive medications and diseases such as AIDS, Medical Mycology has moved away from just being concerned with superficial and cutaneous infections because subcutaneous and systemic invasive fungal diseases are becoming increasingly prevalent in our world.

Present research in Medical Mycology is aimed in several directions. Research into improved diagnostic testing is an important area, with Molecular Biology (particularly PCR-polymerase chain reaction) being a relatively recent area of interest. In addition serological testing such as the galactomannan ELISA (Enzyme-Linked ImmunoSorbent Assay) for the detection of antigens present in systemic aspergillosis has been approved for routine use in the USA. The search for new and improved antifungals is of course a never ending quest, while research into the mechanisms of fungal pathogenicity is a related endeavor.

There are different classification methods for fungi, but the one in common use in most text books is the one originated by Linnaeus in the eighteenth century. Relatedness between fungi leads to a hierarchy of different levels of classification, with terms used to denote different levels in this hierarchy. Fungi that are very closely related are grouped into one species. Related species are grouped into a genus (plural: genera). For example, *Trichophyton rubrum* and *Trichophyton mentagrophytes* are similar fungi that have important relatively minor differences, and so are regarded as belonging to the same genus, but belonging to different species. Related genera are grouped into a family (family names end in -aceae) related families are grouped into orders (order names end in -ales), then we get classes (class names end in -mycetes), divisions (also known as 'phyla'-phylum names end in -mycota) and finally the kingdom (Eumycota-'the true fungi').

It has been estimated that there are between 250,000 and 1.5 million species of fungi on this planet, and about 70,000 of these species have been described [see also 6.58.6.2 – *Nutriceuticals from Mushrooms*; 6.58.6.3 – *Mushroom Production*]. Fortunately for the Medical Mycologist, only about 300 of these species cause human infection, and of these about 30 species are seen regularly. The fungi of medical interest are grouped mainly in four classes.

## **2. Classes of fungi that are of Medical Interest**

### **2.1. Basidiomycetes**

These fungi are the basidiomycetous yeasts, *Cryptococcus neoformans* and *Cryptococcus gattii*, fungi that have the potential of being systemic pathogens. They are causative agent of cryptococcal meningitis and systemic cryptococcal disease that can

lead to lesions in the skin, bones, lungs, or other internal organs.

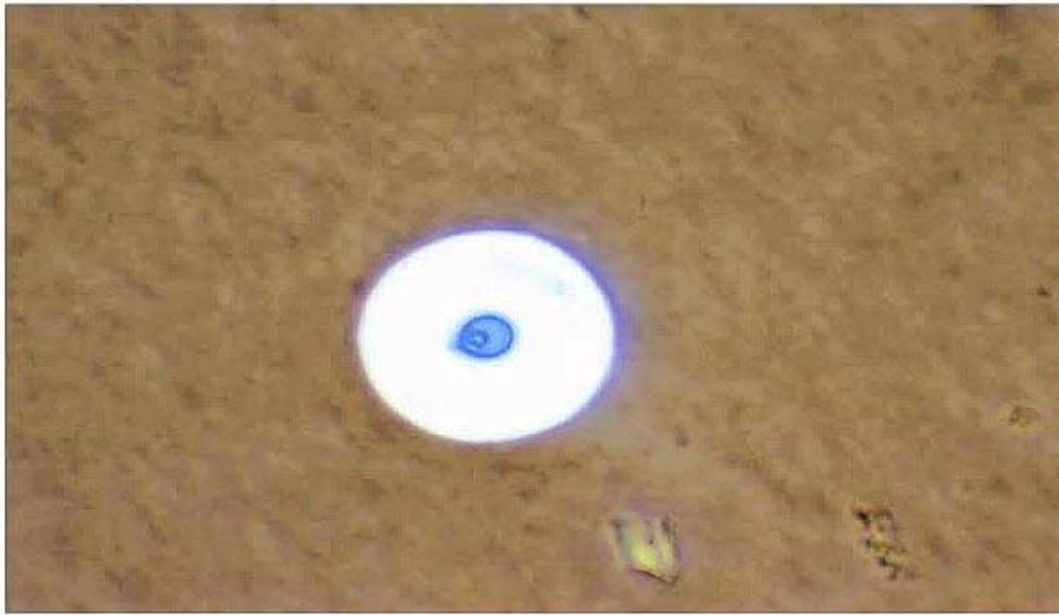


Figure 1: Typical microscopic appearance of *Cryptococcus neoformans* in Indian ink demonstrating surrounding mucopolysaccharide capsule.

In addition to these well-known yeasts, the mycelial phase of some of the macrofungi can cause relatively rare infections, such as meningitis and sinusitis caused by *Schizophyllum commune*.



Figure 2: *Schizophyllum commune*-the basidiocarps of this fungus are only a few millimeters across and may sometimes grow on artificial media.

## 2.2. Zygomycetes

These microfungi produce a sexual fruiting structure called a zygote. It is a primitive class of fungi that can cause acute and fulminant opportunistic systemic infections in immunosuppressed or acidotic diabetic patients, as well as chronic subcutaneous infections in immunocompetent individuals. Most of the medically important members of this class are in the family 'Mucoraceae', and include the genera '*Rhizopus*', '*Absidia*' and '*Apophysomyces*'. In the medical laboratory these fungi are normally recognized by their asexual sporulating structures (sporangia), as the majority of these fungi are heterothallic (i.e. require an opposite mating type) and so do not produce sexual structures on artificial culture.

The entomophthorales are an order within the zygomycete class of fungi that are of relatively minor medical importance. They have the capacity to cause subcutaneous infections known clinically as 'entomophthoromycosis'.

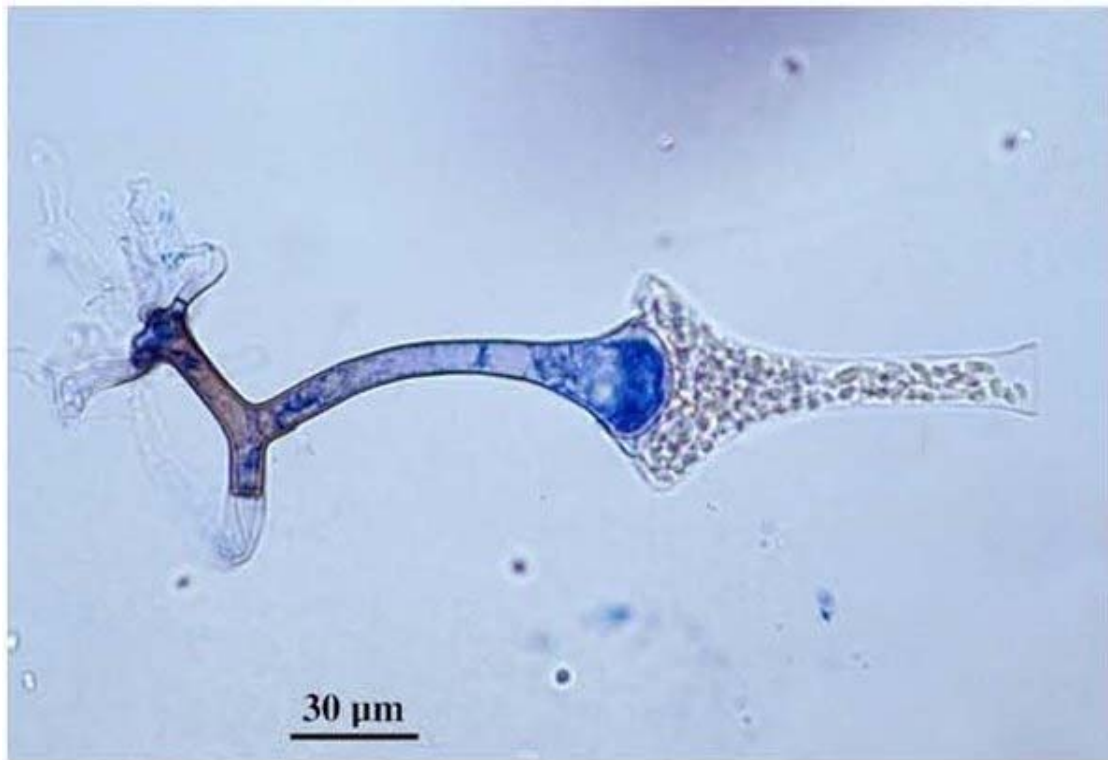


Figure 3 The zygomycete *Saksenaea vasiformis* (from the family *Saksenaeaceae*) showing a typical vase-shaped sporangium (an asexual spore-containing structure). Note the rhizoids (root-like structures) at the base. Sporangiospores fill the neck of the sporangium.

## 2.3. Ascomycetes

These macro- and microfungi produce an ascocarp as a sexual fruiting structure. Many of these fungi do not produce sexual structures when isolated from clinical specimens because they are heterothallic (need an opposite mating type) and so are identified by

their asexual structures. Such fungi are identified by treating them as if they were members of the mitosporic fungi (see below).

The members of this class that may produce ascocarps using artificial culture techniques (because they are homothallic, i.e. have the ability to self-fertilize) include *Pseudallescheria boydii* and *Eurotium* species. *Pseudallescheria boydii* is particularly important as an agent of sinusitis and pneumonia, with this fungus showing a marked predilection for the central nervous system.



Figure 4: Macroscopic appearance of *Pseudallescheria boydii* on Sabouraud's agar

#### **2.4. Mitosporic fungi (Fungi imperfecti).**

Also known in older text books as the deuteromycetes, this is an artificial class where the teleomorph (sexual) state either does not exist or is not known. The anamorph (asexual) states of members of the ascomycetes are often treated taxonomically as if they were members of this group. This artificial class is made up of 3 form-classes:

##### **2.4.1. Blastomycetes**

This group consists of yeasts (single-celled fungi), and these fungi are usually identified by commercial biochemical schemes such as the commercial ID32C assimilation scheme produced by Biomerieux.

##### **2.4.2. Coelomycetes**

This group is of minor importance in Medical Mycology, but is recognized by the formation of conidia formed in asexual structures called 'pycnidia'.



Probably the most important member of this group from a medical perspective is *Phoma* spp. These fungi may cause infections ranging from simple skin lesions to ulcerations of the human cornea.



Figure 5 : Appearance of pycnidium under forty times magnification showing ostiole (a hole) through which conidia escape from the confines of this structure.

### 2.4.3. Hyphomycetes

This is by far the most important group in Medical Mycology, with infections ranging from tinea and ringworms caused by the dermatophytes, to systemic infections caused by *Aspergillus fumigatus*. This grouping is composed of fungi where fruit bodies are absent, and the mycelium is composed of septate hyphae. Asexual propagules (conidia) may be formed directly on the hyphae or on intervening structures. These fungi are differentiated mainly by both macroscopic (color, texture, size of colony, reverse pigment etc.) and microscopic characteristics. These microscopic characteristics include features such as:

- Type of conidiogenous cell. The conidiogenous cells are the cells which produce conidia, and they may be phialides, annelides or the hyphae itself (non-specialized).
- Conidial morphology, especially septation, shape, size, colour and cell wall texture
- The arrangement of conidia as they are borne on the conidiogenous cells, for example whether they are solitary, arthrocatenate or gloiosporae etc.

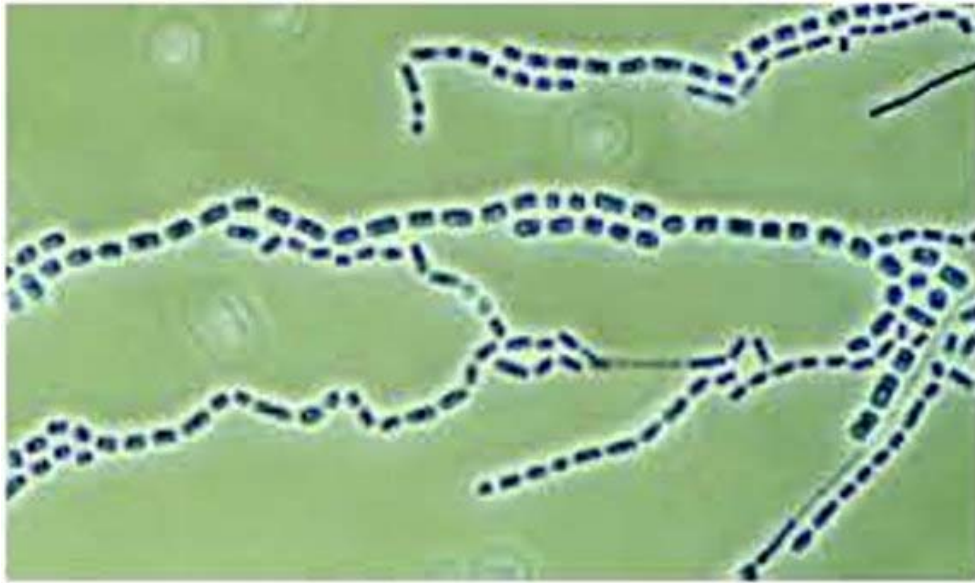


Figure 6 Arthrocatenate (conidia formed in chains within hyphae)

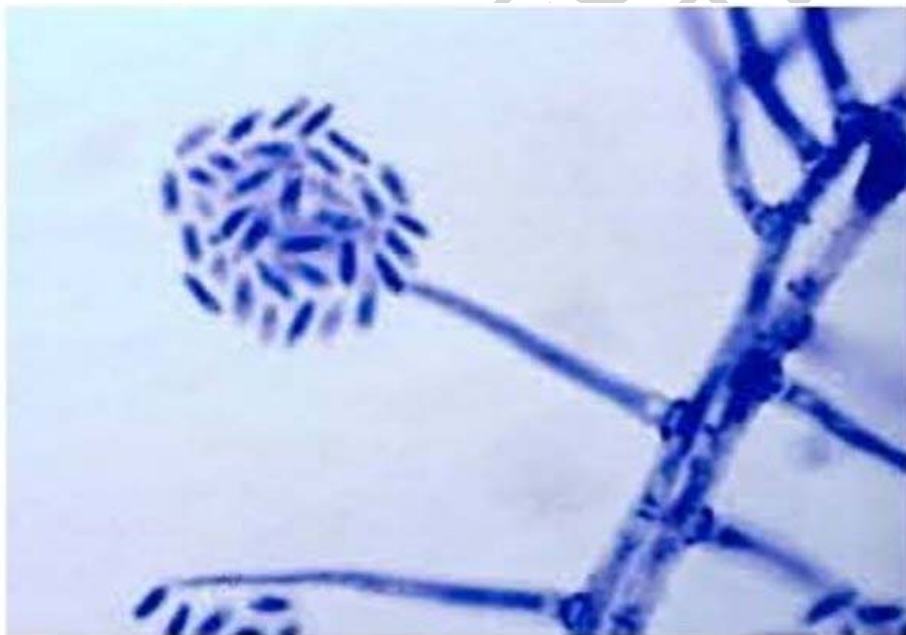


Figure 7 Gloiosporae (conidia formed in sticky masses at the tip of a conidiophore)

Mycology text books often have dichotomous keys that utilize observed microscopic and macroscopic features in an attempt to allow identification of an unknown fungus.

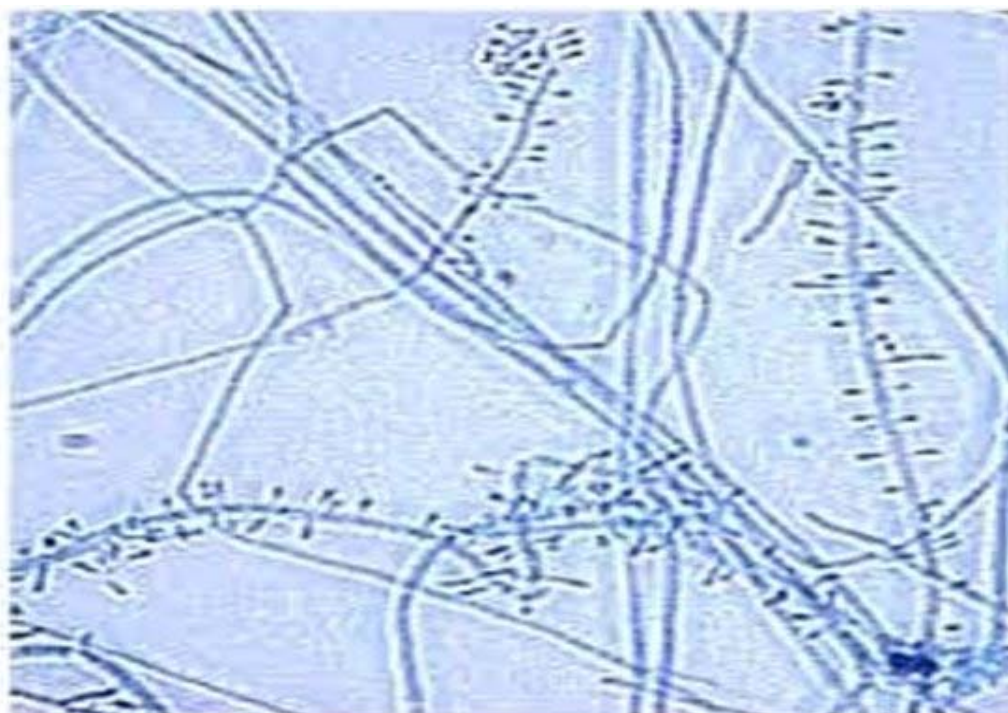


Figure 8 Solitary (conidia formed singly directly on the hyphae)

-  
-  
-

TO ACCESS ALL THE **43 PAGES** OF THIS CHAPTER,  
Visit: <http://www.eolss.net/Eolss-sampleAllChapter.aspx>

### **Bibliography**

Barnett J. A. et al (2000) *Yeasts: Characteristics and Identification 3rd edn*. Cambridge University Press, Cambridge, England. [This book allows both medically important and environmental yeasts to be identified].

de Hoog G. S. et al. (2000). *Atlas of clinical fungi, 2nd edn*. Centraalbureau voor Schimmelcultures, Utrecht/Universitat Rovira i Virgili, Reus, Spain. [This book allows many clinically important fungi, particularly moulds, to be identified by the use of dichotomous keys].

Kwon-Chung K. J. (1992). *Medical Mycology*. Lea & Febiger, Malvern, Pennsylvania, U. S. A. [This book describes the various fungal diseases, as well as the fungi that cause them].

### **Biographical Sketch**

**Stephen Davis**, Senior Medical Scientist, BSc, MASM., born January 25, 1953. He graduated from Adelaide University in 1975. He is working in Mycology Unit, S. A. Pathology, Women's and Children's Hospital Campus, North Adelaide, South Australia. During the late seventies, I was trained by Mrs



Geraldine Kaminski (a.k.a. 'Miss Brown'), a world-renowned Mycologist at the Adelaide Children's Hospital. After a sojourn of a few years during which time I was in charge of the enteric/ renal diagnostic laboratory in the Microbiology Department, I returned to the Mycology Unit and commenced working with Dr David Ellis. I have since published several papers, including research into the use of 'allitridium', a proprietary Chinese garlic extract, as a prophylactic antifungal agent. I am an adjunct lecturer at the University of South Australia, and give lectures and workshops at scientific meetings around Australia.

UNESCO - EOLSS  
SAMPLE CHAPTERS