



## MORPHOLOGY AND GENERAL PROPERTIES OF FUNGI

### 51.1 INTRODUCTION

Fungus is a member of a large group of eukaryotic organisms that includes microorganisms such as yeasts and molds (British English: moulds), as well as the more familiar mushrooms. These organisms are classified as a kingdom, Fungi, which is separate from plants, animals, protists and bacteria. One major difference is that fungal cells have cell walls that contain chitin, unlike the cell walls of plants and some protists, which contain cellulose, and unlike the cell walls of bacteria. These and other differences show that the fungi form a single group of related organisms, named the Eumycota (true fungi or Eumycetes), that share a common ancestor (is a monophyletic group). This fungal group is distinct from the structurally similar myxomycetes (slime molds) and oomycetes (water molds). The discipline of biology devoted to the study of fungi is known as mycology. Mycology has often been regarded as a branch of botany, even though it is a separate kingdom in biological taxonomy. Genetic studies have shown that fungi are more closely related to animals than to plants.

Fungi are not able to ingest their food like animals do, nor can they manufacture their own food the way plants do. Instead, fungi feed by **absorption** of nutrients from the environment around them. They accomplish this by growing through and within the **substrate** on which they are feeding. Numerous hyphae network through the wood, cheese, soil, or flesh from which they are growing. The hyphae secrete digestive enzymes which break down the substrate, making it easier for the fungus to absorb the nutrients which the substrate contains.

This filamentous growth means that the fungus is in intimate contact with its surroundings; it has a very large surface area compared to its volume. While this makes diffusion of nutrients into the hyphae easier, it also makes the fungus susceptible to dehydration and ion imbalance. But usually this is not a problem, since the fungus is growing within a moist substrate.

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Most fungi are **saprophytes**, feeding on dead or decaying material. This helps to remove leaf litter and other debris that would otherwise accumulate on the ground. Nutrients absorbed by the fungus then become available for other organisms which may eat fungi. A very few fungi actively capture prey, such as *Arthrobotrys* which snares nematodes on which it feeds. Many fungi are **parasitic**, feeding on living organisms without killing them. Ergot, corn smut, Dutch elm disease, and ringworm are all diseases caused by parasitic fungi.



### OBJECTIVES

After reading this lesson, you will be able to:

- describe the morphology of fungi
- explain the physiology of fungi
- classify fungi
- describe the colony morphology
- describe the pathogenicity of fungi

## 51.2 MORPHOLOGY OF FUNGI

- (a) **General.** Fungi vary widely in size and shape, from unicellular, microscopic organisms to multicellular forms easily seen with the naked eye. Individual cells range from 1  $\mu$  to 30  $\mu$ . Microscopic fungi exist as either molds or yeasts or both. Internally, fungal cells are fairly typical eucaryotic cells.
- (b) **Molds.** The molds form large multicellular aggregates of long branching filaments, called hyphae. There are vegetative hyphae and reproductive hyphae. Spores are borne on the reproductive hyphae. (Fungal spores should not be confused with bacterial spores that are resistant bodies formed for bacterial survival rather than reproductive purposes.) Spore size, shape and structure are used in the classification and identification of fungi. The tube-like hyphae are responsible for the fluffy appearance of the macroscopic mold colony. The hyphae and other structures combine to form an elaborate network called a mycelium.
- (c) **Yeasts.** These are large (5 to 8  $\mu$ ), single-celled organisms that rarely form filaments. Most yeasts reproduce by the asexual process of budding. Yeast colonies are usually characterized by a smooth surface similar to that of many bacteria.

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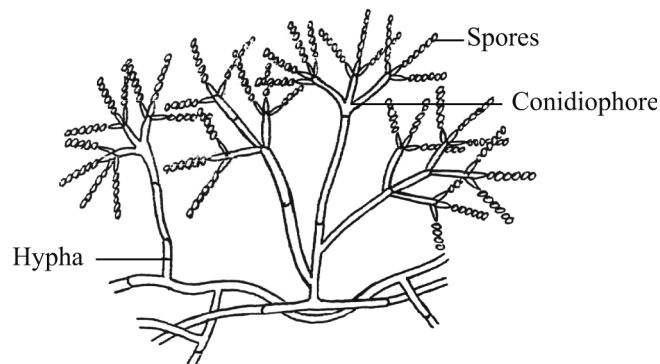
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**51.3 PHYSIOLOGY OF FUNGI**

- (a) **Nutrition.** Most fungi contain complex enzymes and other chemical substances which, when diffused into the host, break down the complex substances available – wood, vegetation, leather, bread, and so forth – into simpler substances that can be used for food. The chemical products of digestion are, therefore, completed outside of the organism, and the fungus absorbs the end products.
- (b) **Reproduction.** Fungi reproduce sexually or asexually, or both, depending upon the species and the environmental conditions. As the name implies, sexual reproduction is the result of the union of two spores. Most fungi reproduce both sexually and asexually. Those that produce only asexual spores are known as Deuteromycetes Fungi imperfecti. This group is important because it contains most of the pathogenic fungi. The yeasts reproduce both by spores and by a process known as budding, which is similar to binary fission. The yeast cell forms a small knoblike protrusion, or bud (Fig. 51.1), that separates from the mother cell and grows until it reaches full size, at which time the process is repeated.
- (c) **Growth.** Fungi grow well under the same conditions that favor the growth of bacteria – warmth and moisture. It is for this reason that fungal infections pose a serious problem to troops in the tropics. As the temperature decreases, fungal activity also decreases; however, the spores are very resistant to cold, some surviving freezing temperatures for long periods of time. On the other hand, fungi are easily killed at high temperatures.



**Fig. 51.1:** Typical mycelium of a fungus.

**51.4 CLASSIFICATION OF FUNGI**

Fungi are usually classified according to biological taxonomy based upon the type of hypha, spore, and reproduction. There are four classes of fungi, whose characteristics are shown in Table 51.1 and figure 51.2.

- (a) **Class Phycomycetes.** The algal fungi: bread molds and leaf molds. The only known mycosis (fungal disease) caused by fungi of this class is mucormycosis, a very rare fungal growth of the upper respiratory tract,



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bronchial mucosa, and lungs. It occurs largely as a complication of a chronic, debilitating disease, such as uncontrolled diabetes.

- (b) **Class Ascomycetes.** The sac fungi: yeasts, mildews, and cheese molds. Fungi of this class are implicated in only three fungus diseases, all of which are rare.
- (c) **Class Basidiomycetes.** Mushrooms, toadstools, rusts, and smuts. The only pathogens in this class are the mushrooms of the genus *Amanita*, which cause severe systemic poisoning (sometimes death) when eaten.
- (d) **Class Deuteromycetes.** Fungi imperfecti: a heterogeneous collection of fungi without sexual reproduction. Most of the pathogens encountered in medical mycology belong to this class.



### INTEXT QUESTION 51.1

- Study of fungi is .....
- Fungi are fed by ..... of nutrients from the environment around them
- ..... of fungi secrete enzymes which helps in absorption of nutrients
- Fungi that produce asexual spores are known as .....
- ..... morphology is used to describe the characteristics of fungal colony

**Table 51.1 Characteristics of Fungi**

Taxonomic class of Fungi	Hypha	Type of Reproduction	Characteristic spore	Origin of Spore	Examples of Fungi	Pathogenicity
Phycomycetes	Asptate	Asexually Sexually	Sporangio-spore Zygospor or oospore	Sporangio-phore Fussion of nuclei	Nuisance fungi including general Absidia, Muclor, and Rhizopus	Very rare Mucormycosis
Ascomycetes	Septate	Asexually	Blastospore Conidium	Budding Conidio-phore	Allescheria Aspergillus Piedraia	Rare Maduromcosis Aspergillosis
		Sexually	Ascospore	Ascus	Saccharomyces (perfect yeast)	Black Piedra
Basidiomycetes	Septate	Sexually	Basidio-spore	Basidium	Mushrooms, smuts and rusts	Rare Mushroom poisoning
Deutero-mycetes {fungi imperfecti}	Septate	Asexually	Thallospore	Thallus (hypha)	Most saprophytes and pathogens encountered in medical mycology (Imperfect mold and yeast)	Most Mycoses encountered in medical mycology
			Conidium	Conidio-phore		

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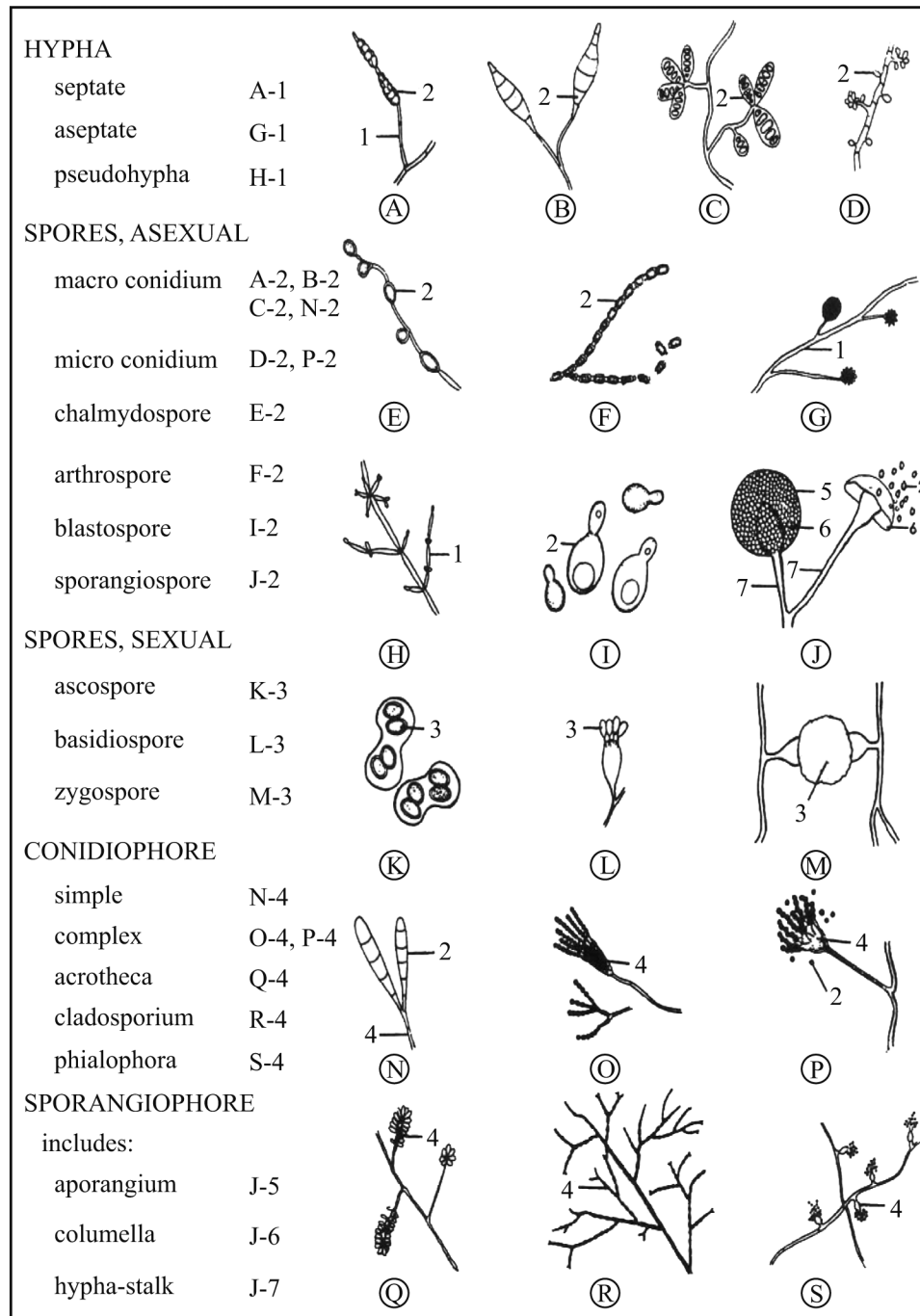


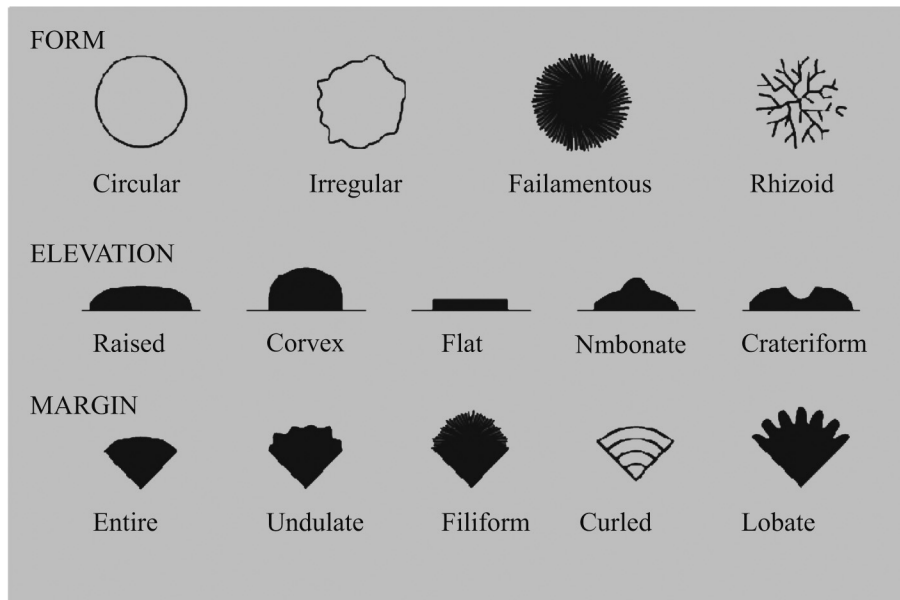
Fig. 51.2

### Colony Morphology

Colony morphology is a method that scientists use to describe the characteristics of an individual colony of fungi growing on agar in a Petri dish. It can be used to help to identify them.



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Different types of fungi will produce different-looking colonies, some colonies may be coloured, some colonies are circular in shape, and others are irregular. A specific terminology is used to describe common colony types. These are:

- Form - What is the basic shape of the colony? For example, circular, filamentous, etc.
- Size – The diameter of the colony. Tiny colonies are referred to as punctiform
- Elevation - This describes the side view of a colony. Turn the Petri dish on end.
- Margin/border – The edge of a colony. What is the magnified shape of the edge of the colony?
- Surface - How does the surface of the colony appear? For example, smooth, glistening, rough, wrinkled, or dull.
- Opacity - For example, transparent (clear), opaque, translucent (like looking through frosted glass), etc.
- Colour - (pigmentation) - For example, white, buff, red, purple, etc.

Yeast colonies are very similar to bacterial colonies.

Moulds often have fuzzy edges. They usually turn into a different colour, from the centre outwards.

### 51.5 PATHOGENIC FUNGI

- (a) Fungal infections are of two types: localized skin infections (dermatomycoses), and systemic infections. Although the former are far

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more common, the latter generally have more serious consequences. Table 51.2 lists the more common fungus diseases and the important etiological agents in each. Note that frequently more than one species of organism may cause identical symptoms.

**Table 51.2**

Disease	Synonym or Brief Description	Important Etiological Agents
<b>Cutaneous and Superficial Mycoses</b>		
Tinea capitis'	Ringworm of the scalp	Microsporum spp Trichophyton spp
Tinea corporis	Ringworm of the body	Same as Tinea capitis
Tinia barbae	Infection of bearded area of face and neck	Trichophyton spp
Tinea cruris	Ringworm of the groin (jock itch)	Trichophyton spp Candida albicans Epidermophyton floccosum
Tinea pedis	Ringworm of the feet (athlete's foot)	Same as Tinea cruris
Tinea versicolor	Depigmented, scaly patches of skin	Malassezia furfur
Otomycosis (aspergillosis)	Fungus infection of the ear canal	Aspergillus spp
Cutaneous Candidiasis (moniliasis, thrush)	Yeast infection of nails, skin mouth, Vagina	Candida albicans and other species
Mycetoma	Tumor-like swelling, draining abscess	Pseudallescheria boydii and other
Actinomycosis	Chronic, suppurative or granulomatous disease of jaw, thorax, or abdomen	Actinomyces israelii [actually classified as bacteria, but cause fungus-like infections]
<b>Subcutaneous and Systemic Fungus Infections</b>		
Nocardiosis	Infection of lungs, other organs, and lower extremities (Madura foot)	Nocardia asteroides [actually classified as bacteria, but cause fungus-like infections]
Chromoblastomycosis	Warty nodules or vegetations of skin and subcutaneous tissues	N. brasiliensis Cladosporium carrionii
Sporotrichosis	Ulcers of skin and underlying tissues and gumma-like swelling of regional lymph nodes.	Fonsecaea pedrosoi
Blastomycosis	Inflammatory lesions of the skin, lungs, or bones.	Phialophora verrucosa Sporotrichum schenckii



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Coccidioidomycosis	Self-limited respiratory disease or chronic progressive infection of various organs	Blastomyces dermatitidis
Histoplasmosis	Fungus infection of the lungs, with fever; anemia; loss of weight, enlargement of lymph nodes, liver, spleen	Coccidioides immitis Histoplasma capsulatum
Cryptococcosis	Systemic fungus infection of lungs or meninges	Cryptococcus neoformans

- (b) Diseases caused by fungi are collectively called mycoses (singular, mycosis). They are divided into four general categories on the basis of the primary tissue affected by the pathogen:
1. Superficial mycoses are infections limited to the hair and dead layers of the skin.
  2. Cutaneous mycoses (dermatophytoses or ringworm) affect only the skin, hair, and nails.
  3. Subcutaneous mycoses affect the subcutaneous tissue below the skin and occasionally bone.
  4. Systemic (“deep”) mycoses infect the internal organs and may spread throughout the host
- (c) Those fungi infecting the outer layers of the skin are rarely severe and are usually transmitted by contact with infected animals or humans. The agents of subcutaneous and systemic mycoses, however, are normally saprophytic fungi growing in the soil. Humans generally acquire these mycoses only when the spores of these organisms are either inhaled or introduced into the body through a break in the skin.
- (d) Some fungi incapable of causing infectious diseases produce toxic substances that poison the person who ingests them. These substances are collectively called mycotoxins. The most commonly known mycotoxin poisoning is from certain mushrooms; however, mycotoxins may be produced by fungi growing on grain, nuts, and other agricultural products.

### Medically Important Fungi

An accurate taxonomic scheme of the major fungal pathogens and contaminants encountered in medicine is not presented here; instead, a simpler but perhaps more useful organization will be applied. Morphology is particularly helpful in speciating filamentous fungi and *Pneumocystis carinii* (see **Other** fungi, below), but may also play a role in identifying certain yeasts.

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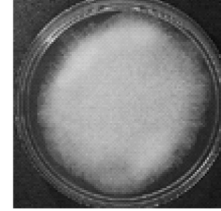
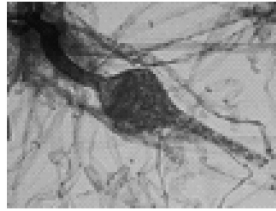
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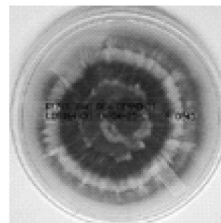
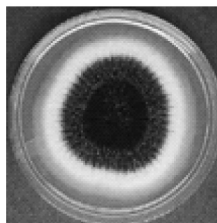
**Zygomycetes**



Zygomycetes are a class of fungi that have characteristically broad, usually aseptate hyphae; zygomycosis is usually characterized by opportunism, invasiveness, and involvement of nasal cavity, paranasal sinuses, and orbit with invasion into the brain (so-called rhinoorbitocerebral mucormycosis), involvement of the lungs, gastrointestinal tract, or skin (the latter especially in burn patients), and occasional dissemination. Its hyphae are generally broader than the hyalohyphomycetes and they lack the pigment found in dematiaceous fungi. Their gross appearance is characterized by rapid, plate-covering growth.

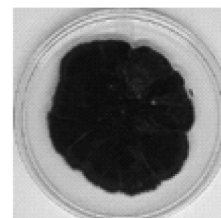
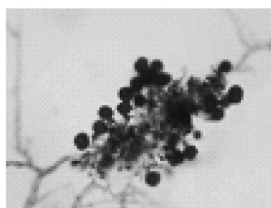
**Hyalohyphomycetes**

Hyalohyphomycetes are a large, heterogeneous group of fungi characterized by narrow, septate hyphae that are colorless on microscopic examination. This is a morphologically diverse group.



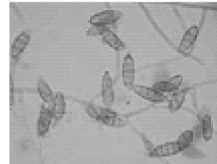
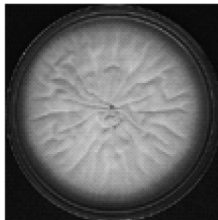
**Dematiaceous fungi**

Dematiaceous fungi are a large, heterogeneous group of fungi characterized by dark colonies grossly and pigmented fungal elements seen on microscopic examination of involved biopsy material.



### Dermatophytes

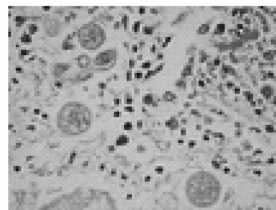
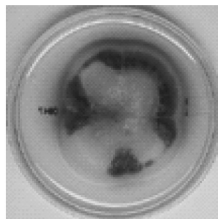
Fungi infecting stratum corneum, hair, and nails. Grossly, colonies often display fluffy or fine texture and are pale colored or white. Grow moderately rapidly to slowly and have narrow, septate hyphae.



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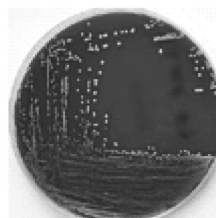
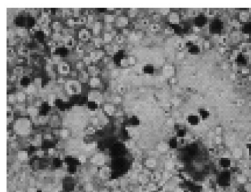
### Dimorphic fungi

Fungi that characteristically grow as a mold under certain environmental conditions (usually 25-30°C) and as a yeast under other conditions (usually at 35-37°C). Medically important dimorphic fungi can be highly pathogenic; special caution is warranted when handling fungal cultures largely because of the risk of culturing one of these organisms.



### Yeasts

Yeasts are unicellular fungi that reproduce by budding (with rare exceptions). Unlike many of the other fungi presented here, biochemical tests and carbohydrate or nitrate assimilation are disproportionately important for identification.



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#### INTEXT QUESTIONS 51.2

1. Disease caused by fungi are collectively called .....
2. Localised fungal infections are called as .....
3. Unicellular fungi that reproduce by budding are .....
4. Involvement of nasal cavity, paranasal sinuses with invasion to brain is called .....



#### WHAT HAVE YOU LEARNT

- Fungus is a member of eukaryotic organisms which includes yeasts and molds
- Scientific study of fungi is known as mycology
- Fungi feed by absorption of nutrients from environment
- Hyphae secrete digestive enzymes which break down the substrate and make it easier for fungus to absorb the nutrients
- Fungi vary widely in size & shape from unicellular microscopic organism to multicellular organism
- Spore size, shape & structure are used in the classification & identification of fungi
- Hyphae and other structures form mycelium
- Fungi reproduce sexually and asexually
- Fungi that produce asexual spores are Deuteromycetes (fungi imperfecti)
- Fungi are classified based upon hyphae, spores and reproduction
- Colony morphology is used to describe individual colonies of fungi
- Fungal infections are localised skin infections and systemic infections
- Mycoses are diseases caused by fungi



#### TERMINAL QUESTIONS

1. Describe the morphology of fungi
2. Explain the physiology of fungi
3. Classify fungi



## ANSWERS TO INTEXT QUESTIONS

### 51.1

1. Mycology
2. Absorption
3. Hypae
4. Deuteromycetes fungi imperfecti

### 51.2

1. Mycoses
2. Dermatomycoses
3. Yeast
4. Rhinoorbitocerebral mucormycosis

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