



CHARACTERISTICS OF FUNGI

Fungi are eukaryotic microorganisms that differ from bacteria and other prokaryotes in many ways.

They possess rigid cell walls containing Chitin,
Mannan and other

The cytoplasmic membrane contains sterols.

They possess true nuclei with nuclear membrane and paired chromosomes.

They divide asexually, sexually or by both processes.

They may be unicellular or multicellular.

Comparison of Fungi and Bacteria

Feature	Fungi	Bacteria	
Diameter	Approximately 4 μm (Candida)	Approximately 1 μm (Staphylococcus)	
Nucleus	Eukaryotic	Prokaryotic	
Cytoplasm	Mitochondria and endoplasmic reticulum present Mitochondria and endoplasmic reticulum absent		
Cell membrane	Sterols present	Sterols absent (except Mycoplasma)	
Cell wall content	Chitin	Peptidoglycan	
Spores	Sexual and asexual spores for reproduction	Endospores for survival, not for reproduction	
Thermal dimorphism	Yes (some)	No	
Metabolism	Require organic carbon; no obligate anaerobes	Many do not require organic carbon; many obligate anaerobes	

- From a diagnostic point of view, fungi may be classified depending on cell morphology into four groups
- Yeast
- Yeast-like fungi
- Moulds
- Dimorphic fungi

Yeasts (for example, Cryptococcus neoformans)

- Unicellular fungi
- Reproduce by budding (bud = blastospore/ blastoconidium)
- Macroscopic appearance pasty colonies(resembling bacterial colonies) in culture
- Microscopic appearance oval to round (3-15 μm in diameter); occur as spherical or oval forms in tissues and in culture; filamentous (hyphae-like) structures are not seen in tissues or in culture.

Yeast-like fungi (for example, Candida albicans)

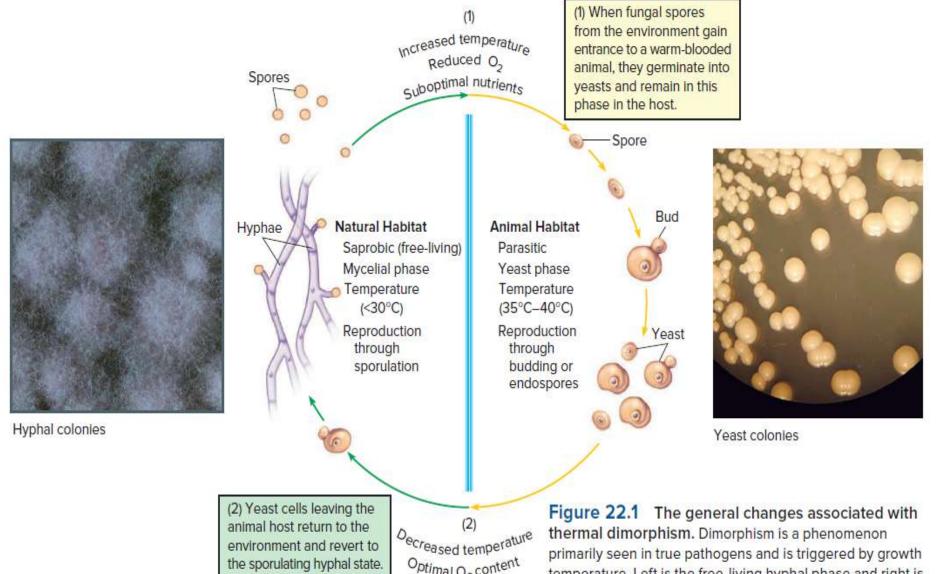
- Unicellular fungi
- Reproduce by budding and by fission
- Macroscopic appearance pasty colonies(resembling bacterial colonies) in culture
- Microscopic appearancespherical or oval forms in tissues and in culture; filamentous structures

Filamentous fungi or moulds (for example, Aspergillus fumigatus)

- Composed of hyphae which may have cross—walls or septa (multicellular) or may be devoid of septa (coenocytic).
- Reproduce by asexual means (spore formation); some exhibit sexual reproduction
- Macroscopic appearance-surface texture may be cottony/ woolly/ velvety/ granular
- Microscopic appearance-thread-like filamentous hyphae (2-10 µm) seen in tissues and in culture
- These may be aseptate (without cross-walls; for example, Zygomycetes) or septate (with cross-walls; for example, Aspergillus fumigatus).

Thermally dimorhic fungi (for example, Histoplasma capsulatum)

- Grow as filamentous forms in culture at 22-25°C (<30°C) and in the environment
- Grow as yeast forms in culture at 37 °C (35°C - 40°C) and in tissues



These conversions can be demonstrated on artificial media in the laboratory.

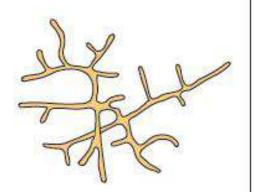
Optimal O2 content Improved nutrients

temperature. Left is the free-living hyphal phase and right is the parasitic yeast phase. Insets reveal the cultural appearance of these phases. (left); Source: James Gathany/CDC; (right): C Kathy Park Talaro

by growth form

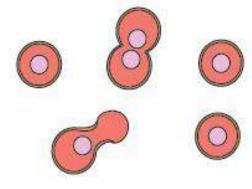
filamentous

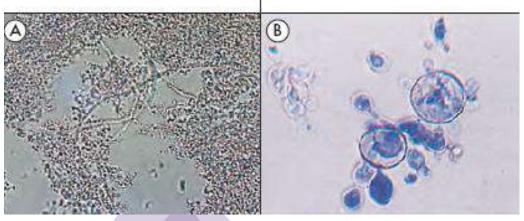
growing as multinucleate, branching hyphae, forming a mycelium

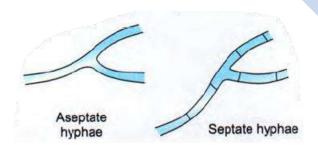


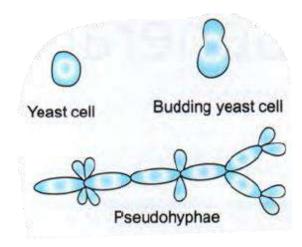
yeasts

growing as ovoid or spherical single cells multiply by budding and division









Systemic classification

The systematic classification of fungi, based on their sexual spore formation, recognizes four classes

- Phycomycetes
- Ascomycetes
- Basidiomycetes
- Fungi imperfecti

Systemic classification

Phycomycetes:

- Lower fungi that have non-septate hyphae and form endogenous asexual spores, called sporangiospores, contained within swollen sac-like structures called sporangia.
- Also produce sexual spores known as oospores in
 some fungi and zygospores in others.
 the other three classes (the higher fungi) have septate hyphae and form exogenous spores called conidia

Systemic classification

Ascomycetes:

- Form sexual spores (ascospores) within a sac or ascus.
- Include both yeasts and filamentous fungi.

Basidiomycetes:

• Form sexual spores (basidiospores) on a basidium or base.

Fungi imperfecti:

 Also called deuteromycetes or hyphomycetes, this is a provisional group consisting of fungi whose sexual phases have not been identified.

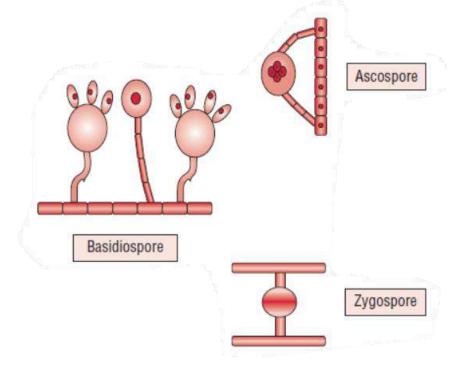
Cell wall and membrane components

- Fungal cell walls are composed largely of chitin, a polymer of N-acetylglucosamine, rather than peptidoglycan, which is a characteristic component of bacterial cell walls. Fungi are, therefore, unaffected by antibiotics (for example, penicillin) that inhibit peptidoglycan synthesis.
- The fungal membrane contains ergosterol rather than the cholesterol found in mammalian membranes.
- These chemical characteristics are useful in targeting chemotherapeutic agents against fungal infections.
- Many such agents interfere with fungal membrane synthesis or function. For example, amphotericin B and nystatin bind to ergosterol present in fungal cell membranes.
- There they form pores that disrupt membrane function, resulting in cell death.

Habitat and nutrition

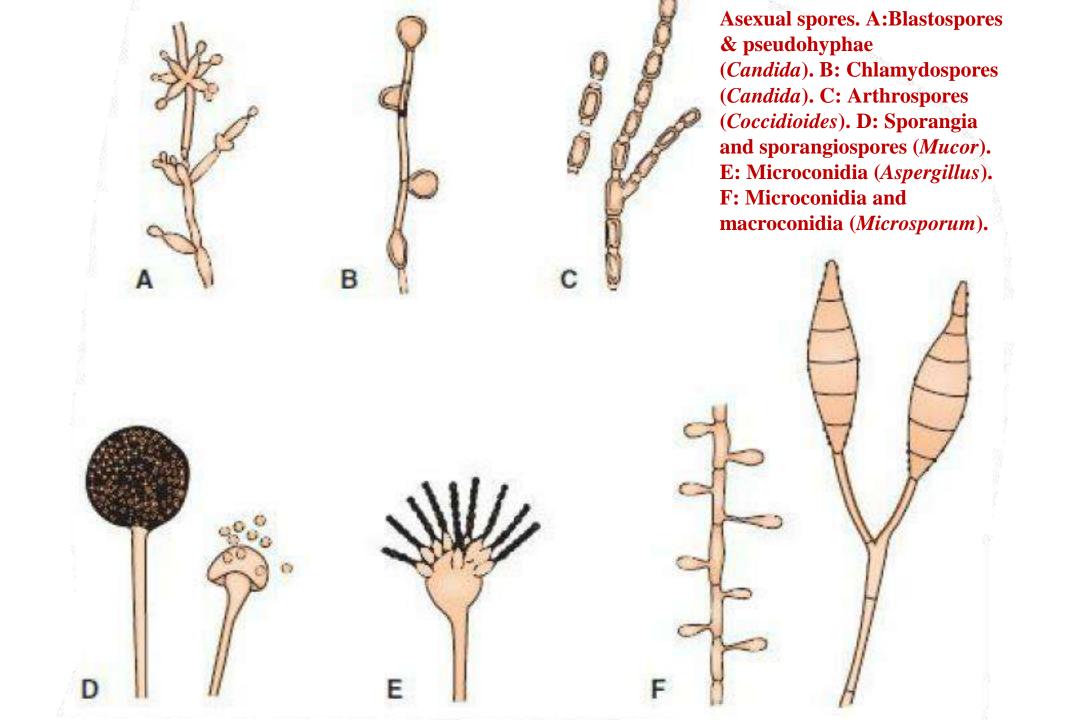
- All fungi are chemoheterotrophs, requiring some preformed organic carbon source for growth.
- Fungi do not ingest food particles as do organisms such as protozoa but depend upon transport of soluble nutrients across their cell membranes.
- To obtain these soluble nutrients, fungi secrete degradative enzymes (for example, cellulases, proteases, nucleases) into their immediate environment, which enable them to live saprophytically on organic waste.
- Therefore, the natural habitat of almost all fungi is soil or water containing decaying organic matter.
- Some fungi can be parasitic on living organisms. However, these parasitic infections usually originate from the individual's contact with fungus-contaminated soil, an exception being Candida, which is part of the normal human mucosal flora

Reproduction of Fungi



- Fungi can reproduce sexually by forming sexual spores and asexually by forming conidia or asexual spores.
- Sexual spores are of three types: zygospores, ascospores, and basidiospores
- Ascospores are formed in a sac called ascus, whereas basidiospores are formed outside on the tip of a pedestal called a basidium. Zygospores are single, large spores with thick wall. The fungi that do not produce sexual spores are called imperfect and are classified as Fungi imperfecti.

- Asexual spores are produced by mitosis.
- Fungi reproduce asexually by forming conidia.
- The shape, color, and arrangement of the conidia are helpful for identification of the fungi.
- Asexual spores can be vegetative or aerial spores as follows:
- Vegetative spores: These include
- (a) arthrospores
- (b) chlamydospores
- (c) blastospores.
- Aerial spores: These include
- (a) sporangiospores
- (b) conidiospores
- (c) microconidia, and
- (d) macroconidia



Human fungal diseases (mycoses) are classified by the location on or in the body where the

They are called cutaneous when limited to the epidermis, subcutaneous when the infection penetrates significantly beneath the skin, and systemic when the infection is deep within the body or disseminated to internal organs.

Systemic mycoses can be further divided into those that are caused by true pathogenic fungi capable of infecting healthy individuals and those that are opportunistic, infecting primarily those individuals who have predisposing conditions, such as immunodeficiency or debilitating diseases (for example, diabetes, leukemia, and Hodgkin and other lymphomas).

Fungi produce and secrete a variety of unusual metabolic products, some of which, when ingested, are highly toxic to animals, including humans.

Thus, fungi can cause poisoning as well as infection.

Lastly, fungal spores, which are critical for dispersal and transmission of the fungus, are also important as human allergenic agent

Important fungal diseases			
Туре	Anatomic location	Representative disease	Causative organisms
Superficial	Hair shaft, dead layer of skin	Pityriasis versicolor, tinea nigra, piedra	Trichosporon, Malassezia, Exophiala
Cutaneous	Epidermis, hair, nails	Tinea (ringworm)	Microsporum, Trichophyton, Epidermophyton
Subcutaneous	Dermis, subcutis	Sporotrichosis Mycetoma	Sporothrix several genera
Systemic	Internal organs	Coccidio ido mycosis Histoplas mosis Blastomycosis Paracoccio ido mycosis	Coccidioides Histoplasma Blastomyces Paracoccidioides
Opportunistic	Internal organs	Cryptococcosis Candidiasis Aspergillosis Pneumocystis pneumonia	Cryptococcus Candida Aspergillus Pneumocystis

Laboratory identification

- Most fungi can be propagated on any nutrient agar surface. The standard medium is Sabouraud dextrose agar, which, because of its low pH (5.0), inhibits bacterial growth while allowing fungal colonies to form
- Various antibacterial antibiotics can also be added to the medium to further inhibit bacterial colony formation.
- Cultures can be started from spores or hyphal fragments.
- Identification is usually based on the microscopic morphology of conidial structures.
- Clinical samples may be pus, blood, spinal fluid, sputum, tissue biopsies, or skin scrapings



Colonies of *Candida albicans* grown on Sabouraud dextrose agar.

Pathogenic fungi

TRUE PATHOGENS

Cutaneous infective agents

- Epidermophyton species
- Microsporum species
- Trichophyton species

Subcutaneous infective agents

- Actinomadura madurae
- Cladosporium
- Madurella grisea
- Phialophora
- Sporothrix schenckii

Systemic infective agents

- _ Blastomyces dermatitidis
- Coccidioides immitis
- Histoplasma capsulatum
- Paracoccidioides brasiliensis

OPPORTUNIȘTIC PATHOGENS

Pathogenic fungi

(continued)

OPPORTUNISTIC PATHOGENS

- Absidia corymbifera
- Aspergillus fumigatus
- _ Candida albicans
- Cryptococcus neoformans
- Pneumocystis jiroveci
- __ Rhizomucor pusillus
- Rhizopus oryzae (R. arrhizus)

CUTANEOUS (SUPERFICIAL) MYCOSES

- Also called dermatophytoses, these common diseases are caused by a group of related fungi, the dermatophytes.
- Dermatophytes fall into three genera, each with many species: Trichophyton, Epidermophyton, and Microsporum.

Pathology

- A defining characteristic of the dermatophytes is their ability to use keratin as a source of nutrition.
- This ability allows them to infect keratinized tissues and structures, such as skin, hair, and nails.
- Although all three genera attack the skin, Microsporum does not infect nails, and Epidermophyton does not infect hair.
- None invades underlying, nonkeratinized tissue
- Dermatophytoses are characterized by itching, scaling(outer layer of skin peels away in large pieces that resemble fish scales) skin patches that can become inflamed

- Tinea pedis ("athlete's foot"):
 Organisms most often
 isolated from infected tissue
 are Trichophyton rubrum, and
 Epidermophyton floccosum.
- The infected tissue is initially between the toes but can spread to the nails, which become yellow and brittle.
- Skin fissures can lead to secondary bacterial infections with consequent lymph node inflammation



Tinea pedis

- Tinea corporis ("ringworm"): Organisms most often isolated are Epidermophyton, Trichophyton and Microsporum.
- Lesions appear as advancing rings with scaly centers
- The periphery of the ring, which is the site of active fungal growth, is usually inflamed and vesiculated.
- Although any site on the body can be affected, lesions most often occur on non hairy areas of the trunk.



Tinea corporis ("ringworm")

- Tinea capitis ("scalp ringworm"): Several species of Trichophyton and Microsporum have been isolated from scalp ringworm lesions,.
- Disease manifestations range from small, scaling patches, to involvement of the entire scalp with extensive hair loss
- The hair shafts can become invaded by Microsporum hyphae, as demonstrated by their green fluorescence in long-wave ultraviolet light
- Tinea unguium (onychomycosis):
 The causative organism is most often
 T. rubrum. Nails thicken and become discolored and brittle.
- Treatment must continue for 3 to 4 months until all infected portions of the nail have grown out and are trimmed off



Tinea capitis ("scalp ringworm")



Tinea unguium

SUBCUTANEOUS MYCOSES

Subcutaneous mycoses are fungal infections of the dermis, subcutaneous tissue, and bone. Causative organisms reside in the soil and decaying or live vegetation. Subcutaneous fungal infections are almost always acquired through traumatic lacerations or puncture wounds.

Sporotrichosis, for example, is often acquired from the prick of a thorn.

As expected, these infections are more common in individuals who have frequent contact with soil and vegetation and wear inadequate protective clothing. The subcutaneous mycoses are not transmissible from human to human.

Sporotrichosis:

- This infection, characterized by a granulomatous ulcer at the puncture site, may produce secondary lesions along the draining lymphatics
- The causative organism, Sporothrix schenckii, is a dimorphic fungus that exhibits the yeast form in infected tissue and the mycelial form upon laboratory culture.
- In most patients, the disease is self-limiting but may persist in a chronic form.
- Dissemination to distant sites is possible in patients with deficiencies in T-cell function (such as in AIDS and lymphomas).



A primary sore is accompanied by a series of nodules and ulcers running along the lymphatic channels of the arm

- Mycetoma ("Madura foot"): Mycetoma appears as a localized abscess, usually on the feet, but is not limited to the lower extremity
- The abscess discharges pus, serum, and blood through sinuses (in this usage, sinus means "abnormal channel").
- The infection can spread to the underlying bone and results in crippling deformities.
- The pathogenic agents are various soil fungi.
- Most common are Madurella and Exophiala species
- Defining characteristic of mycetoma is the presence of colored grains, composed of compacted hyphae, in the exudate.
- The color of the grains (black, white, red, or yellow) is characteristic of the causative organism and, therefore, useful in identifying the particular pathogen.



Mycetoma

