

Biology 3B Laboratory

Fungal Diversity

Objectives

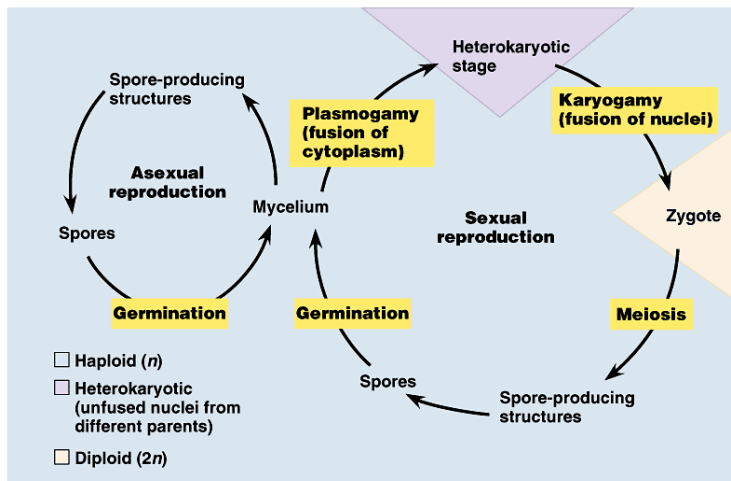
- To describe the general characteristics of the phyla in the kingdom Fungi
- To learn the anatomy, life cycle and identification of representative fungal organisms
- To discuss the ecological role and economic importance of fungi

Introduction

The kingdom Fungi is one of four kingdoms in the domain Eukarya. This kingdom consists of over 70,000 identified species with estimates over 1.5 million fungal species. This kingdom consists of a diverse group of organisms that range from unicellular (yeasts) to multicellular (most) organisms. Fungi are economically and ecologically important. Economically fungi are beneficial in that they are used to produce various food items (leaven bread, cheeses etc.), medicines, beverages, etc. Some fungi are parasitic on plants and animals. Numerous fungi have even cause widespread famine or diseases as a result of infestations (potato famine, ergotism).

All members are **heterotrophic**, where many obtain their nutrients by releasing **exoenzymes** into their surrounding environment to breakdown “food items” outside the body and then absorbing the nutrients into their cells. Fungi that feed on dead organic material are referred to as **saprobies** and comprise one of the principal decomposers on Earth. Parasitic fungi that found on other living organisms have specialized structures called **haustoria** (haustorium – singular) to penetrate the host organism for nutrient absorption. There are still other fungi that form a mutualistic relationship with another organism while a few are even predators of nematode worms.

Although fungi were once classified with plants, fungi have several major differences from plants. As mentioned before, fungi are heterotrophic. Like plants, all fungi have cells walls, however fungal cell walls are composed of **chitin** instead of cellulose. Fungal bodies (vegetative) are composed of long slender filaments called **hypha** (hyphae – plural) which form more complex structure when compacted together. In most fungi, the hyphae form a tangled mass called a **mycelium** (mycelia – plural). These hyphae can be completely separated by **septa** (septum – singular), or incompletely separated thus allowing for communication between adjacent filaments. As a result of this incomplete separation, this is why most fungi grow very rapidly when there is ample water and nutrients present. Some fungi have no separations at all (aseptate) and thus are multinucleated (**coenocytic**).



Fungi can reproduce both sexually and asexually (Figure 1). In either case, haploid **spores** are produced. When these spores land on a suitable substrate, they germinate (divide via mitosis) into a mature haploid organism. During asexual reproduction, reproductive structures such as **sporangia** and **conidia** produce **spores** via mitosis. Two other forms of asexual reproduction include budding, as seen in the imperfect fungi (i.e. yeasts) and by fragmentation of the hyphae.

Figure 1: Generalized fungal lifecycle

There are three distinct phases in sexual

reproduction: **haploid, diploid** and the **heterokaryotic (dikaryotic)** phase. Gamete producing cells (**gametangium/gametangia**) in the haploid organism produces haploid gametes via mitosis. Gametes from different organisms then fuse forming a diploid zygote that undergoes meiosis to form haploid spores. When these spores land on a suitable substrate, they germinate forming the mature haploid organism, beginning the process again.

Scientists that study fungi are called mycologists. They have separated the kingdom Fungi into four distinct phyla and one non-taxonomic group. These are:

Part A: Phylum Chytridiomycota – chytrids

This phylum includes about 790 aquatic species that are commonly called chytrids. Many chytrids are either saprobes or parasites. Members in this phylum were once excluded from being classified as fungi because of flagellated zoospores. However more recent molecular data supports classifying chytrids as a primitive fungus instead of with fungus-like protists. Chytrids have cell walls composed of chitin like other fungi. They also utilize similar enzymes and metabolic pathways as other fungal groups. It has even been hypothesized that chytrids may be the link between protists and fungi

- Examine chytrids if available

Part B: Phylum Zygomycota – Zygote fungi (zygomycetes)

There are approximately 600 species of zygote fungi categorized in this group due to the resting sexual spores called **zygospores**. Most zygomycetes are terrestrial, found living in the soil or are saprobic on decaying plant/animal matter. Zygomycetes that have mutualistic relationships with plant roots are often referred to as **mycorrhizae**.

Rhizopus stolonifer is the black bread mold that most are familiar with. Their hyphae have modifications called **rhizoids** that penetrate the substrate. Hyphae are connected via structures called **stolons**. Hyphae filaments that become upright are called **sporangiophores** (asexual) that terminates at the **columella**. Surrounding the columella is the **sporangium** (sporangia – plural) that produces the asexual haploid spores.

R. stolonifer is **heterothallic**, possessing opposite strains (+ or –), and can reproduce sexually when conditions become less ideal. This requires that (+) and (–) hyphae fuse (see Figure 31.7 in Campbell and Reece). Then hormones cause these hyphae to develop gametangia which will become separated from the fungal body. The nuclei fuse, forming a diploid zygote that develops into the **zygospore**. The zygospore is protected by the thick-walled **zygosporangium** that is resistant to harsh conditions (desiccation, temperature, etc.). When the zygosporangium matures, a sporangium germinates from the zygospore. It is during this time when spores are produced via meiosis and released into the surrounding environment.

- Be able to identify and the know the functions of the following on live and prepared slides:
 - Rhizoids, stolons, hyphae, columella, sporangiophore, sporangium, gametangia, zygospore, zygosporangium
 - Know the portion of the lifecycle (n, 2n) the particular structure is from

Part C: Phylum Ascomycota – Sac fungi (ascomycetes)

There are over 60,000 described species of sac fungi that range in size from unicellular yeasts to cup fungi, morels and truffles. Sac fungi can be found in a variety of habitats from terrestrial to both freshwater and marine environments. More than half of the sac fungi species form a mutualistic relationship typically with a green algae called **lichens**. Others fungi may form mycorrhizae associations with plant roots. Still many other sac fungi are saprobes and pathogens on plants.

Sac fungi are named for the sac-shaped sexual reproductive structure called an **ascus** (asci – plural). The collection of the numerous asci form the fruiting body called the **ascocarp**. There are three different types of ascocarps: the cup-like **apothecium**, the flask-like **perithecium** and the closed **cleistothecium**.

The sexual lifecycle (see Figure 31.10 in Campbell and Reece) begins when haploid mycelia of different mating types (+ and – strains) meet, form swellings that fuse becoming the ascogonium and antheridium. The nuclei from the antheridium cross over to the ascogonium which then produces dikaryotic hyphae. It is the dikaryotic hyphae that develop into the **ascocarp**, fruiting body. Karyokinesis occurs resulting in a diploid nucleus that undergoes meiosis producing four haploid nuclei. Each haploid nucleus then divides by mitosis resulting in eight haploid nuclei that are contained with an ascus. When the cell walls develop around each nucleus, they are now called **ascospores**. Mature ascospores will give rise to new haploid mycelia upon release from asci.

Asexual reproduction in sac fungi occurs in structures called **conidia**. The bead-like conidia are supported by **conidiophores**, which are essentially modified hyphae. Yeasts are also classified as ascomycetes, however are single-celled and reproduce by **budding**. Yeasts can also reproduce sexually, producing four or eight ascospores in each asci.

- Be able to identify and the know the functions of the following on live and prepared slides:
 - Ascus, ascospores, ascocarp, apothecium, perithecium, cleistothecium, conidium, conidiophore
- *Claviceps purpurea* - this species causes purple ergot on rye. If consumed, can cause ergotism with symptoms ranging from hallucinations, spasms and gangrene. The hallucinogen that you may be familiar with is lysergic acid which is used to produce LSD.
 - Be able to identify: asci, perithecium, ascospores and species
- *Pezizia* – this species can be found on decaying straw or wood, manure and even on burnt soils. Some species have brilliantly colored ascocarps.
 - Ascus, ascospores, ascocarp, apothecia,
- *Penicillium* – are often grouped in the non-taxonomic Deuteromycota, the imperfect fungi because sexual reproduction has not been determined. They are included with ascomycetes because of their asexual reproductive structures: conidia and conidiophores. Once the sexual cycle has been determined, they may be move. Members in this genus are of economic importance in that some species produce mycotoxins, are used to ripen certain cheese (Roquefort, Stilton, brie, etc.) and produce penicillin.
 - Species, conidia, conidiophore, economic value

- *Aspergillus* – is another genus that may be lumped with other deuteromycetes, but are believed to be with other ascomycetes. Members in this genus are of economic importance as various species are used to produce many food and consumer products such as: soy sauce, miso, chewing gum, etc. Other species can produce deadly aflatoxins which could cause liver cancer. Aflatoxins are of concern in the improper storage of grains (corn, wheat, etc.) and peanuts.
 - Species, conidia, conidiophore, economic value
- *Saccharomyces* – an unicellular ascomycetes that is of important economic value to the alcohol industry. Varieties of this species are naturally found on grape and may provide the unique flavor for particular wines.
 - Species, identification, economic value

Part D: Phylum Basidiomycota – Club fungi

There are approximately 25,000 club fungi that have been identified. This group is the most recognizable as they include: edible and inedible mushrooms, shelf fungi, puffballs and rusts. Many are important as food, while others are important decomposers and some are parasites. The group derives its name from the club shaped spore producing structure called **basidium** (basidia – plural).

Asexual reproduction is rarely seen in members in this group, but that does not mean that it does not occur. Basidiomycetes reproduce primarily by sexual reproduction which begins when two opposite, haploid strains forming a dikaryotic mycelium. This mycelium develops quickly into **basidiocarps** in response to environmental cues. Beneath the **annulus**, the basidiocarp's **gills** are lined with basidia. Karyokinesis of the nuclei results in the diploid zygote formation which undergoes meiosis and produces four haploid nuclei in each basidia. Each haploid nuclei then enters the appendages that grow out from the basidium. When released, the mature **basidiospores** are wind dispersed. Basidiospores then germinates into the short lived haploid mycelia.

- Be able to identify and the know the functions of the following on live and prepared slides:
- *Coprinus* slide -
 - Basidiocarp, basidia, basidiospore, gills
- Fresh mushroom (*Agaricus spp*) – the common button mushroom that's cultivated for markets.
 - Basidiocarp, basidia, basidiospores, gills, pileus, stipe
- *Puccinia graminis* – a parasitic fungus known as wheat rust. This rust species is **heteroecious** that requires two hosts to complete its lifecycle, wheat and barberry. As you observed prepared slides of *Puccinia*. Uninucleated basidiospores infect barberry leaves during the spring and then develop into a flasked-shaped spermogonium. Observe the **aecia**, which produce the **aeciospores** on barberry leaves. The aeciospores then disperse to infect wheat. On wheat, the rust colored streaks, hence the name rusts, are the **uredinia** that contain the dikaryotic **uredinospores**. Uredinia changes to a black color during the fall and winter and become **telia** with **teliospores**, the over-wintering spores. During the spring, basidia develop producing basidiospores that are wind dispersed to reinfect barberry leaves.
 - Identify: aecia, aeciospore, uredinia, urediniospore, telia, teliospore, barberry or wheat

Part E: Deuteromycota – Imperfect fungi (deuteromycetes)

Deuteromycota is a non-taxonomic category that includes molds and yeasts. Members in this grouping reproduce asexually. When a sexual cycle is identified, then that species is moved into one of the other three taxonomic phyla. Many *Penicillium* and *Aspergillus* species are grouped here, while others are in grouped with ascomycetes. This group is important in that many members contribute to human diseases such as: athlete's foot, ringworm and yeast infections. Beneficial species are important in the production of food items and medicines (antibiotics).

- *Saccharomyces*
- *Candida albicans* – normal yeast inhabitant on moist epithelial tissue found in such places as: the mouth and vagina. Changes in pH or compromised immune systems can result in “yeast” infections or “thrush”.
- *Rhodotorula* pink yeast growing on moist surfaces

Part F: Symbiotic Fungi

- Lichens are a symbiotic relationship primarily between an ascomycetes fungus and a green algae. Both rely on the other for providing something that the other could not obtain alone. The main body mass is fungal and called the **thallus**. Lichens have one of three different types: **foliose** or leafy thallus, **crustose** or crust-like thallus and **fruticose** or branching, cylindrical thallus. Lichens can be found in a variety of environments withstanding harsh environments. As a result, many lichens are often pioneer species that helps to reestablish burned areas or newly formed areas such as volcanic rock.
 - Observe the different types of lichens
- Mycorrhizae are a symbiotic relationship between fungi and plant roots. The fungal component increases the plants ability to absorb minerals thus increasing plant growth. Plant