08 Fungi

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📖 Reading: Chapter 31 in Campbell.

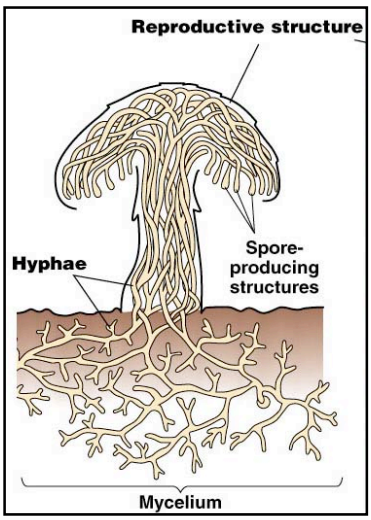
By the time you complete this lab, you should:

- Understand fungal body plans, including mycelia, hyphae, and yeasts.
- Understand the general characteristics of fungal life cycles, including the heterokaryotic stage.
- Be able to recognize fungi in a wide variety of forms.
- Compare and contrast the fungi with plants and animals in terms of body plan and life cycle.

FUNGAL BASICS

CELL FEATURES:	• Eukaryotes. • Often more than one nucleus per cell. • Nuclei are haploid for most of the life cycle; when diploid nuclei are formed, they immediately undergo meiosis to make more haploid nuclei. • Cell wall present, made of chitin. • Long, thin hyphae or roundish cells (yeasts).
BODY PLAN:	• Usually multicellular (except for the unicellular yeasts). Little or no differentiation other than reproductive cells.
MODE OF NUTRITION:	• Heterotrophs; often use extracellular digestion; may consume dead material or be parasites or predators.

Fungi are among our closest relatives outside the animal kingdom. Like animals, they are heterotrophs. Their bodies are specialized for absorbing their food, and, like animals, they do much of their digestion outside their bodies. They secrete enzymes outside their cells to break down food so it can be absorbed. However, unlike animals, they don't swim, walk, or fly to find their food. Fungi move into new food sources by growing or by the passive dispersal of nonmotile spores. The basic body design of fungi is simple, but highly functional: it's all about absorbing food molecules from the environment.



Like plants, fungi have cell walls. However, the cell wall material of fungi is completely different from that of plants. Fungi have cell walls made of **chitin**, the same tough polysaccharide that makes up insect exoskeletons. Plants have cell walls made of cellulose, a different polysaccharide.

Multicellular fungi are typically composed of long, thin filaments called **hyphae**; the whole body of many hyphae is called a **mycelium**. Multicellular fungi are always composed of hyphae; even mushrooms, which are the reproductive structures of underground fungi, are composed of these threadlike filaments of cells. Fungal mycelia have enormous surface area for absorption. Also, the hyphae can rapidly grow through soil as they move toward new food sources.

Some fungi are unicellular; these are called **yeasts**. Yeasts are described in more detail below.

SYSTEMATICS OF FUNGI

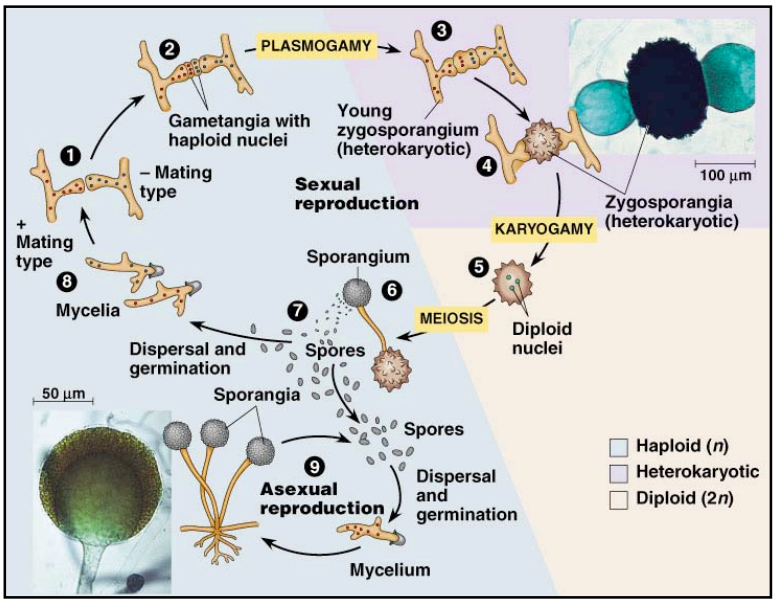
There are four main phyla of fungi:

- **Chytridiomycota.** These unusual aquatic (and sometimes parasitic) fungi are the only fungi with flagellated reproductive cells. We don't have any examples in lab.
- **Zygomycota.** Common molds such as *Rhizopus*, the black bread mold.
- **Ascomycota.** Sac or cup fungi, so called for the saclike form of their reproductive structures. This group includes some edible fungi such as truffles and morels.
- **Basidiomycota.** Club fungi, including most common mushrooms and some others such as the woody shelf fungi that form on trees.

In practice, it's often hard to distinguish the different groups if you're not looking at their reproductive structures. In fact, even experts have been unable to classify certain fungi in which reproductive structures have not been observed. For that reason, **you don't need to remember the names of the phyla of fungi for the lab test!**

THE LIFE CYCLES OF FUNGI

Fungal life cycles are similar to the life cycles of other eukaryotes: a haploid stage is created by meiosis, and two different haploid individuals join together to make a diploid individual. However, most fungi have one key life cycle stage that is unusual: they form a **heterokaryotic** stage, which has two genetically different haploid nuclei living in the same cell. An example of a fungal life cycle is shown by the common bread mold *Rhizopus*:



1) The haploid cells that fuse together are not gametes, they're just part of the regular mycelium.
2) Hyphae of different mating types (there are no males and females in most fungi) join together and form gametangia, each with several haploid nuclei. This fusion is called **plasmogamy**.
3) The gametangia fuse, creating a heterokaryotic stage: a cell that has two different types of haploid nuclei (one from each parent fungal mycelium).
4) This heterokaryotic stage forms a tough outer wall and can remain dormant for a long time.
5) When conditions are favorable, pairs of haploid nuclei fuse, forming diploid nuclei. The fusion of these nuclei is called **karyogamy**.
6) These diploid nuclei immediately undergo meiosis, creating haploid spores.

7) The spores can then grow into new haploid mycelia.

8) Some of these mycelia undergo sexual reproduction.

9) Some of the mycelia undergo asexual reproduction, making new spores by mitosis.

Notice the distinctive features of this life cycle:

- **There's no fertilization**, in which an egg and a sperm join together. Instead, two haploid hyphae join together. They join in two stages. First, there is **plasmogamy**, in which the membranes of the two cells fuse. This creates a **heterokaryotic** cell, with two different kinds of haploid nuclei – one from each parent. The heterokaryotic stage may have multiple nuclei, or just two. The heterokaryotic stage may be short-lived and small, as in *Rhizopus*, or it may be larger and longer-lived, as in mushrooms. Eventually, two different haploid nuclei in the heterokaryotic stage fuse, creating a diploid nucleus. The fusion of the nuclei is called **karyogamy**. (In animals, fertilization consists of fusion of an egg cell and a sperm cell, followed by fusion of their nuclei. The term heterokaryotic is not used for animal life cycles, but there is a brief moment, just before egg and sperm nuclei fuse, in which there is a cell with two genetically different haploid nuclei.)
- **The diploid stage is only a single cell** (the zygote), which then undergoes meiosis to return to the haploid state.

LIFESTYLES OF THE FUNGI

It's not easy to recognize taxonomic group a fungus belongs to just by looking at the mycelium. All the groups can have similar-looking mycelia, and the only identifying characteristics are usually the reproductive stages, which aren't always present. For that reason, fungi are also categorized in terms of their general appearance. Most fungi, regardless of taxonomic relationships, can be categorized as molds, yeasts, or lichens. Another important category is mushrooms, the reproductive structures of basidiomycetes.

MOLDS

"Mold" simply refers to a rapidly-reproducing fungus with a body made of hyphae. Molds crank out huge numbers of spores.

- **Observe the prepared slides of *Rhizopus* mycelium and conjugation.** Compare this to the diagrams in Campbell. Note that there are spores produced by meiosis (as in a plant) and asexual spores that are produced by mitosis. Why is this significant for the organism?
- **Observe the prepared slides of *Penicillium* conidiophores.** This slide shows growth and reproductive phases of a common mold, grown on an orange peel. You should be able to discern the difference between the plant cells (orange peel) and the fungal hyphae.
- **Observe the prepared slides of *Aspergillus* conidiophores.** *Aspergillus* is an ascomycete. Compare this slide to the life cycle of *Neurospora* (p. 617 in Campbell). The conidiophores produce conidia, which are similar to asexual spores. Conidia can either germinate to form new haploid mycelia or they can fuse to specialized hyphae to perform plasmogamy.
- **Observe the fresh specimens of mold in rotting wood.** Note how the fungal hyphae penetrate into the wood. Fungi can secrete digestive enzymes to break down organic material so it can be absorbed.

- **Observe the fresh specimens of mold on an old leaf.** The mycelium is composed of densely packed hyphae.

YEASTS

Yeasts are the fungi whose bodies aren't made of hyphae. Yeasts are unicellular; their cells are usually round or football-shaped. They produce large numbers of new cells by mitosis, and only occasionally undergo sexual reproduction.

The most familiar yeasts are those that are used in making bread and beer or wine, especially the genus *Saccharomyces*.

- **Observe the live *Saccharomyces* yeast.** Put some on a microscope slide, put a cover slip on top, and look at them under the microscope. Can you tell that they are eukaryotes?
- **Observe prepared slides of the yeast *Saccharomyces*.** This is the same species as the live specimens, stained with methylene blue.

Some other yeasts are less helpful for people. For example, *Candida albicans* is a yeast that commonly grows on and in the human body. Usually, it isn't harmful, but under certain conditions it can begin to multiply rapidly in the body, causing disease.

LICHENS

A lichen is two organisms living together: a fungus and a photosynthetic protist (alga) or cyanobacteria. Each partner in this symbiosis is dependent on the other. The alga produces sugars while the fungus provides a protective environment and absorbs nutrients that can be used by the alga.

- **Observe the prepared slides of lichens.** Can you identify the cells of the algae and the fungus?
- **Observe the whole lichens.** How would you know that this isn't a plant or an alga?

MUSHROOMS & CUP FUNGI

Mushrooms are the reproductive structures of the Basidiomycota, and cup fungi are the reproductive structures of the Ascomycota. Both these reproductive structures grow from moldlike mycelia.

- **Observe the fresh mushrooms.** Look at the whole mushroom and look at a thin slice on a microscope slide. Where would you find dikaryotic cells? Diploid cells? Haploid cells? Look for spores forming on the gills of the mushroom. Compare the specimen to the diagram on p. 619 in Campbell.
- **Observe the prepared slides of "*Coprinus* entire pileus."** This is a cross-section of a whole mushroom. Note the spores and the hyphae. Compare this slide to the whole mushroom.
- **Observe the prepared slides of "*Peziza* cup with asci."** This is a cross-section of a whole mushroom. Note the spores and the hyphae.

MYCORRHIZAE

Mycorrhizae are fungi that live in symbiotic associations with plant roots.

- **Observe the fresh and preserved mycorrhizae and plant roots.** Can you identify the cells of the plant and the fungus?

- **Observe the prepared slides of mycorrhizae.** Can you identify the cells of the plant and the fungus? Note that some of the fungal hyphae grow around the outside of the root (ectomycorrhizae), while some penetrate into the interior, even growing inside the plant cells (endomycorrhizae).

STUDY QUESTIONS

You don't need to turn in answers to these questions. However, you may want to think about them to help you prepare for the next lab exam.

1. The terms **plasmogamy** and **karyogamy** are introduced in this lab. Why are these terms used only for the fungi? Do other groups of organisms have similar events?
2. This lab includes two examples of symbiotic interactions involving fungi. What are they? In what way are the fungi particularly suited to these kinds of symbioses?
3. What part of a plant life cycle does a mushroom correspond to? Explain in terms of both similarities and differences.
4. Compare and contrast the life cycle of a fungus with the life cycle of an animal.
5. Compare and contrast the life cycle of a fungus with the life cycle of a moss.
6. How is the fungal body plan, with hyphae, suited to heterotrophy?
7. Compare & contrast the role of spores in fungi and in plants.
8. Suppose your instructor wanted to have examples of haploid, heterokaryotic, and diploid structures of fungi on the lab exam. What specimens could he use?

TERMS & CONCEPTS TO REMEMBER

- Absorption & digestion
- Cell wall
- Chitin
- Heterotroph
- Heterokaryotic
- Hyphae
- Karyogamy
- Lichen
- Life cycle: Haploid, Diploid, Heterokaryotic. Where & when meiosis happens.
- Mold
- Mushroom
- Mycorrhizae
- Mycelium
- Plasmogamy
- *Rhizopus*
- *Saccharomyces*
- Sexual & asexual reproduction
- Spore
- Yeast