Fungi

Objective: After completing this exercise, you should be able to do the following:

- Describe the ecological importance of fungi.
- Describe the life cycle of the Zygomycetes, Ascomycota and Basidiomycota lineages.
- Identify structures associated with both asexual and sexual reproduction of the Zygomycetes, Ascomycota and Basidiomycota lineages.
- Identify example specimens from the Zygomycetes, Ascomycota and Basidiomycota lineages.
- Identify key morphological features of example specimens from the Zygomycetes, Ascomycota and Basidiomycota lineages.

Introduction

Fungi include a diverse group of organisms that play important economic and ecological roles. A *Penicillium* species is used to produce antibiotics. *Saccharomyces* yeast, a unicellular fungus, is used in the production of wine, beer, and leavened bread. Fungi are also a source of food in many cultures, with truffles being the most expensive. The dark green areas seen in Roquefort cheese are patches of the mold *Penicillium roqueforti* growing in cow’s milk.

In ecosystems, fungi share with bacteria the essential role of decomposition, returning to the ecosystem the matter trapped in dead organisms. Fungi that make their living by digesting dead plant material are called **saprophytes**.

Although many fungi are beneficial, others play destructive roles in nature. Some species parasitize animals and plants. Athlete’s foot and ringworm are diseases commonly known to humans. Histoplasmosis is a respiratory disease in humans caused by a fungus found in soil and in bat and bird droppings. Wheat rust, potato late blight, and sudden oak death are plant diseases caused by fungi. The ergot fungus that parasitizes rye causes convulsive ergotism in humans who eat bread made with infested grains.

The destructive behavior of fungi was dramatically demonstrated following Hurricane Katrina in August 2005. Weeks after the hurricane, many homes, hospitals, and businesses remained flooded, promoting heavy growth of fungi. Molds and mildew of varied species covered walls, ceilings, and building contents, and spores filled air-conditioning and ventilation systems. By November many New Orleans were suffering from the “Katrina cough”, respiratory problems associated with infection by fungus spores.

Fungi and Animals are closely related because they both belong to the major eukaryotic lineage known as the **Opisthokonta**. This group has reproductive cells bearing a single posterior flagellum. This fact puts the Opsithokonts in the **Unikonta** lineage of eukaryotes (figure 1).
Figure 1. The Unikonta Lineage of Eukaryotic organisms

The Fungi lineage contains unicellular (yeast) and multicellular, heterotrophic organisms that obtain their nutrients by absorption. As saprobes, they secrete digestive enzymes outside their bodies and absorb the resulting nutrient products into their cells. They often have complex life cycles with alternating sexual and asexual (vegetative) reproduction. They may produce spores either asexually by mitosis or sexually by meiosis.

Fungal cell walls are made of chitin combined with other complex carbohydrates, including cellulose. You may recall that chitin is the main component of insect exoskeletons. Multicellular fungi are made up of thread-like individual filaments, called hyphae, which are organized into the body of the fungus, called the mycelium.

In this exercise, you will learn about the structure of typical fungi and the characteristics of three key lineages of fungi: the Zygomycetes, Ascomycota, and Basidiomycota (figure 2). As you observe these examples, consider interesting questions that might be asked about fungi diversity or ecology. You will use one of these questions to design a simple experiment.
Figure 2: Phylogeny of fungi based on analyses of DNA sequence data.

A. ZYGOMYCETES

One common organism in the Zygomyces is the common bread mold, *Rhizopus stolonifer*. *R. stolonifer* hyphae grow over a substrate, for example a slice of bread, giving the bread a fuzzy appearance. The cells of the hyphae are haploid. In asexual reproduction, certain hyphae grow upright and form a stalk (sporangiophore) that produce sporangia, round structures, on the tips. Mitosis in the sporangia result in haploid spores that, when mature, are dispersed through the air. If they fall onto a suitable medium, they will germinate and grow into a new mycelium.
Rhizopus also reproduces sexually when compatible mating types (designated as (+) and (-)) grow side by side. In this case (+) and (-) hyphae produce extensions called gametangia that fuse (plasmogamy) forming a zygosporangium. Within the zygosporangium, haploid nuclei fuse (karyogamy) producing a diploid nucleus. The diploid nucleus then undergoes meiosis producing haploid spores (figure 3).

![Rhizopus Life Cycle Diagram]

**Procedure:**
1. Refer to pages 24 and 25 in your photo atlas as you work through this exercise.

2. Obtain a sample of living Rhizopus. Use a zoom stereo microscope and light source to observe your sample.

3. **Draw and label the following terms in your notebook.**
   
   a. Mycelium, hypha, sporangium

4. Review the life cycle of Rhizopus in figure 3. Locate the structures in this figure that are visible in your culture.
5. Draw the life cycle into your notebook and circle the structures involved in asexual reproduction

6. Using forceps and aseptic technique remove a small portion of the mycelium with several sporangia of your sample and prepare a wet mount.

7. Draw and label the following terms in your notebook.
   a. Mycelium, hypha, sporangium, spores

8. Complete the Comparison of Fungi by Major Features summary table for the Zygomycetes and attach it to your notebook.

B. ASCOMYCOTA

Fungi in the lineage Ascomycota are called cup fungi, or ascopore-producing fungi. This group includes edible fungi, morels and truffles, but it also includes several deadly plant and animal parasites. For example, chestnut blight and Dutch elm disease have devastated native populations of chestnut and American elm trees. Another sac fungus, Aspergillus flavus, is a contaminant of stored nuts and grains. This fungus produces aflatoxin, the most potent known natural carcinogen.

When present, sexual reproduction in the Ascomycota fungi begins with the production of haploid ascospores via meiosis in an ascus. Asci form within a structure called an ascocarp. In asexual reproduction, spores are produced, but rather than being enclosed within a sporangium as in Zygomycete fungi, the spores, called conidia, are produced on the surface of special reproductive hyphae called conidiophores (figure 4).
Figure 4. Life cycle of the Ascomycota

Other features of sac fungi vary. For example, yeasts are ascomycetes, yet they are unicellular organisms. Yeasts most frequently reproduce asexually by budding, a process in which small cells form by growing off the parent cell. When they reproduce sexually, however, they produce asci, each of which produces four or eight ascospores.

In this exercise you will examine a slide of the sac fungi Peziza and observe demonstrations of additional examples of Ascomycota, including Penicillium growing in Roquefort cheese.

Procedure:
1. Refer to pages 26, 27 and 31 in your photo atlas as you work through this exercise.

2. Obtain a dried or preserved specimen of ascomycetes. Using a stereoscopic microscope observe this specimen. Notice the open, cup-shaped ascocarp, that bears asci within the cup (not visible to the naked eye).

3. **Draw and label the ascocarps in your notebook.**

4. Obtain a prepared slide of Peziza. Using a compound microscope observe the ascocarp, asci, spores, hyphae, and mycelium.

5. **Draw and label the following terms in your notebook. Be sure to include the correct number of ascospores in each ascus.**
a. *Ascocarp, asci, spores, hyphae, mycelium*

6. Obtain a prepared slide of *Penicillium*. Using a compound microscope observe conidiophores, conidia, and mycelium.

7. **Draw and label the following terms in your notebook**
   
a. *Conidiophores, conidia, mycelium*

8. **Complete the Comparison of Fungi by Major Features summary table for the Ascomycota.**

**C. BASIDIOMYCOTA**

The lineage Basidiomycota also called **club fungi** includes the fungi that cause the plant disease wheat rust and corn smut as well as the more familiar puffballs, shelf fungi, edible and non-edible mushrooms. A mushroom is actually a reproductive structure called a **basidiocarp** that produces **spores** via meiosis of a special cell called a **basidium**. Basidiocarps grow upward from an underground **mycelium**. In asexual reproduction, **conidia** form by mitosis.
Figure 5: Basidiomycota life cycle

**Procedure:**

9. Refer to pages 28 and 29 in your photo atlas as you work through this exercise.

10. Obtain a fresh mushroom, a **basidiocarp**, and identify the **stipe** (stalk), **pileus** (cap) and **gills**. Spores form on the surface of the gills. Observe the gills using a zoom stereo microscope.

11. **Draw and label the following terms in your notebook**
   
   a. **Basidiocarp, stipe, pileus, gills**

12. Obtain a prepared slide of a *Coprinus* pileus and observe it using a compound microscope. Is your slide a cross section or longitudinal section through the pileus? Locate the **gills**, **pileus**, and **stipe** under scanning power.

13. **Draw and label the following terms in your notebook.**
14. Switch to a higher power magnification and look for **basidiospores** and the **basidia** from which they formed.

15. **Draw and label the following terms in your notebook.**

   a. **Basidiospores, basidia**

16. **Complete the Comparison of Fungi by Major Features summary table for the Basidiomycota.**

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