Exercise 27

Survey of the Kingdom Fungi

Molds, Sac Fungi, Mushrooms, and Lichens

Learning Objectives

By the end of this exercise you should be able to:

1. Describe the characteristic features of the kingdom Fungi.
2. Discuss variation in structures and sequence of events of sexual and asexual reproduction for the major phyla of the kingdom Fungi.

MULTI-MEDIA **Please visit www.mhhe.com/vodopich10e to review multi-media resources tailored to this lab.**

Fungi are as cute as a colorful mushroom and as ugly as the fuzzy slime on a spoiled pork chop. We slice some species to put on our salads, while others would kill us within minutes of eating them. Some species produce antibiotics vital to medicine, while others cause disease. Fungi decompose dead organisms and recycle vital nutrients, while just as quickly they attack our crops and our refrigerated foods. They do all this, yet they are among the organisms least understood by introductory biology students.

Fungi are basically filamentous strands of cells that secrete enzymes and feed on the organic material on which they are growing. That organic material may be humus in the soil where mushrooms grow or a stale loaf of bread where mold thrives. It may be the skin between your toes inhabited by athlete's foot fungus or a decaying animal on the forest floor being decomposed by fungi digesting the animal's dead tissue. Fungi not only cause disease; they are also important decomposers that recycle nutrients from dead organisms.

The basic structure of a fungus is the **hypha** (pl., *hyphae*)—a slender filament of cytoplasm and nuclei enclosed by a cell wall (fig. 27.1). A mass of these hyphae makes up an individual organism and is collectively called a **mycelium.** A mycelium can permeate soil, water, or living tissue; fungi certainly seem to grow everywhere. In all cases the hyphae of a fungus secrete enzymes for **extracellular digestion** of the organic substrate. Then the mycelium and its hyphae absorb the digested nutrients. For this reason, fungi are called **absorptive heterotrophs.** Heterotrophs obtain their energy from organic molecules made by other organisms.

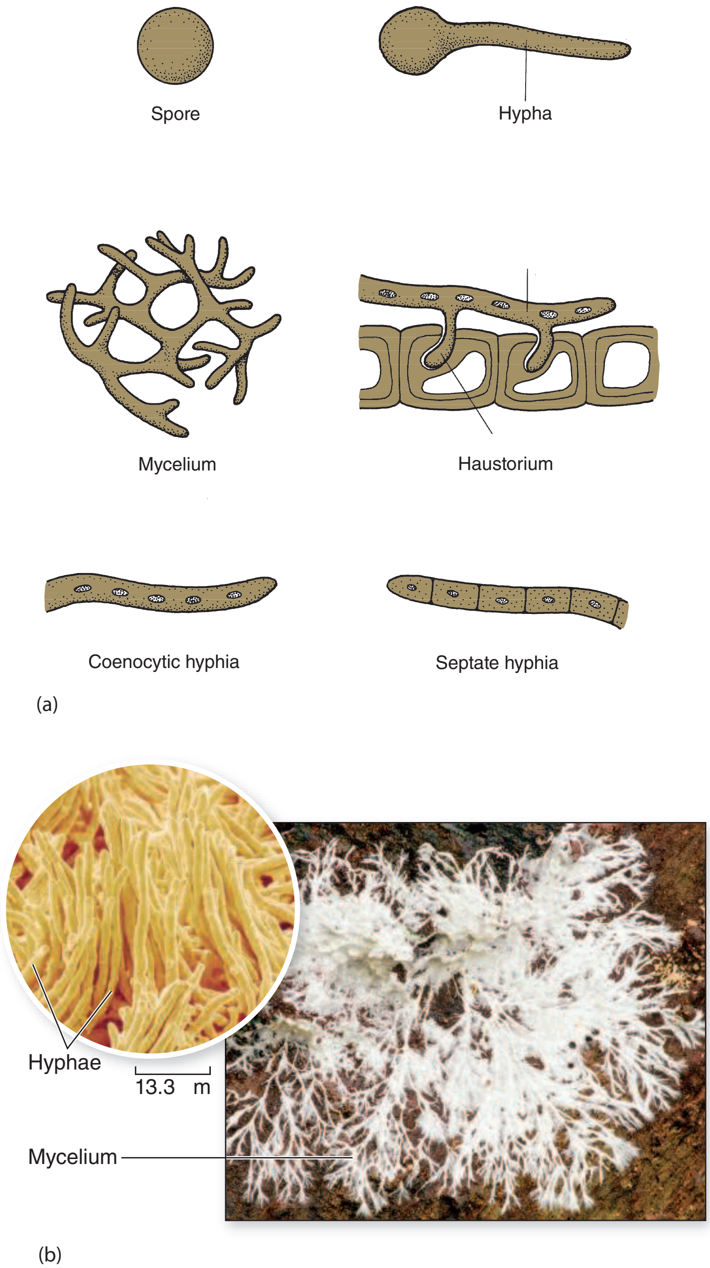


Figure 27.1

Fungal mycelium. (*a*) Fundamental elements of fungal structure. (*b*) This mycelium, composed of hyphae, is growing through leaves on a forest floor in Maryland.

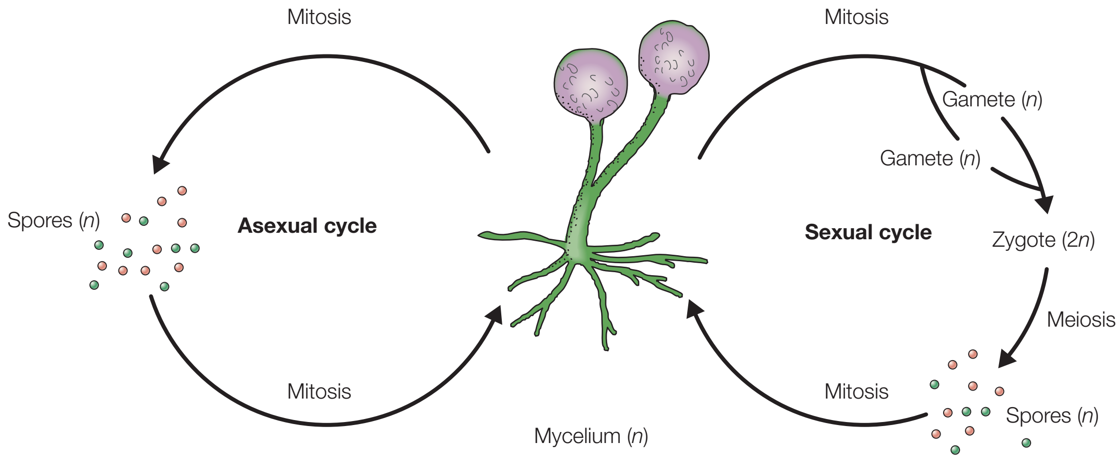


Figure 27.2
Generalized life cycle of a fungus.

Fungi feed on many types of substrates. Most fungi obtain food from dead organic matter and are called **saprophytes.** Other fungi feed on living organisms and are **parasites.** Many of the parasitic fungi have modified hyphae called **haustoria,** which are thin extensions of the hyphae that penetrate living cells and absorb nutrients.

Hyphae of some species of fungi have crosswalls called **septa** that separate cytoplasm and nuclei into cells. Hyphae of other species have incomplete or no septa (i.e., are aseptate) and therefore are **coenocytic** (multinucleate). Notably the cell walls of fungi are usually not cellulose, but instead are made of **chitin,** the same polysaccharides that comprise the exoskeleton of insects and crustaceans.

REPRODUCTION IN KINGDOM FUNGI

Reproduction in fungi can be sexual or asexual. Subtle variation in the patterns and morphology of sexual reproduction distingush one phylum from another.

Asexual Reproduction

Fungi commonly reproduce asexually by mitotic production of haploid vegetative cells called **spores** produced in **sporangia, conidiophores,** and other related structures. Spores are microscopic and surrounded by a covering well suited for the rigors of distribution into the environment. *Pilobolus,* an interesting fungus, points its sporangia toward the sun. This orientation of an organism to light is called **phototaxis.** *Pilobolus* ejects its entire sporangium as far as two meters to distribute its spores.

Budding and **fragmentation** are two other methods of asexual reproduction. Budding, which is mitosis with an uneven distribution of cytoplasm, is common in yeasts. After budding, an outgrowth of the original cell detaches and matures into a new organism. Fragmentation is the breaking of an organism into one or more pieces, each of which can develop into a new individual.

Sexual Reproduction

The sexual life history of fungi includes the familiar events of vegetative growth, genetic recombination, meiosis, and nuclear fusion (karyogamy). However, the timing of these events is unique in fungi. Fungi reproduce sexually when hyphae of two genetically different individuals of the same species encounter each other. In many fungal life cycles, haploid cells (n) from two mating strains will fuse their cytoplasms, **plasmogamy,** and become dikaryotic ($n + n$) with two nuclei per cell. Later the nuclei will fuse, **karyogamy,** to become diploid ($2n$) zygotes. Karyogamy is equivalent to fertilization.

A generalized life cycle of fungi (fig. 27.2) illustrates four important features of fungi:

- Nuclei of a fungal mycelium are haploid during most of the life cycle.
- Gametes are produced by mitosis and differentiation of haploid cells rather than directly from meiosis of diploid cells.
- Meiosis quickly follows formation of the zygote, the only diploid stage.
- Haploid cells produced by meiosis are not gametes; rather, they are spores that grow into a mature haploid organism. Recall that asexual reproduction produces spores by mitosis. In both cases, haploid spores grow into mature mycelia.

None of these features of the sexual cycle are unique to fungi, but together they describe the typical fungal life cycle.

Classification of Fungi

The great diversity of fungi results from modifications of hyphae into varied and specialized reproductive structures often unique to a phylum, genus, or species. The four major phyla of fungi are **Chytridiomycota, Zygomycota, Ascomycota,** and **Basidiomycota.**

Figure 27.3

Chytrids growing on a freshwater alga. The colorless chytrids produce hyphae that penetrate the cellulose cell walls of the dinoflagellate *Ceratium hirundinella,* absorbing organic materials from the alga. Chytrids use these materials to produce spherical flagellate spores that swim away to attack other algal cells.

As you examine members of these phyla, carefully note variations on the fundamental structure of vegetative mycelia and specialized structures associated with sexual and asexual reproduction. The names of phyla of fungi are derived from sexual reproductive structures rather than asexual structures (table 27.1). However, each phylum has various modifications for both sexual and asexual reproduction.

PHYLUM CHYTRIDIOMYCOTA (CHYTRIDS)

Molecular evidence indicates that chytrids may be the most ancient fungi. They are typically aquatic saprobes or parasites on plants, animals, and protists (fig. 27.3). Although they have flagella, considered a nonfungal characteristic, they also have absorptive nutrition and chitinous cell walls and share proteins and nucleic acids common to other fungi. Their distinctive reproductive feature is motile spores with flagella. In some areas, infections by chytrids have significantly reduced the population of many amphibians.

SAFETY FIRST Before coming to lab, you were asked to read this exercise so you would know what to do and be aware of safety issues. In the space below, briefly list the safety issues associated with today's procedures. If you have questions about these issues, contact your laboratory assistant before starting work.

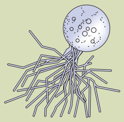
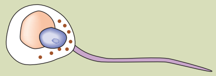
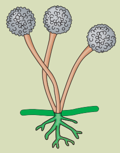
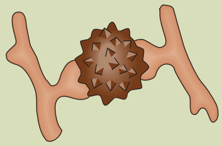
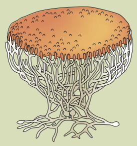
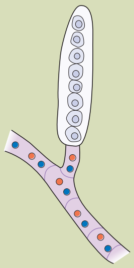
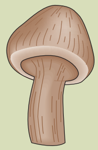
Procedure 27.1

Examine a representative of phylum Chytridiomycota

1. Obtain a culture of *Allomyces* or *Chytridium,* two common genera of chytrids.
2. Prepare a wet mount and use your microscope to examine chytrid morphology. If necessary, review in Exercise 3 the proper use of a compound microscope.
3. Be prepared to compare chytrid morphology with the morphology common to the other major fungal groups.

TABLE 27.1

REPRODUCTIVE FEATURE OF PHYLA OF FUNGI

PHYLUM	KEY REPRODUCTIVE FEATURE
Chytridiomycota (chytrids) 	Motile spores with flagella 
Zygomycota (zygote fungi) 	Resistant zygosporangium as sexual stage 
Ascomycota (sac fungi) 	Sexual spores borne internally in sacs called asci 
Basidiomycota (club fungi) 	Sexual spores borne externally on club-shaped structures called basidia 

Question 1

a. Are hyphae apparent?

b. Are the cells motile?

PHYLUM ZYGOMYCOTA (BREAD MOLDS)

Zygomycetes (750 species), which include common bread molds, derive their name from resting sexual structures called **zygosporangia** that characterize the group. Most zygomycetes are saprophytic and their vegetative hyphae lack septa (i.e., they are aseptate).

Procedure 27.2

Examine common bread mold

1. Obtain from your instructor a petri dish containing a piece of moldy bread moistened and exposed to air for a few days.
2. Note the velvet texture and various colors of the molds.
3. Use a dissecting microscope to examine the mycelia and notice that they grow as a tangled mass of hyphae.

Question 2

a. How many species of mold are on the bread?

b. Is pigment distributed uniformly in each mycelium? If not, where is the pigment concentrated in each mold?

c. What is the adaptive significance of spores forming on ends of upright filaments rather than closer to the protective substrate?

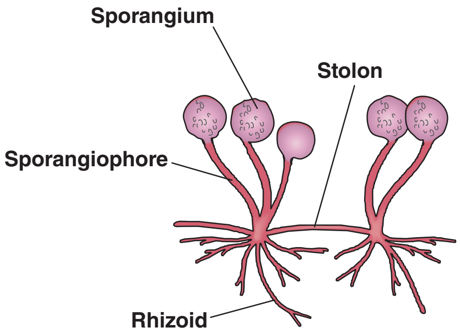


Figure 27.4

Vegetative and asexual reproductive structures of *Rhizopus*, a bread mold.

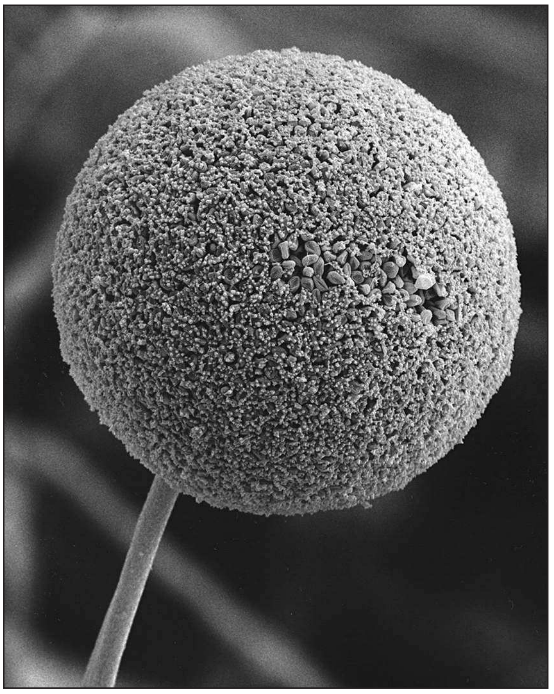
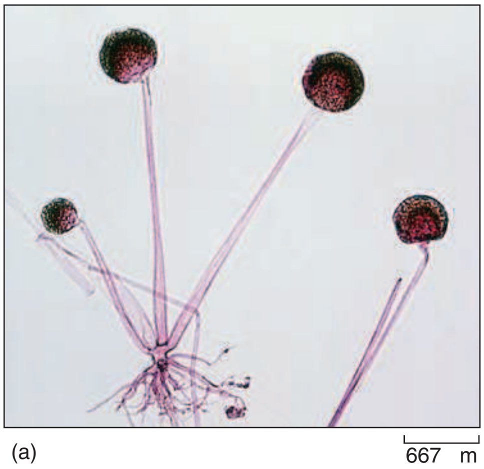


Figure 27.5

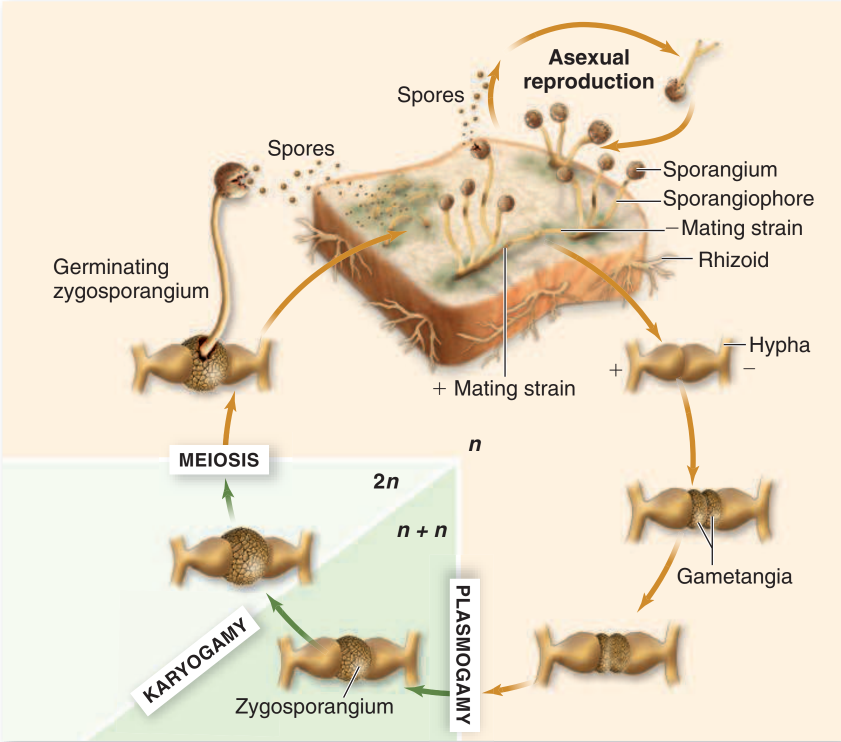
A sporangium of *Rhizopus stolonifer* (500×) releases thousands of spores when it matures and breaks open.

A common genus of bread mold is *Rhizopus*. Its hyphae are modified into **rhizoids** (holdfasts), **stolons** (connecting hyphae), and **sporangiophores** (asexual reproductive structures), as shown in figure 27.4. Sporangiophores are upright hyphal filaments supporting asexually reproducing **sporangia** (fig. 27.5). Within a sporangium, haploid nuclei become spores and are separated by cell walls. These spores are released to the environment when the mature sporangium breaks open. *Rhizopus* appears dark from the thousands of black sporangia of a growing mycelium; hence, a common name of *Rhizopus* is black bread mold.

Because *Rhizopus* is isogamous (meaning that gametes from both strains look alike), the strains are not called male and female, but instead are called + and −. On one side of the plate a + strain of *Rhizopus* was introduced, and on the other side a − strain was introduced. These strains grew toward each other and formed reproductive structures called **gametangia** where they came into contact.



(a)



(b)

Figure 27.6

Rhizopus (*a*) and its life cycle (*b*). Hyphae grow and feed on the surface of the bread or other material and produce clumps of erect, sporangium-bearing stalks. If both + and − strains are present in a colony, they may grow together, and their nuclei may fuse to form diploid (2*n*) zygotes. These zygotes, which are the only diploid cells of the life cycle, form within a thick, dark structure called a zygosporangium (zygospore). Meiosis occurs in the zygosporangium, and vegetative, haploid hyphae grow from the resulting haploid (*n*) cells.

Sexual Reproduction in *Rhizopus*

1. Sexual reproduction begins when hyphae of each strain touch each other (fig. 27.6).

2. Where the hyphae touch, **gametangia** form and appear as swellings. Within the gametangia many nuclei differentiate to serve as gametes from each strain.

3. The wall between the gametangia breaks down, and cells fuse (plasmogamy). Fusion of nuclei (karyogamy) follows and occurs in the zygosporangium.

4. A typically massive and elaborate **zygosporangium** differentiates around the zygotes. Except for the zygotes, all other nuclei are haploid.

5. Soon after the zygosporangium forms, the zygotes undergo meiosis. One or more of the resulting haploid spores soon germinates.

6. The hyphae of the germinating cells break out of the zygosporangium, produce a sporangiophore via mitosis, and form spores asexually.

7. The spores are released and produce a new generation of mycelia.

Procedure 27.3

Examine *Rhizopus*

1. Obtain a pure culture of *Rhizopus* from your instructor. This culture is growing in a sealed petri plate containing nutrient-fortified agar. Do not remove the top of the dish because you may contaminate the culture and unnecessarily release spores into the room.

2. Your instructor has prepared a demonstration slide of *Rhizopus* stained with lactophenol cotton blue for you to examine. Examine this slide and sketch what you see.

3. Your instructor has also prepared some cultures of *Rhizopus* (or *Mucor,* or *Phycomyces*) for observing the structures formed during sexual reproduction. Obtain one of these plates. Locate the area of the plate in which the different strains have come in contact.

4. Locate gametangia and zygosporangia in the living culture.

5. Examine a prepared slide of *Rhizopus* with developed zygosporangia (figs. 27.6 and 27.7). Then observe the zygosporangia where the strains have touched. Be careful not to confuse zygosporangia with dark sporangia on top of sporangiophores.

Question 3

a. In what structure is the dark pigment of *Rhizopus* concentrated?

b. Is *Rhizopus* reproducing sexually as well as asexually in the same petri dish? How can you tell?

PHYLUM ASCOMYCOTA (SAC FUNGI)

Phylum Ascomycota (30,000 species) includes yeasts, some molds, morels, and truffles (fig. 27.8). Its name is derived from a microscopic, sac-shaped reproductive structure called an **ascus.**

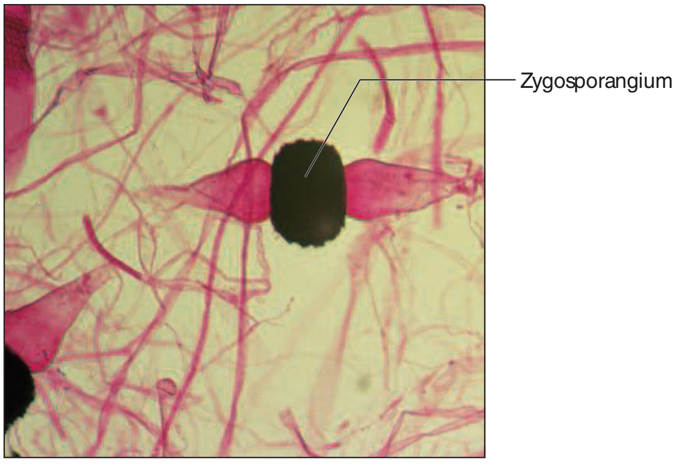


Figure 27.7
Sexual conjugation in *Rhizopus.*

Figure 27.8
Representatives of Ascomycota. All visible structures of fleshy fungi, such as the ones shown here, arise from an extensive network of filaments (hyphae) that penetrate and interweave with the substrate on which they grow. (*a*) A morel, *Morchella esculenta,* a delicious, edible ascomycete that appears in early spring in the northern temperate woods (especially under oaks). (*b*) A cup fungus in the rain forest of the Amazon Basin.

Ascomycetes reproduce asexually by forming spores called **conidia.** Modified hyphae called **conidiophores** partition nuclei in longitudinal chains of beadlike conidia (fig. 27.9). Each conidium contains one or more nuclei. Conidia form on the surface of conidiophores (in contrast to spores that form within sporangia in *Rhizopus*). When mature, conidia are released in large numbers and germinate to produce new organisms. *Aspergillus* and *Pencillium* are common examples of fungi that form conidia. A number of fungal species produce only asexual conidia; these fungi have no known sexual phase and therefore defy classification in the major fungal phyla. They were traditionally classified as fungi imperfecti or deuteromycota. However, most are likely ascomycetes that have lost their ability to sexually reproduce.

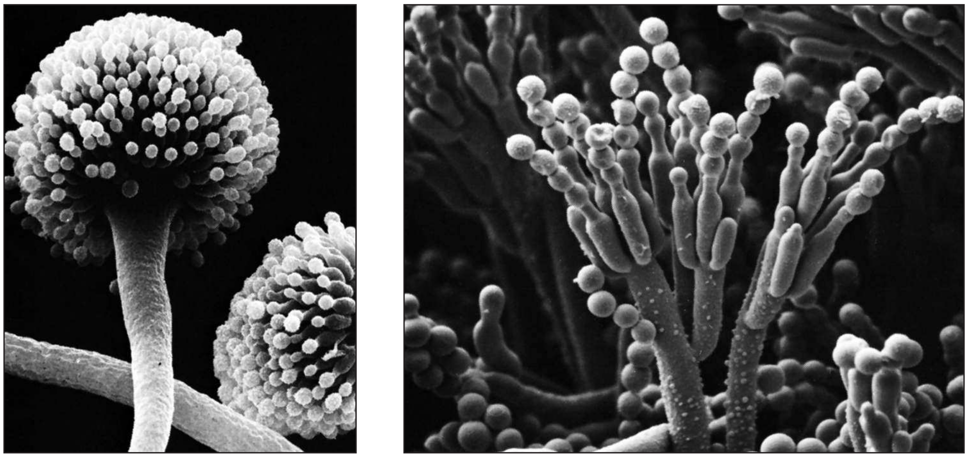


Figure 27.9
Conidiophores. (*a*) Characteristic conidiophores of an ascomycete, as viewed with a scanning electron microscope. (*b*) A colony of *Penicillium,* another important ascomycete, growing on an orange and forming conidia.

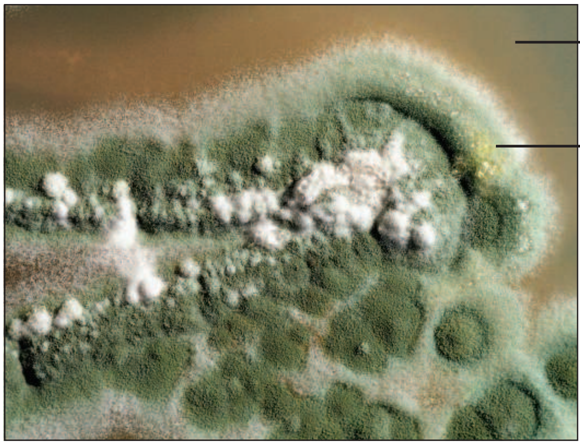


Figure 27.10
Penicillium, an ascomycete, growing on agar.

Many ascomycetes are economically important. For example, species of *Penicillium* are used to produce antibiotics. *Penicillium roquefortii,* which is abundant in caves near Roquefort-sur-Soulzon, France, gives a unique flavor to Roquefort cheese. *Aspergillus oryzae* is used to brew Japanese saki and to enrich food for livestock.

Procedure 27.4

Examine fungi with conidia

1. Obtain a culture plate of living *Aspergillus, Penicillium,* or *Neurospora*. Notice the soft texture of the colonies.
2. Use a dissecting microscope to examine the colonies' hyphae and their reproductive conidia. Note the rounded tufts of these reproductive cells.
3. Conidia are quite small. You will examine them more closely in procedure 27.5.

Procedure 27.5

Examine *Penicillium*

1. Examine a prepared slide of *Penicillium* and a pure, living culture provided by your instructor (fig. 27.10).
2. Notice the formation of conidia.

Question 4
What is the relative size of *Penicillium* hyphae compared with *Rhizopus* hyphae?

Yeasts are common unicellular ascomycetes and include about 40 genera. Most of their reproduction is asexual by cell fission or budding (i.e., the formation of a smaller cell from a larger one). Occasionally, two sexually reproducing yeast cells will fuse to form one cell with two nuclei. This cell functions as an ascus in which syngamy is followed immediately by meiosis. The resulting ascospores function directly as new yeast cells. Yeasts do not form conidia.

The yeast used to produce wine and beer is usually a strain of *Saccharomyces cerevisiae.* The yeasts and other fungi growing naturally on grapes used for making wine may impart a unique flavor to a wine more than does the specific variety of grapes.

Procedure 27.6

Examine *Saccharomyces,* a yeast, and *Peziza,* a cup fungus

1. Obtain and examine a stock culture of *Saccharomyces* (fig. 27.11).
2. Prepare a wet mount of the yeast from a culture dispensed by your instructor. Only a small amount of yeast is needed to make a good slide.
3. Review the description of sexual reproduction in cup fungi.
4. Examine a prepared slide of a cross section through the ascocarp of *Peziza* (fig. 27.12). Locate the asci.

Question 5

a. Do you see chains of yeast cells produced by budding?

b. How is the structure of yeast hyphae different from that of molds?

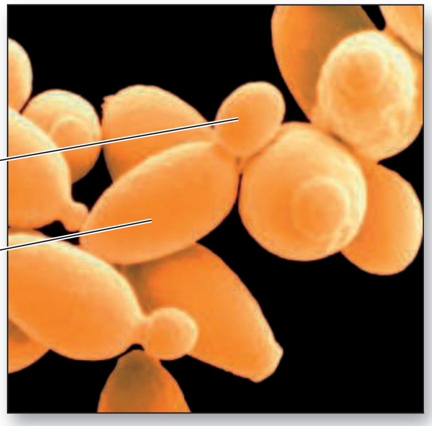


Figure 27.11
Budding in the yeast *Saccharomyces cerevisiae.*

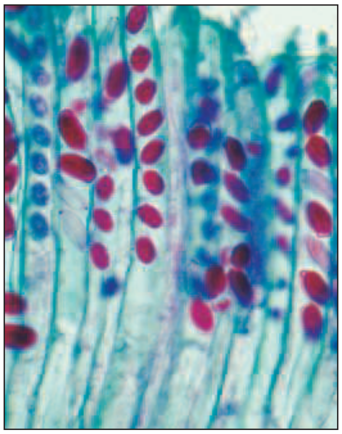


Figure 27.12

Asci from the lining of a cup of *Peziza,* a cup fungus. The diploid (2*n*) zygote in each ascus divides meiotically to produce four haploid (*n*) nuclei. Each of these nuclei then divides mitotically. These meiotic and mitotic divisions produce a column of eight ascospores in each ascus.

Sexual Reproduction in Ascomycota

1. Sexual reproduction begins with contact of monokaryotic hyphae from two mating strains (fig. 27.13).
2. Where the hyphae touch, large multinucleate swellings appear (antheridia and ascogonia) and eventually fuse. Haploid nuclei of the two strains intermingle in the swelling (ascogonium).
3. A **dikaryotic** mycelium grows from this swelling. Each dikaryotic cell has one nucleus from each parent; the nuclei do not fuse immediately.
4. Tightly bundled dikaryotic hyphae grow and mingle with **monokaryotic** hyphae from each parent to form a cup-shaped **ascocarp.**
5. Dikaryotic cells lining the inside of the ascocarp form sac-shaped **asci** (sing., ascus).
6. The nuclei fuse (karyogamy) in each ascus to form a zygote.

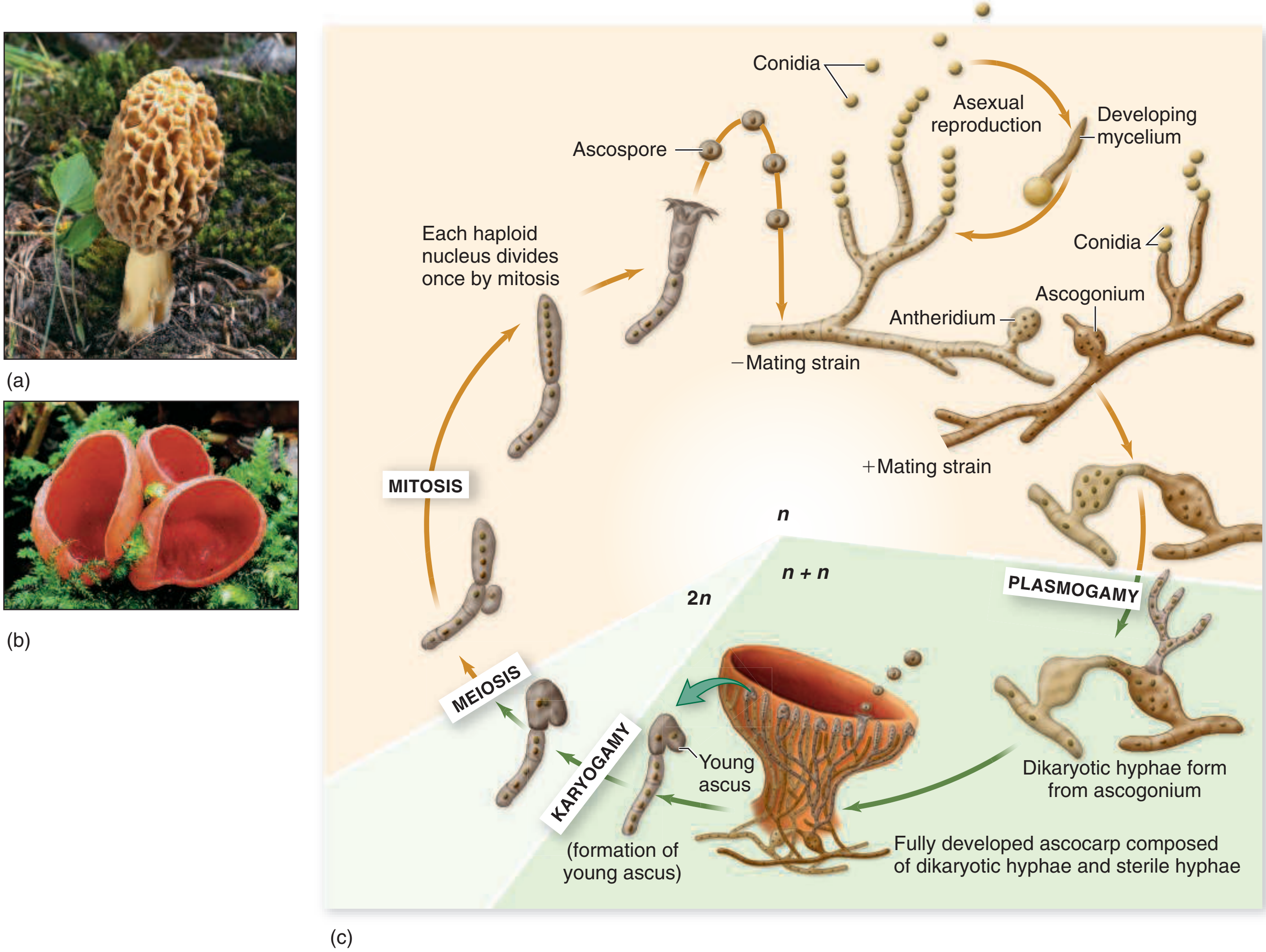


Figure 27.13

The sexual life cycle of an ascomycete. Representative ascomycetes include (*a*) morels and (*b*) cup fungi, both of which undergo (*c*) a sexual life cycle including formation of characteristic asci.

7. After fusion, meiosis produces four haploid **ascospores.**
8. Subsequent mitosis produces eight ascospores within each mature ascus.
9. The asci on the surface of the ascocarp rupture and release ascospores into the environment.
10. Each ascospore can produce a new mycelium.

Question 6
What is the difference between dikaryotic and diploid cells?

PHYLUM BASIDIOMYCOTA (CLUB FUNGI)

Basidiomycetes (25,000 species) are probably the most familiar fungi (fig. 27.14). They include mushrooms, puffballs, shelf fungi, and economically important plant pathogens such as rusts and smuts. *Agaricus campestris* is a common field mushroom, and its close relative *A. bisporus* is cultivated for more than 60,000 tons of food per year in the United States. However, just one bite of *Amanita phaloides,* the "destroying angel" mushroom may be fatal.

Sexual Reproduction in Basidiomycota

1. Haploid hyphae from different mating strains permeate the substrate (fig. 27.15).
2. Septa form between the nuclei in the hyphae and form **monokaryotic primary mycelia.** A monokaryotic mycelium has one nucleus in each cell.
3. Cells of the primary mycelia of different mating strains touch, fuse (plasmogamy), and produce a **dikaryotic secondary mycelium.**
4. The secondary mycelium grows in the substrate.
5. The dikaryotic hyphae of the secondary mycelium eventually coalesce and protrude above the substrate as a tight bundle of hyphae called a basidiocarp (mushroom).
6. The **basidiocarp** forms a cap and gills.
7. Dikaryotic, club-shaped **basidia** form on the surface of the gills. Basidia are the sites of sexual reproduction, especially meiosis.
8. The two nuclei in each basidium fuse (karyogamy) to form a diploid zygote.
9. The zygote soon undergoes meiosis and produces haploid **basidiospores.**
10. The basidiospores are released from the basidia lining the gills and are dispersed by wind.
11. A basidiospore germinates into a new mycelium.

(a) (b) (c)

Figure 27.14
Representative basidiomycetes. (*a*) Fly amanita (*Amanita muscaria*). Many species of *Amanita* are poisonous. The cap of this young specimen is not fully opened. (*b*) A common stinkhorn fungus (*Phallus impudicus*). (*c*) Earthstar (*Geaster*).

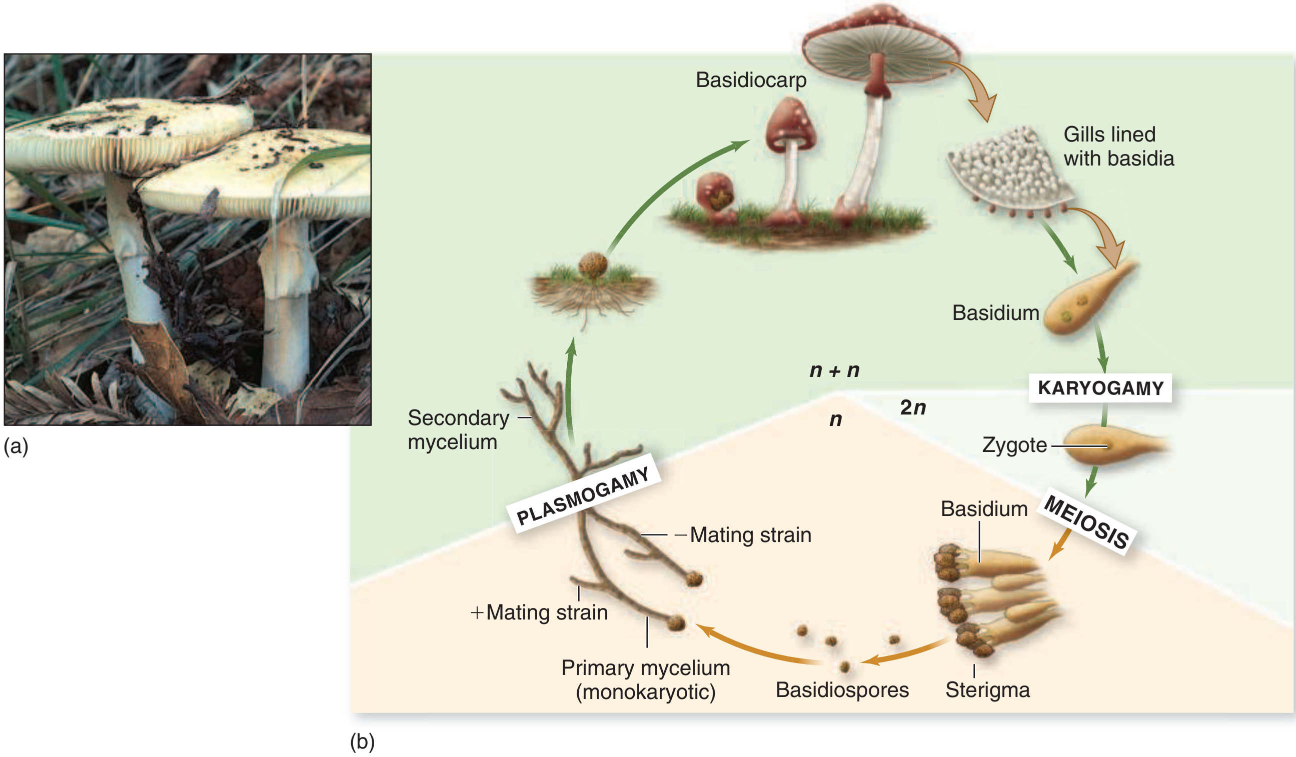


Figure 27.15

Mushrooms (*a*) and their life cycle (*b*). Coalescing mycelia from compatible strains produce dikaryotic hyphae, which form the familiar fruiting bodies of mushrooms. On the gills of the mushroom cap the nuclei in dikaryotic cells fuse, undergo meiosis, and produce basidiospores that germinate into new mycelia. The basidium is the site of karyogamy, which is the fusion of nuclei to form a zygote.

Procedure 27.7

Examine some common mushrooms and their relatives

1. Examine a specimen of an earthstar (*Geaster*). Earthstars are oddly structured basidiomycetes with an array of support structures shaped much like a star (fig. 27.14*c*).
2. Examine some mushrooms. Mushrooms are familiar examples of the aboveground portions of extensive mycelia permeating the soil. Note the mushroom's stalk and umbrellalike **cap** (also called the **pileus**).
3. Find the **gills** on the undersurface of the cap. Gills are lined with microscopic, club-shaped cells called **basidia** where sexual reproduction occurs. Phylum Basidiomycota is sometimes called the "club fungi" and derives its name from these characteristic basidia.

Procedure 27.8

Examine *Coprinus*, a common mushroom

1. Examine a prepared slide of gills from the cap of *Coprinus*, a common mushroom (fig. 27.16).

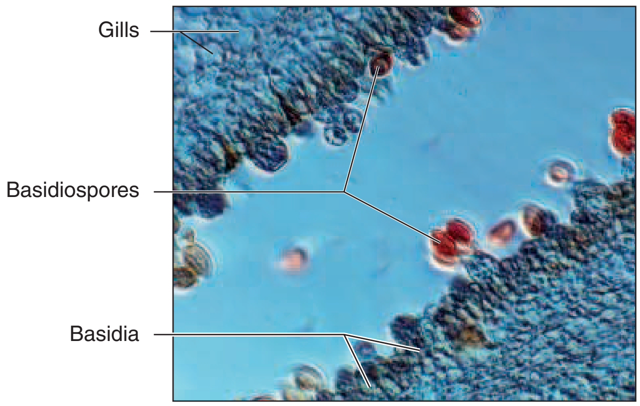


Figure 27.16

Gills of the mushroom *Coprinus*, a basidiomycete.

2. Note the dark basidiospores in rows along the surface of the gills. Interestingly, the gills form perpendicular to the ground and allow spores to free-fall and disperse. Research suggests that gravity influences the orientation of gills.

Question 7

How many spores would you estimate are present on the gills of a single cap of *Coprinus*? Remember that a prepared slide shows only a cross section.

LICHENS

Lichens (25,000 species) are common, brightly colored organisms found on most hard substrates from the tropics to the artic. Trees, rocks, and firm soil provide all the support these slow-growing organisms need. A lichen includes an ascomycete (rarely other fungi) living symbiotically with a photosynthetic alga (a protist) or cyanobacterium. **Symbiosis** means living in a close and sometimes dependent association. About 26 genera of algae occur in different species of lichens. However, the green algae *Trebouxia* and *Trentepohlia* and the cyanobacterium *Nostoc* are in 90% of lichen species.

Lichens reproduce asexually by releasing fragments of tissue or specialized, stress-resistant packets of fungal and algal cells. Each of the two components (fungus and alga) may reproduce sexually by mechanisms characteristic of their phylum, and the new organisms may continue the lichen association.

The durable construction of fungi, linked with photosynthetic algae, enables lichens to proliferate in the harshest terrestrial habitats. Lichens have three basic growth forms: **crustose, foliose,** and **fruticose.** The thallus of crustose lichens grows close to the surface of a hard substrate such as rock or bark. The lichen is flat and two-dimensional. Foliose lichens adhere to their substrate, but some of the thallus peels and folds away from the substrate in small sheets. Fruticose lichens are three-dimensional and often grow away from the substrate with erect stalks. The tips of the stalks are often sites of ascus formation by the sexually reproducing ascomycete symbiont.

Lichens are extremely sensitive to air pollution. This is probably because they are adapted to efficiently absorb nutrients and minerals from the air. This makes lichens particularly susceptible to airborne toxins.

Procedure 27.9

Examine lichens

1. Examine a prepared slide of a cross section of a lichen thallus and note the intimate contact between the symbionts (fig. 27.17).
2. Examine the dried lichens on display and note the three basic growth forms: crustose, fruticose, and foliose (fig. 27.17).

Question 8

a. What are the advantages of having an alga and a fungus in a lichen? What could each organism contribute to the partnership?

b. Would you expect lichens to grow best in rural or urban environments? Why?

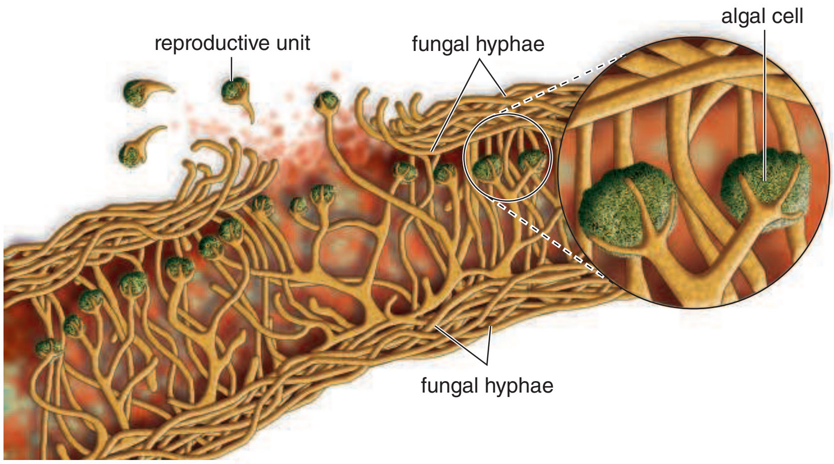
INVESTIGATION

The Antimicrobial Properties of Common Fungi

Observation: Many fungi produce antibiotics that hinder or stop the growth of microbes. These antibiotics are adaptive because they reduce competition and protect the fungus from predators.

Question: Do common fungi such as bread mold produce antimicrobial compounds?

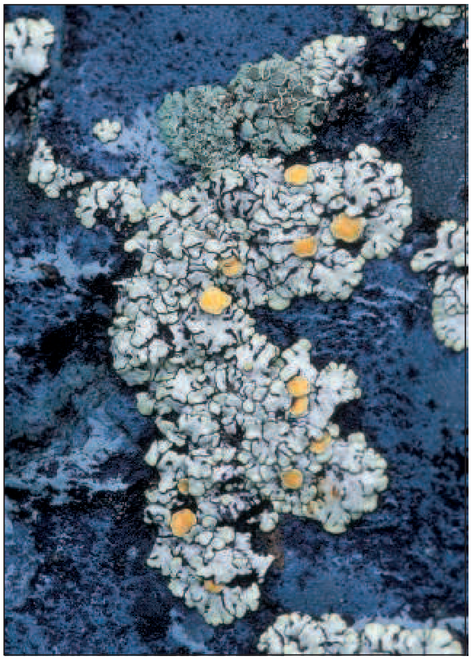
a. Establish a working lab group and obtain Investigation Worksheet 27 from your instructor.
b. Discuss with your group well-defined questions relevant to the preceding observation and question. Choose and record your group's best question for investigation.
c. Translate your question into a testable hypothesis and record it.
d. Outline on Worksheet 27 your experimental design and supplies needed to test your hypothesis. Ask your instructor to review your proposed investigation.
e. Conduct your procedures, record your data, answer your question, and make relevant comments.
f. Discuss with your instructor any revisions to your questions, hypotheses, or procedures. Repeat your work as needed.



(a) Crustose lichen, *Xanthoria*

(b) Fruticose lichen, *Lobaria*

1mm



(c) Foliose lichen, *Xanthoparmelia*

Figure 27.17

Lichen morphology. (*a*) A section of a compact crustose lichen shows the placement of the algal cells and the fungal hyphae, which encircle and penetrate the alga. (*b*) Fruticose lichens are shrublike. (*c*) Foliose lichens are leaflike.

Questions for Further Thought and Study

1. Mushrooms often sprout from soil in rows or circles commonly called "fairy rings." How would you explain the shapes of these formations?

2. What advantages does asexual reproduction have over sexual reproduction?

3. Does dominance of the haploid condition in a fungal life cycle offer an adaptive advantage? Why or why not?

4. Compare and contrast the structure of a fungal mycelium with the structure of a filamentous alga.

5. What is the advantage of maintaining a dikaryotic condition rather than immediate nuclear fusion?

6. In fungi, the only distinction between a spore and a gamete is function. Explain.

7. Describe three ways that fungi affect your life.

8. What are the major differences in the four phyla of fungi?

9. Draw and label a lifecycle for one fungal phylum.

DOING BIOLOGY YOURSELF

Wine-making is a multimillion dollar industry, but the biology of wine-making is simple. Make your own special brand of wine by following the instructions in Exercise 12. Good luck!

WRITING TO LEARN BIOLOGY

Compare and contrast the fundamental life cycle of a fungus with that of plants and animals. When does meiosis occur in the sequence of events? Which stages are haploid and which are diploid?