Chapter 20

Fungi

What You'll Learn

- You will identify the characteristics of the fungi kingdom.
- You will differentiate among the phyla of fungi.

Why It's Important

Fungi decompose organic matter, cleaning the environment and recycling nutrients. They create food products and medicines. However, fungi can also cause significant diseases in humans and plants.

Understanding the Photo

This white ogre mushroom *(Amanita virgineoides)* is native to Japan. It grows on forest floors, where it feeds on decomposing leaves.

Biology Online

Visit bdol.glencoe.com to
- study the entire chapter online
- access Web Links for more information and activities on fungi
- review content with the Interactive Tutor and self-check quizzes

Taylor F. Lockwood

Section

20.1

What is a fungus?

SECTION PREVIEW

Objectives

Identify the basic characteristics of the fungi kingdom.

Explain the role of fungi as decomposers and how this role affects the flow of both energy and nutrients through food chains.

Review Vocabulary

decomposer: organism that breaks down and absorbs nutrients from dead organisms (p. 47)

New Vocabulary

hypha
mycelium
chitin
haustoria
budding
sporangium

Mysterious Rings of Mushrooms

Using Prior Knowledge

Have you ever seen mushrooms that grow in a ring like the one shown here? The visible mushrooms are only one part of the fungus. Beneath the soil's surface are threadlike filaments that may grow a long distance away from the above-ground ring of mushrooms. These filaments can grow for a long time before they produce the surface mushrooms. Mushrooms that grow in rings are only one of many types of fungi, all of which share certain characteristics.

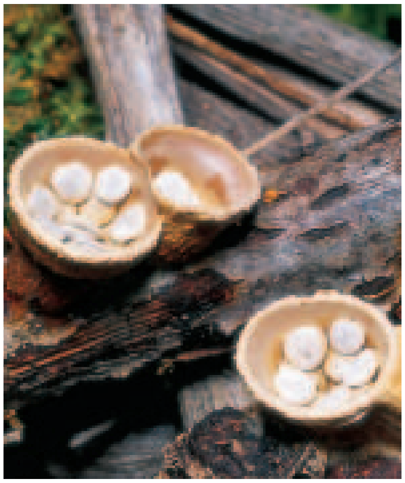
A ring of mushrooms

Infer *Why does a mushroom fairy ring, such as the one shown in the photo, take on a ring shape?*

The Characteristics of Fungi

Fungi are everywhere—in the air and water, on damp basement walls, in gardens, on foods, and sometimes even between people's toes. Some fungi are large, bright, and colorful, whereas others are easily overlooked, as shown in ***Figure 20.1.*** Many have descriptive names such as stinkhorn,

Figure 20.1
Fungi vary in form, size, and color.



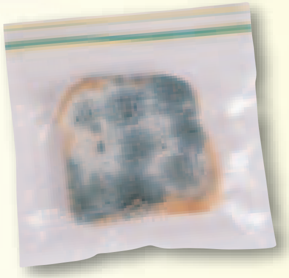
A Bird's nest fungi look like nests, complete with eggs.

B Brightly colored coral fungi resemble ocean corals.

C A fungus killed this insect by feeding on its tissues.

MiniLab 20.1

Observe and Infer



Growing Mold Spores Any mold spore that arrives in a favorable place can germinate and produce hyphae. Can you identify a condition necessary for the growth of bread mold spores?

Procedure

1. Place two slices of freshly baked bakery bread on a plate. Sprinkle some water on one slice to moisten its surface. Leave both slices uncovered for several hours.
2. Sprinkle a little more water on the moistened slice, and place both slices in their own plastic, self-seal bags. Trap air in each bag so that the plastic does not touch the bread's surface. Then seal the bags and place them in a darkened area at room temperature.
3. After five days, remove the bags and look for mold.
4. Remove a small piece of mold with a forceps, place it on a slide in a drop of water, and add a coverslip. Observe the mold under a microscope's low power and high power. **CAUTION:** ***Use caution when working with a microscope, glass slides, and coverslips. Wash your hands with soap and water after working with mold. Dispose of the mold as your teacher directs.***

Analysis

1. **Observe and Infer** Did you observe mold growth on the moistened bread? On the dry bread? How does this experiment demonstrate that there are mold spores in your classroom?
2. **Draw Conclusions** What conclusions can you draw about the conditions necessary for the growth of a bread mold?

puffball, rust, or ringworm. Many species grow best in moist environments at warm temperatures between 20°C and 30°C. You are, however, probably familiar with molds that grow at much lower temperatures on left-over foods in your refrigerator.

Fungi used to be classified in the plant kingdom because, like plants, many fungi grow anchored in soil and have cell walls. However, as biologists learned more about fungi, they realized that fungi belong in their own kingdom.

The structure of fungi

Although there are a few unicellular types of fungi, such as yeasts, most fungi are multicellular. The basic structural units of multicellular fungi are their threadlike filaments called **hyphae** (HI fee) (singular, hypha), which develop from fungal spores, as shown in ***Figure 20.2.*** Hyphae elongate at their tips and branch extensively to form a network of filaments called a **mycelium** (mi SEE lee um). There are different types of hyphae in a mycelium. Some anchor the fungus, some invade the food source, and others form fungal reproductive structures. Use the *MiniLab* on this page to observe the hyphae of some bread mold you grow.

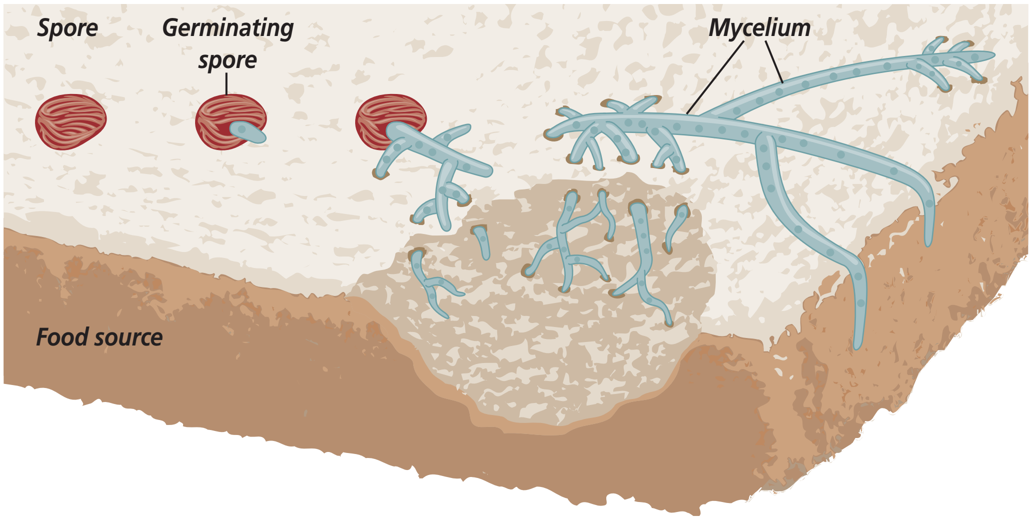


Figure 20.2
A germinating fungal spore produces hyphae that branch to form a mycelium. **Describe** ***What other tasks do hyphae carry out?***

Aaron Haupt

You can use a magnifying glass to see individual hyphae in molds that grow on bread. However, the hyphae of mushrooms are much more difficult to see because they are tightly packed, forming a dense mass.

Unlike plants, which have cell walls made of cellulose, the cell walls of most fungi contain a complex carbohydrate called **chitin** (KI tun). Chitin gives the fungal cell walls both strength and flexibility.

Inside hyphae

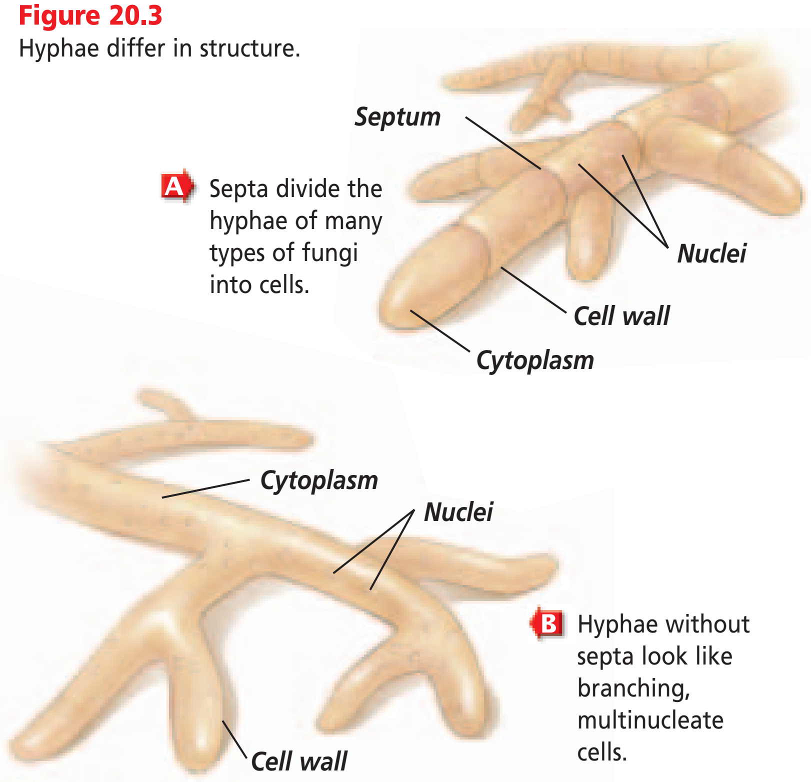
In many types of fungi, cross walls called septa (singular, septum) divide hyphae into individual cells that contain one or more nuclei, ***Figure 20.3.*** Septa are usually porous, allowing cytoplasm and organelles to flow freely and nutrients to move rapidly from one part of a fungus to another.

Some fungi consist of hyphae with no septa. Under a microscope, you see hundreds of nuclei streaming along in a continuous flow of cytoplasm. As in hyphae with septa, the flow of cytoplasm quickly and efficiently disperses nutrients and other materials throughout the fungus.

Adaptations in Fungi

Fungi can be harmful. Some cause food to spoil. Some cause diseases, and some are poisonous. However, they play an important and beneficial role. In a world without fungi, huge amounts of wastes, dead organisms, and debris, which consist of complex organic substances, would litter Earth. Many fungi, along with some bacteria and protists, are decomposers. They break down complex organic substances into raw materials that other living organisms need. Thanks to these organic decomposers, fallen leaves, animal carcasses, and other wastes are eliminated.

Figure 20.3
Hyphae differ in structure.



How fungi obtain food

Unlike plants and some protists, fungi cannot produce their own food. Fungi are heterotrophs, and they use a process called extracellular digestion to obtain nutrients. In this process, food is digested outside a fungus's cells, and the digested products are then absorbed. For example, as some hyphae grow into the cells of an orange, they release digestive enzymes that break down the large organic molecules of the orange into smaller molecules. These small molecules diffuse into the fungal hyphae and move in the free-flowing cytoplasm to where they are needed for growth, repair, and reproduction. The more a mycelium grows, the more surface area becomes available for nutrient absorption.

Reading Check **Summarize** the role of fungi in maintaining equilibrium, including decay in an ecosystem.

Word Origin

haustoria from the Latin word *haurire*, meaning "to drink"; The hyphae that invade the cells of a host to absorb nutrients are called haustoria.

Different feeding relationships

Fungi have different types of food sources. A fungus may be a saprophyte, a mutualist, or a parasite depending on its food source.

Saprophytes are decomposers and feed on waste or dead organic material. Mutualists live in a symbiotic relationship with another organism, such as an alga. Parasites absorb nutrients from the living cells of their hosts. Parasitic fungi may produce specialized hyphae called **haustoria,** (huh STOR ee uh), which penetrate and grow into host cells where they directly absorb the host cells' nutrients. You can see a diagram of haustoria invading host cells in ***Figure 20.4.***

Reproduction in Fungi

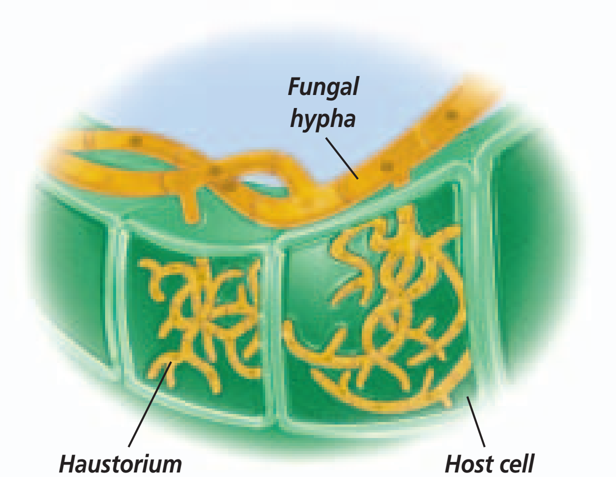
Depending on the species and on environmental conditions, a fungus may reproduce asexually or sexually. Fungi reproduce asexually by fragmentation, budding, or producing spores.

Fragmentation and budding

In fragmentation, pieces of hyphae that are broken off a mycelium grow into new mycelia. For example, when you prepare your garden for planting, you help fungi in the soil reproduce by fragmentation. This is because, every time you dig into the soil, your shovel slices through mycelia, fragmenting them. Most of the fragments will grow into new mycelia.

Figure 20.4
Fungi may be parasites, mutualists, or saprophytes.

A A parasitic fungus is killing this American elm tree.



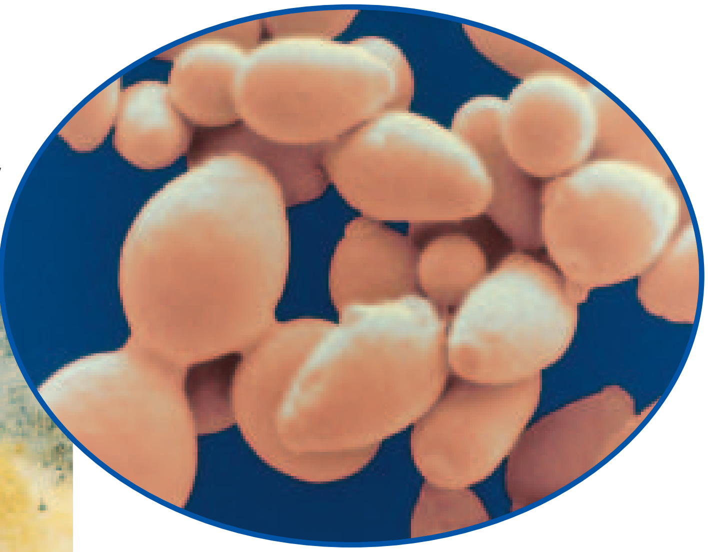
B Fungi can produce haustoria that grow into host cells and absorb their nutrients.

C The saprophytic turkey-tail fungus *(Trametes versicolor)* decomposes the tissues in this dead tree branch.

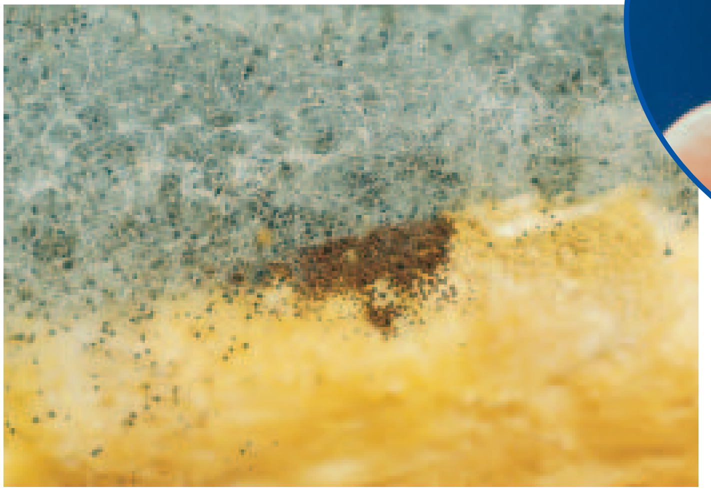
(l)Mark Steinmetz, (r)Sherman Thompson/Visuals Unlimited

Figure 20.5
Fungi reproduce asexually by budding, fragmentation, or spore production.

A Most yeasts reproduce asexually by budding.



Color-enhanced SEM Magnification: 2 250×



B Many fungi, such as this bread mold, can produce spores asexually.

The unicellular fungi called yeasts often reproduce by a process called **budding**—a form of asexual reproduction in which mitosis occurs and a new individual pinches off from the parent, matures, and eventually separates from the parent. You can see a yeast cell and its bud in ***Figure 20.5***.

Reproducing by spores

Recall that a spore is a reproductive cell that can develop into a new organism. Most fungi produce spores. When a fungal spore is transported to a place with favorable growing conditions, a threadlike hypha emerges and begins to grow, eventually forming a new mycelium. The mycelium becomes established in the food source.

In some fungi, after a while, specialized hyphae grow away from the rest of a mycelium and produce a spore-containing structure called a **sporangium** (spuh RAN jee uhm) (plural, sporangia)—a sac or case in which spores are produced. The tiny black spots you see in a bread mold's mycelium are a type of sporangium. In fact, for most fungi, the specialized reproductive hyphal structures where the fungal spores are produced are usually the only part of a fungus you can see, and the sporangia often make up only a very small fraction of the total organism.

Many fungi can produce two types of spores—one type by mitosis and the other by meiosis—at different times during their life cycles. One important criterion for classifying fungi into divisions is their patterns of reproduction, especially sexual reproduction, during the life cycle.

Word Origin

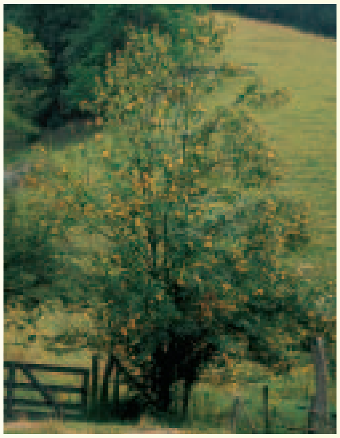
sporangium from the Greek words *sporos,* meaning "seed," and *angeion,* meaning "vessel"; Spores are produced in a sporangium.

The adaptive advantages of spores

Many adaptive advantages of fungi involve spores and their production. First, the sporangia protect spores and, in some cases, prevent them from drying out until they are ready to be released. Second, most fungi produce a large number of spores at one time. For example, a puffball that measures only 25 cm in circumference can produce about 1 trillion spores.

Problem-Solving Lab 20.1

Analyze Information



Why are chestnut trees so rare? The American chestnut tree *(Castanea dentata)* has almost disappeared from the United States, Italy, and France because of a disease known as chestnut blight, which is caused by the fungus *Cryphonectria parasitica.* Since 1900, three to four billion trees have been lost to chestnut blight.

Solve the Problem

Fact: Spores of *C. parasitica* land on the bark of American chestnut trees and germinate. Hyphae grow below the bark and form a canker (diseased tissue) that spreads, producing large areas of dead tissue. Eventually, the nutrient and water supplies of the tree are cut off, and the tree dies.
Fact: *C. parasitica* reproduces by forming spores that are carried by wind, insects, birds, and rain to other trees that then become infected.
Fact: The Japanese chestnut tree *Castanea crenata* is resistant to the *C. parasitica* fungus. This resistance is partially due to the existence of weak fungal strains that cannot kill their host.

Thinking Critically

1. **Predict** Why would it be difficult to control the disease by preventing spores from landing on healthy trees?
2. **Interpret Data** Based on how this fungus grows, why can't fungicides applied to the bark of an infected tree kill the fungus?
3. **Describe** Suggest a solution to the problem in the United States knowing about the resistance of the Japanese chestnut species and the existence of weak disease-causing fungal strains. (Hint: Think about DNA technology.)

Figure 20.6
A passing animal or the pressure of raindrops may have caused these puffballs to discharge the cloud of spores that will be dispersed by the wind.

Producing so many spores increases the germination rate and improves the species survival chances.

Finally, fungal spores are small and lightweight and can be dispersed by wind, water, and animals such as birds and insects. The wind will disperse the spores that the puffballs you see in ***Figure 20.6*** are releasing. Spores dispersed by wind can travel hundreds of kilometers. In the *Problem-Solving Lab* on this page, you can learn about the dispersal methods of a plant fungus that causes the disease called chestnut blight in chestnut trees.

Section Assessment

Understanding Main Ideas

1. Identify the characteristics of the fungi kingdom.
2. Describe how a fungus obtains nutrients.
3. What role do fungi play in food chains?
4. How are the terms *hypha* and *mycelium* related?

Thinking Critically

5. Imagine you are a mycologist (scientist who studies fungi) who finds an inhabited bird's nest. Explain why you would expect to find several different types of fungi growing in the nest.

Skill Review

6. **Measure in SI** Outline the steps you would take to calculate the approximate number of spores in a puffball fungus with a circumference of 10 cm. For more help, refer to *Measure in SI* in the **Skill Handbook.**

bdol.glencoe.com/self_check_quiz

Section 20.2

The Diversity of Fungi

SECTION PREVIEW

Objectives

Identify the four major phyla of fungi.

Distinguish among the ways spores are produced in zygomycotes, ascomycotes, and basidiomycotes.

Summarize the ecological roles of lichens and mycorrhizae.

Review Vocabulary

spore: type of haploid (*n*) reproductive cell that forms a new organism without the fusion of gametes (p. 508)

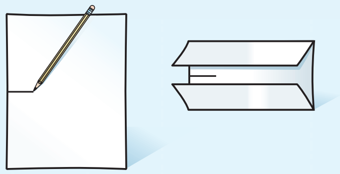
New Vocabulary

stolon
rhizoid
zygospore
gametangium
ascus
ascospore
conidiophore
conidium
basidium
basidiospore
mycorrhiza
lichen

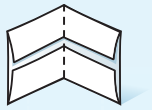
FOLDABLES Study Organizer

Fungi Make the following Foldable to help you organize the main characteristics of the four major phyla of fungi.

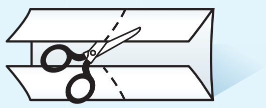
STEP 1 **Draw** a mark at the midpoint of a sheet of paper along the side edge. Then **fold** the top and bottom edges in to touch the midpoint.



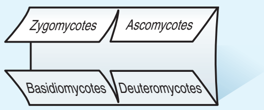
STEP 2 **Fold** in half from side to side.



STEP 3 **Open and cut** along the inside fold lines to form four tabs.



STEP 4 **Label** each tab as shown.



Classify As you read Section 20.2, list the characteristics of the four major phyla of fungi under the appropriate tab.

Zygomycotes

Have you ever taken a slice of bread from a bag and seen some black spots and a bit of fuzz on the bread's surface? If so, then you have probably seen *Rhizopus stolonifer*, a common bread mold. *Rhizopus* is probably the most familiar member of the phylum Zygomycota (zy goh mi KOH tuh). Many other members of about 1000 species of zygomycotes are also decomposers. Zygomycotes reproduce asexually by producing spores. They produce a different type of spore when they reproduce sexually. The hyphae of zygomycotes do not have septa that divide them into individual cells.

Growth and asexual reproduction

When a *Rhizopus* spore settles on a moist piece of bread, it germinates and hyphae begin to grow. Some hyphae called **stolons** (STOH lunz) grow horizontally along the surface of the bread, rapidly producing a mycelium. Some other hyphae form **rhizoids** (RI zoydz) that penetrate the food and anchor the mycelium in the bread. Rhizoids secrete enzymes needed for extracellular digestion and absorb the digested nutrients.

Asexual reproduction begins when some hyphae grow upward and develop sporangia at their tips. Asexual spores develop in the sporangia. When a sporangium splits open, hundreds of spores are released.

Those that land on a moist food supply germinate, form new hyphae, and reproduce asexually again.

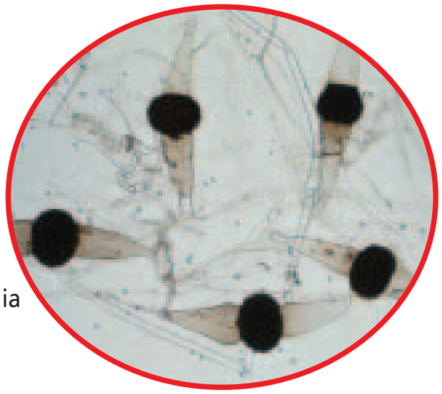
Producing zygospores

Suppose that the bread on which *Rhizopus* was growing began to dry out. This unfavorable environmental condition could trigger the fungus to reproduce sexually. When zygomycotes reproduce sexually, they produce **zygospores** (ZI guh sporz), which are thick-walled spores that can withstand unfavorable conditions.

Sexual reproduction in *Rhizopus* occurs when haploid hyphae from two compatible mycelia, called plus and minus mating strains, grow together and fuse. Where the haploid hyphae fuse, they each form a **gametangium** (ga muh TAN ghee uhm), a structure containing a haploid nucleus. When the haploid nuclei of the two gametangia fuse, a diploid zygote forms. The zygote develops a thick wall, becoming a dormant zygospore.

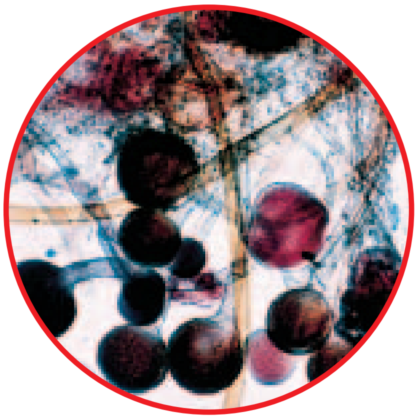
A zygospore may remain dormant for many months, surviving periods of drought, cold, and heat. When environmental conditions are favorable, the zygospore absorbs water, undergoes meiosis, and germinates to produce a hypha with a sporangium. Each haploid spore formed in the sporangium can grow into a new mycelium. Look at ***Figure 20.7*** to see how *Rhizopus* reproduces both sexually and asexually.

Figure 20.7
During its life cycle, the black bread mold, *Rhizopus stolonifera,* reproduces both asexually and sexually.



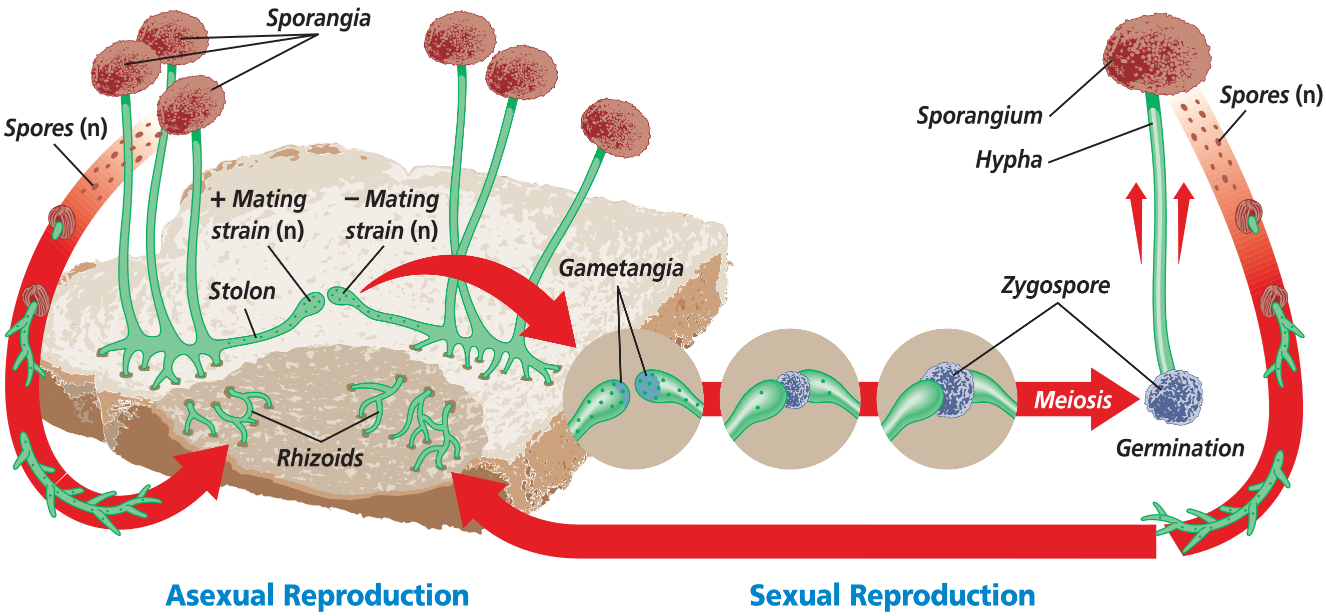
A Zygospores form where gametangia have fused.

LM Magnification: 100×



B These *Rhizopus* sporangia are filled with thousands of haploid spores.

LM Magnification: 27×



(l)James Richardson/Visuals Unlimited, (r)John D. Cunningham/Visuals Unlimited

Ascomycotes

The Ascomycota is the largest phylum of fungi, containing about 30 000 species. The ascomycotes are also called sac fungi. Both names refer to tiny saclike structures, each called an **ascus,** in which the sexual spores of the fungi develop. Because they are produced inside an ascus, the sexual spores are called **ascospores.**

During asexual reproduction, ascomycotes produce a different kind of spore. Fungal hyphae grow up from the mycelium and elongate to form **conidiophores** (kuh NIH dee uh forz). Chains or clusters of asexual spores called **conidia** develop from the tips of conidiophores. Wind, water, and animals disperse these haploid spores. Some conidia and conidiophores are shown in ***Figure 20.8.***

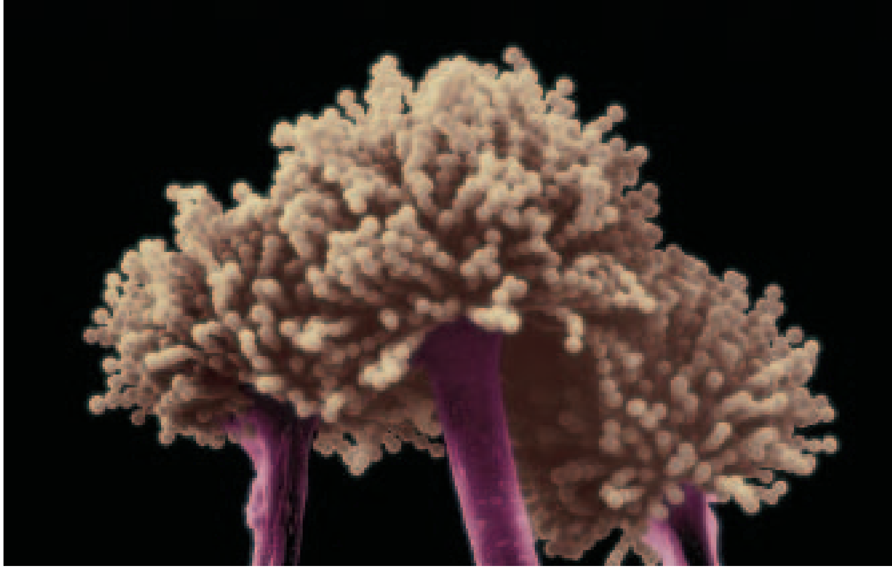
Important ascomycotes

You've probably encountered a few types of sac fungi in your refrigerator in the form of blue-green, red, and brown molds on decaying foods. Other sac fungi are familiar to farmers and gardeners because they cause plant diseases such as apple scab and ergot of rye. Learn more about the dangers of fungi in the *Connection to Social Studies* at the end of this chapter.

Not all sac fungi have a bad reputation. Ascomycotes can have many different forms, as you can see in ***Figure 20.9.*** Morels and truffles are two edible members of this phylum. Perhaps the most economically important ascomycotes are the yeasts.

Yeasts are unicellular sac fungi that rarely produce hyphae and usually reproduce asexually by budding. Yeasts are anaerobes and ferment sugars to produce carbon dioxide and ethyl alcohol. Because yeasts produce alcohol, they are used to make wine and beer. Other yeasts are used in baking because they produce carbon dioxide, the gas that causes bread dough to rise and take on a light, airy texture. Use the *BioLab* at the end of this chapter to experimentally determine the temperature at which yeasts function most efficiently.

Yeasts are also important tools for research in genetics because they have large chromosomes. A vaccine for the disease hepatitis B is produced by splicing human genes with those of yeast cells. Because yeasts multiply rapidly, they are an important source of the vaccine.



Color-enhanced SEM Magnification: 305×

Figure 20.8
Most ascomycotes reproduce asexually by producing conidia in structures called conidiophores.

Figure 20.9
Many ascomycotes are cup shaped or have cup-shaped indentations that are lined with asci.

A Morels are prized for their flavor.

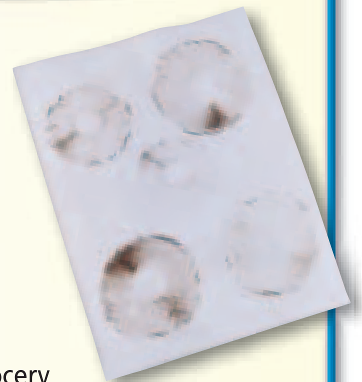
B The orange cuplike structures of this ascomycote are visible on the dead bark.

(t)Dr. Dennis Kunkel/Phototake, NYC, (bl)Matt Meadows, (br)David Dennis/Tom Stack & Associates

MiniLab 20.2

Classify

Examining Mushroom Gills



Spore prints can often help in mushroom identification by revealing the pattern of a mushroom's gills and the color of its spores. Use this technique to see how a mushroom's gills are arranged.

Procedure

1. Break off the stalks from some grocery store mushrooms. Place the caps in a paper bag for a few days.
2. When the undersides of the caps are very dark brown, set the caps, gill side down, on a white sheet of paper. Be sure that the gills are touching the surface of the paper.
3. After leaving the caps undisturbed overnight, carefully lift the caps from the paper and observe the results.
4. Wash your hands with soap and water. Dispose of fungi as your teacher directs.

Analysis

1. **Observe** What color are the spores on the paper?
2. **Compare** How does the pattern of spores on the paper compare with the arrangement of gills on the underside of the mushroom cap that produced it?

Basidiomycotes

Of all the diverse kinds of fungi, you are probably most familiar with some of the about 25 000 species in the phylum Basidiomycota. Mushrooms, puffballs, stinkhorns, bird's nest fungi, and bracket fungi are all basidiomycotes. So are the rust and smut fungi. Use the *MiniLab* to distinguish some mushroom species.

Basidia and basidiospores

Basidiomycotes have club-shaped hyphae called **basidia** (buh SIHD ee uh) that produce spores and give them their common name—club fungi. Basidia usually develop on short-lived, visible reproductive structures that have varied shapes and sizes, as you can see in ***Figure 20.10.*** Spores called **basidiospores** are produced in basidia during reproduction.

A basidiomycote, such as a mushroom, has a complex reproductive cycle. How does a mushroom reproduce? Study ***Figure 20.11*** to find out.

Figure 20.10
Basidiomycotes have many different forms, and what you see are their reproductive structures.

A Smuts are parasites that attack plants such as corn.

B Shelf fungi, such as this sulfur shelf, often grow on tree branches and fallen logs.

C A typical mushroom, such as this *Mycena,* has a cap that sits on top of a stalk.

INSIDE STORY

The Life of a Mushroom

Figure 20.11

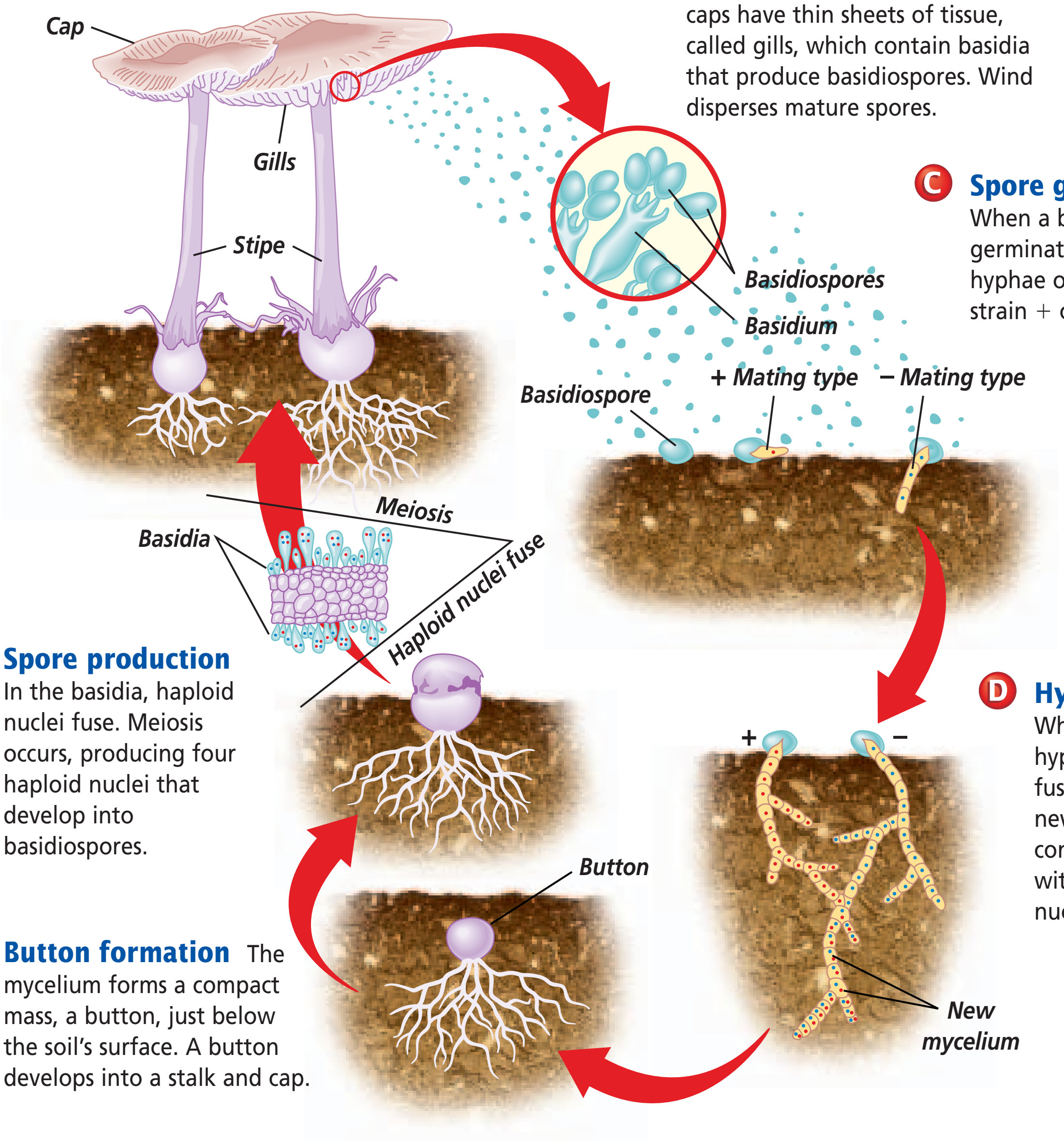
What you call a mushroom is a reproductive structure of the fungus. Most of the fungus is underground and not visible. A single mushroom can produce hundreds of thousands of spores as a result of sexual reproduction. Most types of mushrooms have no asexual reproductive stages in their life cycle. **Critical Thinking** ***Why are spores of mushrooms produced above ground?***

Mycena pura

A Stalk and cap Above ground, a mushroom consists of a stalk that supports a cap.

B Gills The undersides of most caps have thin sheets of tissue, called gills, which contain basidia that produce basidiospores. Wind disperses mature spores.

C Spore germination When a basidiospore germinates, it produces hyphae of either mating strain + or −.



D Hyphae fusion When different hyphae meet, they fuse and form a new mycelium containing cells with two haploid nuclei.

F Spore production In the basidia, haploid nuclei fuse. Meiosis occurs, producing four haploid nuclei that develop into basidiospores.

E Button formation The mycelium forms a compact mass, a button, just below the soil's surface. A button develops into a stalk and cap.

Mark Steinmetz

Deuteromycotes

There are about 25 000 species of fungi classified as deuteromycotes, which have no known sexual stage in their life cycle, unlike the zygomycotes, ascomycotes, and basidiomycotes. Although the deuteromycotes may only be able to reproduce asexually, another possibility is that their sexual phase has not yet been observed by mycologists, biologists who study fungi.

Word Origin

mycorrhiza from the Greek words *mykes,* meaning "fungus," and *rhiza,* meaning "root"; Mycorrhizae are mutualistic relationships between fungi and plants.

Diverse deuteromycotes

If you've ever had strep throat, pneumonia, or other kinds of bacterial infection, your doctor may have prescribed penicillin—an antibiotic produced from a deuteromycote that is commonly seen growing on fruit, as shown in ***Figure 20.12.*** Other deuteromycotes are used in the making of foods, such as soy sauce and some kinds of blue-veined cheese. Still other deuteromycotes are used commercially to produce substances such as citric acid, which gives jams, jellies, soft drinks, and fruit-flavored candies a tart taste.

Mutualism: Mycorrhizae and Lichens

Certain fungi live in a mutualistic association with other organisms. Two of these mutualistic associations that are also symbiotic are called mycorrhizae and lichens.

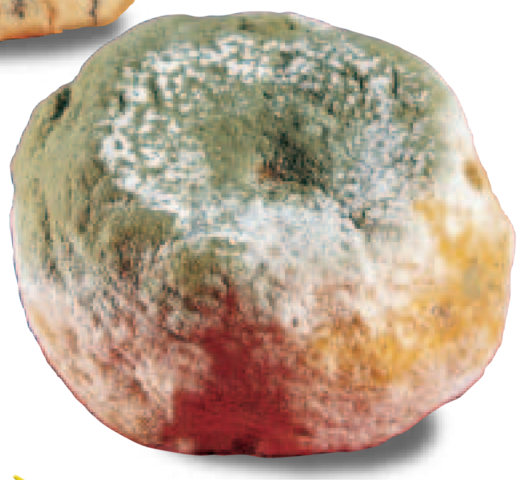
Mycorrhizae

A **mycorrhiza** (my kuh RHY zuh) is a mutualistic relationship in which a fungus lives symbiotically with a plant. Most of the fungi that form mycorrhizae are basidiomycotes, but some zygomycotes also form these important relationships.

How does a plant benefit from a mycorrhizal relationship? Fine, threadlike hyphae grow harmlessly around or into the plant's roots, as shown in ***Figure 20.13.*** The hyphae increase the absorptive surface of the plant's roots, resulting in more nutrients entering the plant. Phosphorus, copper, and other minerals in the soil are absorbed by the hyphae and then released into the roots. In addition, the

Figure 20.12
Many deuteromycotes are useful.

A Bleu cheese has a distinctive flavor. The blue splotches are patches of fungal spores.



B The antibiotic penicillin is derived from *Penicillium* mold, shown here growing on an orange.

CONTENTS

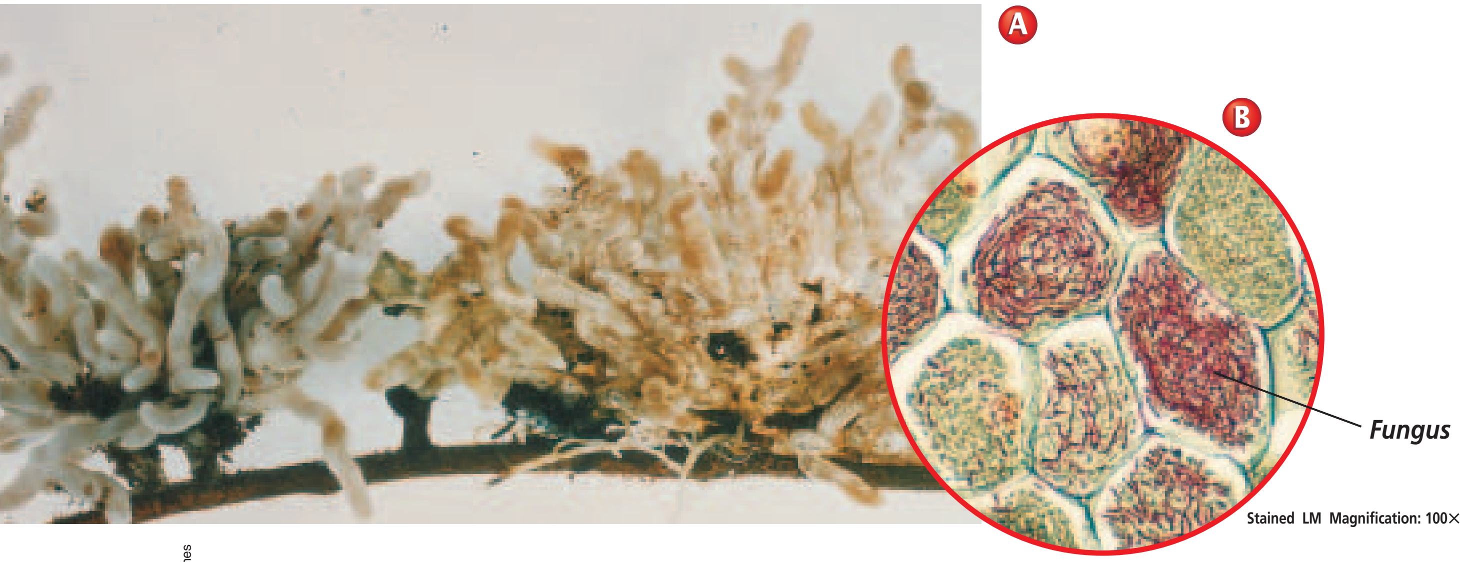


Figure 20.13
The fungal part of a mycorrhiza surrounds plant roots **(A).** The red filaments in the plant cells are fungal hyphae **(B).** Infer ***How does mycorrhiza benefit a host plant?***

fungus also may help to maintain water in the soil around the plant. In turn, the mycorrhizal fungus benefits by receiving organic nutrients, such as sugars and amino acids, from the plant.

About 80 to 90 percent of all plant species have mycorrhizae associated with their roots. Plants of a species that have mycorrhizae grow larger and are more productive than those that don't. In fact, some species cannot survive without mycorrhizae. Some orchid seeds, for example, usually do not germinate without a symbiotic fungus to provide water and nutrients.

Lichens

It's sometimes hard to believe that the orange, green, and black blotches that you see on rocks, trees, and stone walls are alive. The blotches may look like flakes of old paint or pieces of dried moss, but they are forms of lichens. See ***Figure 20.14.***

Figure 20.14
Lichens have a variety of forms.

A Some lichens form crust-like growths on bare rocks and stone walls.

B Each stalk of these British soldier lichens is about 3 cm tall.

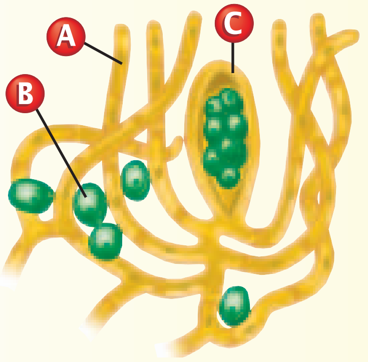
C Some lichens resemble leaves, like these lichens growing on a dead twig.

(tl)Science VU/Visuals Unlimited, (tr)Runk-Schoenberger/Grant Heilman Photography, (bl)Eastcott/Momatiuk/Earth Scenes, (bc)John Gerlach/Visuals Unlimited, (br)Zig Leszczynski/Earth Scenes

Problem-Solving Lab 20.2

Think Critically

What's inside a lichen?
A lichen consists of a fungus and an alga or cyanobacterium that live symbiotically. The prefix *sym* means "together," and *biotic* means "life." The word *symbiosis* describes the fact that there are two different life forms living together.



Solve the Problem

You find a lichen and make a thin slice through it. You magnify the slice under the microscope and draw what you observe—the diagram above.

Thinking Critically

1. **Outline** Using color as a clue, list the letters that identify the algal and fungal parts of the lichen.
2. **Explain** Structure C is a reproductive part. After examining it, you conclude that this is a reproductive structure of an ascomycote. Explain how you knew this.
3. **Experiment** Scientists have wondered if the parts of a lichen can survive by themselves. Describe an experiment that might answer this question.

Figure 20.15
Cladina stellaris is a common lichen on the tundra and a favorite food of caribou and reindeer.

Roger Powell/Visuals Unlimited

A **lichen** (LI kun) is a symbiotic association between a fungus, usually an ascomycote, and a photosynthetic green alga or a cyanobacterium, which is an autotroph.

The fungus portion of the lichen forms a dense web of hyphae in which the algae or cyanobacteria grow. Together, the fungus and its photosynthetic partner form a structure that looks like a single organism. Use the *Problem-Solving Lab* to find out more about a lichen's structure.

Lichens need only light, air, and minerals to grow. The photosynthetic partner provides the food for both organisms. The fungus, in turn, provides its partner with water and minerals that it absorbs from rain and the air, and protects it from changes in environmental conditions.

There are about 20 000 species of lichens. They range in size from less than 1 mm to several meters in diameter. Most lichens grow slowly, increasing in diameter only 0.1 to 10 mm per year. Some lichens may be thousands of years old.

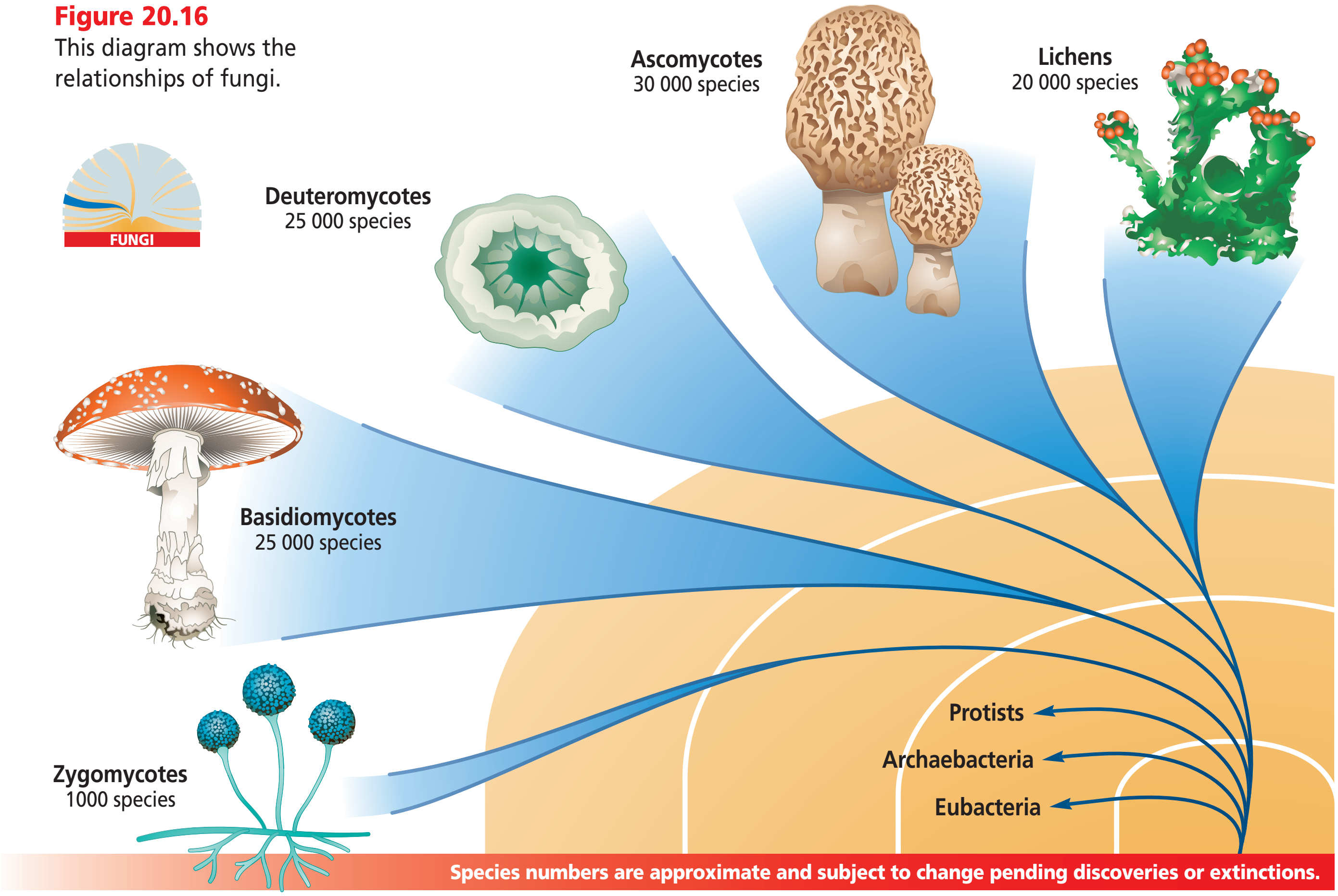
Found worldwide, lichens are pioneers, being among the first to colonize a barren area. Lichens live in arid deserts, on bare rocks exposed to bitter-cold winds, and just below the timberline on mountain peaks. On the arctic tundra, lichens, such as the one shown in ***Figure 20.15***, are the dominant form of vegetation. Both caribou and musk oxen graze on lichens there, much like cattle graze on grass elsewhere.

Not only are lichens pioneers, but they are also indicators of pollution levels in the air. The fungus readily absorbs materials from the air. If pollutants are present, they kill the fungus. Without the fungal part of a lichen, the photosynthetic partner also dies.

Reading Check **Describe** the components that make up a lichen and what each contributes.

CONTENTS

Figure 20.16
This diagram shows the relationships of fungi.



Origins of Fungi

Mycologists hypothesize that the ascomycotes and the basidiomycotes evolved from a common ancestor and that the zygomycotes evolved earlier, as you can see in ***Figure 20.16.***

Although fossils can provide clues as to how organisms evolved, fossils of fungi are rare because fungi are composed of soft materials. The oldest fossils that have been identified as fungi are over 400 million years old.

Section Assessment

Understanding Main Ideas

1. What occurs underground between the time a basidiospore germinates and a mushroom button forms?
2. Explain how the deuteromycotes differ from members of the other divisions of fungi. Explain how they are all similar.
3. Who are the partners in a mycorrhizae? Describe how each partner benefits in a mycorrhizal relationship.
4. How does a hyphae called a stolon differ from a rhizoid?

Thinking Critically

5. You are working with a team of environmental engineers to monitor air pollution levels. How might you use lichens to collect data and determine the air quality?

Skill Review

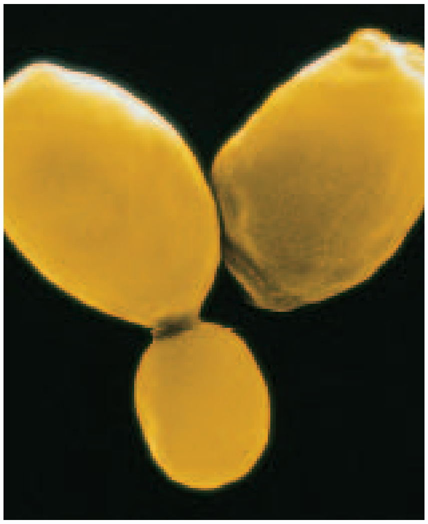
6. **Compare and Contrast** What are the similarities and differences between the fungal reproductive structures, ascospores and conidiophores? For more help, refer to *Compare and Contrast* in the **Skill Handbook.**

INTERNET
BioLab

Before You Begin

Does temperature affect the rate of carbon dioxide production by yeast? Look at the experimental setup pictured at the right. As yeast metabolizes in the stoppered container, the carbon dioxide that is produced is forced out through the bent tube into the open tube, which contains a solution of bromothymol blue (BTB). Carbon dioxide causes chemical reactions that result in a color change in the BTB. Differences in the time required for this color change to occur indicate the relative rates of carbon dioxide production by yeasts.

Color-enhanced SEM Magnification: 2270×



Yeast cells

Does temperature affect yeast metabolism?

PREPARATION

Problem
How can you determine the affect of temperature on the metabolism of yeast? Brainstorm ideas among the members of your group.

Hypotheses
Decide on one hypothesis that you will test. Your hypothesis might be that low temperature slows down the metabolic activity of yeast, or that a high temperature speeds up the metabolic activity of yeast.

Objectives
In this BioLab, you will:
- **Measure** the rate of yeast metabolism using a BTB color change as a rate indicator.
- **Compare** the rates of yeast metabolism at several temperatures.
- **Use the Internet** to collect and compare data from other students.

Possible Materials
bromothymol blue solution (BTB)
straw
small test tubes (4)
large test tubes (3)
one-hole stoppers with glass tube inserts for large test tubes (3)
yeast/white corn syrup mixture
water/white corn syrup mixture
water/yeast mixture
test-tube rack
250-mL beakers (3)
ice cubes
Celsius thermometer or temperature probe
hot plate
graduated cylinder
glass-marking pencil
10 cm of rubber tubing (3)
aluminum foil

Safety Precautions

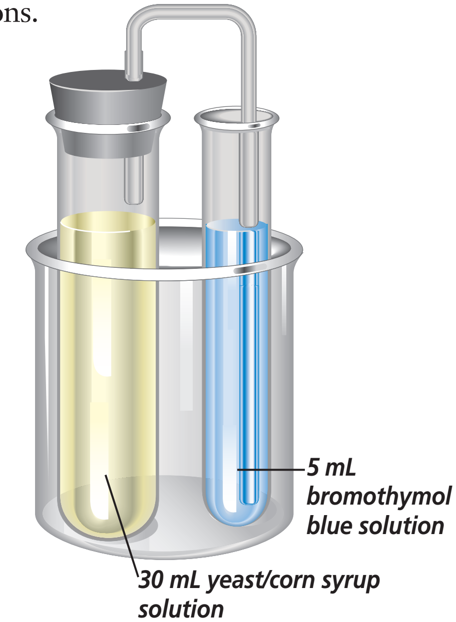
CAUTION: ***Always wear goggles in the lab. Be careful in attaching rubber tubing to the glass tube inserts in the stoppers. Avoid touching the top of the hot plate. Wash your hands thoroughly at the end of your experiments.***

Skill Handbook
If you need help with this lab, refer to the **Skill Handbook.**

Dr. Dennis Kunkel/Phototake, NYC

Plan the Experiment

1. Decide on ways to test your group's hypothesis.
2. Record your procedure, and list the materials and amounts of solutions that you will use. Design a data table for recording your observations.
3. Pour 5 mL of BTB solution into a test tube. Use a straw to blow gently into the tube until you observe a series of color changes. Cover this tube with aluminum foil, and set it aside in a test-tube rack. Record your observations of the color changes caused by carbon dioxide in your breath.



Check the Plan

Discuss the following to decide on your procedure.

1. What data on color change and time will you collect? How will you record your data?
2. What variables will you control?
3. What control will you use?
4. Assign tasks for each member of your group.
5. ***Make sure your teacher has approved your experimental plan before you proceed further.***
6. Carry out your experiment. Visit **bdol.glencoe.com/internet_lab** to post your data.
7. **CLEANUP AND DISPOSAL** Check with your teacher for instructions on disposal of yeast and BTB.

Analyze and Conclude

1. **Check Your Hypothesis** Explain whether your data support your hypothesis. Use your experimental data to support or reject your hypothesis concerning temperature effects on the rate of yeast metabolism.
2. **Use the Internet** How did the data you collected compare with that of other students? Compare experimental designs. Did differences in experimental design account for any differences in data collected?
3. **Make Inferences** What must be the role of white corn syrup in this experiment?
4. **Identify Variables** Describe some variables that your group had to control in this experiment. Explain how you controlled each variable.
5. **Draw Conclusions** Did your experiment clearly show that differences in rates of yeast metabolism were due to temperature differences?
6. **ERROR ANALYSIS** What errors did your group make? How could you improve the experiment?

Share Your Data

Find this BioLab using the link below, and post your data in the data table provided for this activity. Using the additional data from other students on the Internet, analyze the combined data and briefly describe your experimental design.

bdol.glencoe.com/internet_lab

connection to Social Studies

The Dangers of Fungi

Fungi are both friend and foe. Some, such as mushrooms, provide food. Other fungi produce antibiotics such as penicillin. Many others break down dead tissue and recycle organic molecules, thereby keeping Earth from being buried under tons of unusable organic debris. Yet, fungi also damage crops, buildings, and animals.

Fungi cause many plant diseases that can kill plants and cause sickness and death in animals that feed on infected plants. Fungi also directly cause some human diseases.

Wheat attacked by the fungus *Puccinia graminis*

Plant pathogens Fungi that cause the plant diseases called rusts are difficult to control. Rusts are successful because they are pleomorphic—each species produces many kinds of spores that can infect different hosts. The wind can spread their spores over hundreds of miles. For example, *Puccinia graminis* is a fungus that causes black stem rust in cereal grains, such as rice and wheat. *P. graminis* produces five kinds of spores, some of which also infect barberry plants.

Rye, another cereal plant, can host the fungus *Claviceps purpurea*, which causes a disease called ergot. Animals contract ergot after eating infected rye. Human epidemics of ergot poisoning have occurred throughout history after people ate food made from grain infected by *C. purpurea*.

Fungi can also cause major losses of timber. For example, near the end of the nineteenth century, chestnut seedings infected with the fungus *Endothia parasitica* were brought into the United States. By 1950, *E. parasitica* had destroyed most of the country's chestnut trees. Other fungi have devastated the North American populations of elm trees and eastern and western white pines.

In addition to infecting live trees, fungi damage structures built of wood. When ships were primarily wooden, dry rot always threatened their loss. Fungi cause dry rot when they grow in moist wooden structures.

Human pathogens Although bacteria and viruses cause most human diseases, fungi cause their share. Most fungi are dermatophytes, that is, they invade skin, nails, and hair. Among the more common human fungal infections are ringworm and athlete's foot. Some fungal spores can be inhaled into the lungs where they can establish an infection that can spread throughout the body.

Fungi can cause substantial economic loss, disease, and even death. But their critical role in recycling organic matter and their benefit as a source of food and medicinal drugs are essential to human survival on Earth.

Writing About Biology

Reproduction Many fungi reproduce both asexually and sexually. In a short report, discuss the advantage of having two kinds of reproduction.

To find out more about fungi, visit bdol.glencoe.com/social_studies

Chapter 20 Assessment

Study Guide

Section 20.1

What is a fungus?

Key Concepts

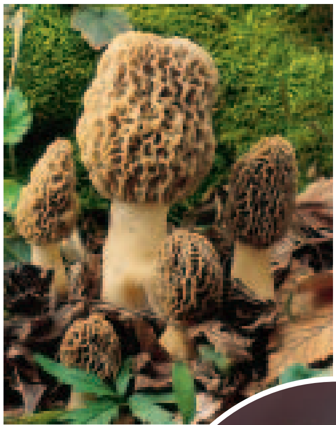
- The structural units of a fungus are hyphae, which grow and form a mycelium.
- Fungi are heterotrophs that carry out extracellular digestion. A fungus may be a saprophyte, a parasite, or a mutualist in a symbiotic relationship with another organism.
- Many fungi produce both asexual and sexual spores. One criterion for classifying fungi is by their patterns of reproduction, especially sexual reproduction, during the life cycle.

Vocabulary

budding (p. 533)
chitin (p. 531)
haustoria (p. 532)
hypha (p. 530)
mycelium (p. 530)
sporangium (p. 533)

Section 20.2

The Diversity of Fungi



Key Concepts

- Zygomycotes form asexual spores in a sporangium. They reproduce sexually by producing zygospores.
- Ascomycotes reproduce asexually by producing spores called conidia and sexually by forming ascospores.
- In basidiomycotes, sexual spores are produced on club-shaped structures called basidia.
- Deuteromycotes may reproduce only asexually.
- Fungi play an important role in decomposing organic material and recycling the nutrients on Earth.
- Certain fungi associate with plant roots to form mycorrhizae, a symbiotic relationship between a fungus and a plant.
- A lichen, a symbiotic association of a fungus and an alga or cyanobacterium, survives in many inhospitable habitats.

Vocabulary

ascospore (p. 537)
ascus (p. 537)
basidiospore (p. 538)
basidium (p. 538)
conidiophore (p. 537)
conidium (p. 537)
gametangium (p. 536)
lichen (p. 542)
mycorrhiza (p. 540)
rhizoid (p. 535)
stolon (p. 535)
zygospore (p. 536)

FOLDABLES Study Organizer

To help you review the phyla of Fungi, use the Organizational Study Fold on page 535.

bdol.glencoe.com/vocabulary_puzzlemaker

(t)Mark Steinmetz, (c)Matt Meadows, (b)John Gerlach/Visuals Unlimited

Chapter 20 Assessment

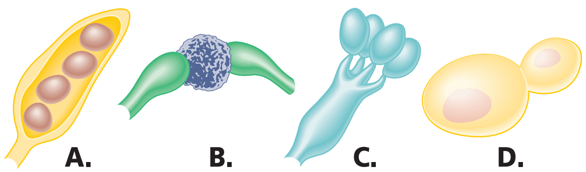
Vocabulary Review

Review the Chapter 20 vocabulary words listed in the Study Guide on page 547. Determine if each word is true or false. If false, replace the underlined word with the correct vocabulary word.

1. <u>Hyphae</u> are threadlike filaments that develop from fungal spores.
2. Club-shaped hyphae that produce spores are called <u>basidia</u>.
3. A <u>mychorrhiza</u> is a symbiotic association between a fungus and a photosynthetic green alga or cyanobacterium.
4. The saclike structure in which sexual spores develop is called a <u>conidiophore</u>.
5. A network of hyphae filaments make up a <u>mycelium</u>.

Understanding Key Concepts

6. Most fungi function as ________ in their environments.
   A. consumers
   B. producers
   C. decomposers
   D. autotrophs
7. Which of the following is a type of asexual reproduction in fungi?
   A. sporangium
   B. budding
   C. mycelium
   D. haustoria
8. Mushrooms, puffballs, and bracket fungi belong to the group called ________.
   A. club fungi
   B. sac fungi
   C. Zygomycota
   D. Deuteromycota
9. Which drawing represents a zygospore?



10. Fungi sometimes live in a mutualistic relationship with a plant. They might help their host by ________.
    A. using the food supplied by the host
    B. using energy made by the host
    C. supplying water to the host
    D. providing the host with spores
11. Soy sauce, citric acid, and penicillin all come from ________.
    A. club fungi
    B. sac fungi
    C. zygomycotes
    D. deuteromycotes
12. The basic structural unit of a multicellular fungus is a ________.
    A. spore
    B. hyphae
    C. stalk
    D. mycellium
13. The complex carbohydrate found in the cell walls of most fungi is ________.
    A. chitin
    B. cellulose
    C. glycogen
    D. starch
14. Unlike other fungi, ________ are known to reproduce only asexually.
    A. zygomycotes
    B. ascomycotes
    C. basidiomycotes
    D. deuteromycotes
15. The photo at right shows bread mold structures that are called ________.
    A. hyphae
    B. rhizoids
    C. zygospores
    D. sporangia

LM Magnification: 27×

Constructed Response

16. **Open Ended** Your neighbor is pulling up mushrooms that are growing in his lawn. He tells you that he heard mushrooms won't come back again if they are quickly removed. What would you tell him?
17. **Infer** Why is being able to produce spores that can be widely dispersed such an important adaptation for fungi?
18. **Describe** When you transplant flowers, shrubs, or trees, why is it a good idea to leave the soil intact around a plant's roots?

John D. Cunningham/Visuals Unlimited

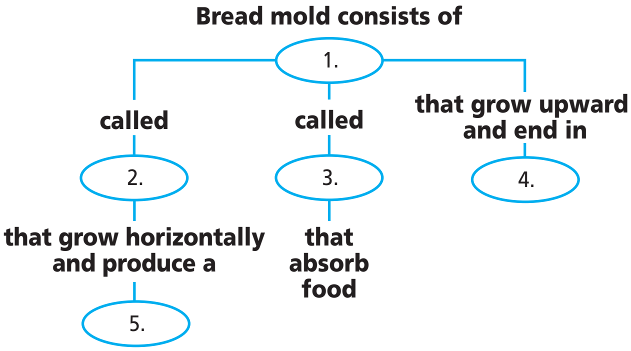
bdol.glencoe.com/chapter_test

CONTENTS

Chapter 20 Assessment

Thinking Critically

19. Concept Map Use the following terms: sporangia, rhizoids, hyphae, stolons, mycellium.



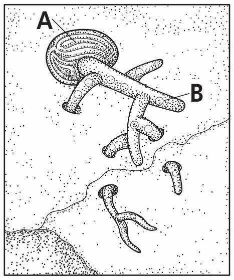
20. REAL WORLD BIOCHALLENGE Since the introduction of penicillin, fungi have played a major role in the development of antibiotic medicines. Visit **bdol.glencoe.com** to find out more about some examples of fungi that have been used in the development of antibiotics. Why was the development of penicillin so important to the United States? Write an essay that explains what you find out about the development of antibiotics. Share your information with the class.

Standardized Test Practice

All questions aligned and verified by The Princeton Review

Part 1 Multiple Choice

Use the diagram to answer questions 21 and 22.



21. Structure A and structure B represent a ________ and ________.

A. fungal capsule—mycelium
B. spore—hypha
C. hypha—lichen
D. lichen—mycelium

22. The process illustrated is called ________.

A. photosynthesis **C.** germination
B. fertilization **D.** host invasion

23. Which group of fungi produces sexual spores on a clublike structure?

A. zygomycotes **C.** basidiomycotes
B. ascomycotes **D.** deuteromycotes

24. Which fungi reproduce only asexually?

A. zygomycotes **C.** basidiomycotes
B. ascomycotes **D.** deuteromycotes

Use the information below and your knowledge of science to answer questions 25–27.

The metabolic activity of yeasts at various temperatures is shown in the table below. A chemical indicator added to the yeast solution changed color when yeast cells were metabolizing.

Metabolic Activity of Yeasts	
Temperature of Yeast Solution	Time Needed for Color Change
2°C	No color change
25°C	44 minutes
37°C	22 minutes

25. The yeasts were most active at ________.

A. 2°C **C.** 37°C
B. 25°C **D.** 22°C

26. Yeast cells were metabolizing at ________.

A. 2°C and 25°C **C.** 2°C
B. 2°C and 37°C **D.** 25°C and 37°C

27. The rate of a chemical reaction is not affected by ________.

A. temperature **C.** a catalyst
B. reactant concentration **D.** buoyancy

Part 2 Constructed Response/Grid In

Record your answers on your answer document.

28. Open Ended Describe the ways that fungi reproduce.

29. Open Ended Summarize the role of fungi in maintaining and disrupting equilibrium, including diseases in plants and animals.

bdol.glencoe.com/standardized_test

Viruses, Bacteria, Protists, and Fungi

Archaebacteria and eubacteria occupy most habitats on Earth, and protists and fungi are almost as diverse. But, viruses enter and take over their cells and the cells of all other organisms.

Viruses

There are many kinds of viruses, nonliving particles, most of which can cause diseases in the organisms they infect. Most viruses are much smaller than the smallest bacterium, and none respire or grow.

Structure

Viruses consist of a core of DNA or RNA surrounded by a protein coat, called a capsid. The capsid may be enclosed by a layer called an envelope that is made of phospholipids and proteins. Depending on their nucleic acid content, viruses are classified as either DNA or RNA viruses.

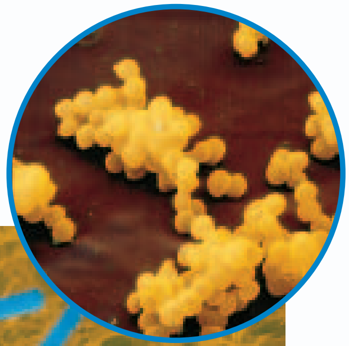
Replication

Viruses replicate only inside cells. First, a virus attaches to a specific molecule on a cell's membrane. Then, it enters the cell where it begins either a lytic or a lysogenic cycle. In the lytic cycle, the viral nucleic acid causes the host to produce new virus particles that are then released, killing the host. In the lysogenic cycle, the viral DNA becomes part of the host's chromosome for a while, and later may enter a lytic cycle.

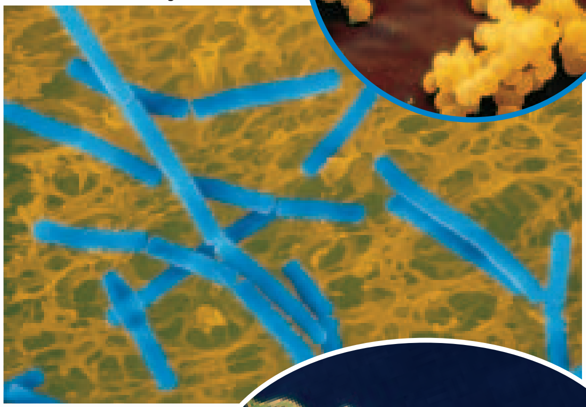
Bacteria

A bacterium is a unicellular prokaryote. Most of its genes are contained in a circular chromosome in the cytoplasm. A cell wall surrounds its plasma membrane. Bacteria may be heterotrophs, photosynthetic autotrophs, or chemosynthetic autotrophs. They reproduce asexually by binary fission and sexually by conjugation.

Color-enhanced SEM Magnification: 10 000×



Color-enhanced SEM Magnification: 1445×



Color-enhanced SEM Magnification: 625×

Bacteria occur in three basic shapes: spheres, rods, and spirals.

Adaptations

Many bacteria are obligate aerobes, needing oxygen to respire. Some bacteria called obligate anaerobes are killed by oxygen. Still other bacteria can live either with or without oxygen. Some bacteria can produce endospores to help them survive unfavorable environmental conditions.

Importance

Some bacteria cause diseases. Other bacteria fix nitrogen, recycle nutrients, and help make food products and medicines.

Protists

Kingdom Protista is a diverse group of heterotrophic, autotrophic, parasitic, and saprophytic eukaryotes. Although many protists are unicellular, some are multicellular. They all live in aquatic or very moist places.

Protozoans: Animal-like protists

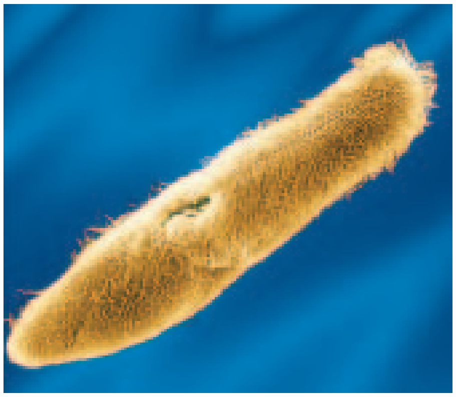
Animal-like protists known as protozoans are unicellular, heterotrophic organisms. Many protozoans are classified based on their adaptations for locomotion in the environment.

Phylum Rhizopoda is composed of the protozoans called amoebas that use pseudopodia, extensions of their plasma membrane, to move and engulf prey. Phylum Mastigophora is composed of protozoans that use flagella to move around. Some parasitic protozoan species that have flagella cause disease, but other flagellated species are helpful. Members of the phylum Ciliophora move by beating hairlike projections called cilia. *Paramecium* is a widely studied ciliate.

Sporozoans are grouped together because they are all parasites and many produce spores. Most have very complex life cycles with different stages. *Plasmodium*, the protozoans that cause the disease malaria, have a sexual stage in mosquitoes and an asexual stage in humans.

Color-enhanced SEM Magnification: 130×

***Plasmodium* may infect more than one hundred million people every year in African and South American countries.**



Color-enhanced TEM Magnification: 4000×

The beating cilia of a *paramecium* produce water currents for collecting food.

Vital Statistics

Protists

Distribution: worldwide in aquatic and moist habitats
Niches: producers, herbivores, predators, parasites, and decomposers
Number of species: more than 60 000
Size range: less than 2 micrometers in length to greater than 100 meters (328 feet) in length

Focus on Adaptations

Archaebacteria: The Extremists

Archaebacteria are unicellular prokaryotes, most of which survive in extremely harsh environments. A group of archaebacteria that produce methane live in the intestinal tracts of animals and in sewage treatment plants. A second group thrives in hot, acidic environments, such as in the thermal springs of Yellowstone National Park or around the hot vents on ocean floors. A third group survive in extremely salty water such as that found in Utah's Great Salt Lake.

Utah's Great Salt Lake

(t)Meckes/Ottawa/Photo Researchers, (c)Dr. Dennis Kunkel/Phototake, NYC, (b)Leonard L.T. Rhodes/Earth Scenes

LM Magnification: 400×

Color-enhanced LM Magnification: 200×

Euglenas use one or two flagella to move.

The shells of diatoms contain silica.

Algae: Plantlike Protists

Autotrophic protists are called algae. They are grouped on the basis of body structure and the pigments they contain. Photosynthetic algae produce a great deal of Earth's atmospheric oxygen. They are unicellular and multicellular.

Euglenas

Unicellular algae that can be both autotrophs and heterotrophs are classified in the phylum Euglenophyta. Most species have chlorophyll for photosynthesis. When there is no light, some euglenas can ingest food.

Diatoms

Unicellular algae called diatoms are classified in phylum Bacillariophyta. In addition to chlorophyll, diatoms contain carotenoids, pigments with a golden-yellow color. Diatoms live in both saltwater and freshwater environments.

Dinoflagellates

Dinoflagellates, members of the phylum Dinoflagellata, are unicellular algae surrounded by hard, armorlike plates and propelled by flagella. They may contain a variety of pigments, including chlorophyll, caretenoids, and red pigments. Marine blooms of dinoflagellates can cause toxic red tides.

Red Algae

Members of the phylum Rhodophyta are multicellular marine algae. Because of their red and blue pigments, some species can grow at depths of 100 meters.

Brown Algae

About 1500 species of algae are classified in phylum Phaeophyta and all contain a brown pigment. The largest brown algae are the giant kelps that can grow to about 60 meters in length.

Magnification: 8×

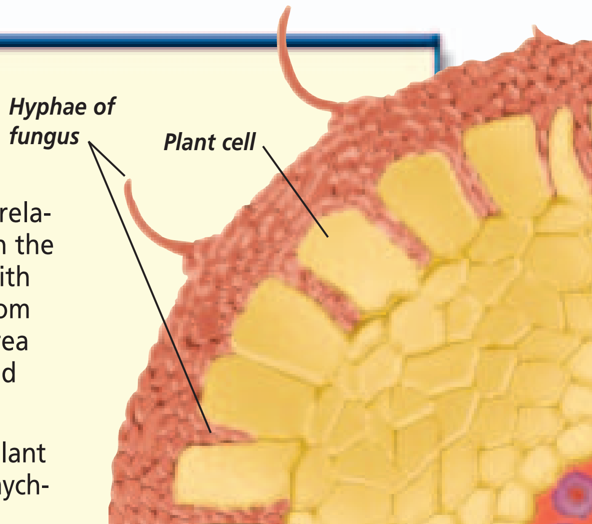
A chocolate slime mold

Focus on Adaptations

Mycorrhizae

Some plants live in association with mutualistic fungi. These relationships, called mycorrhizae (my kuh RHY zuh), benefit both the fungi and the plants. The hyphae of the fungus are entwined with the roots of the plant, and absorb sugars and other nutrients from the plant's root cells. In turn, the fungus increases the surface area of the plant's roots, allowing the roots to absorb more water and minerals.

The relationship enables the fungus to obtain food and the plant to grow larger. Some plants have grown so dependent on their mychorrhizal relationships that they cannot grow without them.



Fungal hyphae can grow among a plant's root cells.

Green Algae

The green algae in the phylum Chlorophyta, may be unicellular, colonial, or multicellular. The major pigment in their cells is chlorophyll, and some also have yellow pigments.

Funguslike Protists

Funguslike protists include the slime molds, water molds, and downy mildews. They are saprophytes, decomposing organic material to obtain its nutrients.

Fungi

Members of Kingdom Fungi are mostly multicellular, eukaryotic organisms that have cell walls made of chitin. The structural units of a fungus are hyphae. Fungi secrete enzymes into a food source to digest the food and then absorb the digested nutrients.

Fungi may be saprophytes, parasites, or mutualists. They play a major role in decomposing organic material and recycling Earth's nutrients.

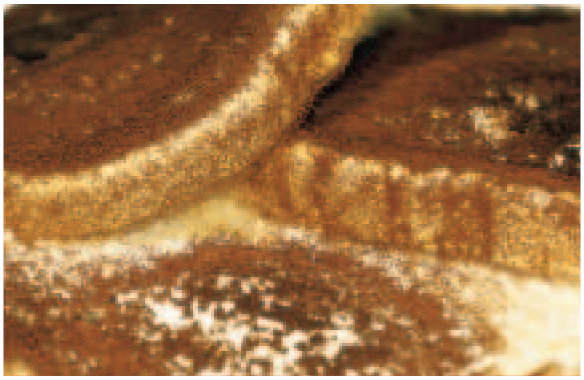
These mushrooms have gills containing basidia on the underside of their caps.

Club Fungi

Club fungi include mushrooms, puffballs, and bracket fungi, and all are members of phylum Basidiomycota. Club fungi have club-shaped structures called basidia in which their sexual spores are produced.

Zygospore-Forming Fungi

Members of phylum Zygomycota produce thick-walled, sexual spores called zygospores. Zygomycotes also form many asexual spores in sporangia.



Some of this bread mold's hyphae (HI fee) form a mat called a mycelium that is anchored in the food source by other hyphae called rhizoids.

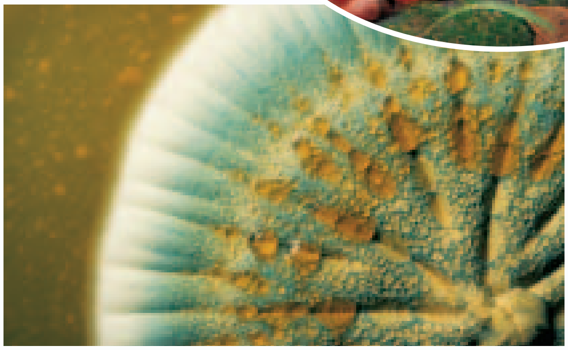
Sac Fungi

Fungi that produce sexual spores called ascospores in saclike structures called asci are classified in phylum Ascomycota. Sac fungi produce asexual spores, called conidiospores, which develop in chains or clusters from the tips of elongated hyphae called conidiophores.

Lichens

A lichen is a symbiotic association of a mutualistic fungus and a photosynthetic alga or cyanobacterium. Lichens live in many inhospitable areas, such as cold climates and high altitudes, but they are sensitive to pollution and do not grow well in polluted areas.

Ascomycota, such as this scarlet cup, produce spores inside cup-shaped sacs.



Imperfect fungi, such as this *Penicillium* mold, are classified in phylum Deuteromycota. Sexual reproduction has never been observed in imperfect fungi.

Standardized Test Practice

The Princeton Review — TEST-TAKING TIP

Investigate

Ask what kinds of questions to expect on the test. Ask for practice tests so that you can become familiar with the test-taking materials.

Part 1 Multiple Choice

1. The core of a virus contains ________.
- **A.** phospholipids
- **B.** nucleic acids
- **C.** amino acids
- **D.** proteins

2. Photosynthetic bacteria include ________.
- **A.** cyanobacteria
- **B.** anaerobes
- **C.** methanogens
- **D.** chemoautotrophs

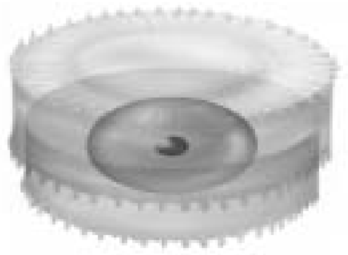
3. The most likely place to find archaebacteria would be in ________.
- **A.** food
- **B.** a DNA lab
- **C.** a hot sulfur spring
- **D.** a fast flowing stream

4. The bacterial name associated with a rod shape is ________.
- **A.** bacillus
- **B.** coccus
- **C.** spirillum
- **D.** nucleic acid

5. A key enzyme utilized by an RNA virus is ________.
- **A.** reverse transcriptase
- **B.** provirus
- **C.** attachment protein
- **D.** capsid

6. Penicillin kills bacteria by interfering with the enzymes that link the sugar chains in the ________.
- **A.** nucleus
- **B.** cell wall
- **C.** plasmid
- **D.** capsule

7. In the ________ cycle, viruses use the cell's energy and raw materials to copy themselves, then burst from the cell.
- **A.** cell
- **B.** lysogenic
- **C.** plasmid
- **D.** lytic



8. In the illustration of a diatom above, the shell is made of ________.
- **A.** protein
- **B.** silica
- **C.** carbohydrate
- **D.** lipid

9. A population explosion of dinoflagellates that produces a strong nerve toxin is ________.
- **A.** only possible in freshwater
- **B.** *Pfiesteria piscicida*
- **C.** a red tide
- **D.** rare in warm, polluted waters

10. A student finds a species of autotrophic algae with a long filament that propels it through the water. The filament is a ________.
- **A.** flagellum
- **B.** pseudopod
- **C.** cilium
- **D.** microtubule

11. The major pigment of green algae is ________.
- **A.** red
- **B.** carotene
- **C.** chlorophyll
- **D.** a chloroplast

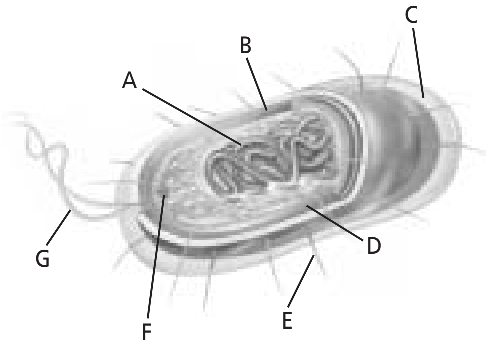
12. Mushrooms are classified in phylum ________.
- **A.** Basidiomycota
- **B.** Zygomycota
- **C.** Ascomycota
- **D.** Deuteromycota

13. Cell walls of fungi contain ________.
- **A.** cellulose
- **B.** spores
- **C.** hyphae
- **D.** chitin

14. A puffball is a type of ________.
- **A.** sac fungus
- **B.** club fungus
- **C.** lichen
- **D.** imperfect fungus

15. Lichens are sensitive to ________.
- **A.** pollution
- **B.** cold
- **C.** drought
- **D.** predators

Use the information below and your knowledge of science to answer questions 16–19.



16. The organism pictured is ________.
- **A.** prokaryotic
- **B.** eukaryotic
- **C.** multicellular
- **D.** not a living organism

17. The component designated as C is most commonly found in ________.
- **A.** disease causing viruses
- **B.** harmless viruses
- **C.** disease causing bacteria
- **D.** harmless bacteria

18. Component F is a ________.
- **A.** ribosome
- **B.** pilus
- **C.** nucleus
- **D.** plasmid

19. The physical law that best explains why component G causes the organism to move is ________.
- **A.** Newton's first law of motion
- **B.** Newton's third law of motion
- **C.** Ohm's law
- **D.** Boyle's law

Part 2 Constructed Response/Grid In

Record your answers on your answer document.

20. Open Ended Compare and contrast the structures and functions of viruses to those of cells. Why are viruses not considered to be living?

21. Open Ended In agricultural regions where farmers use large amounts of nitrogen fertilizers in their fields, local ponds and lakes often develop a thick, green scum containing algae in late summer. Hypothesize why this happens.

22. Open Ended Both fungi and animals are heterotrophs. Contrast the interactions of fungi and plants with the interactions of animals and plants.

23. Open Ended Describe some vastly different characteristics among organisms in the Kingdom Protista. What common characteristics link them as protists?