# Chapter 20 Organizer

Refer to pages 4T-5T of the Teacher Guide for an explanation of the National Science Education Standards correlations.

| Section | Objectives | Activities/Features |
|---|---|---|
| **Section 20.1**<br>**What Is a Fungus?**<br>National Science Education Standards UCP.1, UCP.2, UCP.5; A.1, A.2; C.1, C.4, C.5, C.6; F.5 (1 session, 1 block) | 1. **Identify** the basic characteristics of fungi.<br>2. **Explain** the role of fungi as decomposers and how this role affects the flow of both energy and nutrients through food chains. | **MiniLab 20-1:** Growing Mold Spores, p. 546<br>**Problem-Solving Lab 20-1,** p. 550 |
| **Section 20.2**<br>**The Diversity of Fungi**<br>National Science Education Standards UCP.1-5; A.1, A.2; C.1, C.3, C.4, C.5, C.6; F.1, F.4, F.5; G.1-3 (3 sessions, ½ block) | 3. **Identify** the four major divisions of fungi.<br>4. **Distinguish** among the ways spores are produced in zygomycotes, ascomycotes, and basidiomycotes.<br>5. **Summarize** the ecological roles of lichens and mycorrhizae. | **MiniLab 20-2:** Examining Mushroom Gills, p. 554<br>**Inside Story:** The Life of a Mushroom, p. 555<br>**Problem-Solving Lab 20-2,** p. 558<br>**Internet BioLab:** Does temperature affect the metabolic activity of yeast? p. 560<br>**Social Studies Connection:** The Dangers of Fungi, p. 562 |

Need Materials? Contact Carolina Biological Supply Company at 1-800-334-5551 or at **http://www.carolina.com**

## MATERIALS LIST

### BioLab

**p. 560** bromthymol blue solution, drinking straw, small test tubes (4), large test tubes, (3), one-hole stoppers with glass tube inserts (3), yeast/white corn syrup mixture, water/white corn syrup mixture, water/yeast mixture, test-tube rack, 250-mL beakers (3), ice cubes, thermometer, hot plate, 50-mL graduated cylinder, glass-marking pencil, 10 cm length rubber tubing (3), aluminum foil

### MiniLabs

**p. 546** bakery bread, water, plate, self-seal plastic bags (2), forceps, microscope, microscope slide, coverslip, dropper, water

**p. 554** fresh mushrooms, paper bag, white paper

### Alternative Lab

**p. 546** small paper cups, macaroni, aluminum foil, water, cardboard, oatmeal flakes, cotton swab, mold spores, plastic wrap

### Quick Demos

**p. 547** fresh mushrooms, paper, pencil

**p. 553** microscope, microscope slide, coverslip, dropper, water, forceps, preserved specimen of *Peziza*

## Key to Teaching Strategies

- **L1** Level 1 activities should be appropriate for students with learning difficulties.
- **L2** Level 2 activities should be within the ability range of all students.
- **L3** Level 3 activities are designed for above-average students.
- **ELL** ELL activities should be within the ability range of English Language Learners.
- **COOP LEARN** Cooperative Learning activities are designed for small group work.
- **P** These strategies represent student products that can be placed into a best-work portfolio.
- These strategies are useful in a block scheduling format.



# Fungi

## Teacher Classroom Resources

| Section | Reproducible Masters | Transparencies |
|---|---|---|
| **Section 20.1**<br>**What Is a Fungus?** | **Reinforcement and Study Guide,** pp. 87-88 L2<br>**Concept Mapping,** p. 20 L3 ELL<br>**Critical Thinking/Problem Solving,** p. 20 L3<br>**BioLab and MiniLab Worksheets,** p. 93 L2<br>**Tech Prep Applications,** pp. 29-30 L2<br>**Content Mastery,** pp. 97-98, 100 L1 | **Section Focus Transparency 48** L1 ELL |
| **Section 20.2**<br>**The Diversity of Fungi** | **Reinforcement and Study Guide,** pp. 89-90 L2<br>**BioLab and MiniLab Worksheets,** pp. 94-96 L2<br>**Laboratory Manual,** pp. 141-144 L2<br>**Content Mastery,** pp. 97, 99-100 L1 | **Section Focus Transparency 49** L1 ELL<br>**Basic Concepts Transparency 31** L2 ELL<br>**Basic Concepts Transparency 32** L2 ELL<br>**Reteaching Skills Transparency 31** L1 ELL |

### Assessment Resources

**Chapter Assessment,** pp. 115-120
**MindJogger Videoquizzes**
**Performance Assessment in the Biology Classroom**
**Alternate Assessment in the Science Classroom**
**Computer Test Bank**
**BDOL Interactive CD-ROM,** Chapter 20 quiz

### Additional Resources

**Spanish Resources** ELL
**English/Spanish Audiocassettes** ELL
**Cooperative Learning in the Science Classroom** COOP LEARN
**Lesson Plans/Block Scheduling**

## NATIONAL GEOGRAPHIC Teacher's Corner

**Index to National Geographic Magazine**
***The following articles may be used for research relating to this chapter:***
"Leafcutters: Gardeners of the Ant World," by Mark W. Moffett, July 1995.
"The Wild World of Compost," by Cecil E. Johnson, August 1980.
"Bizarre World of Fungi," by Paul A. Zahl, October 1965.

## GLENCOE TECHNOLOGY

The following multimedia resources are available from Glencoe.

**Biology: The Dynamics of Life**
**CD-ROM** ELL
Video: *Fungal Decay*
Exploration: *The Five Kingdoms*
BioQuest: *Biodiveristy Park*
Animation: *Life Cycle of a Mushroom*
**Videodisc Program**
Fungal Decay
Life Cycle of a Mushroom

**The Secret of Life Series**
Six Kingdoms
Fungi
Mycorrhizae

# Chapter 20

## Getting Started Demo

After students have observed moldy fruit, show them other fungi. Have them discuss the similarities and differences they observe.

### Theme Development

The theme of **unity within diversity** is prominent in discussions of the diversity of fungi. The theme of **energy** is evident when the role of fungi as decomposers is discussed.

## 0:00 Out of Time?

If time does not permit teaching the entire chapter, use the BioDigest at the end of the unit as an overview.

## Internet Address Book

internNET CONNECTION Note Internet addresses that you find useful in the space below for quick reference.

Chapter

# 20 Fungi

### What You'll Learn

- You will identify the characteristics of fungi.
- You will differentiate among the divisions of fungi.

### Why It's Important

By decomposing organic matter, fungi clean your environment and recycle nutrients.

## Getting Started

***Observing a Fungus***

Use a magnifying glass to observe a moldy piece of fruit. *How does the appearance of the mold differ from that of bacterial colonies?*

internNET CONNECTION To find out more about fungi, visit the Glencoe Science Web Site.
**www.glencoe.com/sec/science**

**Chanterelles, mushrooms eaten as delicacies, grow under oak and pine trees from early spring through late fall. Other fungi such as the deadly *Amanita muscaria* mushroom (inset) should never be eaten.**





## Multiple Learning Styles

Look for the following logos for strategies that emphasize different learning modalities.

***Kinesthetic*** Activity, p. 548; Quick Demo, p. 553; Project, p. 555; Portfolio, p. 558

***Visual-Spatial*** Quick Demo, p. 547; Meeting Indivdual Needs, p. 548; Portfolio, pp. 548, 552; Biology Journal, p. 552; Enrichment, p. 557

***Intrapersonal*** Enrichment, p. 548

***Linguistic*** Biology Journal, p. 549; Enrichment, pp. 552, 556; Discussion, p. 559

***Logical-Mathematical*** Portfolio, p. 557

***Naturalist*** Reteach, pp. 549, 559; Tech Prep, p. 554; Meeting Individual Needs, p. 557

Section

# 20.1 What Is a Fungus?

**SECTION PREVIEW**

**Objectives**

**Identify** the basic characteristics of fungi.

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

**Vocabulary**

hypha
mycelium
chitin
haustoria
budding
sporangium

*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*

## 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, puffball, rust, or ringworm. Many

**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.



## Assessment Planner

**Portfolio Assessment**
- **Portfolio, TWE,** pp. 548, 552, 557, 558
- **Problem-Solving Lab, TWE,** p. 550
- **Assessment, TWE,** p. 556

**Performance Assessment**
- **MiniLab, SE,** pp. 546, 554
- **MiniLab, TWE,** p. 546
- **Alternative Lab, TWE,** pp. 546-547
- **Assessment, TWE,** p. 548
- **BioLab, SE,** p. 561
- **BioLab, TWE,** p. 561

**Knowledge Assessment**
- **Alternative Lab, TWE,** pp. 546-547
- **Section Assessment, SE,** pp. 550, 559
- **Problem-Solving Lab, TWE,** p. 558
- **Assessment, TWE,** p. 559
- **Chapter Assessment, SE,** pp. 563-565

**Skill Assessment**
- **Assessment, TWE,** p. 549
- **MiniLab, TWE,** p. 554



# Prepare

### Key Concepts

This section describes the structure of fungi and how fungi obtain nutrients and reproduce.

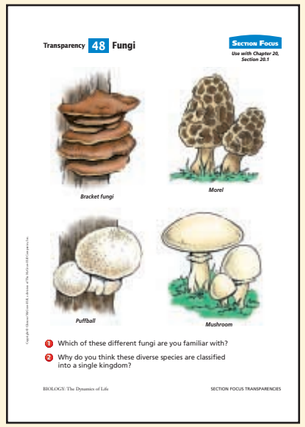
### Planning

- Obtain bread and plastic bags for MiniLab 20-1 and mushrooms for the Quick Demo.
- Begin to grow molds for the Alternative Lab and the Activity one week ahead of time.

# 1 Focus

### Bellringer

Before presenting the lesson, display **Section Focus Transparency 48** on the overhead projector and have students answer the accompanying questions. L1 ELL




## Resource Manager

Section Focus Transparency 48 and Master L1 ELL

# 2 Teach

## MiniLab 20-1

**Purpose**
Students will identify a requirement for bread mold to grow.

**Process Skills**
observe and infer, experiment

**Teaching Strategies**
- Mold grows quickly on bakery bread that lacks preservatives.
- Identify calcium propionate on bread ingredient labels as a mold inhibitor. Have students design an experiment to test its effectiveness.
- Have students wear aprons, gloves, and goggles and wash their hands after they finish. Remind them to use caution when working with glass slides and coverslips and when opening the bags containing mold.
- Autoclave or incinerate all fungal samples to destroy them.

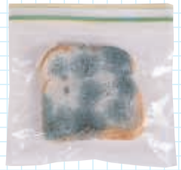
**Expected Results**
After 4-6 days, mold will grow only on moist bread slices.

**Analysis**
1. Only moist bread had mold. It suggests that there might be spores in the classroom air.
2. Molds require water and food for growth.

**Assessment**
**Performance** Have students design an experiment to show that air contains mold spores that will grow on bread. Use the Performance Task Assessment List for Designing an Experiment in **PASC,** p. 23. L2

## MiniLab 20-1 Observing and Inferring

**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. 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. What conclusions can you draw about the conditions necessary for the growth of a bread mold?

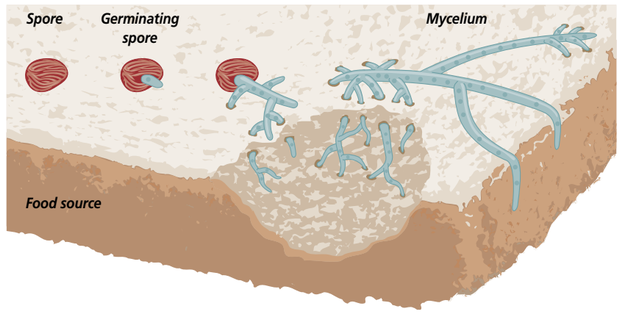
species grow best in moist environments at warm temperatures between 20°C and 30°C. You are, however, probably familiar with molds that grow at much lower temperatures on left-over foods in your refrigerator.

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.**






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** (KITE un). 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.

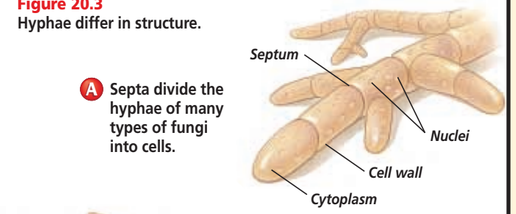
Some fungi consist of hyphae with no septa. When you look at these hyphae under a microscope, you see hundreds of nuclei streaming along in a continuous flow of cytoplasm. As in hyphae with septa, the flow of cytoplasm quickly and efficiently disperses nutrients and other materials throughout the fungus.

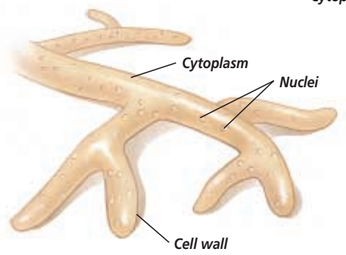
## Adaptations in Fungi

Fungi can have some negative aspects—spoiled food, diseases, and poisonous mushrooms. However, they play an important role in the interactions of organisms because they decompose large quantities of Earth's organic wastes. 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 several species of bacteria and protists, are decomposers. They break down complex organic substances into raw materials that living organisms need. Thanks to these organic decomposers, fallen leaves, animal carcasses, and other organic materials that become waste are eventually decomposed.

**Figure 20.3**
**Hyphae differ in structure.**

**A** Septa divide the hyphae of many types of fungi into cells.




**B** Hyphae without septa look like branching, multinucleate cells.

### How fungi obtain food

Unlike plants and some protists, fungi cannot produce their own food. Fungi are heterotrophs, and they must 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.



**Quick Demo**

*Visual-Spatial* Provide small student groups with mushrooms purchased from a supermarket and ask them to record their observations. After four or five minutes, have the groups share their lists. L1
COOP LEARN

**GLENCOE TECHNOLOGY**

**CD-ROM**
**Biology: The Dynamics of Life**
Video: *Fungal Decay*
Disc 3

**VIDEODISC**
**Biology: The Dynamics of Life**
*Fungal Decay* (Ch. 15)
Disc 1, Side 2, 24 sec.

**Resource Manager**
**BioLab and MiniLab Worksheets,** p. 93 L2

# Alternative Lab

## Mold Growth

**Purpose**
Students will show that mold grows on any moist, organic material.

**Materials**
small paper cups, macaroni, aluminum foil, water, cardboard pieces, oatmeal flakes, swab with mold spores, plastic wrap

**Procedure**
Give students the following directions.
1. Number eight small paper cups 1-8 and label each with your name and date. Add the following to each cup (1/8 full): cup #1 cardboard, #2 moist cardboard, #3 oatmeal, #4 moist oatmeal, #5 macaroni, #6 moist macaroni, #7 aluminum foil ball, #8 wet aluminum foil ball.
2. Rub a cotton swab with mold spores on the surface of each cup's contents.
3. Cover each cup with plastic wrap and place the cups in a designated area.
4. Check the cups each day for a week.
5. Design a data table to record your observations, including the amount of mold growth.
6. Dispose of any mold that grows as your teacher directs.

**Analysis**
1. What evidence suggests that mold feeds on organic matter? *All organic materials showed mold growth. The only inorganic material, aluminum foil, showed no growth.*
2. Explain the role of the cups without water. *They were controls, showing that molds require moisture to grow.*

**Assessment**
**Knowledge** Have the students hypothesize whether the following items will support mold growth and explain why: dry cereal, penny, wet penny, wet cracker, cooked and uncooked rice. Use the Performance Task Assessment List for Formulating a Hypothesis in **PASC,** p. 21. L2

## Activity

***Kinesthetic*** Use any mold that grows on food to illustrate the appearance of hyphae. Have students prepare some wet mounts of the mold and view it under low- and then high-power magnification. Have students wear aprons, gloves, and goggles and wash their hands after handling the fungal samples. Caution them to use care when working with glass slides and coverslips and when viewing a slide under high power. L2 ELL

## Enrichment

***Intrapersonal*** A fungus called *Aspergillus flavus* can invade stores of grains and nuts. It produces a chemical called aflatoxin, a carcinogen that can destroy the liver if ingested. Have students research the ways to identify tainted grain and nuts. L3

## Using Science Terms

Have students compare the terms *extracellular digestion* and *intracellular digestion* and provide an example of each. L2

## Assessment

**Performance** Have students observe a slide of budding yeast cells. Ask them to sketch what they see, label their drawings, and write a paragraph about the process. L2

**Resource Manager**

Concept Mapping, p. 20
L3 ELL

### 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.***

**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.

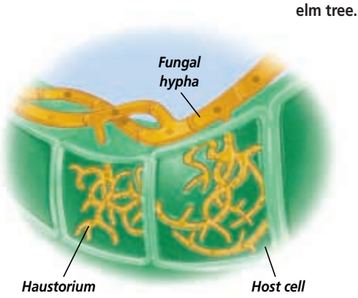
## Reproduction in Fungi

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.**




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

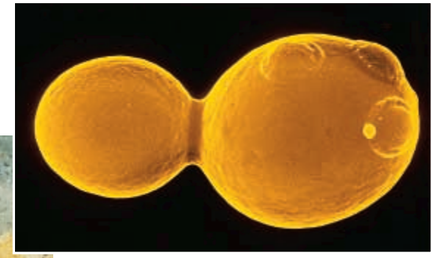
**A** A parasitic fungus is killing this American elm tree.

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



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

**A** Most yeasts reproduce asexually by budding.



**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 hyphal structures where the fungal spores are produced are usually the only part of a fungus you can see, and the sporangia often represent only a 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.

### 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 produces about 1 trillion spores. Producing so many spores increases

**WORD Origin**

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



## 3 Assess

### Check for Understanding

Have students explain how the following are related. L1

- hyphae—mycelium
- cell wall—chitin
- decomposers—extracellular digestion
- reproduction—sporangium
- spores—budding

### Reteach

***Naturalist*** Have students outline fungal characteristics, including structure, nutrition, and reproduction. L1

### Extension

Yeast cells respire aerobically and undergo fermentation anaerobically. Review the processes and ask students to compare and contrast them. L1

**Assessment**

**Skill** Have students make a table that compares the cellular organizations, methods of obtaining food, cell wall compositions, and habitats of fungi and plants. L1

**GLENCOE TECHNOLOGY**

**CD-ROM**
**Biology: The Dynamics of Life**
Exploration: *The Five Kingdoms*
Disc 3

**VIDEODISC**
**The Secret of Life**
*Six Kingdoms*

**Resource Manager**

Reinforcement and Study Guide, pp. 87-88 L2
Content Mastery, p. 98 L1

### Meeting Individual Needs

**Learning Disabled**

***Visual-Spatial*** Give students a diagram of mold growing on bread. The diagram should also show sporangia, some of which are releasing spores. Have students label where reproduction, digestion, and feeding occur. L1 ELL

**Portfolio**

**Fungi Adaptations**

***Visual-Spatial*** Ask students to diagram the fungi they observed in the Getting Started and the Activity and compare them in writing, explaining their adaptations and feeding relationships. L2 P

**Biology Journal**

**Feeding Relationships**

***Linguistic*** Have the students write about the feeding relationships of fungi as if they were writing a newspaper article describing an outbreak of parasitic fungi. L2

## Problem-Solving Lab 20-1

### Purpose

Students will analyze information about chestnut blight fungus.

### Process Skills

analyze information, draw a conclusion, apply concepts

### Teaching Strategies

- Compare the chestnut blight and Dutch Elm disease.
- Explain the role of a plant's vascular tissue.
- Review the meanings of fungal strain, canker, and fungicide.

### Thinking Critically

1. Answers will vary. It's hard to keep trees free of insects, birds, wind, and rain.
2. The fungus grows under the bark.
3. Answers will vary—import some Japanese chestnut trees, breed *dentata* species with *crenata* species.

### Assessment

**Portfolio** Ask students to find the derivation of the word *canker* and explain why it so well describes chestnut blight symptoms. Use the Performance Task Assessment List for Oral Presentation in **PASC,** p. 71. L2

## 4 Close

### Activity

Have each student list five words or phrases about fungi, only four of which are related, and exchange lists. Ask them to identify the unrelated item and explain how the other items are related.



## Problem-Solving Lab 20-1

**Analyzing 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.

### Analysis

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. Why would it be difficult to control the disease by preventing spores from landing on healthy trees?
2. Based on how this fungus grows, why can't fungicides applied to the bark of an infected tree kill the fungus?
3. 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.**

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. What is the function of pores in hyphal septa?
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 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. **Measuring 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 *Practicing Scientific Methods* in the **Skill Handbook.**



## Section Assessment

1. Materials, such as food, are easily transported through them.
2. Hyphae invade a food source where they release enzymes that digest the food. The hyphae absorb digested foods.
3. Fungi are decomposers that break down and recycle dead organic material, providing nutrients for autotrophs.
4. A mycelium is made up of hyphae.
5. Fungi use a variety of organic materials for food. Different fungi may feed on feathers, excrement, or twigs in the nest.
6. Divide a puffball into many small similar-sized sections. Use a sampling technique to estimate the number of spores in one small section. Multiply the estimate by the number of remaining sections.

Section

# 20.2 The Diversity of Fungi

**SECTION PREVIEW**

**Objectives**

**Identify** the four major divisions of fungi.

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

**Summarize** the ecological roles of lichens and mycorrhizae.

**Vocabulary**

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

*Scientists who study fungi are called mycologists. A mycologist would look for certain features to help identify a mushroom like the one shown here. In particular, the mycologist would look at the spores the mushroom produced. This is because one basis for classifying fungi includes the reproductive characteristics of a fungus. As you'll see, the names of fungal divisions reflect the type of spores produced by fungi.*

**A *Mycena* mushroom (above) and the mushroom's gills (inset)**

## 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 division Zygomycota (zy goh mi KOH tuh). Many other members of about 1500 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,



## Internet Address Book

**inter**NET CONNECTION Note Internet addresses that you find useful in the space below for quick reference.

_____

_____

_____

_____

## Resource Manager

Section Focus Transparency 49 and Master L1 ELL



## Prepare

### Key Concepts

Fungal diversity is described. Then, the characteristics of lichens and mycorrhizae are explained. Finally, possible origins of fungi are presented.

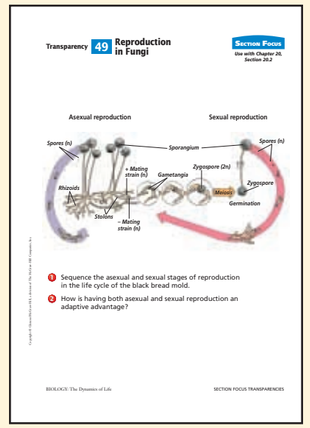
### Planning

- Buy supermarket mushrooms for MiniLab 20-2 and the Tech Prep. Obtain mushroom guides for the Tech Prep.
- Collect lichens for the Enrichment.
- Purchase some blue cheese for the Portfolio.
- Purchase yeast cakes and white corn syrup and prepare a BTB solution for the Biolab. Prepare the short glass tubes.

## 1 Focus

### Bellringer

Before presenting the lesson, display **Section Focus Transparency 49** on the overhead projector and have students answer the accompanying questions. L1 ELL



# 2 Teach

## Reinforcement

Explain that hyphae have different names, depending on their function. Examples are rhizoids, stolons, and sporangia. Have students describe the role of each of these hyphae and then the role of the hyphae called a *mycelium*.

## Using Science Terms

Have students find the meanings of the four terms *sporangium*, *gametangium*, *zygospore*, and *ascospore* and explain how the name of each structure suits its function.

## Enrichment

***Linguistic*** Ask students to research and report on the medical use of cyclosporine, a chemical produced from the soil fungus *Tolypocladium inflatum*. This chemical suppresses the immunity that causes the rejection of transplanted organs. More than 90% of transplant patients survive rejection today because of cyclosporine. L3

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 then fuse. Where the haploid hyphae fuse, they each form a **gametangium** (gam ee 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.

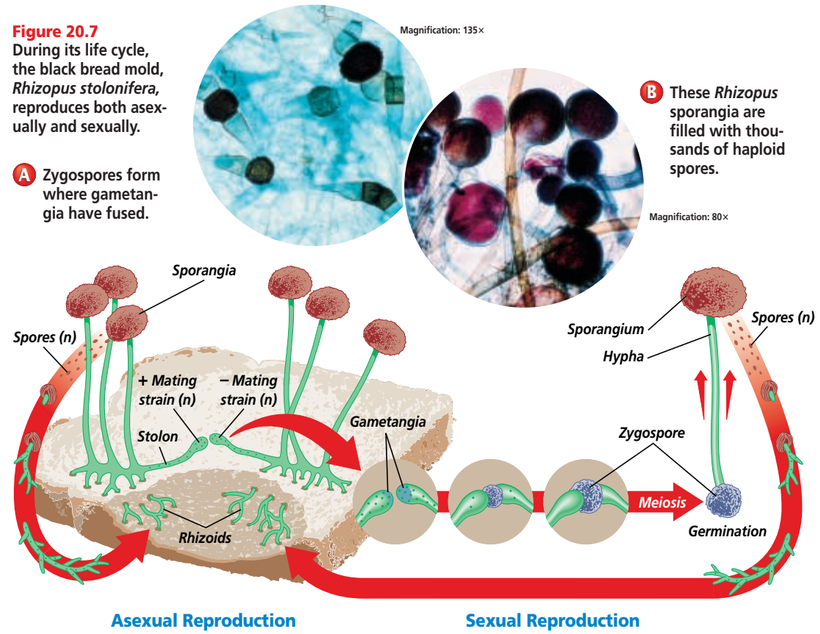



**Figure 20.7**
**During its life cycle, the black bread mold, *Rhizopus stolonifera*, reproduces both asexually and sexually.**

**A** **Zygospores form where gametangia have fused.**

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



## Ascomycotes

The Ascomycota is the largest division 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. Hyphae grow up from the mycelium and elongate to form **conidiophores** (kuh NIHD ee 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 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 *Social Studies Connection* 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 division. 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.


Magnification: 1200×

**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 scarlet cup-like structures of this ascomycote are visible on the dead bark.**

### Quick Demo

***Kinesthetic*** Have students remove a fingernail-sized portion of a preserved specimen of the fungus *Peziza*. Instruct them to prepare a wet mount slide, and gently squash the mount with their thumbs or pencil erasers. Warn students to use caution when using glass microscope slides and coverslips. Ask them to observe the specimen under both low- and high-power magnification and sketch what they see. *They should see perfect asci filled with exactly eight ascospores.* L2 ELL

The BioLab at the end of the chapter can be used at this point in the lesson.

INTERNET BioLab

### Resource Manager

Critical Thinking/Problem Solving, p. 20 L3

### Biology Journal

**Fungus Reproduction**

***Visual-Spatial*** Have students make a table about the three ways that fungi reproduce asexually. Ask them to include an example of each and briefly describe and diagram each reproductive process. L2

### Portfolio

**Concept Map**

***Visual-Spatial*** Have students construct a concept map that uses the following structures and functions: stolons, sporangia, rhizoids, absorb nutrients, form spores, produce mycelia. L1 P

### Biology Journal

**Important Ascomycotes**

TECH PREP

Have students make a table for their journals listing Ascomycotes that are important to people. Ask them to explain why each fungus listed is either helpful or harmful. L2

## MiniLab 20-2

**Purpose**
Students will observe the arrangement of mushroom gills.

**Process Skills**
observe and infer, experiment

**Teaching Strategies**
- Have students wear aprons, gloves, and goggles and wash their hands after they finish.
- Find an area where nothing will disturb the caps overnight.
- Have students make wet mounts of the spores, examine them under low- and high-power magnification, and sketch their observations. L2 ELL

**Expected Results**
Spores will form a pattern on the paper corresponding to the gills' locations.

**Analysis**
1. brown
2. Spores are formed toward the edges of the gills. The patterns are the same.

**Assessment**

**Skill** Give students spore patterns from different mushrooms and use them to reconstruct the gill arrangements. Use the Performance Task Assessment List for Scientific Drawing in **PASC,** p. 55. L2 ELL

**GLENCOE TECHNOLOGY**

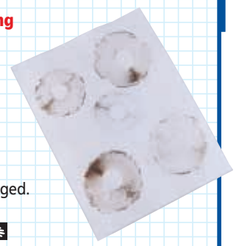
**CD-ROM**
**Biology: The Dynamics of Life**
Animation: *Life Cycle of a Mushroom,* Disc 3

**VIDEODISC**
**Biology: The Dynamics of Life**
*Life Cycle of a Mushroom* (Ch. 16)
Disc 1, Side 2, 1 min. 30 sec.



## MiniLab 20-2 Classifying

**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. What color are the spores on the paper?
2. 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?

## Basidiomycetes

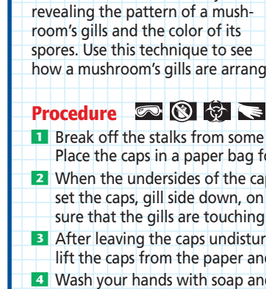
Of all the diverse kinds of fungi, you are probably most familiar with some of the 25 000 species in the division Basidiomycota. Mushrooms, puffballs, stinkhorns, bird's nest fungi, and bracket fungi are all basidiomycotes. So are the rust and smut fungi. Use the *MiniLab* to distinguish some mushroom 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 the *Inside Story* 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 *Nycena,* has a cap that sits on top of a stalk.



**TECHPREP**

**Mushrooms**
***Naturalist*** Provide students with an assortment of store-bought mushrooms and a mushroom field guide. Ask them to identify each mushroom. L3 ELL

**Resource Manager**
**BioLab and MiniLab Worksheets,** p. 94 L2
**Laboratory Manual,** pp. 141-144 L2

## INSIDE STORY

# The Life of a Mushroom

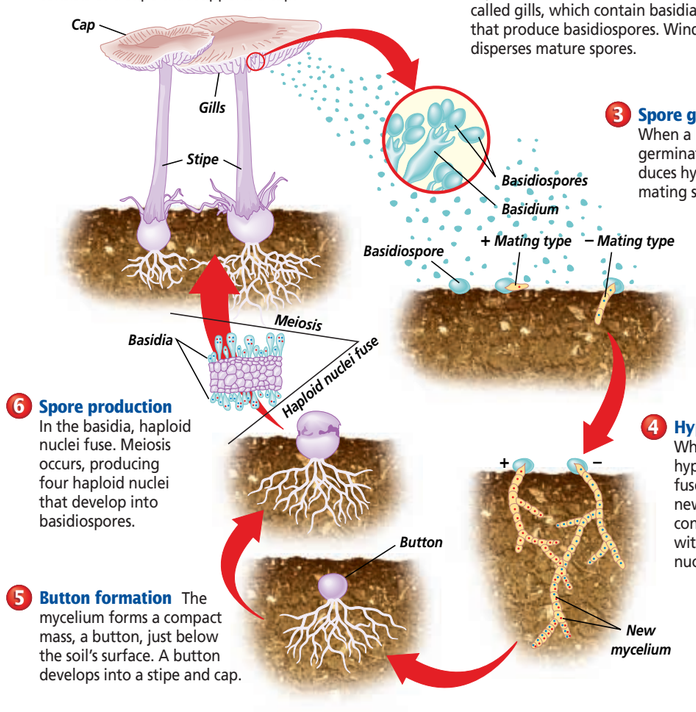
***What you call a mushroom is a reproductive structure of the fungus. Most of the fungus is underground and not visible. A single mushroom can produce hundreds of thousands of spores as a result of sexual reproduction. Most types of mushrooms have no asexual reproductive stages in their life cycle.***

***Critical Thinking*** ***Why are spores of mushrooms produced above ground?***

*Mycena pura*

**1 Stipe and cap** Above ground, a mushroom consists of a stipe that supports a cap.

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




**3 Spore germination** When a basidiospore germinates, it produces hyphae of either mating strain + or –.

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

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

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



**MEETING INDIVIDUAL NEEDS**

**Learning Disabled**
Have students use the Inside Story and teacher input to guide their construction of a flowchart that shows a mushroom's life cycle. L1 ELL

**PROJECT**

**Mushroom Farming**
***Kinesthetic*** Have students follow the directions for growing the organisms in a mushroom farm kit. Ask them to record the changes they observe as the mushrooms grow. L2 ELL COOP LEARN

## INSIDE STORY

**Purpose**
Students will follow the steps in the life cycle of a mushroom.

**Teaching Strategies**
- Remind students that Basidiomycetes spores result from sexual reproduction.

**Visual Learning**
- Point out that in step 4, the nuclei from each original + and – type are in the same cell but not fused. Ask if the cells are haploid, diploid, or haploid + haploid in chromosome number. *haploid + haploid*
- Ask students to use the diagram to explain when fertilization occurs. *just prior to spore formation in the basidium*
- Have students explain the adaptive value of producing many basidiospores. *Many spores ensure the continued life cycle of the fungus.*

**Critical Thinking**
The spores are produced aboveground so that they can be easily dispersed by air currents.

**Resource Manager**
**Basic Concepts Transparency 31 and Master** L2 ELL
**Reteaching Skills Transparency 31 and Master** L1 ELL

## Assessment

**Portfolio** Have students make a table of the fungal divisions based on their sexual reproduction. The table should include each division's name, characteristic structures, other general information, and an illustrated representative organism. L2

### Discussion

Tell students that, to avoid poisonous mushrooms, they should never eat ones collected from fields. Explain that even mycologists may be unsure of the identity of some mushrooms.

### Enrichment

***Linguistic*** Have interested students research mushroom folklore. One good reference is: "Who put the toad in toadstools?" A. Morgan, *New Scientist*, vol. 112, December 1986/January 1987. L3

### Reinforcement

Review the methods by which zygomycetes, ascomycetes, and basidiomycetes reproduce sexually. Emphasize that deuteromycetes form a separate group mainly because nobody has observed them reproduce sexually.

### Enrichment

Have students research the discovery of penicillin and explain how it affected the medical field. L2

## Deuteromycetes

There are about 25 000 species of fungi, classified as the deuteromycotes, that have no known sexual stage in their life cycle, unlike the zygomycotes, ascomycotes, and basidiomycetes. Although the deuteromycetes 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.

### Diverse deuteromycetes

If you've ever had strep throat, pneumonia, or another kind 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 20.11.*** Other deuteromycetes are used in the making of foods, such as soy sauce and some kinds of blue-veined cheese. Still other deuteromycetes are used commercially to produce substances such as citric acid, which gives jams, jellies, soft drinks, and fruit-flavored candies a tart taste.

**WORD Origin**

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

## 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 basidiomycetes, but some zygomycotes also form these important relationships.

How does a plant benefit from a mycorrhizal relationship? Fine, threadlike hyphae surround and often grow harmlessly into the plant's roots, as shown in ***Figure 20.12.*** 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 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.

In addition to trees, 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 the extreme, some species cannot survive without mycorrhizae. Orchid seeds, for example, usually do not germinate without a symbiotic fungus to provide water and nutrients.

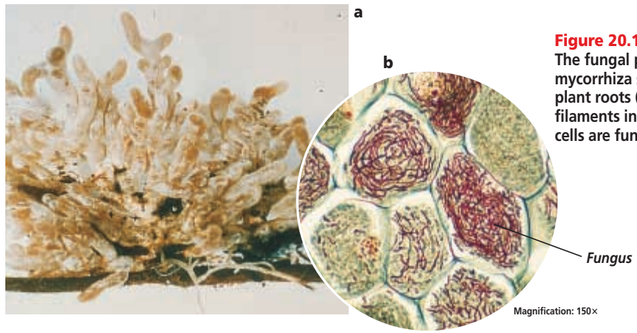



**Figure 20.12**
**The fungal part of a mycorrhiza surrounds plant roots (a). The red filaments in the plant cells are fungal hypae (b).**

### 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, ***Figure 20.13.*** They may look like flakes of old

**Figure 20.13**
**Lichens have a variety of forms.**

**A** Some lichens form crustlike growths on bare rocks and stone walls.

**B** Each stalk of a British soldier lichen is about 3 cm tall.

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





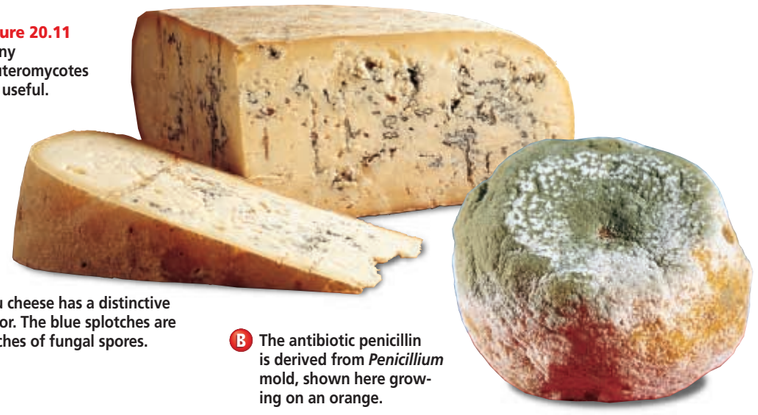


**Figure 20.11**
**Many deuteromycotes are useful.**

**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.

## Cultural Diversity

### A Fungus Called Ergot

The fungus ergot produces many chemicals, including ergotamine. In ancient Greece and Peru and also during the Middle Ages in Europe, ergot was used in small quantities for spiritual and medicinal purposes.

Ergot grows on rye and causes severe symptoms if it is milled in flour that people ingest. Eating ergot causes Saint Anthony's fire, a disease with symptoms that include uncontrolled behavior, hallucinations, hysteria, and facial redness. Some historians suggest that ergot may have caused the bizarre behavior of the people tried for witchcraft in Salem, Massachusetts, during colonial times.

## Portfolio

### Designing an Experiment

***Logical-Mathematical*** Have students hypothesize the effects of acid rain on mushroom growth. Then ask them to design a procedure that tests their hypothesis. Remind them to include experimental controls. L2 P

## Meeting Individual Needs

### English Language Learners

***Naturalist*** Have students make a table that compares mycorrhizae and lichens. The left side of the table should list the two symbiotic relationships. The column heads should include: Type of relationship, Organisms involved, Habitat, Advantage to the organisms. L2 ELL

### Enrichment

***Visual-Spatial*** Soak lichens overnight in water. Have students examine the water with a stereomicroscope. They should observe many tiny animals called "water bears" or tardigrades. Have students diagram the tardigrades and research them. L3 ELL

**GLENCOE TECHNOLOGY**

**CD-ROM**
**Biology: The Dynamics of Life**
BioQuest: *Biodiversity Park*
Disc 3, 4

**VIDEODISC**
**The Secret of Life**
*Fungi*

*Mycorrhizae*

**Resource Manager**
Tech Prep Applications, pp. 29-30 L2

## Problem-Solving Lab 20-2

### Purpose

Students will differentiate between a lichen's fungal and algal components.

### Process Skills

compare and contrast, think critically, design an experiment, interpret scientific diagrams

### Teaching Strategies

- Make sure that students are familiar with the composition of lichens before doing this activity.
- Review symbiosis and discuss the life styles, including mutualism, that the term includes.

### Thinking Critically

1. Structure B is the algal part because it is green, the color of chlorophyll. Structure A is the fungal part because it is not green and probably cannot make its own food.
2. Structure C shows a sac or ascus that contains spores.
3. Answers will vary. Separate the algae and fungi and try to maintain each part separately by providing nutrients and water to the fungus and light, carbon dioxide, and water to the alga.

### Assessment

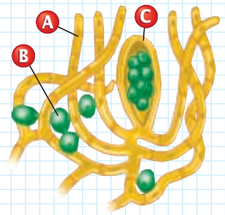
**Knowledge** Have students research and write a report about the consequences of Norwegian lichens absorbing radioactive elements after the Chernobyl nuclear accident in Russia. Use the Performance Task Assessment List for Writing in Science in **PASC,** p. 87. L3



## Problem-Solving Lab 20-2 — Thinking 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.




### Analysis

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. Using color as a clue, list the letters that identify the algal and fungal parts of the lichen. Explain your choices.
2. 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 information.
3. Scientists have wondered if the parts of a lichen can survive by themselves. Describe an experiment that might answer this question.

**Figure 20.14** ***Cladina stellaris*** **is a common lichen on the tundra and a favorite food of caribou and reindeer.**

paint or dried moss, but they are lichens. 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. Lichens grow slowly, increasing in diameter only 0.1 to 10 mm per year. Very large 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 20.14,*** 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. This is because the fungus readily absorbs materials from the air. If air pollutants are present, they kill the fungus. Without the fungal part of a lichen, the photosynthetic partner also dies.

### Portfolio

**Checking Out Moldy Cheese**

***Kinesthetic*** Have students prepare wet mount slides of the fungus in blue cheese and observe it under a microscope. Remind them to be careful when working with microscopes and slides. Ask them to diagram and describe their observations. L2 P



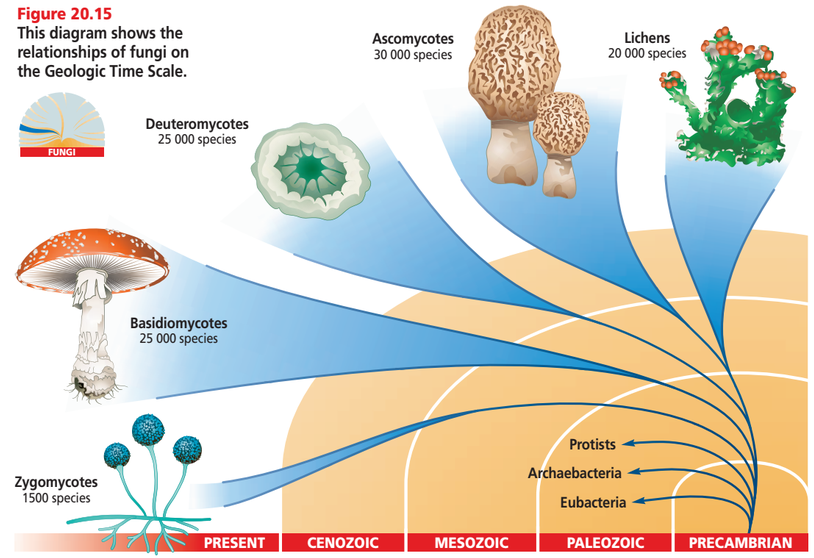



**Figure 20.15** **This diagram shows the relationships of fungi on the Geologic Time Scale.**

## 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 20.15.***

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 between 450 and 500 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 archaeologists on Easter Island in the Pacific Ocean. Huge stone statues were carved and erected on the island by an extinct civilization. How might you use lichens to help determine when the statues were carved?

**Skill Review**

6. **Comparing and Contrasting** What are the similarities and differences between ascospores and conidiophores? For more help, refer to *Thinking Critically* in the **Skill Handbook.**

### Section Assessment

1. The hyphae of opposite mating types fuse and form a mycelium. Eventually, the mycelium forms a compact mass called a button.
2. Deuteromycotes have no known means of reproducing sexually. They are fungi.
3. The plant receives additional minerals and water absorbed by the fungus. The fungus receives the plant's excess food.
4. A stolon grows on a food's surface; a rhizoid invades a food source.
5. Determine the annual rate of growth for the lichens on the stones and divide it into a lichen's size to determine its approximate age.
6. Ascomycetes sexually produce ascospores inside an ascus. They produce conidiophores asexually.



# 3 Assess

## Check for Understanding

Have students explain the following relationships. L1

- stolon, rhizoid, hyphae
- mating types, zygospores, zygomycota;
- ascomycota, asci, spores
- basidiomycota, basidia spores
- penicillin, deuteromycota
- lichen, mycorrhiza, mutualism

## Reteach

***Naturalist*** Have student groups explain how each division's fungi obtain food, reproduce, and enter into symbiotic relationships. L1 COOP LEARN

## Extension

Have students compile a list of foods derived from fungi. L2

### Assessment

**Knowledge** Ask students for an example, a description of the spore-forming structures and the economic importance of each fungal division. L2

# 4 Close

## Discussion

***Linguistic*** Have students describe the type of buildings, conditions, and special equipment needed to grow mushrooms. L2

### Resource Manager

**Basic Concepts Transparency 32 and Master** L2 ELL
**Reinforcement and Study Guide,** pp. 89-90 L2
**Content Mastery,** pp. 97, 99-100 L1

INTERNET BioLab

### Time Allotment

Initial session: 20 minutes to review procedure and do the setup. Second session: class period.

### Process Skills

design an experiment, observe and infer, record data, relate cause and effect, communicate

## Preparation

- Prepare BTB solution as follows: add 0.5 g BTB powder to 500 mL distilled water to make stock. Dilute 10 mL of stock in 500 mL distilled water for students to use.
- Pretest diluted BTB solution by exhaling into it through a straw. If its color fails to change from blue to dark or light green within 60 seconds, adjust the pH by adding a drop of concentrated hydrochloric acid to the stock, diluting again, and retesting. Repeat until the desired change occurs within 60 seconds. If the stock turns green, mix in one or two drops of concentrated ammonium hydroxide.
- Add a packet of yeast and 20 mL white corn syrup to 250 mL water to make a yeast/corn syrup mixture.

### Alternative Materials

Use a solution of 20% sucrose instead of corn syrup.Use yeast cake (found in supermarkets), which begins to ferment faster than packet yeast.

### Possible Hypotheses

If yeast metabolism is not affected by temperature, then BTB solution will turn green in the same time period regardless of temperature.



INTERNET BioLab

# Does temperature affect the metabolic activity of yeast?

*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.*

Magnification: 9100×

## 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
hot plate
50 mL graduated cylinder
glass-marking pencil
10 cm rubber tubing (3)
aluminum foil

### Safety Precautions

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 after cleaning out test tubes at the end of your experiments.

### Skill Handbook

Use the **Skill Handbook** if you need additional help with this lab.



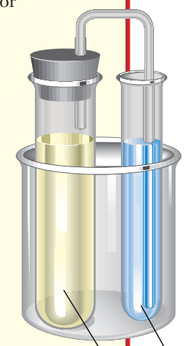
## Plan the Experiment

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.
3. Design a data table for recording your observations.
4. 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.
7. Visit the Glencoe Science Web Site to **post your data.**




## Analyze and Conclude

1. **Checking Your Hypotheses** 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. **Using 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. **Making Inferences** What must be the role of white corn syrup in this experiment?
4. **Identifying Variables** Describe some variables that your group had to control in this experiment. Explain how you controlled each variable.
5. **Drawing Conclusions** Did your experiment clearly show that differences in rates of yeast metabolism were due to temperature differences?

### Sharing Your Data

internNET CONNECTION Find this BioLab on the Glencoe Science Web Site at **www.glencoe.com/sec/science.** Post your data in the data table provided for this activity. Briefly describe your experimental design. Compare it to that of other students.



INTERNET BioLab

## Analyze and Conclude

1. Answers will vary. The warmer the water, the more rapid the color change of BTB.
2. The Internet data should support student hypotheses.
3. It is the food for yeast.
4. The volume of water/corn syrup and the amount of yeast used were variables and had to be kept constant.
5. Because controls will vary, such as a tube with no yeast/corn syrup, some data will show more difference than other data.

### Assessment

**Performance** Have students design an experiment to measure the actual volume of gas given off by a yeast/corn syrup solution at different temperatures or to test the effect of different foods on the fermentation rate of yeast. Use the Performance Task Assessment List for Designing an Experiment in **PASC,** p. 23. L2

### Sharing Your Data

internNET CONNECTION To navigate to the Internet BioLabs, choose the Biology: The Dynamics of Life icon at Glencoe's Web Site. Click on the student site icon, then the BioLabs icon. Students should pool data only from identical temperatures. If data from different temperatures are pooled inadvertently, the results will be inaccurate.

## Procedure

### Teaching Strategies

- Have students wear aprons and goggles and wash their hands at the the end of the lab. Caution them to use care when working with chemicals.
- BTB is an acid indicator. Carbon dioxide reacts with water to produce carbonic acid.
- Students can measure the amount of gas collected in each tube rather than rely on BTB color change. Carbon dioxide gas will collect through water displacement in an inverted tube filled with water and placed in the beaker of water with a rubber tube inserted into its mouth.

### Possible Procedures

- Control tubes may consist of stoppered tubes with no yeast/corn syrup mixture.

### Data and Observations

More carbon dioxide gas is produced by yeast immersed in warm water temperatures. These tubes change color more rapidly than those at cooler temperatures.

### Resource Manager

**BioLab and MiniLab Worksheets,** pp. 95-96 L2

## Social Studies Connection

### Purpose

Students will learn how fungi have influenced some historical events.

### Teaching Strategies

- Ask students to discuss criteria for deciding whether an organism is beneficial or detrimental to humans. *For example, fungi that are considered pests in one culture may be used as a food in another.*
- Discuss how events that at first seem negative can lead to positive outcomes. *The discovery of penicillin and the develpment of iron ships are examples.*

### Connection to Biology

Sexual reproduction leads to genetic diversity. Asexual spores can be resistant to inhospitable conditions.



## Social Studies Connection

# 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.

**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 grammis* is a fungus that causes black stem rust in cereal grains, such as rice and wheat. *P. grammis* produces five kinds of spores, some of which also infect barberry plants.

Rye, another cereal plant, can host the fungus *Claviceps purpurea*, which causes the disease called ergot. Animals will 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 1940–1950, *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.

Wheat attacked by the fungus *Puccinia grammis*

**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.

### Connection to Biology

Many fungi reproduce both asexually and sexually. What is the advantage of having two kinds of reproduction?

**interNET CONNECTION** To find out more about fungi, visit the Glencoe Science Web Site.
**www.glencoe.com/sec/science**



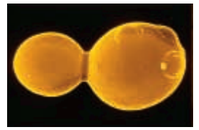
## Internet Address Book

**interNET CONNECTION** Note Internet addresses that you find useful in the space below for quick reference.

# Chapter 20 Assessment

## Summary

### Section 20.1 What Is a Fungus?



**Main Ideas**

- The structural units of a fungus are hyphae, which grow and form a mycelium.
- Fungi are heterotrophs that have 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 their patterns of reproduction, especially sexual reproduction, during the life cycle.

**Vocabulary**

budding (p. 549)
chitin (p. 547)
haustoria (p. 548)
hypha (p. 546)
mycelium (p. 546)
sporangium (p. 549)

### Section 20.2 The Diversity of Fungi

**Main Ideas**

- 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. 553)
ascus (p. 553)
basidiospore (p. 554)
basidium (p. 554)
conidiophore (p. 553)
conidium (p. 553)
gametangium (p. 552)
lichen (p. 558)
mycorrhiza (p. 556)
rhizoid (p. 551)
stolon (p. 551)
zygospore (p. 552)

## Understanding Main Ideas

1. Which of the following two terms are least related to each other?
   **a.** Zygomycota—gametangium
   **b.** Ascomycota—morel
   **c.** Basidiomycota—mushroom
   **d.** Deuteromycota—sexual spore
2. Most fungi function as _____ in their environments.
   **a.** consumers **c.** decomposers
   **b.** producers **d.** autotrophs
3. Which of the following is a type of asexual reproduction in fungi?
   **a.** sporangium **c.** mycelium
   **b.** budding **d.** haustoria



## GLENCOE TECHNOLOGY

**VIDEOTAPE**
**MindJogger Videoquizzes**
**Chapter 20:** *Fungi*
Have students work in groups as they play the videoquiz game to review key chapter concepts.

## Resource Manager

**Chapter Assessment,** pp. 115-120
**MindJogger Videoquizzes**
**Computer Test Bank**
**BDOL Interactive CD-ROM,** Chapter 20 quiz



## Chapter 20 Assessment

### Main Ideas

Summary statements can be used by students to review the major concepts of the chapter.

### Using the Vocabulary

To reinforce chapter vocabulary, use the Content Mastery Booklet and the activities in the Interactive Tutor for Biology: The Dynamics of Life on the Glencoe Science Web Site.
**www.glencoe.com/sec/science**

THE PRINCETON REVIEW ***All Chapter Assessment questions and answers have been validated for accuracy and suitability by The Princeton Review.***

### Understanding Main Ideas

1. d
2. c
3. b

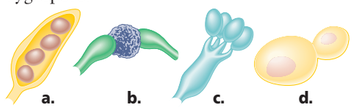
4. a
5. b
6. b
7. c
8. d
9. b
10. b
11. hypha
12. haustoria
13. mycelium
14. chitin
15. zygospores
16. rhizoid
17. deuteromycotes
18. ascospores; ascus
19. deuteromycote
20. sporangia

## Applying Main Ideas

21. The bulk of the mushroom lies below ground and therefore cannot be destroyed this way.
22. Fewer lichens may be an indicator of an increase in the amount of pollutants.
23. This may provide spores with an opportunity to land on new or different food sources.
24. This could prevent destruction and disruption of any mycorrhiza that may be present.

Chapter 20 Assessment

4. Mushrooms, puffballs, and bracket fungi belong to the group called _____.
   **a.** club fungi **c.** Zygomycota
   **b.** sac fungi **d.** Deuteromycota
5. Club fungi get their name from the club-shaped _____ they form.
   **a.** spores **c.** haustoria
   **b.** basidia **d.** conidia
6. Which of the following drawings represents a zygospore?

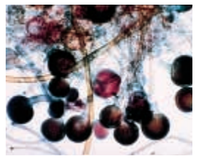



7. Fungi sometimes live in a mutualistic relationship with a plant. They might help their host by _____.
   **a.** using the food supplied by the host
   **b.** using energy made by the host
   **c.** supplying water to the host
   **d.** providing the host with spores
8. Soy sauce, citric acid, and penicillin all come from _____.
   **a.** club fungi **c.** zygomycetes
   **b.** sac fungi **d.** deuteromycetes
9. Which of the following organisms is NOT a part of the symbiotic association called a lichen?
   **a.** fungus **c.** alga
   **b.** plant **d.** cyanobacterium
10. Fungi such as yeasts and blue molds that occur on decaying food belong to the group called _____.
    **a.** club fungi **c.** zygomycotes
    **b.** sac fungi **d.** deuteromycotes
11. The basic structural unit of a multicellular fungus is a _____.

**THE PRINCETON REVIEW — Test-Taking Tip**

**Practice, Practice, Practice**
Practice to improve your performance. Don't compare yourself with anyone else.

12. Some fungi use specialized hyphae called _____, which grow into host cells.
13. A network of filaments made up of threadlike hyphae is a _____.
14. The complex carbohydrate found in the cell walls of most fungi is _____.
15. A bread mold might produce _____ if its food source dried out.
16. Suppose you study a fungus that has hyphae penetrating a food source and holding the mycelium in place. You would identify this type of hyphae as a _____.
17. Unlike other fungi, _____ are known to reproduce only asexually.
18. Sac fungi produce sexual spores called _____ in a structure known as a _____.
19. Penicillin is produced by a type of fungus called a _____.
20. The photo at right shows bread mold structures that are called _____.



## Applying Main Ideas

21. 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?
22. While hiking along a trail through a woods near your rapidly growing city, you notice that there are fewer lichens on the rocks and trees than there used to be. How might you interpret this change in the forest ecosystem?
23. Why is being able to produce spores that can be widely dispersed such an important adaptation for fungi?
24. When you transplant flowers, shrubs, or trees, why is it a good idea to leave the soil intact around a plant's roots?

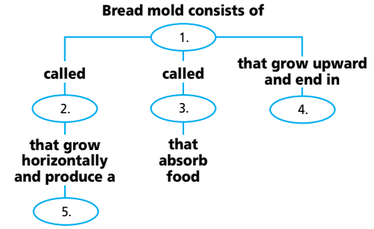


Chapter 20 Assessment

## Thinking Critically

25. **Recognizing Cause and Effect** When making bread, yeast is usually activated by combining it with sugar and warm water. Then, it is added to the rest of the ingredients. The resulting dough rises due to carbon dioxide released by the yeast cells. How would mixing yeast with sugar and ice water affect the way the dough rises?
26. **Comparing and Contrasting** Both fungi and animals are heterotrophs. Contrast the interactions of fungi and plants with the interactions of animals and plants.
27. **Interpreting Scientific Illustrations** To what division could the fungus in the photomicrograph at right belong? What additional information would you need before being able to place this fungus in its proper division?

28. **Concept Mapping** Complete the concept map by using the following vocabulary: sporangia, rhizoids, hyphae, stolons, mycellium.




**CD-ROM**
For additional review, use the assessment options for this chapter found on the ***Biology: The Dynamics of Life Interactive CD-ROM*** and on the Glencoe Science Web Site.
**www.glencoe.com/sec/science**

## Assessing Knowledge & Skills

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.

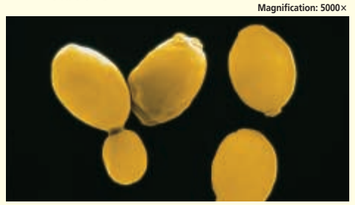
**Table 20.1 Metabolic activities of yeasts**

| Test tube number | Temperature of yeast solution | Time elapsed until color change |
|---|---|---|
| 1 | 2°C | no color change |
| 2 | 25°C | 44 minutes |
| 3 | 37°C | 22 minutes |

**Interpreting Data** Study ***Table 20.1*** and answer the following questions.

1. At what temperature was the yeast most active?
   **a.** 2°C **c.** 37°C
   **b.** 25°C **d.** 22°C
2. No color change indicated that yeasts were _____.
   **a.** metabolizing **c.** too hot
   **b.** not metabolizing **d.** dead
3. In which test tubes were yeast cells metabolizing?
   **a.** Numbers 1, 2, and 3
   **b.** Numbers 1 and 3
   **c.** Number 1
   **d.** Numbers 2 and 3
4. **Observing and Inferring** How was the temperature related to the rate of yeast metabolism?

Magnification: 5000×





Chapter 20 Assessment

## Thinking Critically

25. The bread would be flat. Ice water slows yeast respiration and therefore reduces the amount of carbon dioxide gas produced.
26. A few fungal species are mutualists, but fungi are mainly decomposers or parasites. They live off dead or living organic material. Plants are autotrophs and supply the food used by most fungi. Animals are consumers, depending on plants directly or indirectly for their food.
27. The fungus could be either a Basidiomycote or an Ascomycote. You would have to know if the spores are in asci or basidia to classify it correctly.
28. 1. Hyphae; 2. Stolons; 3. Rhizoids; 4. Sporangia; 5. Mycellium

## Assessing Knowledge & Skills

1. c
2. b
3. d
4. Yeast metabolizes more slowly at low temperatures than at high temperatures.

National Science Education Standards
UCP.1, UCP.2, UCP.3, UCP.5, C.1, C.4, C.5, F.1, F.4

# Prepare

## Purpose

This BioDigest can be used for an overview of viruses and bacteria, protists, and fungi. You may wish to use this summary to teach about viruses and the three types of organisms in place of the chapters in the Viruses, Bacteria, Protists, and Fungi unit.

## Key Concepts

Students study the diversity of life in four kingdoms. They learn about viruses and the characteristics, ecology, and classification of bacteria, protists, and fungi.

# 1 Focus

## Bellringer

To begin, have students compare and contrast a bacterial culture in a petri dish, *Spirogyra* in a test tube, and a bracket fungus. *Each is alive and made of cells. They do not look like each other.* L2 ELL

## GLENCOE TECHNOLOGY

**VIDEOTAPE**
**The Secret of Life**
*Nothing to Sneeze at: Viruses*

**CD-ROM**
**Biology: The Dynamics of Life**
Animation: *The Lytic Cycle, The Lysogenic Cycle*





For a **preview** of the viruses, bacteria, protists, and fungi unit, study this BioDigest before you read the chapters. After you have studied the viruses, bacteria, protitsts, and fungi chapters, you can use the BioDigest to **review** the unit.

# 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.

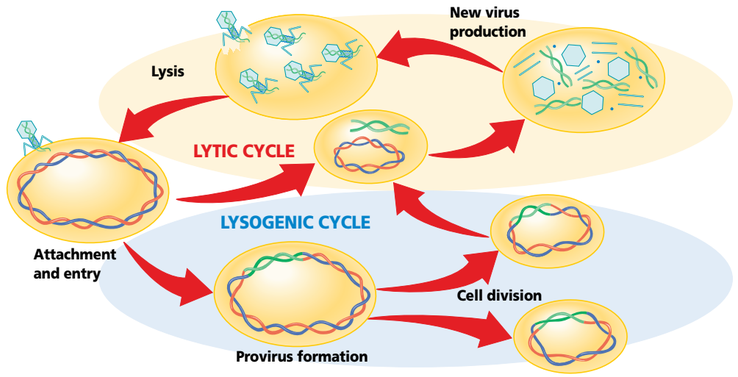
### Replication

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.

**VITAL STATISTICS**

**Viruses**
**Reports of some viral cases:**
HIV—3 000 000 cases worldwide; 18 000 new cases per day
Polio—more than 200 000 cases worldwide
Mumps—fewer than 2000 cases in the U. S.
Smallpox—0 cases worldwide; eliminated by vaccine

**The lytic and lysogenic cycles**










## 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.

### Adaptations

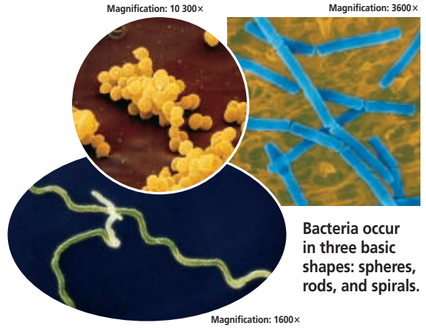
Many bacteria are obligate aerobes, needing oxygen to respire. Some bacteria called obligate anaerobes are killed by oxygen. Still other bacteria can live either with or without oxygen. Some bacteria can produce endospores to help them survive unfavorable environmental conditions.

### Importance

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

Magnification: 10 300×

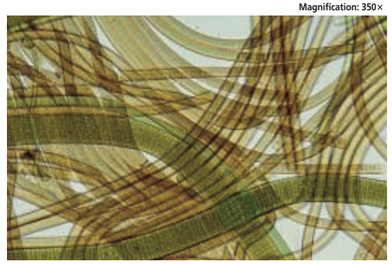
Magnification: 3600×



Magnification: 1600×

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

Magnification: 350×



***Oscillatoria*—a photosynthetic bacterium**

**VITAL STATISTICS**

**Archaebacteria and Bacteria**
**Numbers of Species:**
Archaebacteria—approximately 600 named species
Eubacteria—more than 4000 named species
**Reproduction Rates:**
Slowest—*Mycobacterium tuberculosis* reproduces every 13 to 16 hours in broth.
Fastest—*Escherichia coli* reproduces every 12.5 minutes in broth.

**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***



# Multiple Learning Styles

Look for the following logos for strategies that emphasize different learning modalities.

***Kinesthetic*** Building a Model, p 568
***Visual-Spatial*** Activity, pp. 567, 568, 571; Bulletin Board Display, p. 568; Quick Demo, p. 570
***Interpersonal*** Extension, p. 571
***Linguistic*** Meeting Individual Needs, p. 568; Biology Journal, p. 568
***Naturalist*** Portfolio, p. 569; Using a Model, p. 570; Check for Understanding, p. 570; Reteach, p. 571

## Assessment Planner

**Portfolio Assessment**
**Portfolio, TWE,** p. 569
**Performance Assessment**
**Assessment, TWE,** p. 568
**Knowledge Assessment**
**BioDigest Assessment, SE,** p. 571





# 2 Teach

## Activity

***Visual-Spatial*** Have students view prepared slides of bacteria that show the three most common bacterial shapes: spherical, rodlike, and spiral-shaped. L2 ELL

## Visual Learning

- Have students compare and contrast the viral lytic and lysogenic cycles on page 566.
- Have them look at the Vital Statistics on page 566 and hypothesize reasons why the diseases vary in occurrence.
- Ask students to look at the Focus on Adaptations on page 567 and explain why archaebacteria are often considered extremists.

## Reinforcement

Review the biogeochemical cycles discussed in Chapter 2. Then discuss how bacteria are important in nitrogen fixation and nutrient cycling.

## GLENCOE TECHNOLOGY

**CD-ROM**
**Biology: The Dynamics of Life**
Video: *Binary Fission*
Disc 3

## Assessment

**Performance** Have students use the information in the photos and the vital statistics box on this page to explain why protozoans are important.

### Activity

***Visual-Spatial*** Have students use a microscope to look at slides of pond water. Ask them to use guides to identify the protists they see. Remind them to be careful when using microscopes and slides. L2 ELL

### Building a Model

***Kinesthetic*** Have students construct models that show how protozoans move. L1 ELL COOP LEARN

### Bulletin Board Display

***Visual-Spatial*** Have students make a display of all the viruses, bacteria, and protists they can find in magazine photos. L2 ELL

**GLENCOE TECHNOLOGY**

**VIDEODISC**
**Biology: The Dynamics of Life,** *Protists* (Ch. 12)
Disc 1, Side 2, 26 sec.

**The Infinite Voyage:** *Secrets from a Frozen World, The Antarctic Peninsula: Pack Ice and Life Cycles* (Ch. 6),10 min. 30 sec.

*Effect of UV Radiation on Phytoplankton* (Ch. 8)
4 min. 30 sec.







# 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.

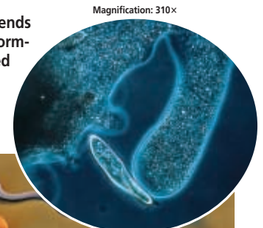
## Protozoans: Animal-like protists

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

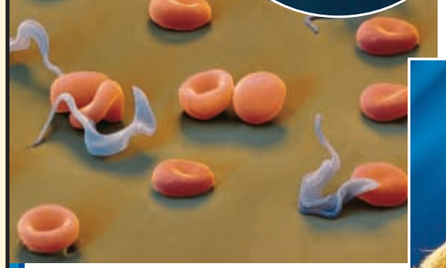
Phylum Rhizopoda is composed of the protozoans called amoebas that use pseudopodia, extensions of their plasma membrane, to move and engulf prey. Phylum Mastigophora is composed of protozoans that use flagella to move around. Some parasitic protozoan species that have flagella cause disease, but other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

**An amoeba extends pseudopodia, forming a cup-shaped trap for prey.**

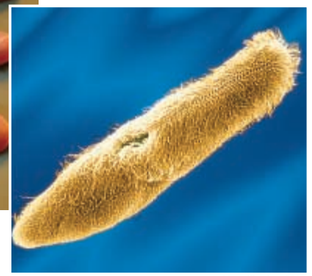
Magnification: 310×



Magnification: 5800×



**Trypanosomes use flagella to move and cause the disease called sleeping sickness.**



Magnification: 380×

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

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

Magnification: 6000×

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.

### 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







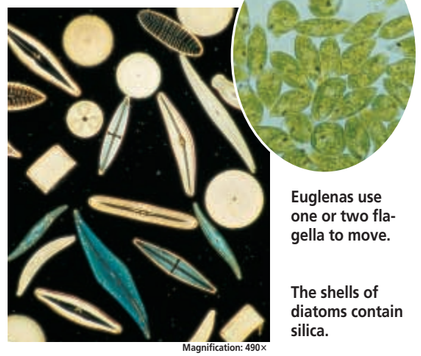
## Algae: Plantlike protists

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.

Magnification: 1000×



Magnification: 490×

**Euglenas use one or two flagella to move.**

**The shells of diatoms contain silica.**

## 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.

## 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.

Magnification: 350×

**This green alga is *Spirogyra.***

**A chocolate slime mold.**





### Visual Learning

- Ask students to compare the algae shown in the photographs and describe the differences they observe. *The diatoms are surrounded by silica shells, euglenas are unicellular and have at least one flagellum, and Spirogyra are filamentous and have spiral chloroplasts.*
- Ask students to describe the appearance of the slime mold in the photo on this page. *It resembles a giant amoeba.*

### Quick Demo

Show students samples of both slime mold plasmodiums and fruiting bodies. Discuss why slime molds were once classified as fungi.

**GLENCOE TECHNOLOGY**

**CD-ROM**
**Biology: The Dynamics of Life**
Exploration: *The World of Protists; Protists; Kelp Forests*
Disc 3

### Meeting Individual Needs

**English Language Learners**

***Linguistic*** Have students rewrite a summary of the BioDigest information in both their native language and English. L2 ELL

### Biology Journal

**The Diversity of Protists**

***Linguistic*** Have students describe three protists they observed when they viewed slides of pond water in the Activity. L1

### Portfolio

**Types of Algae**

***Naturalist*** Have students make a table of algae phyla. The table should include information such as the phylum's name, its characteristics, general information, and an example. L2 P

## Visual Learning

Have students use the photos on this page to compare the reproductive structures of mushrooms and bread mold.

## Using a Model

***Naturalist*** Display a model of a eukaryotic cell. Use the model to explain similarities and differences between protists and fungi.

## Quick Demo

***Visual-Spatial*** Collect some lichens and discuss how they differ with students.

## GLENCOE TECHNOLOGY

**CD-ROM**
**Biology: The Dynamics of Life**
Animation: *Life Cycle of a Mushroom; Fungal Decay*
Disc 3

# 3 Assess

## Check for Understanding

***Naturalist*** Have students differentiate among viruses, bacteria, protists, and fungi using examples and the unique characteristics of each.





BIODIGEST

## 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.

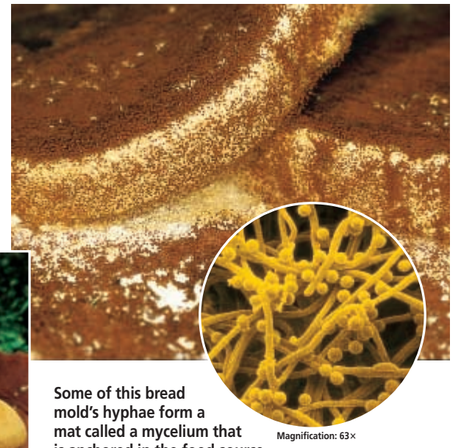
### Club Fungi

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.

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

### 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 form a mat called a mycelium that is anchored in the food source by other hyphae called rhizoids.**

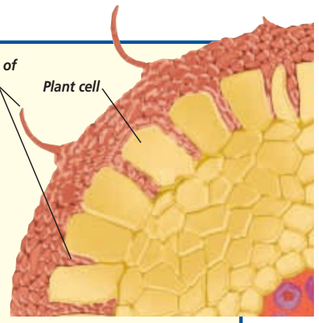
Magnification: 63×

## Focus on Adaptations

### Mycorrhizae

Some plants live in association with mutualistic fungi. These relationships, called mycorrhizae, 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.**



## Internet Address Book

internNET CONNECTION

Note Internet addresses that you find useful in the space below for quick reference.



BIODIGEST

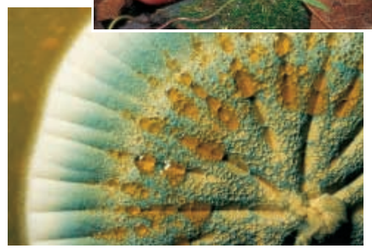
### Sac Fungi

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**

## BioDigest Assessment

### Understanding Main Ideas

1. The core of a virus contains _____.
   **a.** phospholipids **c.** amino acids
   **b.** nucleic acids **d.** proteins
2. Photosynthetic bacteria include _____.
   **a.** cyanobacteria **c.** methanogens
   **b.** anaerobes **d.** chemoautotrophs
3. The most likely place to find archaebacteria would be in _____.
   **a.** food **c.** a hot sulfur spring
   **b.** a DNA lab **d.** a fast flowing stream
4. Mastigophorans use _____ to move.
   **a.** pseudopods **c.** flagella
   **b.** cilia **d.** None of these.
5. The major pigment of green algae is _____.
   **a.** red **c.** chlorophyll
   **b.** carotene **d.** a chloroplast
6. _____ have silica cell walls.
   **a.** Protozoans **c.** Euglenas
   **b.** Diatoms **d.** Funguslike protists
7. Mushrooms are classified in phylum _____.
   **a.** Basidiomycota **c.** Ascomycota
   **b.** Zygomycota **d.** Deuteromycota
8. Cell walls of fungi contain _____.
   **a.** cellulose **c.** hyphae
   **b.** spores **d.** chitin
9. A puffball is a type of _____.
   **a.** sac fungus **c.** lichen
   **b.** club fungus **d.** imperfect fungus
10. Lichens are sensitive to _____.
    **a.** pollution **c.** drought
    **b.** cold **d.** predators

### Thinking Critically

1. Why are many archaebacteria called extremists?
2. Distinguish between protozoans and algae.
3. Why are mycorrhizae important to plants?
4. Compare a bacterium and a protozoan.



BIODIGEST ASSESSMENT

### Understanding Main Ideas

1. b
2. a
3. c
4. c
5. c
6. b
7. a
8. d
9. b
10. a

### Thinking Critically

1. They survive in environments that most organisms cannot tolerate.
2. Protozoans are unicellular, animal-like protists, and algae are either unicellular or multicellular plantlike protists.
3. They provide additional surface area for water and mineral absorption by plant roots.
4. A bacterium is a small, prokaryote and a protozoan is a unicellular eukaryote.



BIODIGEST

## Reteach

***Naturalist*** Have students prepare a table that includes examples, unique characteristics, and general information about viruses and the archaebacteria, eubacteria, protists, and fungi. L2

## Extension

***Interpersonal*** Have students work in groups, using information on pages 570 and 571, to explain the symbiotic relationships of lichens and mycorrhizae. L2 COOP LEARN

## Assessment

**Knowledge** Provide students with pictures of viruses, bacteria, protists, and fungi from magazines, journals, or drawings. Have them identify what each picture depicts. L1 ELL

# 4 Close

## Activity

***Visual-Spatial*** Have students identify organisms studied in this BioDigest from microscope slides. L2

## Resource Manager

**Reinforcement and Study Guide,** pp. 91-92 L2
**Content Mastery,** pp. 101-104 L1