Chapter 20 Organizer

Refer to pages 457-5 of the Teacher Guide for an explanation of the National Science Education Standards correlations.

### Materials List

**BioLab**
- p. 560: bromothylol 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,
- p. 546: bakery bread, water, plate, self-seal plastic bags (2), forceps, microscope slide, coverslip, dropper, water

**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

### Activities/Features

<table>
<thead>
<tr>
<th>Section</th>
<th>Objectives</th>
<th>Activities/Features</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Section 20.1</strong></td>
<td><strong>What Is a Fungus?</strong></td>
<td>National Science Education Standards UCP 1-6; A.1, A.2; C.1, C.4, C.5, C.6; E.5 (1 session, 1 block)</td>
</tr>
<tr>
<td>1. Identify</td>
<td>the basic characteristics of fungi.</td>
<td>MiniLab 20-1: Growing Mold Spores, p. 546 Problem-Solving Lab 20-1, p. 550</td>
</tr>
<tr>
<td>2. Explain</td>
<td>the role of fungi as decomposers and how this role affects the flow of both energy and nutrients through food chains.</td>
<td></td>
</tr>
<tr>
<td><strong>Section 20.2</strong></td>
<td><strong>The Diversity of Fungi</strong></td>
<td>National Science Education Standards UCP 1-5; A.1, A.2; C.1, C.4, C.5, C.6; E.1, F.4, E.5; G.1-3 (3 sessions, 1/2 block)</td>
</tr>
<tr>
<td>3. Identify</td>
<td>the four major divisions of fungi.</td>
<td>MiniLab 20-2: Examining Mushroom Gills, p. 554</td>
</tr>
<tr>
<td>4. Distinguish</td>
<td>among the ways spores are produced in zygomycotes, ascomycotes, and basidimycotes.</td>
<td></td>
</tr>
<tr>
<td>5. Summarize</td>
<td>the ecological roles of lichens and mycorrhizae.</td>
<td></td>
</tr>
</tbody>
</table>

### Teacher Classroom Resources

<table>
<thead>
<tr>
<th>Section</th>
<th>Reproducible Masters</th>
<th>Transparencies</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Section 20.1</strong></td>
<td><strong>What Is a Fungus?</strong></td>
<td>Section Focus Transparency 48</td>
</tr>
<tr>
<td>Reinforcement and Study Guide, pp. 87-88</td>
<td>L1</td>
<td>ELL</td>
</tr>
<tr>
<td>Concept Mapping, p. 20</td>
<td>E2</td>
<td>ELL</td>
</tr>
<tr>
<td>Critical Thinking/Problem Solving, p. 20</td>
<td>L2</td>
<td></td>
</tr>
<tr>
<td>BioLab and MiniLab Worksheets, p. 93</td>
<td>L2</td>
<td></td>
</tr>
<tr>
<td>Tech Prep Applications, pp. 29-30</td>
<td>E2</td>
<td>ELL</td>
</tr>
<tr>
<td>Content Mastery, p. 97-98, 100</td>
<td>E2</td>
<td></td>
</tr>
<tr>
<td><strong>Section 20.2</strong></td>
<td><strong>The Diversity of Fungi</strong></td>
<td>Section Focus Transparency 49</td>
</tr>
<tr>
<td>Reinforcement and Study Guide, pp. 89-90</td>
<td>L2</td>
<td>ELL</td>
</tr>
<tr>
<td>BioLab and MiniLab Worksheets, p. 94-96</td>
<td>L2</td>
<td>ELL</td>
</tr>
<tr>
<td>Laboratory Manual, pp. 141-144</td>
<td>L2</td>
<td>ELL</td>
</tr>
<tr>
<td>Content Mastery, p. 97, 99-100</td>
<td>L2</td>
<td>ELL</td>
</tr>
</tbody>
</table>

### Additional Resources

- Spanish Resources ELL
- English/Spanish Audiocassettes ELL
- Cooperative Learning in the Science Classroom COOP LEARN

### 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: Biodiversity 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

### 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.

### Teacher's Corner

**Index to National Geographic Magazine**

The following articles may be used for research relating to this chapter:
**Chapter 20**

**Fungi**

**GETTING STARTED**

**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.

**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?

**Internet Address Book**
To find out more about fungi, visit the Glencoe Science Web Site: www.glencoe.com/sec/science

**Chapter Focus Transparency 48**

**Section 20.1**
**What Is a Fungus?**

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.

**The Characteristics of Fungi**
Mushrooms vary in form, size, and color. 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 ringworts. Many are only visible to the naked eye.

Bird’s nest fungi look like nests, complete with eggs. Brightly colored coral fungi resemble ocean corals.

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

**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. 548, 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

**Resource Manager**

**Section Focus Transparency 48**

**Multiple Learning Styles**

- Kinesthetic Activity, p. 548
- Quick Demo, p. 553
- Project, p. 558
- Portfolio, p. 552

- Visual-Spatial Quick Demo, p. 547
- Meeting Individual Needs, p. 548
- Portfolio, pp. 548
- 552: Biology Journal, p. 552
- Enrichment, p. 557

- Linguistic: Enrichment, p. 548

- Logical-Mathematical: Portfolio, p. 557
- Naturalist: Reteach, p. 549
- 559: Tech Prep, p. 564
- Meeting Individual Needs, p. 557
- **Vocabulary**
  - hypha
  - mycelium
  - chitin
  - budding
  - spore
  - sporangium

**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 mushroom for the Quick Demo.
- Begin to grow molds for the Alternative Lab and the Activity one week ahead of time.
**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 for the growth of bread mold spores?

**Procedure**

1. Place two slices of lightly 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 or six days, remove the bags and look for mold.
4. Remove a small piece of mold from a fungus, place it on a slide in a drop of water, and add a cover slip. Observe the mold under a microscope's low power and high power.

**Caution:** Use caution when working with a microscope; glass slides and cover slips. Wash your hands, rinse, and wash 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 the conditions necessary for fungal growth?
2. What conclusions can you draw about the conditions necessary for the growth of a bread mold?

**Figure 20.2 A germinating fungal spore produces hyphae that branch to form a mycelium.**

- **Spore**
- **Mycelium**
- **Food source**
- **Germating spore**

The more a mycelium grows, the more a fungus expands. Inside hyphae, enzymes break down sugars to make nutrients. Enzymes can also digest proteins. Fungi contain enzymes that break down proteins from other organisms—spoiled food, diseases, and dead bodies. Thanks to these organic decomposers, fallen leaves, animal carcasses, and other organic materials that become waste are eventually decomposed.

**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.

**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.

**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, paper wrap

**Procedure**

Give students the following directions.

1. Number eight small paper cups 1-8 and label each with your name and date.
2. Add the following to each cup (18 fl. 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
3. Rub a cotton swab with mold spores on the surface of each cup's contents.
4. Cover each cup with plastic wrap and place the cups in a designated area.
5. Check the cups each day for a week.
6. Design a data table to record your observations, including the amount of mold growth.
7. 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 crater, cooked and uncooked rice. Use the Performance Task Assessment for Formulating a Hypothesis in PASc, p. 21.
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.

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.

Using Science Terms
Have students compare the terms extracellular digestion and intracellular digestion and provide an example of each.

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.

Resource Manager
Concept Mapping, p. 20

Meeting Individual Needs
Learning Disabled 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.

Portfolio
Fungi Adaptations Ask students to diagram the fungi they observed in the Getting Started and the Activity and compare them with writing, explaining their adaptations and feeding relationships.

Biological 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. Have students contrast them.

3 Assess
Check for Understanding Have students explain how the following are related: hypophy—mycelium cell wall—chitin decomposers—extracellular digestion reproduction—sporangium spores—budding

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

Extension
Yeast cells require aerobic and undergo fermentation anaerobically. Review the processes and ask students to compare and contrast them.

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

VIDEODISC The Secret of Life Six Kingdoms

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

Figure 20.5
Most yeasts reproduce asexually by budding.

Reteach
Figure 20.4
Fungus may be parasites, mutualists, or saprophytes.

Figure 20.1
What is a fungus?

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 uh nuhm) (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 the chances that some will land in a suitable habitat and grow into new mycelia.
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. The fungus grows under the bark. The fungus grows under the bark.
2. Answers will vary—import of which are related, and exchange or phrases about fungi, only four related, and exchange or phrases about fungi, only four.
3. Answers will vary—import of which are related, and exchange or phrases about fungi, only four.

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 areas of dead tissue. Eventually, the nutrient and water supplies of the tree are cut off, and the tree dies. Fact: Spores of C. parasitica reproduced by forming spores that are carried by wind, insects, birds, and rain to other trees that then become infected.
- Fact: C. parasitica reproduced by forming spores that are carried by wind, insects, birds, and rain to other trees that then become infected.

Thinking Critically
1. Why would it be difficult to control the disease by preventing spores from landing on healthy trees? A mycelium is made up of hyphae. Hyphae invade a food source where they release enzymes that digest the food. The hyphae absorb digested foods.
2. Based on how this fungus grows, why can’t fungicides applied to the bark of an infected tree kill the fungus? Hyphae invade a food source where they release enzymes that digest the food. The hyphae absorb digested foods. Some other hyphae form a mycelium. Some other hyphae form a mycelium. Each hypha grows horizontally along the surface of a food source.
3. Support a solution to the problem in the United States knowledge about the resistance of the Japanese chestnut trees and the existence of weak disease-causing fungal strains. (Hint: Think about DNA technology.) A mycelium is made up of hyphae. Hyphae invade a food source where they release enzymes that digest the food. The hyphae absorb digested foods.

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.

Understanding Main Ideas
1. What is the function of pores in hypophil sepia? Some other hyphae form a mycelium. Each hypha grows horizontally along the surface of a food source.
2. Describe how a fungus obtains nutrients. A mycelium is made up of hyphae. Hyphae invade a food source where they release enzymes that digest the food. The hyphae absorb digested foods.
3. What role do fungi play in food chains? A mycelium is made up of hyphae. Hyphae invade a food source where they release enzymes that digest the food. The hyphae absorb digested foods.
4. How are the terms hypha and mycelium related? A mycelium is made up of hyphae. Hyphae invade a food source where they release enzymes that digest the food. The hyphae absorb digested foods.

Section Assessment
- 1. What is the function of pores in hypophil sepia? Some other hyphae form a mycelium. Each hypha grows horizontally along the surface of a food source.
- 2. Describe how a fungus obtains nutrients. A mycelium is made up of hyphae. Hyphae invade a food source where they release enzymes that digest the food. The hyphae absorb digested foods.
- 3. What role do fungi play in food chains? A mycelium is made up of hyphae. Hyphae invade a food source where they release enzymes that digest the food. The hyphae absorb digested foods.
- 4. How are the terms hypha and mycelium related? A mycelium is made up of hyphae. Hyphae invade a food source where they release enzymes that digest the food. The hyphae absorb digested foods.

6. Measuring in St. 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. A mycelium is made up of hyphae. Hyphae invade a food source where they release enzymes that digest the food. The hyphae absorb digested foods.

5. Imagine you are a mycologist who finds an unrelated item and explain how the other items are related.

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

Resource Manager
Section Focus Transparency 49 and Master

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 1950, 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 areas of dead tissue. Eventually, the nutrient and water supplies of the tree are cut off, and the tree dies. Fact: C. parasitica reproduced by forming spores that are carried by wind, insects, birds, and rain to other trees that then become infected.
- Fact: C. parasitica reproduced by forming spores that are carried by wind, insects, birds, and rain to other trees that then become infected.

Thinking Critically
1. Why would it be difficult to control the disease by preventing spores from landing on healthy trees? A mycelium is made up of hyphae. Hyphae invade a food source where they release enzymes that digest the food. The hyphae absorb digested foods.
2. Based on how this fungus grows, why can’t fungicides applied to the bark of an infected tree kill the fungus? Hyphae invade a food source where they release enzymes that digest the food. The hyphae absorb digested foods. Some other hyphae form a mycelium. Some other hyphae form a mycelium. Each hypha grows horizontally along the surface of a food source.
3. Support a solution to the problem in the United States knowledge about the resistance of the Japanese chestnut trees and the existence of weak disease-causing fungal strains. (Hint: Think about DNA technology.) A mycelium is made up of hyphae. Hyphae invade a food source where they release enzymes that digest the food. The hyphae absorb digested foods.
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.

Understanding Main Ideas
1. What is the function of pores in hypophil sepia? Some other hyphae form a mycelium. Each hypha grows horizontally along the surface of a food source.
2. Describe how a fungus obtains nutrients. A mycelium is made up of hyphae. Hyphae invade a food source where they release enzymes that digest the food. The hyphae absorb digested foods.
3. What role do fungi play in food chains? A mycelium is made up of hyphae. Hyphae invade a food source where they release enzymes that digest the food. The hyphae absorb digested foods.
4. How are the terms hypha and mycelium related? A mycelium is made up of hyphae. Hyphae invade a food source where they release enzymes that digest the food. The hyphae absorb digested foods.

Section Assessment
- 1. What is the function of pores in hypophil sepia? Some other hyphae form a mycelium. Each hypha grows horizontally along the surface of a food source.
- 2. Describe how a fungus obtains nutrients. A mycelium is made up of hyphae. Hyphae invade a food source where they release enzymes that digest the food. The hyphae absorb digested foods.
- 3. What role do fungi play in food chains? A mycelium is made up of hyphae. Hyphae invade a food source where they release enzymes that digest the food. The hyphae absorb digested foods.
- 4. How are the terms hypha and mycelium related? A mycelium is made up of hyphae. Hyphae invade a food source where they release enzymes that digest the food. The hyphae absorb digested foods.

6. Measuring in St. 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. A mycelium is made up of hyphae. Hyphae invade a food source where they release enzymes that digest the food. The hyphae absorb digested foods.

5. Imagine you are a mycologist who finds an unrelated item and explain how the other items are related.

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

Resource Manager
Section Focus Transparency 49 and Master
Researchers have studied the effects of transplanted organs. More information is needed about the rejection of transplanted organs. Today, patients with transplanted organs survive rejection today because of cyclosporine. This chemical suppresses the immune system of the transplanted organ. The rejection process occurs when haploid hyphae from the mycelium and elongate to form conidiophores (kuhl nih de euh fore). Chains or clusters of ascomycotes 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 moulds 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 Soil Studio Convention 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. Morrels and truffles are two edible members of this division. Perhaps the most economically important ascomycotes are the yeasts. Yeasts are unicellular sac fungi that reproduce sexually and asexually. Yeasts are aerobic microorganisms that multiply rapidly, they are an important source of the vinegar used in the production of wine. Yeasts are unicellular fungi that reproduce asexually by budding. Yeasts produce alcohol by fermenting sugar. These Rhizopus sporangia show examples of what is seen under high-power magnification and are helpful or harmful. The BioLab at the end of this chapter can be used at this point in the lesson.
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  L3  L4

**Expected Results**

Spores will form a pattern on the paper corresponding to the gills’ locations.

**Analysis**

1. Isomorph
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  L3  L4

**Basidiomycotes**

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 basidiomycetes. So are the rust and smut fungi. Use the Minilab to distinguish some mushroom species.

**Purpose**

What you call a mushroom is a reproductive structure of the fungus. Most of the fungi 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?

**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?

**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  L3  L4

**Basidiomycotes**

- Spores are formed toward the edges of the gills. The patterns are the same.
- Spores are formed toward the edges of the gills. The patterns are the same.

**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 underside 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?

**Figure 20.10**

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

**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

**Critical Thinking**

The spores are produced above-ground so that they can be easily dispersed by air currents.

**Resource Manager**

Basic Concepts Transparency 31 and Master  L2  L3  L4

Reteaching Skills Transparency 31 and Master  L1  L2  L3

**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  L2  L4

**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.
Deuteromycotes
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 basidomycotes. Although the deuteromycotes may only be able to reproduce sexually, another possibility is that their sexual phase has not yet been observed by mycologists, who study fungi.

Diverse deuteromycotes
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 and plants. The antibiotic penicillin is commonly seen growing on fruit, such as soy sauce and some kinds of blue-reinited cheese. Still other deuteromycotes are used commercially to produce substances such as citric acid, which gives jams, jellies, soft drinks, and fruit-flavored candies a tart taste.

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

Mycorrhizae
A mycorrhiza (my kuh RHY zuh) is a mutualistic relationship in which a fungus lives symbiotically with a plant. Most of the fungi that form mycorrhizae are basidomycotes, 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, resulting in more nutrients entering the plant. Phosphorus, copper, and other minerals in the soil are absorbed by the mycorrhiza 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.

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 20.12. They may look like flakes of old

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.

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

Reinforcement
Review the methods by which zygomycotes, ascomycotes, and basidomycotes reproduce sexually. Emphasize that deuteromycotes 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.

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 uncontrollable 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.

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.
LS

Figure 20.14

Girola stellata is a common lichen on the tundra and a favorite food of caribou and reindeer.

Problem-Solving Lab 20.2

What’s inside a lichen? A lichen consists of a fungus and an alga or cyanobacterium that live symbiotically. The prefix myc means “fungus.” The alga or cyanobacterium is called a “mycote.” Explain how you know this information.

Thinking Critically

1. Using color as a clue, list the letters that identify the algal part 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 ascomycete. Explain how you know this information.
3. Scientists have wondered if the parts of a lichen can survive by themselves. Describe an experiment that might answer this question.

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. Color is an important characteristic of fungi. List the letters that identify the fungal part of the lichen. Explain your choices.
2. Figure 20.15 includes a mycete. What is a mycete?
3. Structure D is a reproductive part. After examining it, you conclude that this is a reproductive structure of a basidiomycete. Explain how you know this information.

Figure 20.15

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

Section Assessment

1. What are the three main characteristics of fungi? Describe each one.
2. Describe the structure and function of a fungal hypha.
3. How do fungi reproduce sexually and asexually?

Thinking Critically

2. Lichens belong to which group of organisms? How do you know?

Origins of Fungi

Mycologists hypothesize that the ascomycetes and the basidiomycetes evolved from a common ancestor and that the zygomycetes 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.

Figure 20.16

The diversity of fungi on Earth can be divided into five fungal groups: the Ascomycota, the Basidiomycota, the Zygomycota, the Glomeromycota, and the Deuteromycota.

Check for Understanding

1. What are the two largest groups of fungi? What is the smallest group?
2. Which group of fungi is divided into three divisions?
3. Which group of fungi is divided into two divisions?

Section Assessment

1. What are the three main characteristics of fungi? Describe each one.
2. Describe the structure and function of a fungal hypha.
3. How do fungi reproduce sexually and asexually?

Thinking Critically

2. Lichens belong to which group of organisms? How do you know?

Section Assessment

1. What are the three main characteristics of fungi? Describe each one.
2. Describe the structure and function of a fungal hypha.
3. How do fungi reproduce sexually and asexually?

Thinking Critically

2. Lichens belong to which group of organisms? How do you know?

Section Assessment

1. What are the three main characteristics of fungi? Describe each one.
2. Describe the structure and function of a fungal hypha.
3. How do fungi reproduce sexually and asexually?

Thinking Critically

2. Lichens belong to which group of organisms? How do you know?

Section Assessment

1. What are the three main characteristics of fungi? Describe each one.
2. Describe the structure and function of a fungal hypha.
3. How do fungi reproduce sexually and asexually?

Thinking Critically

2. Lichens belong to which group of organisms? How do you know?

Section Assessment

1. What are the three main characteristics of fungi? Describe each one.
2. Describe the structure and function of a fungal hypha.
3. How do fungi reproduce sexually and asexually?

Thinking Critically

2. Lichens belong to which group of organisms? How do you know?

Section Assessment

1. What are the three main characteristics of fungi? Describe each one.
2. Describe the structure and function of a fungal hypha.
3. How do fungi reproduce sexually and asexually?

Thinking Critically

2. Lichens belong to which group of organisms? How do you know?
Does temperature affect the metabolic activity of yeast?

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)
- 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/yeast mixture
- Test-tube rack
- Graduated cylinder
- Ice cubes
- Beakers (3)
- Corks
- Glass-marking pencil
- Graduated aluminum funnel
- Rubber tubing (3)

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 glass.
- 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.

Procedure

1. Prepare BTB solution as follows: add 0.5 g BTB powder to 100 mL distilled water to make stock. Dilute 10 mL of stock in 500 mL distilled water for students to use.
2. Pretreat 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 color change occurs within 60 seconds. If the stock turns green, mix in one or two drops of concentrated ammonium hydroxide.
3. Add a packet of yeast and 20 mL white corn syrup to 250 mL water to make a yeast/corn syrup mixture.

Possible Hypotheses

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

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.

Analysis and Conclude

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.

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

Materials

- Bromothymol blue solution
- Water/white corn syrup mixture
- Yeast/white corn syrup mixture
- One-hole stopper for large test tubes (3)
- 10 cm rubber tubing (3)
- Glass-marking pencil
- Graduated cylinder
- Ice cubes
- Beakers (3)
- Corn syrup mixture
- 250 mL water to make a yeast/corn syrup mixture
- 20 mL white corn syrup to make a yeast/corn syrup mixture
- BTB is an acid indicator. Carbon dioxide reacts with water to produce carbonic acid. 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.

Hypotheses

Possible Hypotheses

What begins to ferment faster when cake (found in supermarkets), and sugar is added to water and heated at 56°C? Is it possible that temperatures will affect the rate of yeast metabolism? What chemical change might occur when yeast is introduced to warm water? Is there a rate at which 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.

Possible Hypotheses

The same time period regardless of temperature. Affected by temperature, then yeast metabolism is not

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. Rots are successful because they are plasmodic—each species produces many kinds of spores that can infect different hosts. The wind can spread their spores over hundreds of miles. For example, Puccinia graminis is a fungus that causes black stem rust in cereal grains, such as rice and wheat. P. graminis produces five kinds of spores, some of which also infect barberry plants. Rye, another cereal plant, can host the fungus Claviceps purpurea, which causes 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 seedlings 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.

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 tinea pedis (athlete’s foot) and tinea versicolor (ringworm). 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.

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. Rots are successful because they are plasmodic—each species produces many kinds of spores that can infect different hosts. The wind can spread their spores over hundreds of miles. For example, Puccinia graminis is a fungus that causes black stem rust in cereal grains, such as rice and wheat. P. graminis produces five kinds of spores, some of which also infect barberry plants. Rye, another cereal plant, can host the fungus Claviceps purpurea, which causes 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 seedlings 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.

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 tinea pedis (athlete’s foot) and tinea versicolor (ringworm). 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.

Fungi are heterothallics 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.

Teaching Strategies
Ask students to discuss criteria for deciding whether an organism is beneficial or detrimental to humans. For example, near the end of the nineteenth century, chestnut seedlings 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.

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 tinea pedis (athlete’s foot) and tinea versicolor (ringworm). 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.

Fungi are heterothallics 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.

Teaching Strategies
Ask students to discuss criteria for deciding whether an organism is beneficial or detrimental to humans. For example, near the end of the nineteenth century, chestnut seedlings 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.

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 tinea pedis (athlete’s foot) and tinea versicolor (ringworm). 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.

Fungi are heterothallics 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.

Teaching Strategies
Ask students to discuss criteria for deciding whether an organism is beneficial or detrimental to humans. For example, near the end of the nineteenth century, chestnut seedlings 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.

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 tinea pedis (athlete’s foot) and tinea versicolor (ringworm). 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.

Fungi are heterothallics 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.
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, spores, mycelium.

**APPLICATIONS**

6. Soy sauce, citric acid, and penicillin all come from ________. 
7. Which of the following organisms is NOT a type of fungus? 
   - a. fungus 
   - b. plant 
   - c. cyanobacterium 
8. Some fungi use specialized hyphae called ________ that grow upward and in ________ that absorb food. 
9. 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?
10. 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?
11. 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?
12. Complete the concept map by using the following vocabulary: sporangia, rhizoids, hyphae, spores, mycelium.

**TEST-TAKING TIP**

Practice, Practice, Practice. Practice to improve your performance. Don’t compare yourself with anyone else.
Vital Statistics

**Archaebacteria and Bacteria**

**Numbers of Species:**
- Archaebacteria—approximately 600 named species
- Eubacteria—more than 4000 named species

**Reproduction Rates:**
- Shewanella—Archaebacteria, tuberculosis reproduce every 10 to 14 hours in broth.
- Fusion—E. coli reproduces every 12.5 minutes in broth.

**Biogenesis**

**Bacteria**

A bacterium is a unicellular prokaryote. Most of its genes are contained in a circular chromo-

ome in the cytoplasm. A cell wall surrounds its plasma membrane. Bacteria may be heterotrophic, photosynthetic, autotrophic, or chemosynthetic autotrophic. 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.

---

**Prepared**

**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.

---

**Focus 1**

**Bellringer**

To begin, have students compare contrast a bacterial culture in a test tube, and a bracket fungus. Each is alive and made of cells. They do not respire or grow.

**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 are visible 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.

The lytic and lysogenic cycles

**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.

**NEW VIRUS PRODUCTION**

**LYTIC CYCLE**

**LYSOCIC CYCLE**

**Protein formation**

**Cell division**

**Attachment and entry**

**Oscillatoria—a photosynthetic bacterium.**

---

**Focus on Adaptations**

**Archaebacteria: The Extremists**

A. Archaeabacteria are unicellular prokaryotes, most of which survive in extremely harsh environ-
ments. A group of archaeabacteria 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.
Protists

Kingdom Protista is a diverse group of heterotrophic, autotrophic, parasitic, and apathrophic 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.

Plasmodium is a widely studied ciliata. Plasmodium vivax is the protozoan that causes malaria, which is transmitted by mosquitoes. Malaria mainly affects the liver and the blood and cause the disease malaria, have a sexual stage in mosquitoes and an asexual stage in humans.

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.

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

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.

Ciliophora move by beating hairlike projections called cilia. Paramecium is a widely studied ciliate.

Sporozoans are grouped together because they are all parasites and many produce spores.

Most have very complex life cycles with different stages. Plasmodium, the protozoans that cause the disease malaria, have a sexual stage in mosquitoes and an asexual stage in humans.

Diatoms

Diatoms are surrounded by silica shells, euglenas are unicellular and have at least one flagellum, and Sporozoa 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.

Euglenas use one or two flagella to move. The shells of diatoms contain silica.

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, and Sporozoa 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.

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.

Fungi-like Protists

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

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

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

Club Fungi

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

Zygospore-Forming Fungi

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

Sac Fungi

Fungi that produce sexual spores called ascospores in sac-like structures called sacs 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 mutistic 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.

Mycorrhizae

Some plants live in association with mutistic fungi. These relationships, called mycorrhizae, benefit both the fungi and the plants. The hyphae of the fungi are intertwined 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 relationships enable 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.

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

BiO Digest Assessment

Understanding Main Ideas

1. The core of a virus contains __________.
   a. phospholipids
   b. nucleic acid
   c. proteins

2. Photosynthetic bacteria include __________.
   a. cyanobacteria
   b. methanogens
   c. an aerobes
   d. chemohotrophs

3. The most likely place to find archaeabacteria would be __________.
   a. food
   b. DNA lab
   c. a hot sulfur spring
   d. a fast flowing stream

4. Mastigophorans use __________ to move.
   a. pseudopods
   b. cilia
   c. flagella
   d. None of these.

5. The major pigment of green algae is __________.
   a. red
   b. canthaxanthin
   c. chlorophyll
   d. a chloroplast

Thinking Critically

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

Internet Address Book

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

Internet Address

1. www.example1.com
2. www.example2.com
3. www.example3.com

BioDigest Assessment

Understanding Main Ideas

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

Thinking Critically

1. They survive in environments that most organisms cannot tolerate.