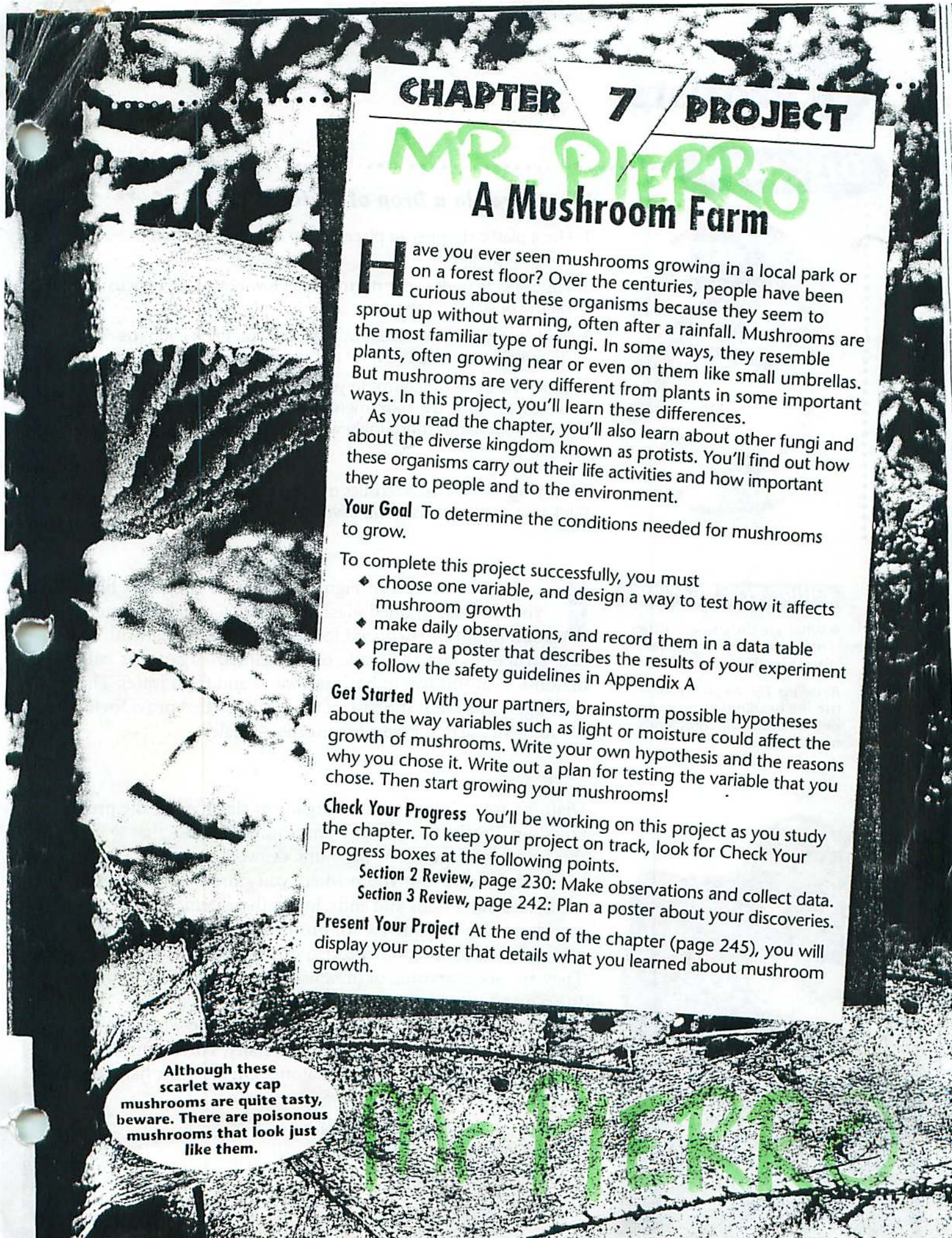


Although these scarlet waxy cap mushrooms are quite tasty, beware. There are poisonous mushrooms that look just like them.

CHAPTER 7 PROJECT

A Mushroom Farm

Have you ever seen mushrooms growing in a local park or on a forest floor? Over the centuries, people have been curious about these organisms because they seem to sprout up without warning, often after a rainfall. Mushrooms are the most familiar type of fungi. In some ways, they resemble plants, often growing near or even on them like small umbrellas. But mushrooms are very different from plants in some important ways. In this project, you'll learn these differences.

As you read the chapter, you'll also learn about other fungi and about the diverse kingdom known as protists. You'll find out how these organisms carry out their life activities and how important they are to people and to the environment.

Your Goal To determine the conditions needed for mushrooms to grow.

To complete this project successfully, you must

- choose one variable, and design a way to test how it affects mushroom growth
- make daily observations, and record them in a data table
- prepare a poster that describes the results of your experiment
- follow the safety guidelines in Appendix A

Get Started With your partners, brainstorm possible hypotheses about the way variables such as light or moisture could affect the growth of mushrooms. Write your own hypothesis and the reasons why you chose it. Write out a plan for testing the variable that you chose. Then start growing your mushrooms!

Check Your Progress You'll be working on this project as you study the chapter. To keep your project on track, look for Check Your Progress boxes at the following points.

Section 2 Review, page 230: Make observations and collect data.
Section 3 Review, page 242: Plan a poster about your discoveries.

Present Your Project At the end of the chapter (page 245), you will display your poster that details what you learned about mushroom growth.

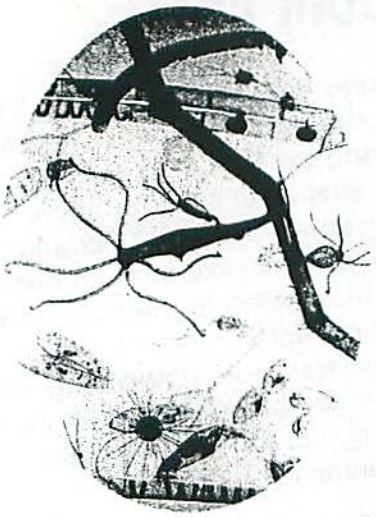
SECTION 1

Protists

DISCOVER

ACTIVITY

What Lives in a Drop of Water?



1. Use a plastic dropper to place a drop of pond water on a microscope slide.
2. Put the slide under your microscope's low-power lens. Focus on the objects you see.
3. Find at least three different objects that you think might be organisms. Observe them for a few minutes.
4. Draw the three organisms in your notebook. Below each sketch, describe the movements or behaviors of the organism. Wash your hands thoroughly when you have finished.

Think It Over

Observing What characteristics did you observe that made you think that each organism was alive?

GUIDE FOR READING

- **What are the characteristics of animal-like, funguslike, and plantlike protists?**

Reading Tip **As you read, use the headings to make an outline of the different kinds of protists.**

Look at the objects in Figure 1. What do they look like to you? Jewels? Stained glass windows? Crystal ornaments? You might be surprised to learn that these beautiful, delicate structures are the walls of unicellular organisms called diatoms. Diatoms live in both salt water and fresh water. These tiny organisms are at the base of the food web that provides food for some of Earth's largest organisms—whales.

What Is a Protist?

Diatoms are only one type of organism classified in the protist kingdom. Protists are so different from each other that you can think of this kingdom as the "junk drawer" kingdom. You may have a drawer in your room where you store ticket stubs, postcards, and other odds and ends. Just as these items don't really fit anywhere else in your room, protists don't really fit into any other biological kingdom. Protists do share some characteristics. They are all eukaryotes, or organisms that have cells with nuclei. In addition, all protists live in moist surroundings.

Despite these common characteristics, the word that best describes the protist kingdom is diversity. For example, most protists are unicellular like the diatoms. On the other hand, some

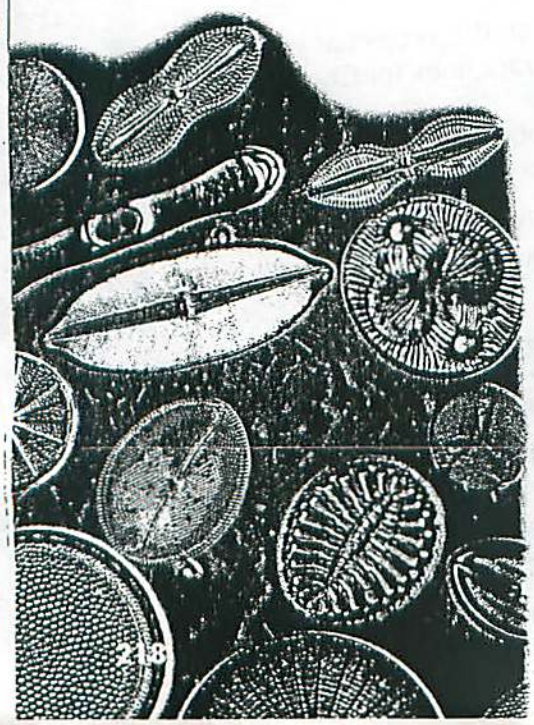
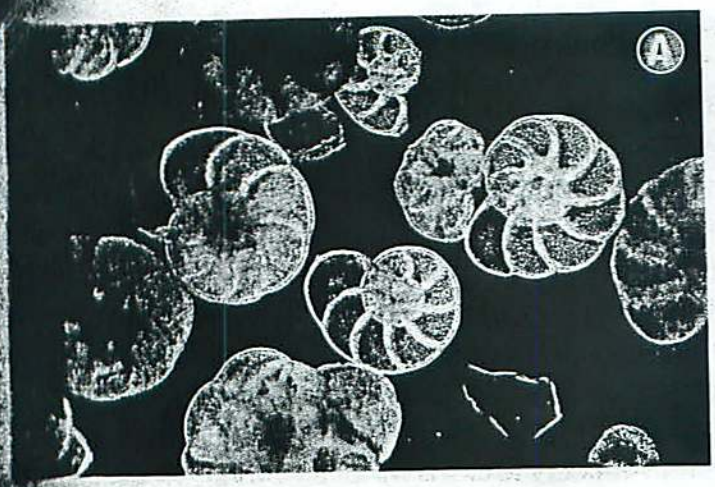


Figure 1 These delicate-looking diatoms are classified in the protist kingdom.



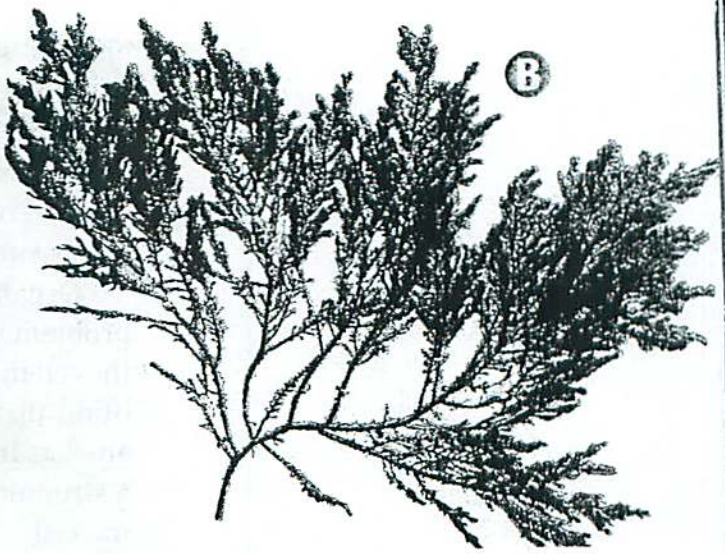


Figure 2 The protist kingdom includes animal-like, plantlike, and funguslike organisms. **A.** These shells contained unicellular, animal-like protists called foraminifera. **B.** This red alga is a multicellular, plantlike protist that lives on ocean floors. **C.** This yellow slime mold is a funguslike protist.
Comparing and Contrasting In what way are animal-like protists similar to animals? How do they differ?

rotists are multicellular. In fact, the protists known as giant lps can be over 100 meters long. Protists also vary in how they otain food—some are heterotrophs, some are autotrophs, and hers are both. Some protists cannot move, while others zoom ound their moist surroundings.

Because of the great variety of protists, scientists have pro-osed different ways of grouping these organisms. One useful y of grouping protists is to divide them into three categories: imal-like protists, funguslike protists, and plantlike protists.

Checkpoint *What characteristics do all protists share?*

nimal-like Protists

hat image pops into your head when you think of an animal? tiger chasing its prey? A snake slithering onto a rock? Most eople immediately associate animals with movement. In fact, ovement is often involved with an important characteristic of nimals—obtaining food. All animals are heterotrophs that must btain food by consuming other organisms.

Like animals, animal-like protists are heterotrophs. And most animal-like protists, or **protozoans** (proh tuh ZOH unz), are able to move from place to place to obtain their food. Unlike animals, however, protozoans are unicellular. Some scientists distinguish between four types of protozoans based on the way these organisms move and live.

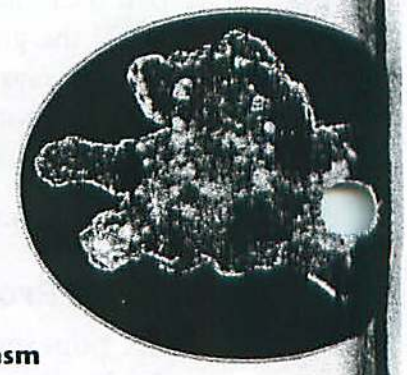
Protozoans With Pseudopods The ameba in *Exploring Protozoans* on the next page belongs to the group of protozoans called sarcodines. Sarcodines move and feed by forming **pseudopods** (SOO doh pahdz)—temporary bulges of the cell membrane that fill with cytoplasm. The word *pseudopod* means "false foot." Pseudopods form when the cell membrane pushes outward in one location. The cytoplasm flows into the bulge

and the rest of the organism follows. Pseudopods enable sarcodines to move in response to changes in the environment. For example, amebas use psuedopods to move away from bright light. Sarcodines also use pseudopods to trap food. The organism extends a pseudopod on each side of the food particle. The two pseudopods then join together, trapping the particle inside.

Organisms that live in fresh water, such as amebas, have a problem. Small particles, like those of water, pass easily through the cell membrane into the cytoplasm. If the excess water were to build up inside the cell, the ameba would burst. Fortunately, amebas have a **contractile vacuole** (kun TRAK til VAK yoo ohl), a structure that collects the extra water and then expels it from the cell.

EXPLORING *Protozoans*

Amebas are sarcodines that live either in water or soil. They feed on bacteria and smaller protists in the surroundings. Paramecia are ciliates that live mostly in fresh water. Like amebas, paramecia feed on bacteria and smaller protists.



AMEBA

Pseudopod
An ameba uses pseudopods to move and feed. Pseudopods form when the cell membrane bulges and cytoplasm flows into the bulge.

Cytoplasm

Nucleus
The nucleus controls the cell's functions and is involved in reproduction. Amebas usually reproduce by binary fission.

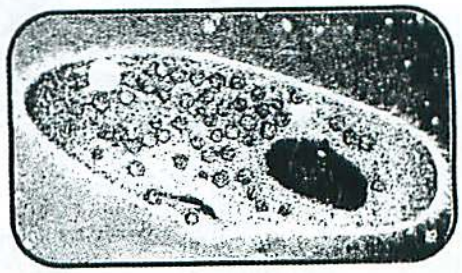
Cell membrane
Because the cell membrane is very thin and flexible, an ameba has no definite shape.

Contractile vacuole
The contractile vacuole collects excess water from the cytoplasm and expels it from the cell.

Food vacuole
When the ends of two pseudopods fuse around food, they form a food vacuole. Food is broken down inside the food vacuole in the cytoplasm.

Protozoans With Cilia The second type of animal-like protist is the ciliate. Ciliates have structures called **cilia** (SIL ee uh) which are hairlike projections from cells that move with a wavelike pattern. They use cilia to move, obtain food, and sense the environment. Cilia act something like tiny oars to move a ciliate. Their movement also sweeps food into the organism.

Ciliates have complex cells. In *Exploring Protozoans*, you see a ciliate called a paramecium. Notice that the paramecium has two nuclei. The large nucleus controls the everyday tasks of the cell. The small nucleus functions in reproduction. Paramecia usually reproduce asexually by binary fission. Sometimes, they reproduce by conjugation. This occurs when two paramecia join together and exchange genetic material.



PARAMECIUM

Contractile vacuoles
Two contractile vacuoles collect excess water from the cytoplasm and expel it from the cell.

Cytoplasm

Small nucleus

Anal pore
Wastes leave through the anal pore.

Large nucleus

Pellicle
A stiff but flexible covering, called the pellicle, surrounds a paramecium and gives it shape. The cell membrane makes up the inner part of the pellicle.

Cilia
Thousands of cilia project through the pellicle. The beating cilia enable a paramecium to move smoothly in one direction.

Food vacuole
A food vacuole forms and pinches off from the oral groove. It moves into the cytoplasm. Inside the vacuole, the food is broken down and then distributed.

Oral groove
The oral groove is a funnel-like indentation lined with cilia. The cilia move water containing food into the vacuole that forms at the end of the oral groove.

Figure 3 When people drink from freshwater streams and lakes, they may become ill. Below you see the organism that makes them sick, a protozoan called *Giardia lamblia.*

Protozoans With Flagella The third type of protozoans are called zooflagellates (zoh uh FLAJ uh lits)—animal-like protists that use flagella to move. Most zooflagellates have one to eight long, whiplike flagella that help them move.

Many zooflagellates live inside the bodies of other organisms. For example, one type of zooflagellate lives in the intestines of termites. The zooflagellates digest the wood that the termites eat, producing sugars for themselves and for some termites. In turn, the termites protect the zooflagellates. The interaction between these two species is an example of **symbiosis** (sim bee OH sis) a close relationship where at least one of the species benefits. When both partners benefit from living together, the relationship is a type of symbiosis called **mutualism.**

INTEGRATING HEALTH Sometimes a zooflagellate harms the animal in which it lives. In Figure 3 you see a zooflagellate called *Giardia.* This zooflagellate is a parasite in humans. When a person drinks water containing *Giardia,* the zooflagellates attach to the person's intestine, where they feed and reproduce. The person develops a serious intestinal condition. This can occur even in unpopulated areas where wild animals, such as beavers, deposit *Giardia* into streams, rivers, and lakes.

Other Protozoans The fourth type of protozoans, the sporozoans, are characterized more by the way they live than by the way they move. Sporozoans are parasites that feed on the cells and body fluids of their hosts. They move in a variety of ways. Some have flagella and some depend on hosts for transport. One even slides from place to place on a layer of slime that it produces.

Many sporozoans have more than one host. For example, *Plasmodium* is a sporozoan that causes malaria, a serious dis

TRY THIS

Feeding Paramecia

ACTIVITY

In this activity you will feed *Chlorella,* a plantlike protist, to paramecia.

1. Use a plastic dropper to place one drop of paramecium culture on a micrscope slide. Add some cotton fibers to slow down the paramecia.
2. Use the microscope's low-power objective to find some paramecia.
3. Add one drop of *Chlorella* to the paramecium culture on your slide.
4. Switch to high power and locate a paramecium. Observe what happens. Then wash your hands.

Inferring What evidence do you have that paramecia are heterotrophs? That *Chlorella* are autotrophs?

of the blood. Two hosts are involved in *Plasmodium's* life cycle—humans and a species of mosquitoes found in tropical areas. The disease spreads when a healthy mosquito bites a person with malaria, becomes infected, and then bites a healthy person. Symptoms of malaria include high fevers that alternate with severe chills. These symptoms can last for weeks, then disappear, only to reappear a few months later.

Checkpoint *What structures do protozoans use to move?*

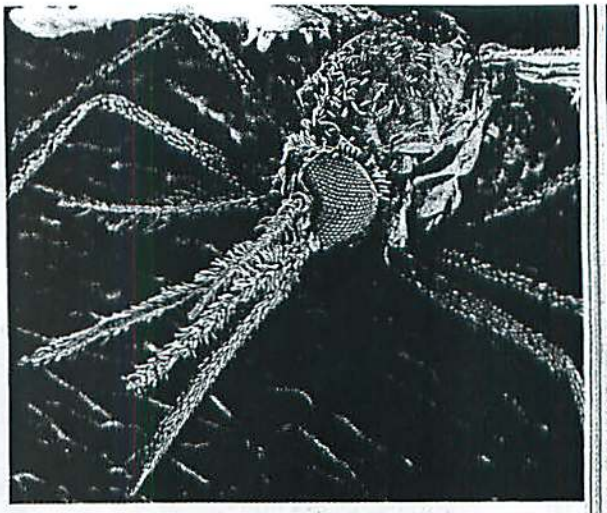


Figure 4 *Anopheles* mosquitoes can carry a sporozoan, *Plasmodium*, which causes malaria in people. ***Relating Cause and Effect*** *Why do you think it is difficult to control the spread of malaria?*

Funguslike Protists

The second group of protists are the funguslike protists. Recall from Chapter 6 that fungi include organisms such as mushrooms and yeast. Until you learn more about fungi in Section 3, you can think of fungi as the "sort of like" organisms. Fungi are "sort of like" animals because they are heterotrophs. They are "sort of like" plants because their cells have cell walls. In addition, most fungi use spores to reproduce. A **spore** is a tiny cell that is able to grow into a new organism.

Like fungi, funguslike protists are heterotrophs, have cell walls, and use spores to reproduce. Unlike fungi, however, all funguslike protists are able to move at some point in their lives. The three types of funguslike protists are water molds, downy mildews, and slime molds.

Water Molds and Downy Mildews Most water molds and downy mildews live in water or in moist places. These organisms grow as tiny threads that look like a fuzzy covering. Figure 5 shows a fish attacked by a water mold.

Water molds and downy mildews also attack food crops, such as potatoes, cabbages, corn, and grapes. A water mold destroyed the Irish potato crops in 1845 and 1846. The loss of these crops led to a famine that resulted in the deaths of over one million Irish people. Many others left Ireland and moved to other countries, such as Canada and the United States.

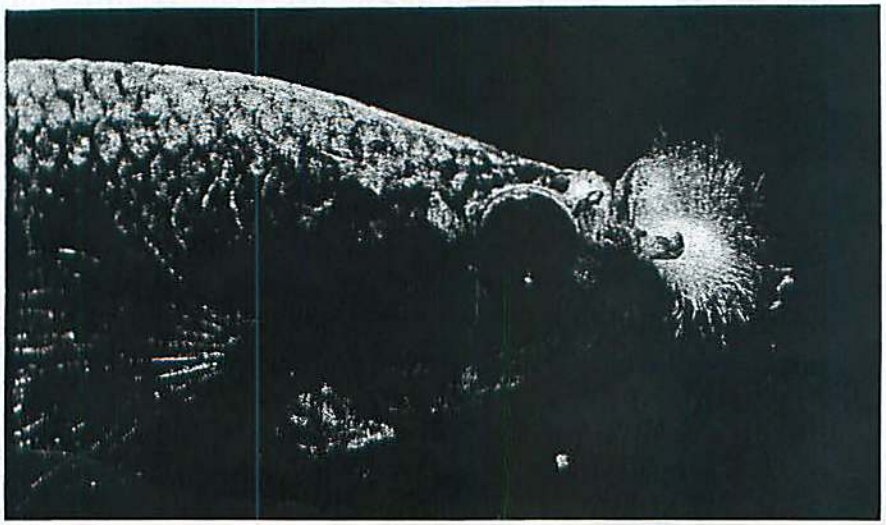


Figure 5 This threadlike water mold is a parasite that grows on fish. The water mold eventually kills the fish.

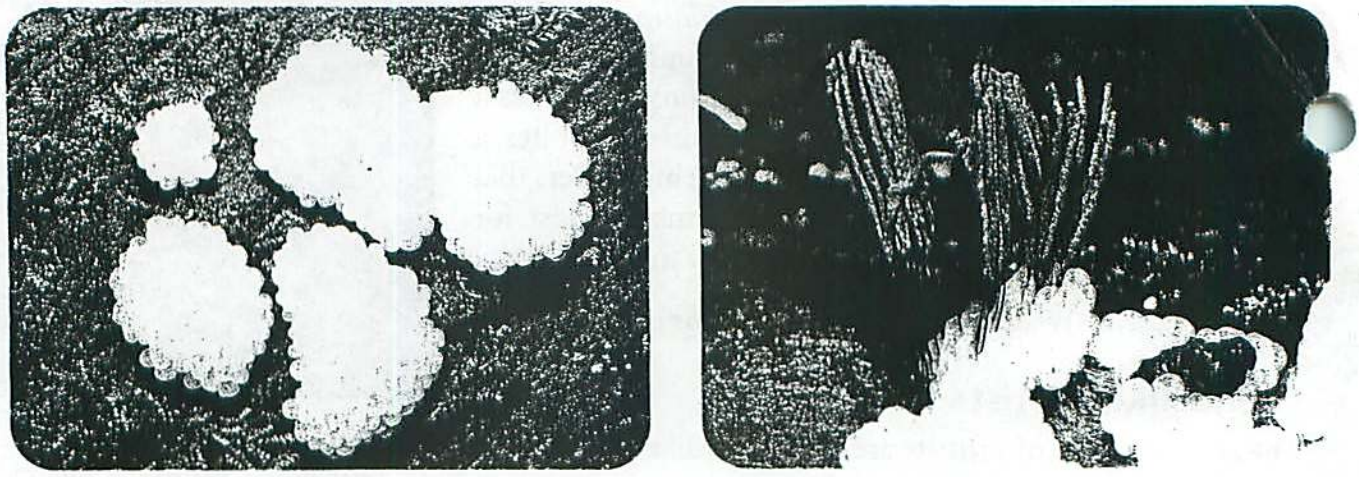


Figure 6 Slime molds, like the chocolate tube slime mold (left), feed on microorganisms on the surfaces of decaying materials. When food runs low, they grow stalks that produce spores (right).

Slime Molds Slime molds live in moist soil and on decaying plants and trees. Slime molds are often beautifully colored. Many are bright yellow, like the one in Figure 6. Their glistening bodies creep over fallen logs and dead leaves on shady, moist forest floors. They move in an amebalike way by forming pseudopods and oozing along the surfaces of decaying materials. Slime molds feed on bacteria and other microorganisms.

Some slime molds are large enough to be seen with the naked eye. Many, however, are so small that you need a microscope to see them. When the food supply decreases or other conditions change, some tiny slime molds creep together and form a multicellular mass. Spore-producing structures grow out of the mass and release spores, which can develop into a new generation of slime molds.

☑ *Checkpoint* *In what environments are slime molds found?*

Plant-like

If you've ever seen seaweed at a beach, then you are familiar with a type of plantlike protist. Plantlike protists, which are commonly called **algae** (AL jee), are even more varied than the animal-like and funguslike protists. **The one characteristic that all algae share is that, like plants, they are autotrophs.**

Some algae live in the soil, others live on the barks of trees, and still others live in fresh water and salt water. Algae that live on the surface of ponds, lakes, and oceans are an important food source for other organisms in the water. In addition, most of the oxygen in Earth's atmosphere is made by these algae.

Algae range greatly in size. Some algae, such as diatoms, are unicellular. Others are groups of unicellular organisms that live together in colonies. Still others, such as seaweeds, are multicellular. Recall from Chapter 1 that a unicellular organism carries

out all the functions necessary for life. But the cells of a multicellular organism are specialized to do certain tasks. When single-celled algae come together to form colonies, some of the cells may become specialized to perform certain functions, such as reproduction. However, most cells in a colony continue to carry out all functions. Colonies can contain from four up to thousands of cells.

Algae exist in a wide variety of colors because they contain many types of **pigments**—chemicals that produce color. Depending on their pigments, algae can be green, yellow, red, brown, orange, or even black. Read on to learn about the types of algae that live on Earth.

Euglenoids Euglenoids are green, unicellular algae that are found mostly in fresh water. Unlike other algae, euglenoids have one animal-like characteristic—they can be heterotrophs under certain conditions. When sunlight is available, euglenoids are autotrophs that produce their own food. However, when sunlight is not available, euglenoids will act like heterotrophs by finding and taking in food from their environment.

In Figure 7 you see a euglena, which is a common euglenoid. Notice the long whiplike flagellum that helps the organism move. Locate the eyespot near the flagellum. Although the eyespot is not really an eye, it contains pigments. These pigments are sensitive to light and help a euglena recognize the direction of a light source. You can imagine how important this response is to an organism that needs light to make food.

Sharpen Skills

ACTIVITY

Predict what will happen when you pour a culture of euglenas into a petri dish, then cover half the dish with aluminum foil. Give a reason for your prediction.

Then carry out the experiment with a culture of euglenas in a plastic petri dish. Cover half the dish with aluminum foil as shown. After 10 minutes, uncover the dish. What do you observe? Was your prediction correct? Explain why euglenas behave this way.

Figure 7 Euglenas are unicellular algae that live in fresh water. In sunlight, euglenas make their own food. Without sunlight, they obtain food from their environment. *Interpreting Diagrams What structures help a euglena find and move toward light?*

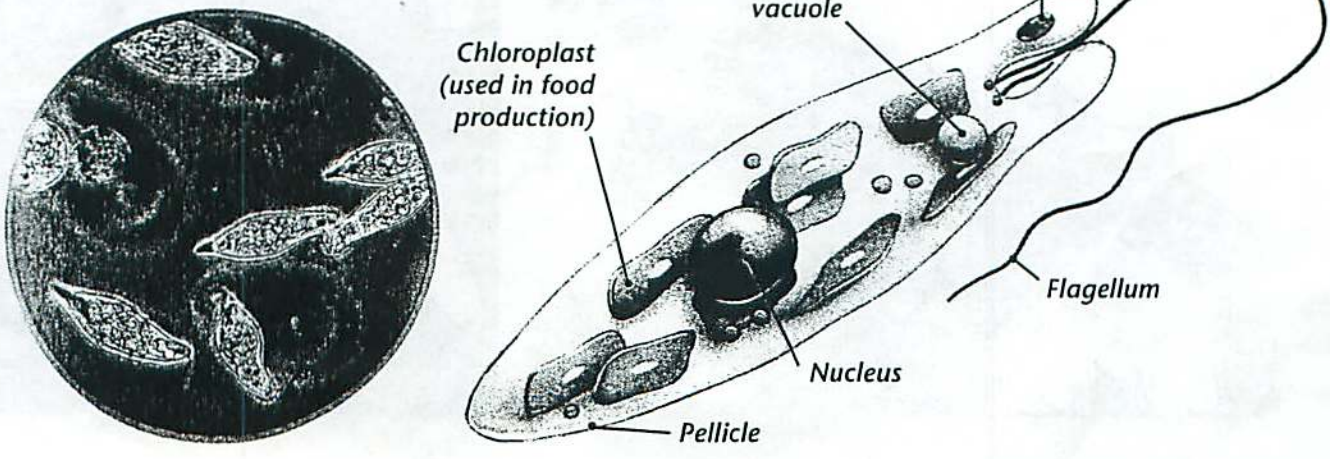


Figure 8 Dinoflagellates, such as these *Gonyaulax,* have rigid plates for protection. They use flagella to move through the water.

Dinoflagellates Dinoflagellates are unicellular algae covered by stiff plates that look like a suit of armor. Because they have different amounts of green, red, and other pigments, dinoflagellates exist in a variety of colors.

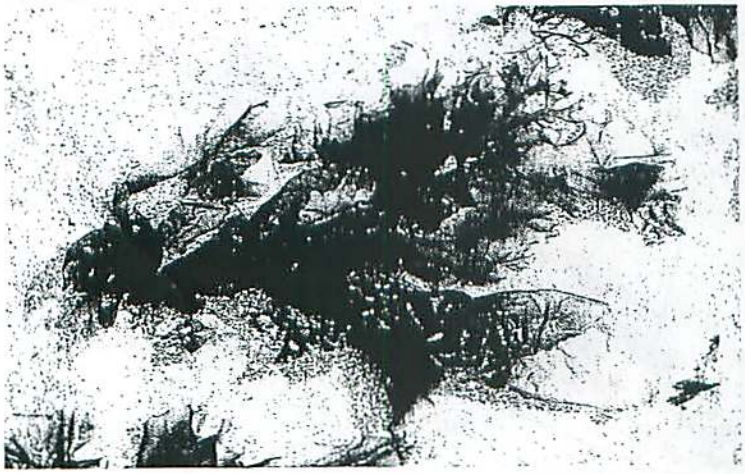
All dinoflagellates have two flagella held in grooves between their plates. When the flagella beat, the dinoflagellates twirl like toy tops through the water. Many glow in the dark and look like miniature fireflies dancing on the ocean's surface at night.

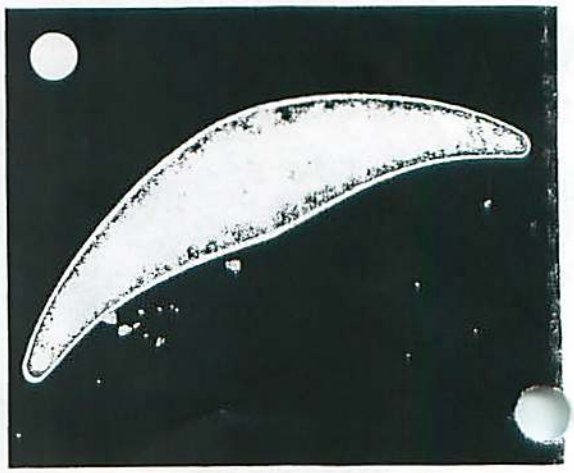
Diatoms Diatoms are unicellular protists with beautiful glasslike cell walls. Some float on the surface of freshwater and saltwater environments. Others attach to objects such as rocks in shallow water. Diatoms move by oozing slime out of slits in their cell walls. They then glide in the slime. Diatoms are a food source for heterotrophs in the water.

INTEGRATING TECHNOLOGY When diatoms die, their cell walls collect on the bottoms of oceans and lakes. Over time, they form layers of a coarse material called diatomaceous (dy uh tuh MAY shus) earth. This makes a good polishing agent. Manufacturers add diatomaceous earth to most toothpastes. Diatomaceous earth is also used in many household scouring products as well as in swimming pool filters. It is even used as an insecticide. The sharp edges puncture the bodies of insects.

Green Algae As their name suggests, all green algae contain green pigments. Otherwise, green algae are quite diverse, as you can see in Figure 9. Although most green algae are unicellular, some form colonies, and a few are multicellular. You might have seen multicellular green algae, or green seaweed, washed up on a beach. Most green algae live in either freshwater or saltwater surroundings. The few that live on land are found along the bases of trees or in moist soils.

Figure 9 Green algae range in size from unicellular organisms to multicellular seaweeds. **A.** The multicellular sea lettuce, *Ulva,* lives in oceans. **B.** This unicellular alga, *Closterium,* lives in fresh water.





Red Algae Almost all red algae are multicellular seaweeds. Divers have found red algae growing at depths greater than 260 meters below the ocean's surface. Their red pigments are especially good at absorbing the small amount of light that enters deep ocean waters.

Red algae are used by humans in a variety of ways. Carrageenan (kar uh JEE nun), a substance extracted from red algae, is used in products such as ice creams and hair conditioners. For people in many Asians cultures, red algae is a nutrient-rich delicacy that is eaten fresh, dried, or toasted.

Brown Algae Many of the organisms that are commonly called seaweeds are brown algae. In addition to their brown pigment, brown algae also contain green, yellow, and orange pigments. As you can see in Figure 10, a typical brown alga has many plantlike structures. Holdfasts anchor the alga to rocks. Stalks support the blades, which are the leaflike structures of the alga. Brown algae also have gas-filled sacs called bladders that allow the algae to float upright in the water.

Brown algae flourish in cool, rocky waters. Brown algae called rockweed live along the Atlantic coast of North America. Giant kelps, which can grow to 100 meters in length, live in some Pacific coastal waters. The giant kelps form large underwater "forests" where many organisms, including sea otters and abalone, live. Some people eat brown algae for their nutrients. Substances called algins are extracted from brown algae and used as thickeners in foods such as puddings and salad dressings.

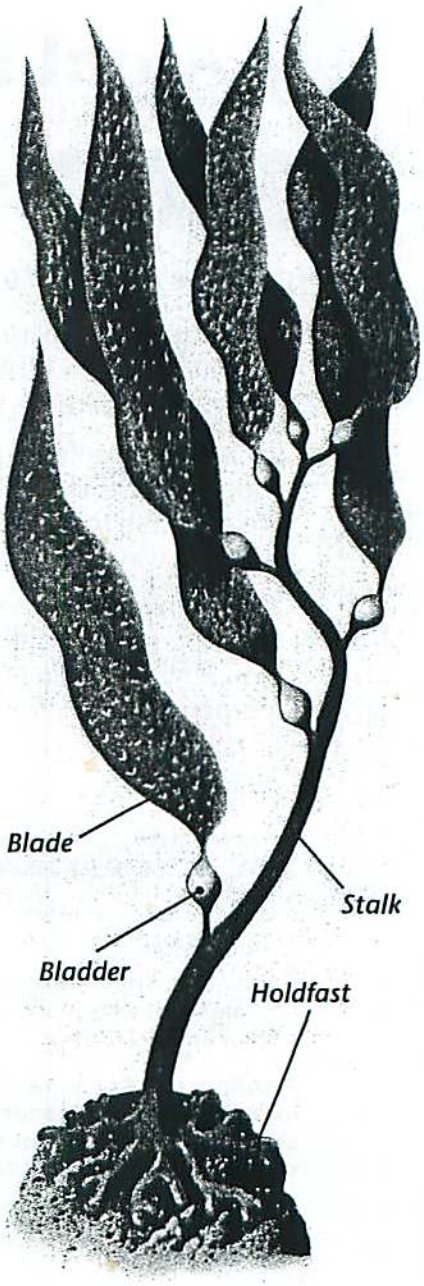


Figure 10 Giant kelps have many plantlike structures. *Applying Concepts What plant structures do the holdfasts and blades resemble?*

Section 1 Review

1. What characteristic do all protozoans share?
2. What are three characteristics of the funguslike protists?
3. What characteristic do algae share with plants?
4. **Thinking Critically Making Judgments** Would you classify a euglena as an animal-like protist or as a plantlike protist? Explain your answer.

Science at Home

Kitchen Algae Look through your kitchen with a family member to find products that contain substances made from algae. Look for both food and non-food items. First tell your family member that words such as diatomaceous earth, algin, and carrageenan are substances that come from algae. Make a list of the products and the algae-based ingredient they contain. Share your list with the class.

SECTION 2

Algal Blooms

DISCOVER ACTIVITY

How Can Algal Growth Affect Pond Life?

1. Pour water into a plastic petri dish until the dish is half full. The petri dish will represent a pond.
2. Sprinkle a spoonful of green paper punches into the water in the petri dish to represent green algae growing in the pond water.
3. Sprinkle two more spoonfuls of paper punches into the water to represent one cycle of algae reproduction.

4. Sprinkle four more spoonfuls of paper punches into the water to represent the next reproduction cycle of the algae.

Predicting How might algae growing on the surface affect organisms living deep in a pond?

GUIDE FOR READING

- What makes red tides dangerous?
- How does the rapid growth of algae affect a pond or lake?

Reading Tip As you read, look for evidence of the dangers of algal blooms. Make a list of sentences from the text that provide this evidence.

Over a five week period one year, the bodies of 14 humpback whales washed up along beaches on Cape Cod, Massachusetts. The whales showed no outward signs of sickness. Their stomachs were full of food. Their bodies contained plenty of blubber to insulate them from changes in water temperature. What caused such healthy-looking animals to die?

When biologists examined the dead whales' tissues, they identified the cause of the puzzling deaths. The whales' cells contained a deadly toxin produced by a dinoflagellate called *Alexandrium tamarense*. For reasons that scientists don't fully understand, the population of these algae grew rapidly in the ocean waters through which the whales were migrating. When the whales fed on the toxin-producing algae or on fishes that had eaten the algae, the toxins reached a deadly level and killed the whales.

Algae are common in both saltwater and freshwater environments on Earth. They float on the surface of the waters and use sunlight to make food. The rapid growth of a population of algae is called an **algal bloom.** The deaths of the humpbacks is one example of the damage that an algal bloom can cause.

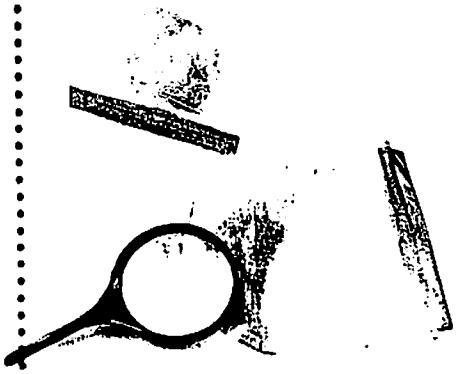
A humpback whale

SECTION 3

Fungi

DISCOVER ACTIVITY

Do All Molds Look Alike?



1. Your teacher will give you two sealed, clear plastic bags—one containing moldy bread and another containing moldy fruit. CAUTION: *Do not open the sealed bags at any time.*
2. Examine each mold. In your notebook, describe what you see.
3. Then, use a hand lens to examine each mold. Sketch each mold in your notebook and list its characteristics.
4. Return the sealed bags to your teacher. Wash your hands.

Think It Over

Observing How are the molds similar? How do they differ?

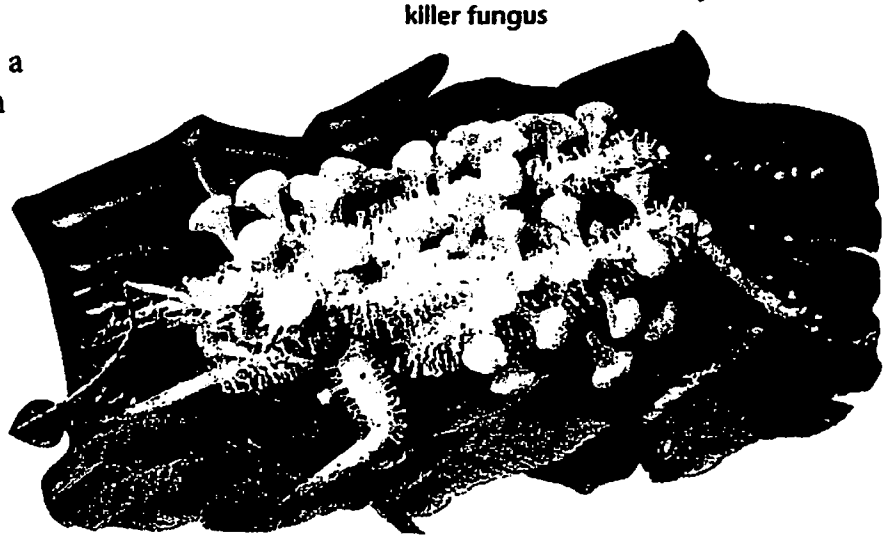
Unnoticed, a speck of dust lands on a cricket's back. But this is no ordinary dust—it is alive! Tiny glistening threads emerge from the dust and begin to grow into the cricket's moist body. As they grow, the threads release chemicals that slowly dissolve the cricket's living tissues. The threads continue to grow deeper into the cricket's body. Within a few days, the cricket's body is little more than a hollow shell filled with a tangle of the deadly threads. Then the threads begin to grow up and out of the dead cricket. They produce long stalks with knobs at their tips. When one of the knobs breaks open, it will release thousands of dustlike specks, which the wind can carry to new victims.

GUIDE FOR READING

- What characteristics do fungi share?
- How do fungi obtain food?
- What roles do fungi play in the living world?

Reading Tip Before you read, preview the headings. Record them in outline form, leaving space for writing notes.

▼ A bush cricket attacked by a killer fungus



The strange cricket-killing organism is a member of the fungi kingdom. Although you may not have heard of a cricket-killing fungus before, you are probably familiar with other kinds of fungi. For example, the molds that grow on stale bread or on decaying fruit are all fungi. Mushrooms that sprout in forests or yards are also fungi.

Fungi vary in size from the unicellular yeasts to the multicellular fungi, such as mushrooms and the bracket fungi that look like shelves growing on tree trunks. **Most fungi share three important characteristics: They are eukaryotes, use spores to reproduce, and are heterotrophs that feed in a similar way.** In addition, fungi need moist, warm places in which to grow. They thrive on moist foods, damp tree barks, lawns coated with dew, damp forest floors, and even wet bathroom tiles.

Except for yeast cells, which are unicellular, the cells of fungi are arranged in structures called hyphae. **Hyphae** (HY fee) (singular *hypha*) are the branching, threadlike tubes that make up the bodies of multicellular fungi. The hyphae of some fungi are continuous threads of cytoplasm that contain many nuclei. Substances move quickly and freely through the hyphae.

The appearance of a fungus depends on how its hyphae are arranged. In some fungi, the threadlike hyphae are loosely tangled. Fuzzy-looking molds that grow on old foods have loosely tangled hyphae. In other fungi, hyphae are packed tightly together. For example, the stalk and cap of the mushrooms in Figure 13 are made of hyphae packed so tightly that they appear solid. Underground, however, a mushroom's hyphae form a loose, threadlike maze in the soil.

Checkpoint *What structures make up the bodies of multicellular fungi?*

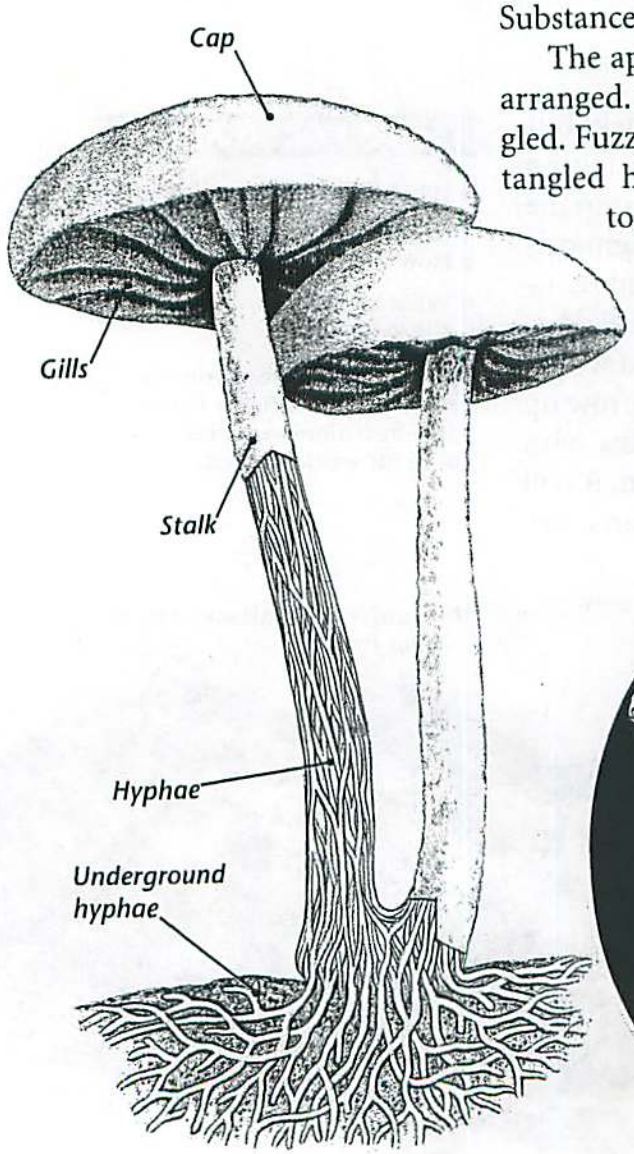


Figure 13 The hyphae in the stalk and cap of a mushroom are packed tightly to form very firm structures. Underground hyphae, on the other hand, are arranged loosely. *Inferring* *What function do you think the underground hyphae perform?*

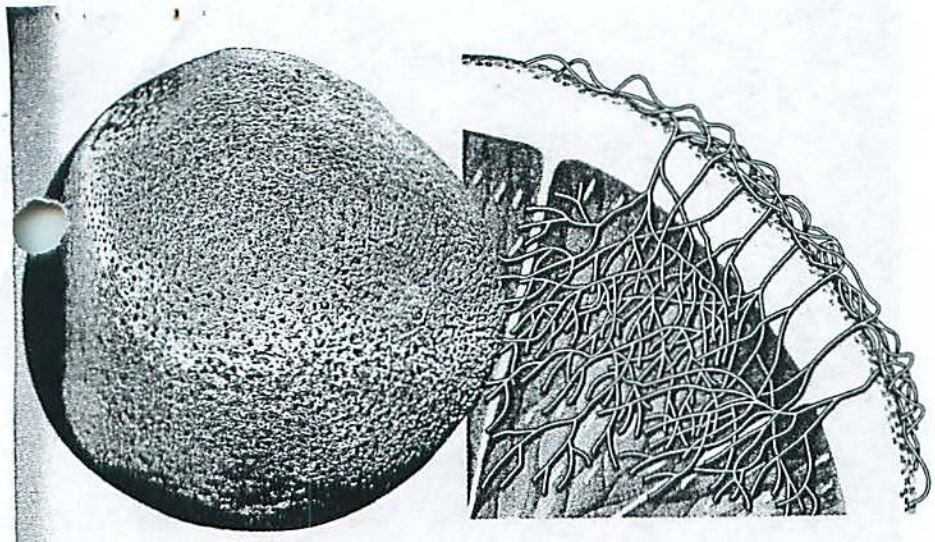


Figure 14 The mold *Penicillium* often grows on old fruits such as this orange. Notice that some hyphae grow deep inside the orange. These hyphae digest the food and absorb the smaller chemicals.

How Do Fungi Obtain Food?

Although fungi are heterotrophs, they do not take food into their bodies as you do. Instead fungi absorb food through hyphae that grow into the food source.

Look at Figure 14 to see how a fungus feeds. **First, the fungus grows hyphae into a food source. Then digestive chemicals ooze from the tips of the hyphae into the food. The digestive chemicals break down the food into small substances that can be absorbed by the hyphae.** Imagine yourself sinking your fingers down into a chocolate cake and dripping digestive chemicals out of your fingertips. Then imagine your fingers absorbing the digested particles of the cake. That's how a fungus feeds.

Some fungi feed on the remains of dead organisms. Other fungi are parasites that break down the chemicals in living organisms. For example, athlete's foot is a disease caused by a fungus that feeds on chemicals in a person's skin. Dutch elm disease is caused by a fungus that feeds on elm trees and eventually kills the trees.

Reproduction in Fungi

Like it or not, fungi are everywhere. The way they reproduce guarantees their survival and spread. Fungi usually reproduce by producing lightweight spores that are surrounded by a protective covering. Spores can be carried easily through air or water to new sites. Fungi produce many more spores than will ever grow into new fungi. Only a few of the thousands of spores that a fungus releases will fall where conditions are right for them to grow into new organisms.

TRY THIS

Making Spore Prints

ACTIVITY

In this activity, you will examine the reproductive structures of a mushroom.

1. Place a fresh mushroom cap, gill side down, on a sheet of white paper. **CAUTION:** *Do not eat the mushroom.*
2. Cover the mushroom cap with a plastic container. Wash your hands with soap.
3. After two days, carefully remove the container and then the cap. You should find a spore print on the paper.
4. Examine the print with a hand lens. Then wash your hands with soap.

Predicting Use your spore print to estimate how many spores a mushroom could produce. Where would spores be most likely to grow into new mushrooms?

Figure 15 Budding is a form of asexual reproduction that occurs in yeast. The small yeast cell that grows from the body of a parent cell is identical to the parent.

Fungi produce spores in structures called **fruiting bodies**, which are reproductive hyphae that grow out of a fungus. The appearances of fruiting bodies vary from one type of fungus to another. For some fungi, such as mushrooms and puffballs, the part of the fungus that you see is the fruiting body. In other fungi, such as bread molds, the stalklike fruiting bodies gr... upward from the hyphae on the surface of the bread. T... knoblike structure, or spore case, at the tip of a stalk contains the spores.

Asexual Reproduction Most fungi reproduce both asexually and sexually. When there is adequate moisture and food, most fungi reproduce asexually by growing fruiting bodies that release thousands of spores.

Unicellular yeast cells undergo a form of asexual reproduction called **budding.** In budding, no spores are produced. Instead, a small yeast cell grows from the body of a large, well-fed parent cell in a way that might remind you of a bud forming on the branch of a tree. The new cell then breaks away and lives on its own.

Sexual Reproduction When growing conditions become unfavorable, fungi may reproduce sexually. In sexual reproduction, the hyphae of two fungi grow together and genetic material is exchanged. A new spore-producing structure grows from the joined hyphae. The new structure produces spores, which can develop into fungi that differ from either parent.

Checkpoint What is a fruiting body?

TRY THIS

Spreading Spores

In this activity you will make a model of a fruiting body.

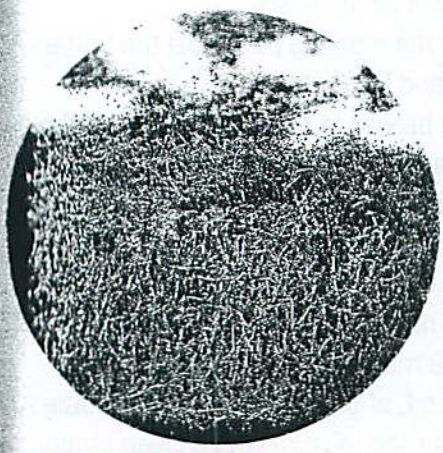
ACTIVITY

1. Break a cotton ball into five equal-sized pieces. Roll each piece into a tiny ball.
2. Insert the cotton balls into a balloon through the opening in its neck.
3. Repeat Steps 1 and 2 until the balloon is almost full.
4. Inflate the balloon. Tie a knot in its neck. Tape the knotted end of the balloon to a stick.
5. Stand the stick upright in a mound of modeling clay.
6. Pop the balloon with a pin. Observe what happens.

Making Models Draw a diagram of the model you made. Label the stalk, the spore case, and the spores. Use your model to explain why fungi are found just about everywhere.

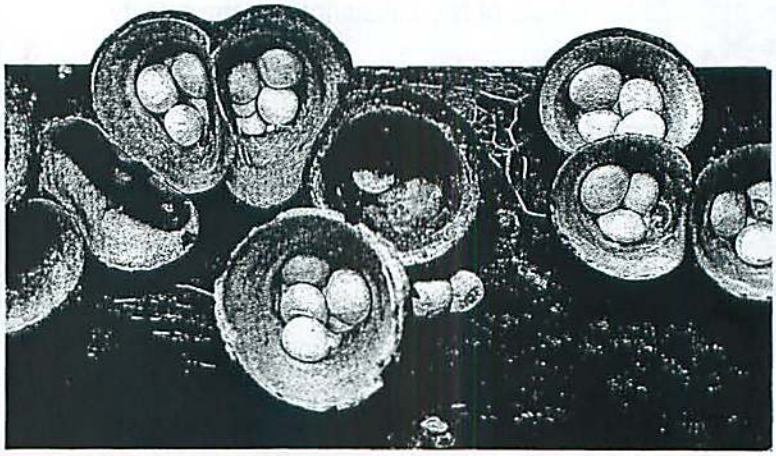
Classification of Fungi

Fungi are classified into groups based on the shape of the spore-producing structures and on their ability to reproduce sexually. The four groups of fungi—the threadlike fungi, the sac fungi, the club fungi, and the imperfect fungi—are shown in Figure 16.



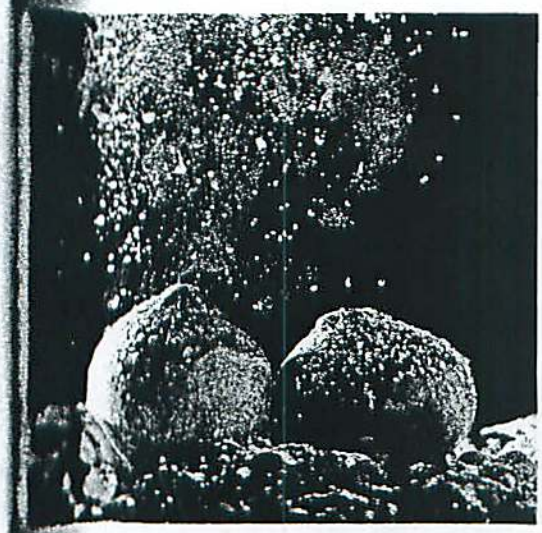
Threadlike Fungi

This group contains about 600 different species of molds, including many common bread molds, such as this *Rhizopus*. These fungi produce spores in their threadlike hyphae.



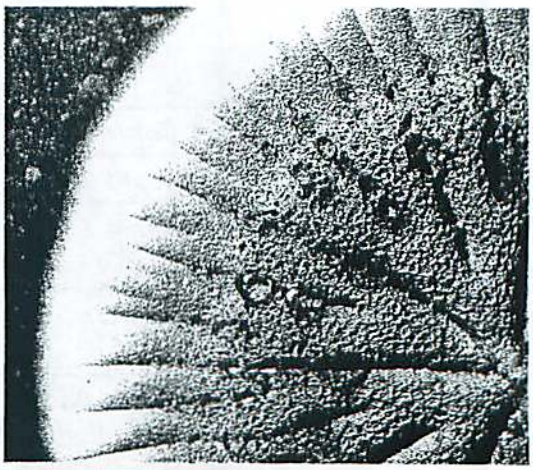
Sac Fungi

This group contains over 30,000 diverse species of fungi, including yeast, morels, truffles, and some fungi that cause plant diseases, such as Dutch elm disease. They are called sac fungi because they produce spores in structures that look like sacks. The sac fungi in the photo are called bird's nest fungi.



Club Fungi

This group includes about 25,000 species of mushrooms, bracket fungi, plant parasites, and puffballs. Club fungi produce spores in structures that look like clubs. One of the puffballs in the photo is shooting out its spores.



Imperfect Fungi

The 25,000 species in this group include this *Penicillium*, the source of an important antibiotic. The fungi in this group are not known to reproduce sexually.

Figure 16 The four groups of fungi differ in the appearance of their spore-producing structures and in how they reproduce.
Classifying To which group do mushrooms belong?

Skills Lab

Drawing Conclusions

What's for Lunch?

In this lab, you will draw conclusions about the effects of two substances on the activity of yeast.

Problem

How does the presence of sugar or salt affect the activity of yeast?

Materials

marking pen
5 plastic straws
salt
beaker
graduated cylinder
5 small narrow-necked bottles
5 round balloons
sugar
warm water (40–45°C)
dry powdered yeast

Procedure

1. Copy the data table into your notebook. Then read over the entire procedure to see how you will test the activity of the yeast cells in bottles A through E. Write a prediction about what will happen in each bottle.
2. Gently stretch each of the 5 balloons so that they will inflate easily.
3. Using the marking pen, label the bottles A, B, C, D, and E.
4. Use a beaker to fill each bottle with the same amount of warm water. **CAUTION:** *Glass is fragile. Handle the bottles and beaker gently to avoid breakage. Do not touch broken glass.*
5. Put 5 mL of salt into bottle B.
6. Put 5 mL of sugar into bottles C and E.
7. Put 30 mL of sugar into bottle D.
8. Put 2 mL of powdered yeast into bottle A, and stir the mixture with a clean straw. Remove the straw and discard it.
9. Immediately place a balloon over the opening of bottle A. Make sure that the balloon opening fits very tightly around the neck of the bottle.
10. Repeat Steps 8 and 9 for bottle B, bottle C, and bottle D.

DATA TABLE

Bottle	Contents	Prediction	Observations
A	Yeast alone		
B	Yeast and 5 mL of salt		
C	Yeast and 5 mL of sugar		
D	Yeast and 30 mL of sugar		
E	No yeast and 5 mL of sugar		

11. Place a balloon over bottle E without adding yeast to the bottle.
12. Place the 5 bottles in a warm spot away from drafts. Observe and record what happens.

Analyze and Conclude

1. Which balloons changed in size during this lab? How did they change?
2. Explain why the balloon changed size in some bottles and not in others. What caused that change in size?
3. Do yeast cells use sugar as a food source? How do you know?
4. Do yeast cells use salt as a food source? How do you know?
5. What did the results from bottle C show, compared with the results from bottle D?
6. **Think About It** If you removed bottle E from your experiment, would you be able to conclude whether or not sugar is a food source for the yeast cells? Why or why not?

Design an Experiment

Develop a hypothesis about whether yeast cells need light to carry out their life activities. Then design an experiment to test your hypothesis. Obtain your teacher's permission before you carry out the experiment.

Fungi and the Living World

Fungi affect humans and other organisms in many ways. **Fungi play an important role as decomposers on Earth. In addition, many fungi provide foods for people. Some cause disease and some fight disease. Still other fungi live in symbiosis with other organisms.**

Environmental Recycling Like bacteria, many fungi are decomposers—organisms that break down the chemicals in dead organisms. For example, many fungi live in the soil and break down the chemicals in dead plant matter. This process returns important nutrients to the soil. Without fungi and bacteria, Earth would be buried under dead plants and animals.

Food and Fungi When you eat a slice of bread, you benefit from the work of yeast. Bakers add yeast to bread dough to make it rise. Yeast cells use the sugar in the dough for food and produce carbon dioxide gas as they feed. The gas forms bubbles, which cause the dough to rise. You see these bubbles as holes in a slice of bread. Without yeast, bread would be flat and solid. Yeast is also used to make wine from grapes. Yeast cells feed on the sugar in the grapes and produce carbon dioxide and alcohol.

Other fungi are also important sources of foods. Molds are used in the production of foods such as some cheeses. The blue streaks in blue cheese, for example, are actually growths of *Penicillium roqueforti.* People enjoy eating mushrooms in salads and soups and on pizza. Because some mushrooms are poisonous, however, you should never pick or eat wild mushrooms.

Figure 17 Many food crops are lost each year due to fungal diseases. The ear of corn in the photo has been attacked by a fungus called corn smut. ***Making Generalizations*** *Why is the spread of fungal diseases difficult to control?*

Checkpoint *What are three foods that fungi help to produce?*

Disease-Causing Fungi Many fungi cause serious diseases in plants that result in huge crop losses every year. Corn smut and wheat rust are two club fungi that cause diseases in important food crops. Fungal plant diseases also affect other crops, including rice, cotton, and soybeans.

INTEGRATING HEALTH Some fungi cause diseases in humans as well. Athlete's foot causes an itchy irritation in the damp places between toes. Ringworm, another fungal disease, causes an itchy, circular rash on the skin. Because the fungi that cause the

diseases produce spores at the site of infection, the diseases can spread easily from person to person. Both diseases can be treated with antifungal medications.

Disease-Fighting Fungi In 1928 a Scottish biologist, Alexander Fleming, was examining petri dishes in which he was growing bacteria. To his surprise, Fleming noticed a spot of a bluish-green mold growing in one dish. Curiously, no bacteria were growing near the mold. Fleming hypothesized that the mold, a fungus named *Penicillium*, produced a substance that killed the bacteria growing near it. Fleming's work led to the development of the first antibiotic, penicillin. It has saved the lives of millions of people with bacterial infections. Since the discovery of penicillin, many additional antibiotics have been isolated from both fungi and eubacteria.

Fungus-Plant Root Associations Some fungi help plants grow larger and healthier when their hyphae grow among the plant's roots. The hyphae spread out underground and absorb water and nutrients from the soil for the plant. With more water and nutrients, the plant grows larger than it would have grown without its fungal partner. The plant is not the only partner that benefits. The fungi get to feed on the extra food that the plant makes and stores.

Many plants are so dependent on their fungal partners that they cannot survive well without them. For example, orchids cannot grow without their fungal partners.

Language Arts CONNECTION

Folk tales are ancient stories that were passed down by word of mouth over many generations. Folk tales often involve magical elements, such as fairies—supernatural beings with powers to become invisible, change form, and affect the lives of people.

The circle of mushrooms in Figure 18 was often mentioned in folk tales. These circles were said to be the footprints of fairies who danced there at midnight. These mushroom circles were given the name "fairy rings"—a name that is still used today. People believed that the area inside a fairy ring was a magical location. Cutting down the tree inside a fairy ring was believed to bring bad luck.

In Your Journal

A type of mushroom called a toadstool is mentioned in some folk tales. Write a paragraph that could be part of a folk tale that reveals how toadstools got their name.

Figure 18 The fruiting bodies of these mushrooms have emerged in an almost perfect circular pattern. This pattern is called a fairy ring. The mushrooms share the same network of underground hyphae.

Figure 19 Lichens consist of a fungus living together with either algae or autotrophic bacteria. A. This lichen—a British soldier—probably gets its name from its scarlet red tops, which stand upright. B. The lichens covering these rocks are slowly breaking down the rocks to create soil.

Lichens A **lichen** (LY kun) consists of a fungus and either algae or autotrophic bacteria that also live together in a mutualistic relationship. You have probably seen some familiar lichens—irregular, flat, crusty patches that grow on tree barks or rocks. The fungus benefits from the food produced by the algae or bacteria. The algae or bacteria, in turn, obtain water and minerals from the fungus.

Integrating Earth Science Lichens are often called "pioneer" organisms because they are the first organisms to appear on the bare rocks in an area after a volcano, fire, or rock slide has occurred. Over time, the lichens break down the rock into soil in which other organisms can grow. Lichens are also useful as indicators of air pollution. Many species of lichens are very sensitive to pollutants and die when pollution levels rise. By monitoring the growth of lichens, scientists can assess the air quality in an area.

Section 3 Review

1. List three characteristics that fungi share.
2. Explain how a fungus feeds. What do fungi feed on?
3. Describe three roles that fungi play in the world.
4. **Thinking Critically Classifying** Explain why mushrooms are classified as fungi rather than as plants.

Check Your Progress

Continue to observe your mushrooms and collect data. Begin to review your data to see which conditions favored mushroom growth. How do your results compare with your hypothesis? Begin to plan your poster now. Think about how you can use graphs and diagrams to display your results. *(Hint:* Draw a rough sketch of your poster, and show it to your teacher. Include a labeled drawing of a mushroom.)

CHAPTER 7 STUDY GUIDE

SECTION 1 Protists

Key Ideas

- Animal-like protists, or protozoans, include sarcodines, ciliates, zooflagellates, and sporozoans. Like animals, these protists are heterotrophs. Most protozoans move by using pseudopods, cilia, or flagella.
- Funguslike protists include water molds, downy mildews, and slime molds. Like fungi, these protists are heterotrophs, have cell walls, and use spores to reproduce.
- Plantlike protists, or algae, include euglenoids, dinoflagellates, diatoms, green algae, red algae, and brown algae. Like plants, these organisms are autotrophs.

Key Terms

protozoan
pseudopod
contractile vacuole
cilia
symbiosis
mutualism
spore
algae
pigment

SECTION 2 Algal Blooms

INTEGRATING

Key Ideas

Red tides occur when a population of algae increases quickly in ocean waters. Some algae can secrete toxins that poison animals.

Nutrients in a lake or pond build up over time, causing an increase in the numbers of algae. An accelerated rate of eutrophication can lead to the deaths of many organisms in the lake or pond.

Key Terms

algal bloom
red tide
eutrophication

SECTION 3 Fungi

Key Ideas

Most fungi are eukaryotes, use spores to reproduce, and are heterotrophs.

Most fungi feed by absorbing food through their hyphae. The hyphae secrete digestive chemicals into a food source, which is broken down into small substances that are absorbed by the hyphae.

Fungi produce spores in fruiting bodies. Most fungi reproduce both asexually and sexually.

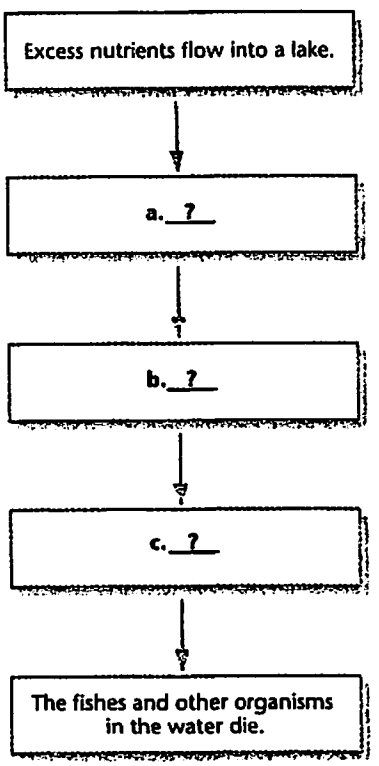
Fungi are decomposers that recycle Earth's chemicals.

Key Terms

hypha
fruiting body
budding
lichen

Organizing Information

Flowchart Copy this flowchart about changes in a lake onto a separate sheet of paper. Then complete the flowchart and add a title. (For more on flowcharts, see the Skills Handbook.)



Reviewing Content

For more review of key concepts, see the Interactive Student Tutorial CD-ROM.

Multiple Choice

Choose the letter of the best answer.

1. Which of the following characteristics describes *all* protists?
   a. They are unicellular.
   b. They can be seen with the unaided eye.
   c. Their cells have nuclei.
   d. They are unable to move on their own.
2. Which protist uses cilia to move?
   a. euglena b. ameba
   c. paramecium d. diatom
3. Which statement is true of slime molds?
   a. They are always unicellular.
   b. They are autotrophs.
   c. They are animal-like protists.
   d. They use spores to reproduce.
4. An overpopulation of saltwater algae is called a(n)
   a. pigment.
   b. lichen.
   c. red tide.
   d. eutrophication.
5. A lichen is a symbiotic association between which of the following?
   a. fungi and plant roots
   b. algae and fungi
   c. algae and bacteria
   d. protozoans and algae

True or False

If the statement is true, write true. If it is false, change the underlined word or words to make the statement true.

6. Sarcodines use flagella to move.
7. Eutrophication is the process by which nutrients in a lake build up over time, causing an increase in the growth of algae.
8. Most fungi are made up of threadlike structures called hyphae.
9. All mushrooms are classified as sac fungi.
10. Most fungi that live among the roots of plants are beneficial to the plants.

Checking Concepts

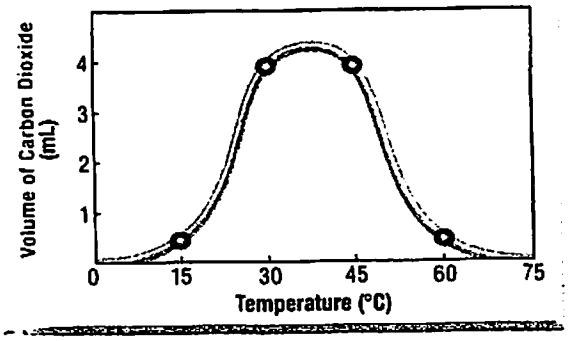
11. Describe the process by which an ameba obtains its food.
12. Describe the differences among algae in terms of their sizes.
13. Compare how animal-like, funguslike, and plantlike protists obtain food.
14. What problems can an algal bloom cause in an ocean? What problems can an algal bloom cause in a lake?
15. How does sexual reproduction occur in fungi?
16. Explain how both organisms that make up a lichen benefit from their symbiotic relationship.
17. **Writing to Learn** Imagine you are a spore inside a ripe puffball. An animal passing by brushes against the puffball and punctures the outer covering of your spore case. Write a description about what happens to you next.

Thinking Critically

18. **Comparing and Contrasting** Describe the ways in which amebas and paramecia are similar to one another. How are they different?
19. **Problem Solving** What are some actions that homeowners could take to discourage the growth of mildew in their basement? Explain why these actions might help solve the problem.
20. **Predicting** If all algae suddenly disappeared from Earth's waters, what would happen to living things on Earth? Explain your answer.
21. **Relating Cause and Effect** You see some green scumlike material growing on the walls of your freshwater aquarium at home. List some possible reasons why this growth has occurred.

Applying Skills

When yeast is added to bread dough, the yeast cells produce carbon dioxide, which causes the dough to rise. The graph below shows how temperature affects the amount of carbon dioxide that is produced. Use the graph to answer Questions 22–24.



22. **Interpreting Data** Explain how temperature affects the amount of carbon dioxide that the yeast cells produce.

23. **Inferring** Use the graph to explain why yeast is dissolved in warm water rather than cold water when it is used to make bread.

24. **Predicting** Based on the graph, would you expect bread dough to continue to rise if it were placed in a refrigerator (about 2°–5°C)? Explain.

Performance Assessment

CHAPTER PROJECT

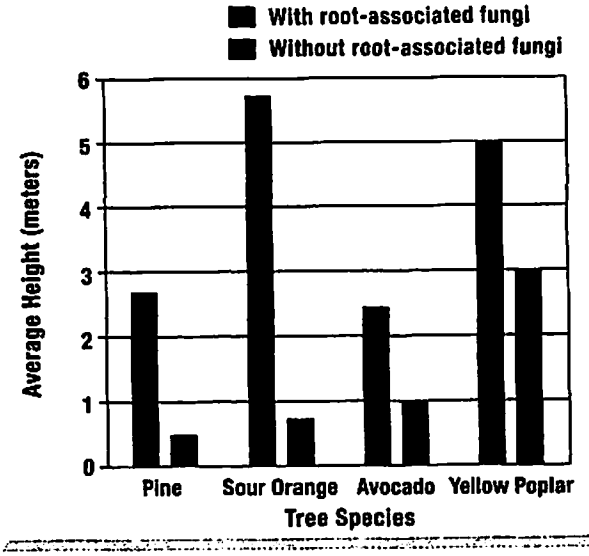
Present Your Project Now it's time to finalize your poster. Include your hypothesis, and describe the conditions that produced the best mushroom growth. Make sure your graph is easy to understand. Check that your drawing of a mushroom is clearly labeled.

Reflect and Record What did you learn about mushrooms from this project? Did you encounter and solve any problems? Did the project raise new questions for you? If so, how could you answer those questions?

Test Preparation

Use these questions to prepare for standardized tests.

Study the graph. Then answer Questions 25–28.



25. What is the best title for this graph?
   a. The Growth Rates of Trees
   b. The Heights of Four Tree Species
   c. The Effect of Root-Associated Fungi on Tree Growth
   d. The Growth of Root-Associated Fungi

26. Which of the following statements is supported by the graph's data?
   a. All trees grew equally well.
   b. Trees with root-associated fungi grew taller than similar trees without such fungi.
   c. Yellow poplars are the tallest tree species.
   d. The data support none of the statements.

27. Based on the graph, which type of tree had the largest growth change with root-associated fungi?
   a. pine b. sour orange
   c. avocado d. yellow poplar

28. What is the average height difference between avocado trees that grew with root-associated fungi and those that grew without such fungi?
   a. 1.5 meters b. 2.0 meters
   c. 2.25 meters d. 5.0 meters