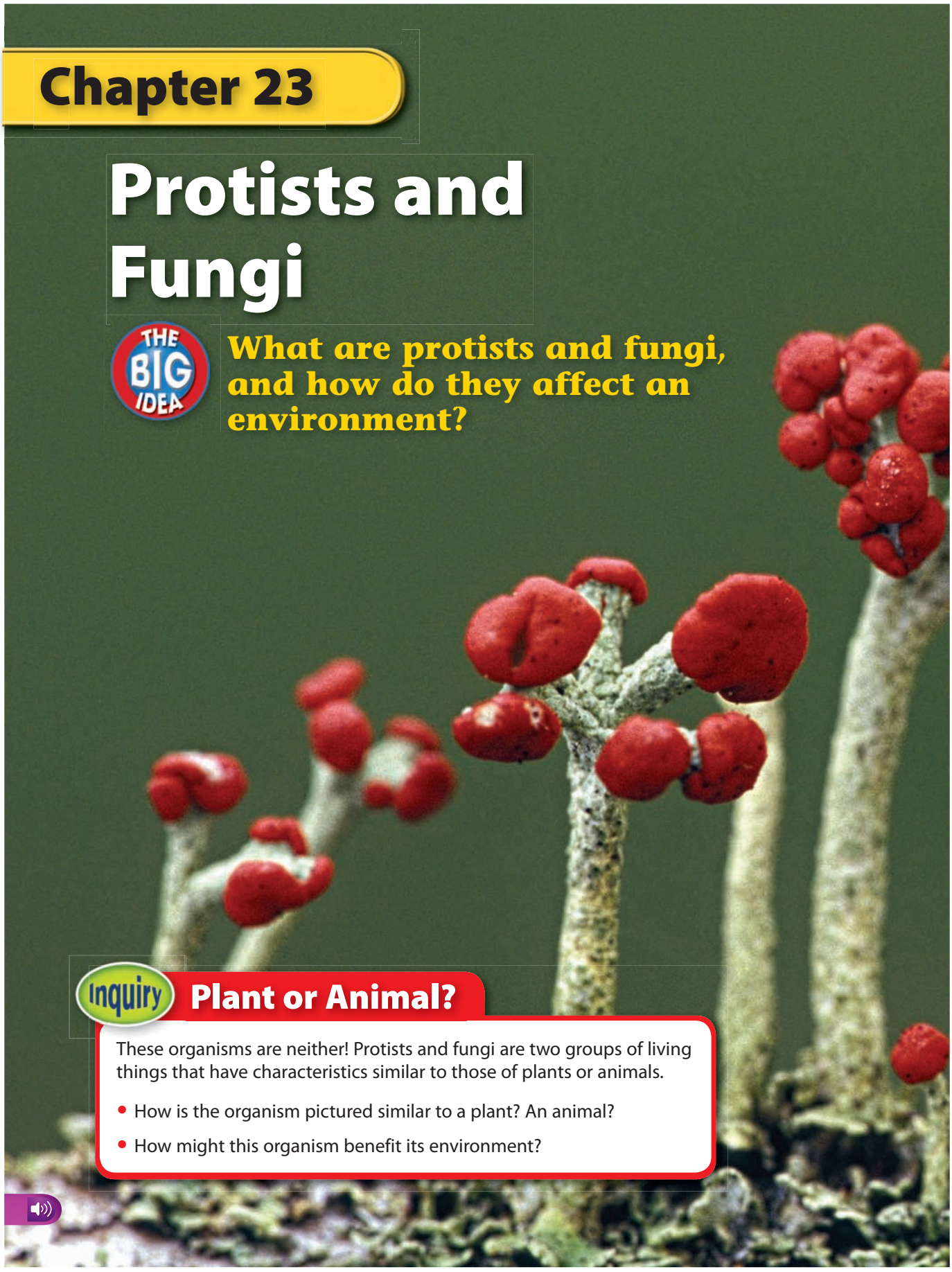
Chapter 23

Protists and Fungi

THE BIG IDEA

What are protists and fungi, and how do they affect an environment?

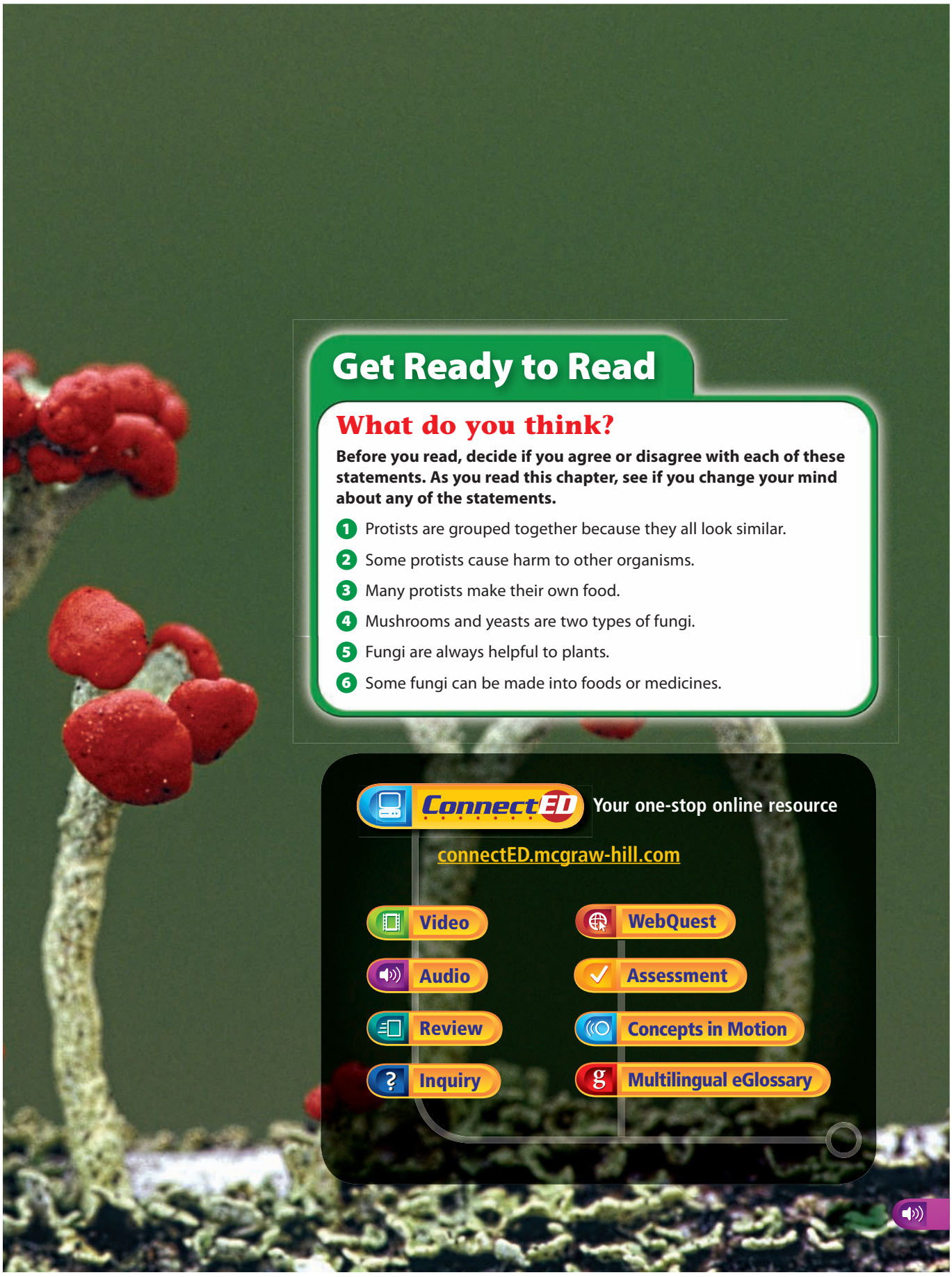


inquiry

Plant or Animal?

These organisms are neither! Protists and fungi are two groups of living things that have characteristics similar to those of plants or animals.

- How is the organism pictured similar to a plant? An animal?
- How might this organism benefit its environment?



Get Ready to Read

What do you think?

Before you read, decide if you agree or disagree with each of these statements. As you read this chapter, see if you change your mind about any of the statements.

1. Protists are grouped together because they all look similar.
2. Some protists cause harm to other organisms.
3. Many protists make their own food.
4. Mushrooms and yeasts are two types of fungi.
5. Fungi are always helpful to plants.
6. Some fungi can be made into foods or medicines.

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Lesson 1

What are protists?

Reading Guide

Key Concepts

ESSENTIAL QUESTIONS

- What are the different types of protists and how do they compare?
- How are protists beneficial?

Vocabulary

protist
algae
diatom
protozoan
cilia
paramecium
amoeba
pseudopod

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Inquiry Grabbing a Snack?

The protist group includes diverse organisms. What is the larger organism doing in the photo? How is this organism similar to an animal?

Launch Lab

10 minutes

How does a protist react to its environment?

Like other organisms, protists can react to their environment in many ways. One type of protist called *Euglena* has specialized structures to move, perform photosynthesis, and react to light.

1. Read and complete a lab safety form.
2. Place a **Petri dish** containing a ***Euglena* culture** on a white piece of **paper.** Using a **hand lens,** observe the *Euglena.*
3. Carefully cut a hole the size of a dime in a piece of **aluminum foil.** Place the foil on top of the dish so that the hole is centered over the top. Shine the light from a **desk lamp** at the hole.
4. At the end of class, remove the foil and observe the *Euglena* again.

Think About This

1. Where were the *Euglena* in the dish at the beginning of class? At the end?
2. Why do you think this behavior is beneficial to *Euglena*?
3. **Key Concept** What structures do you think help *Euglena* react to its environment?

What are protists?

When you see a living thing, one of the first questions you might have is whether it is a plant or an animal. You might recognize a dog as an animal because of its fur. You might know a flower is a plant because of its leaves. Besides appearance, organisms can also be classified by structures in their cells. For example, a plant cell has a cell wall made of cellulose and a membrane made of flexible fats. A plant cell often contains chloroplasts, organelles that carry out photosynthesis. An animal cell also has a membrane made of flexible fats but does not contain chloroplasts or have a cell wall. These characteristics make it easy to identify both types of cells. However, some organisms, such as the protist shown in **Figure 1,** cannot be classified as easily.

A **protist** *is a member of a group of eukaryotic organisms, which have a membrane-bound nucleus.* Members of the protist group share some characteristics with plants, animals, or organisms known as fungi. However, they are not classified as any of these groups. Although protists are classified together, they are diverse and have different adaptations for movement and for finding food.

Reading Check What is a protist?

Figure 1 Many photosynthetic algae look like plants.

Review Vocabulary
asexual reproduction a type of reproduction in which one parent reproduces without a sperm and an egg joining

Reproduction of Protists

Most protists reproduce asexually. What does the offspring of **asexual reproduction** look like? It is an exact copy of the parent. Asexual reproduction can create new organisms quickly. However, many protists can also reproduce sexually. Offspring of sexual reproduction are genetically different from the parents. Sexual reproduction takes more time, but it creates new organisms with a variety of characteristics.

Classification of Protists

Scientists usually classify organisms according to their similarities. However, protists are a unique and diverse classification of organisms. Typically, a protist is any eukaryote that cannot be classified as a plant, an animal, or a fungus. However, protists might look and act very much like these other types of organisms. Scientists classify protists as plantlike, animal-like, or funguslike based on which group they most resemble, as shown in Table 1.

Key Concept Check What are the different types of protists?

Review Personal Tutor

Table 1 Protists Classified into One of Three Groups

Classification	Plantlike	Animal-like	Funguslike
Example	algae 	paramecium 	slime mold 
Characteristics	• make their own food • unicellular or multicellular	• eat other organisms for food • mostly microscopic and unicellular	• break down organic matter for food • mostly multicellular

Plantlike Protists

You might have seen brown, green, or red seaweed at the beach or in an aquarium. These seaweeds are algae (AL jee; singular, alga), one type of plantlike protist. Why might they be classified as plantlike? **Algae** *are plantlike protists that produce food through photosynthesis using light energy and carbon dioxide.* Most plantlike protists, however, are much smaller than the multicellular algae shown in Table 1. You can't see most algae without a microscope.

Diatoms

A type of microscopic plantlike protist with a hard outer wall is a **diatom** (DI uh tahm). Diatoms are so common that if you filled a cup with water from the surface of any lake or pond, you would probably collect thousands of them. Look at the unicellular diatoms shown at the top of **Figure 2.** A diatom can resemble colored glass. In fact, the cell walls of diatoms contain a large amount of silica, the main mineral in glass.

Dinoflagellates

Can you guess how the protist in the middle of **Figure 2** moves? This organism is a dinoflagellate (di noh FLA juh lat), a unicellular plantlike protist that has flagella—whiplike parts that enable the protist to move. The flagella beat back and forth, enabling the dinoflagellate to spin and turn. Some of these protists glow in the dark because of a chemical reaction that occurs when they are disturbed.

Reading Check What purpose do flagella serve?

Euglenoids

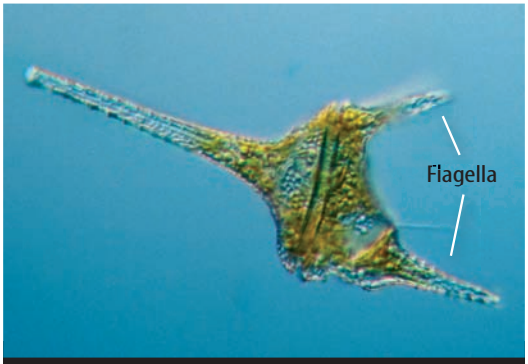
Another type of plantlike protist also uses flagella to move but has a unique structure covering its body. A euglenoid (yew GLEE noyd), shown at the bottom of **Figure 2,** is a unicellular plantlike protist with a flagellum at one end of its body. Instead of a cell wall, euglenoids have a rigid, rubbery cell coat called a pellicle (PEL ih kul). Euglenoids have eyespots that detect light and determine where to move. Euglenoids swim quickly and can creep along the surface of water when it is too shallow to swim. These protists have chloroplasts and make their own food. If there is not enough light for making food, they can absorb nutrients from decaying matter in the water. Animals such as tadpoles and small fish eat euglenoids.

Reading Check What characteristics do plantlike protists share with plants?

Word Origin

diatom
from Greek *diatomos,* means "cut in two"


Diatoms



Dinoflagellate

Euglenoid

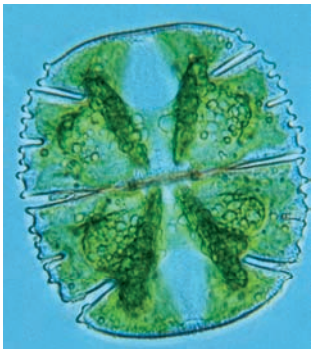
Figure 2 All of these microscopic organisms are protists. The cell walls of diatoms contain silica. The dinoflagellate has two flagella that cause it to spin. The euglenoid has a flagellum and a rigid cell coat.

Algae

Recall that algae are photosynthetic plantlike protists. Some algae are big and multicellular, like the seaweeds in **Figure 3.** Other algae are unicellular and can be seen only with a microscope. Algae are classified as red, green, or brown, depending on the pigments they contain.

Some types of red and brown algae appear similar to plants. Unlike plants, these algae do not have a complex organ system for transporting water and nutrients. Instead of roots, they have holdfasts, structures that secrete a chemical-like glue that fastens them to the rocks.

One unusual green alga is volvox. In **Figure 3** you can see that many volvox cells come together to form a larger sphere. These cells move together as one group and beat their flagella in unison. Some cells produce parts necessary for sexual reproduction. The volvox cells in the front of the group have larger eyespots that sense light for photosynthesis. Do you think volvox should be considered unicellular or multicellular?



Unicellular Algae

Multicellular Algae

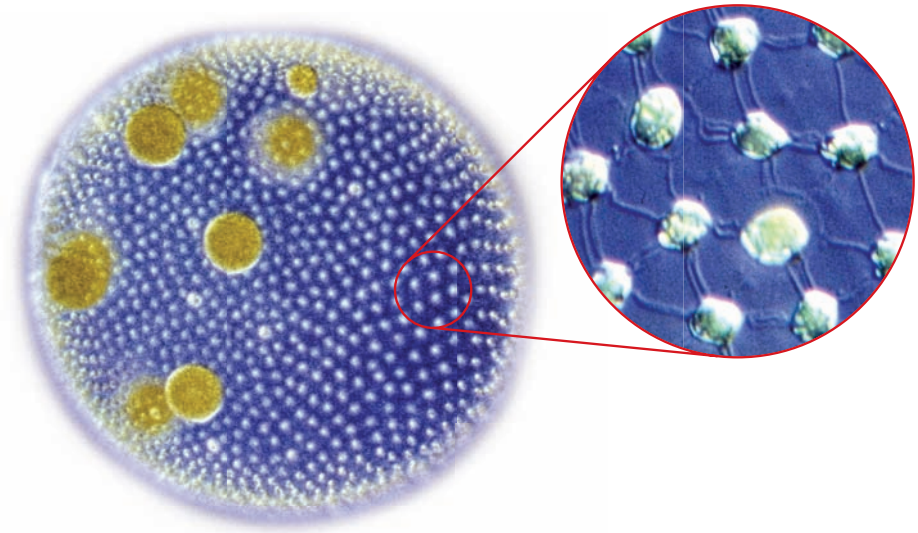


Figure 3 Volvox are unicellular green algae that join together to form a sphere. ▼

The Importance of Algae

Do you use algae in your everyday life? You might be surprised by all the materials you use that contain algae. You might be eating algae if you snack on ice cream, marshmallows, or pudding. Algae are a common ingredient in other everyday products, including toothpaste, lotions, fertilizers, and some swimming pool filters.

Algae and Ecosystems

Algae provide food for animals and animal-like protists. They also provide shelter for many aquatic organisms. In **Figure 4,** you can see that some brown algae grow tall. Thick groups of tall brown algae are called kelp forests. Sea otters and seals come to the kelp forest to eat smaller animals.

Key Concept Check How are algae beneficial to an ecosystem?

Do you think algae ever cause problems in an ecosystem? Algae and other photosynthetic protists can help remove pollution from the water. However, this pollution can be a food source for the algae, allowing the population of algae to increase quickly. The algae produce wastes that can poison other organisms. As shown in **Figure 5,** when the number of these protists increase, the water can appear red or brown. This is called a red tide or a harmful algal bloom (HAB).

Reading Check What causes a red tide?

Kelp Forest

▲ **Figure 4** Brown algae can form thick kelp forests that are home to many animals and other protists.

Figure 5 Red tides can be harmful to aquatic organisms. ▼

Animal-like Protists

Some protists are similar to plants, but others are more like animals. **Protozoans** (proh tuh ZOH unz) *are protists that resemble tiny animals.* Animal-like protists all share several characteristics. They do not have chloroplasts or make their own food. Protozoans are usually microscopic and all are unicellular. Most protozoans live in wet environments.

Ciliates

~~Cilia~~ (SIH lee uh) *are short, hairlike structures that grow on the surface of some protists.* Protists that have these organelles are called ciliates. Cilia cover the surface of the cell. They can beat together and move the animal-like protist through the water.

Reading Check What function do cilia perform?

A common protozoan with these cilia is the **paramecium** (pa ruh MEE see um; plural, paramecia)—*a protist with cilia and two types of nuclei.* One example of a paramecium is shown in Figure 6. A paramecium, like most ciliates, gets its food by forcing water into a groove in its side. The groove closes and a food vacuole, or storage area, forms within the cell. The food particles are digested and the extra water is forced back out. Ciliates reproduce asexually, but they can exchange some genetic material through a **process** called conjugation (kahn juh GAY shun). This results in more genetic variation.

ACADEMIC VOCABULARY
process
(noun) an event marked by gradual changes that lead toward a particular result

Paramecium

Concepts in Motion Animation

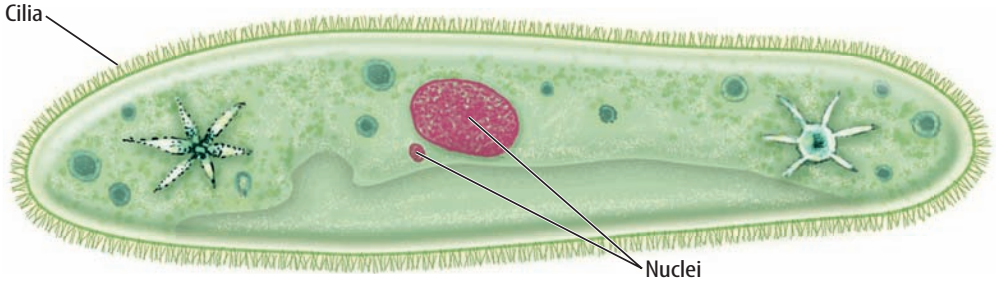


Figure 6 A paramecium, like the one shown above, has two nuclei and is covered with hairlike structures called cilia.

Flagellates

Recall that dinoflagellates, a type of plant-like protist, use one or more flagella to move. A type of protozoan also has one or more flagella—a flagellate. However, a flagellate does not always spin when it moves.

Flagellates eat decaying matter including plants, animals, and other protists. Many flagellates live in the digestive system of animals and absorb nutrients from food eaten by them.

Sarcodines

Animal-like protists called sarcodines (SAR kuh dinez) have no specific shape. At rest, a sarcodine resembles a random cluster of cytoplasm, or cellular material. These animal-like protists can ooze into almost any shape as they slide over mud or rocks.

An ~~amoeba~~ (uh MEE buh) *is one common sarcodine with an unusual adaptation for movement and getting nutrients.* An amoeba moves by using a **pseudopod**, *a temporary "foot" that forms as the organism pushes part of its body outward.* It moves by first stretching out a pseudopod then oozing the rest of its body up into the pseudopod. This movement is shown in **Figure 7.**

Amoebas also use pseudopods to get nutrients. An amoeba surrounds a smaller organism or food particle with its pseudopod and then oozes around it. A food vacuole forms inside the pseudopod where the food is quickly digested. You can see an amoeba capturing its prey in the photo at the beginning of this lesson.

Some sarcodines get nutrients and energy from ingesting other organisms, while others make their own food. Some sarcodines even live in the digestive systems of humans and get nutrients and energy from the human's body.

Amoeba Movement

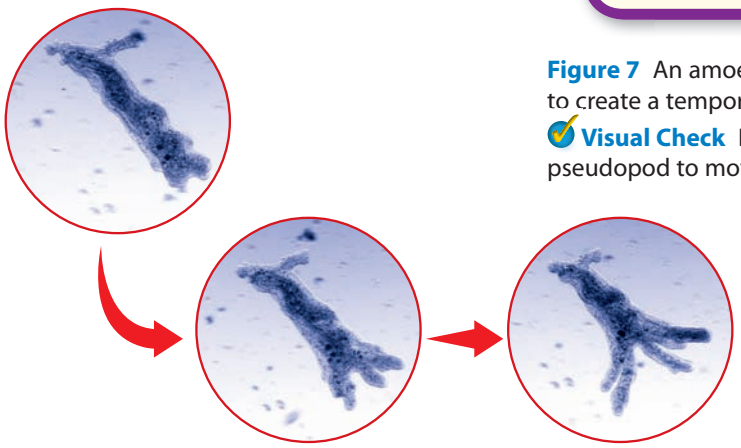


Figure 7 An amoeba moves by extending its body to create a temporary "foot."
Visual Check How does the amoeba use the pseudopod to move?

Inquiry MiniLab — 15 minutes

How can you model the movement of an amoeba?

The way an amoeba moves is so unusual that scientists use the term to describe a specific type of movement. Organisms that move by oozing are said to have "amoeboid" movement.

1. Read and complete a lab safety form.
2. Half-fill a **sock** with **dry beans.** Tie the end of the sock closed with a piece of **string.**
3. Place the sock on a flat surface and spread the beans evenly within the sock.
4. Demonstrate the organism's movement by pushing the beans forward in the sock until the sock moves.

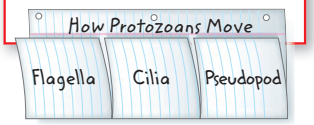
5. Model how amoebas capture their food by pushing the beans and sock around your finger.

Analyze and Conclude

1. **Explain** how amoebas capture their food.
2. **Formulate** models to demonstrate how other animal-like protists move.
3. **Key Concept** How does an amoeba move like some animals?

FOLDABLES®

Fold a sheet of paper to make a three-tab book. Label your book as shown. Use it to organize your notes about protozoans and how they move.



The Importance of Protozoans

Imagine living in a world without organisms that decompose other organisms. Plant material and dead animals would build up until the surface of Earth quickly became covered. Many protozoans are beneficial to an environment because they break down dead plant and animal matter. This decomposed matter is then recycled back into the environment and used by living organisms.

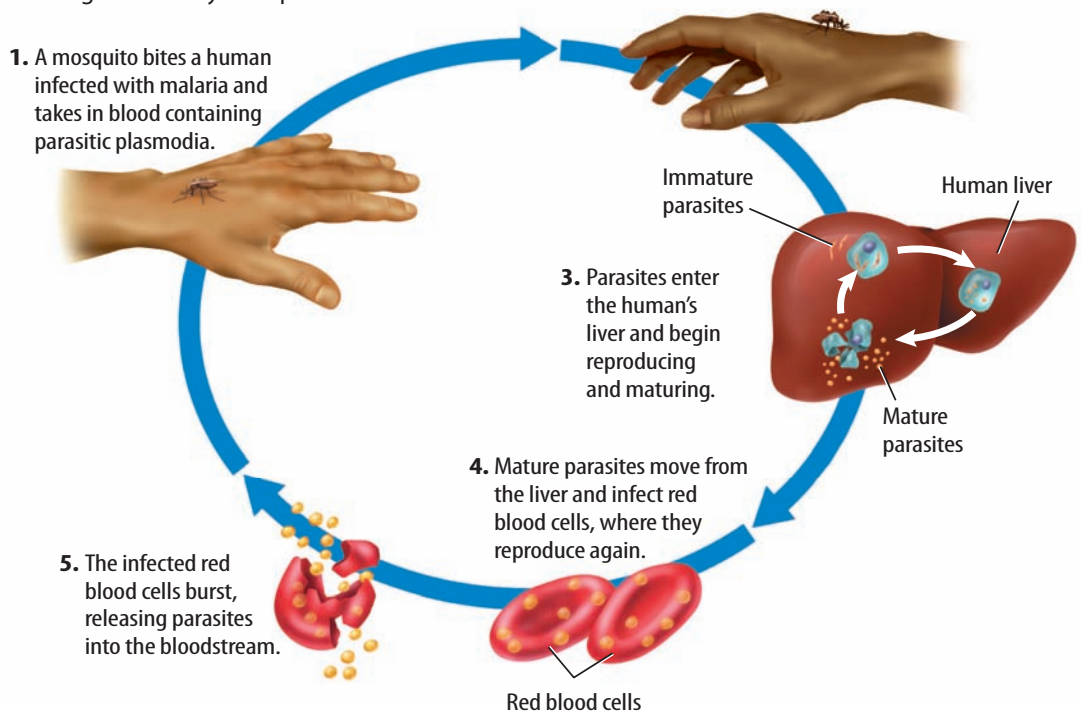
Some protozoans can cause disease by acting as parasites. These organisms can live inside a host organism and feed off it. Protozoan parasites are responsible for millions of human deaths every year.

One example of a disease caused by a protist is malaria. **Figure 8** illustrates how malaria develops and is spread to humans by mosquitoes. Protozoan parasites called plasmodia (singular, plasmodium) live and reproduce in red blood cells. Malaria kills more than one million people each year.

Key Concept Check In what ways are protists helpful and harmful to humans?

Plasmodium Life Cycle

Figure 8 A small parasitic protozoan called plasmodium causes malaria. It is transferred among humans by mosquitoes.



Funguslike Protists

In addition to plantlike and animal-like protists, there are funguslike protists. These protists share many characteristics with fungi. However, because of their differences from fungi, they are classified as protists.

Slime and Water Molds

Have you ever seen a strange organism like the one shown in **Figure 9?** These funguslike protists, called slime molds, look like they could have come from another planet. The body of the slime mold is composed of cell material and nuclei floating in a slimy mass. Most slime molds absorb nutrients from other organic matter in their environment.

A Funguslike Protist

Figure 9 Slime molds come in a variety of colors and forms. These protists often live on the surfaces of plants.

A water mold is another kind of funguslike protist that lives as a parasite or feeds on dead organisms. Originally classified as fungi, water molds often cause diseases in plants.

Both slime molds and water molds reproduce sexually and asexually. The molds usually reproduce sexually when environmental conditions are harsh or unfavorable.

Importance of Funguslike Protists

Funguslike protists play a valuable role in the ecosystem. They break down dead plant and animal matter, making the nutrients from these dead organisms available for living organisms. While some slime molds and water molds are beneficial, many others can be very harmful.

Many funguslike protists attack and consume living plants. The Great Irish Potato Famine resulted from damage by a funguslike protist. In 1845 this water mold destroyed more than half of Ireland's potato crop. More than one million people starved as a result.

Key Concept Check How are funguslike protists beneficial to an environment?

Lesson 1 Review

Assessment Online Quiz
Inquiry Virtual Lab

Visual Summary

Protists are a diverse group of organisms that cannot be classified as plants, animals, or fungi.

Protists are grouped according to the type of organisms they most resemble. Diatoms are one type of plantlike protist.

Some protists use hairlike structures called cilia to move.

FOLDABLES®

Use your lesson Foldable to review the lesson. Save your Foldable for the project at the end of the chapter.

What do you think NOW?

You first read the statements below at the beginning of the chapter.

1. Protists are grouped together because they all look similar.
2. Some protists cause harm to other organisms.
3. Many protists make their own food.

Did you change your mind about whether you agree or disagree with the statements? Rewrite any false statements to make them true.

Use Vocabulary

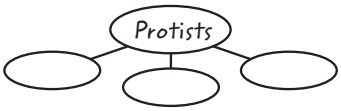
1. **Distinguish** between cilia and flagella.
2. **Define** *pseudopod* in your own words or with a drawing.

Understand Key Concepts

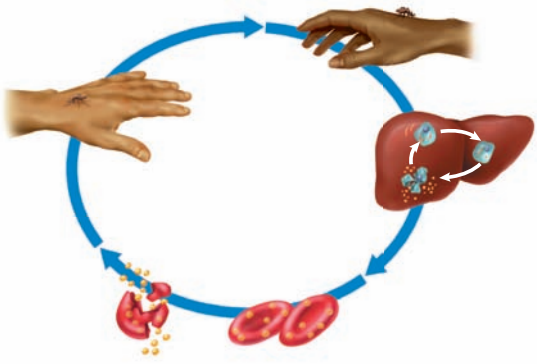
3. **List** three groups of animal-like protists and three groups of plantlike protists.
4. **Describe** one example of how protists benefit humans.
5. Identify which protist causes red tides.
   - **A.** algae
   - **B.** diatoms
   - **C.** euglenoids
   - **D.** paramecia

Interpret Graphics

6. **Identify** Copy and fill in the graphic organizer with the three categories of protists.



7. The image below shows the plasmodium life cycle.



Explain in your own words how this disease can be spread among people.

Critical Thinking

8. **Formulate** a plan for deciding to classify a newly discovered protist.

GREEN SCIENCE

The Benefits of Algae

Big Benefits from Tiny Organisms

▲ **Processing plants, such as this one, are a major source of algae oil.**

Algae are protists that can do more than just cover a pond as slimy scum. They release oxygen through photosynthesis. In fact, most of the oxygen in Earth's atmosphere comes from photosynthesis that occurs in algae, plants, and some bacteria. Algae are also food for many organisms, including humans. But algae can provide something else very valuable—oil.

A microalga is another type of protist that is very small and reproduces quickly. The total mass of some microalgae can double several times a day. More than half of their mass is fats, also called lipids, that store energy. One type of lipid, triglycerides, can be turned into diesel oil, gasoline, and jet fuel.

Microalgae can grow outdoors in ponds and produce 100 times more oil per acre than any other crop. They also can grow indoors under lights in photobioreactors. A photobioreactor is a tank filled with water and nutrients. Photosynthesis requires carbon dioxide. Instead of releasing carbon dioxide gas into the atmosphere, power plants can pump it into photobioreactors for microalgae to use. Also, microalgae can grow in water that is unsafe to drink. Using this technology, microalgae can grow in areas, such as deserts, where it is not ordinarily possible to grow other crops.

It's Your Turn

RESEARCH Protists, including algae, are important sources of food. Research five types of organisms that depend on protists for food. Make a display of your results to share with your class.

Lesson 2

What are fungi?

Reading Guide

Key Concepts

ESSENTIAL QUESTIONS

- What are the different types of fungi and how do they compare?
- Why are fungi important?
- What are lichens?

Vocabulary

hyphae
mycelium
basidium
ascus
zygosporangia
mycorrhizae
lichen

Multilingual eGlossary

The organism pictured is a puffball mushroom, named for the puff of material that it releases. What do you think the material is? What is the purpose of the puff of material?

Launch Lab

10 minutes

Is there a fungus among us?

The mold you see on food is fungi that are consuming and decomposing it. Fungi are also found as molds or mushrooms on wood, mulch, and other organic materials.

1. Read and complete a lab safety form.
2. Examine the different **samples of fungi** your teacher provides. Use a **magnifying lens** to observe similarities and differences among the samples.
3. Record your observations in your Science Journal. Include drawings of the different structures or characteristics you notice.

Think About This

1. What similarities did you see among the fungi samples?
2. Why do you think your teacher had the mold samples in closed containers?
3. **Key Concept** In what ways do you think the fungi you observed are helpful or not helpful to people?

What are fungi?

What would you guess is the world's largest organism? A fungus in Oregon is the largest organism ever measured by scientists. It stretches almost 9 km^2. Fungi, like protists, are eukaryotes. Scientists estimate more than 1.5 million species of fungi exist.

Fungi form long, threadlike structures that grow into large tangles, usually underground. *These structures, which absorb minerals and water, are called* **hyphae** (HI fee). *The hyphae create a network called the* **mycelium** (mi SEE lee um), shown in **Figure 10.** The fruiting body of the mushroom, the part above ground, is also made of hyphae.

Fungi are heterotrophs, meaning they cannot make their own food. Some fungi are parasites, obtaining nutrients from living organisms. Fungi dissolve their food by releasing chemicals that decompose organic matter. Fungi then absorb the nutrients.

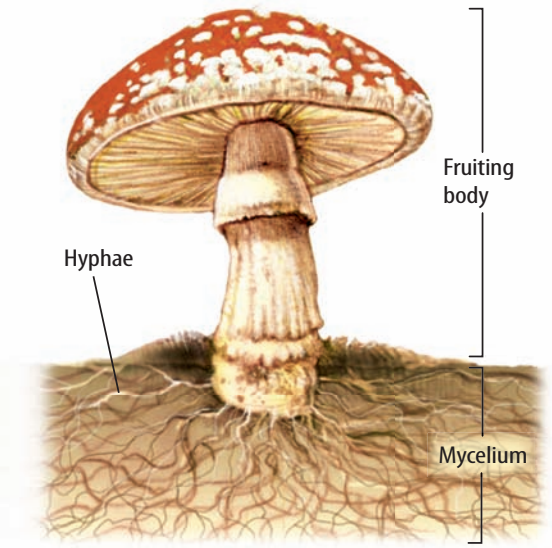


Figure 10 Mushrooms are common fungi. In the drawing, you can see mycelium, the network of hyphae. The hyphae release enzymes and absorb water and nutrients.

Types of Fungi

Scientists group fungi based on how they look and how they reproduce. Although fungi can reproduce sexually or asexually, almost all reproduce asexually by producing spores. Spores are small reproductive cells with a strong, protective outer covering. The spores can grow into new individuals.

The classification of fungi often changes as scientists learn more about them. Today, scientists recognize four groups of fungi: club fungi, sac fungi, zygote fungi, and imperfect fungi. As technology helps scientists understand more about fungi, the categories might change.

Key Concept Check What are the four groups of fungi?

Club Fungi

When you think of fungi, you might think of a **mushroom.** Mushrooms belong to the group called club fungi. They are named for the clublike shape of their reproductive structures. However, the mushroom is just one part of the fungus. The part of the mushroom that grows above ground is a structure called a basidiocarp (bus SIH dee oh karp). Inside the basidiocarp are the **basidia** (buh SIH dee uh; singular, basidium), *reproductive structures that produce sexual spores*. Most of a club fungus is a network of hyphae that grows underground and absorbs nutrients.

Science Use v. Common Use
mushroom
Science Use a type of club fungi
Common Use the part of a fungus above the ground

Reading Check Where does most of a club fungus grow?

Many club fungi are named for their various shapes and characteristics. Club fungi include puffballs like those at the beginning of the lesson, stinkhorns, and the bird's nest fungi shown in **Figure 11.** There is even a club fungus that glows in the dark due to a chemical reaction in its basidiocarp.

Figure 11 Club fungi, such as this bird's nest fungus, use basidiospores to reproduce.

Visual Check Which part of the fungus is club-shaped?

Club Fungi

Sac Fungi

Do you know what bread and a diaper rash have in common? A type of sac fungus causes bread dough to rise. A different sac fungus is responsible for a rash that babies can develop on damp skin under their diapers. Many sac fungi cause diseases in plants and animals. Other common sac fungi, such as truffles and morels, are harvested by people for food.

Like club fungi, sac fungi are named for their reproductive structures. *The* **ascus** (AS kuhs; plural, asci) *is the reproductive structure where spores develop on sac fungi.* The ascus often looks like the bottom of a tiny bag or sack. The spores from sac fungi are called ascospores (AS kuh sporz). Sac fungi can undergo both sexual and asexual reproduction. Many yeasts are sac fungi, including the common yeast used to make bread, as shown in **Figure 12.** When the yeast is mixed with water and warmed, the yeast cells become active. They begin cellular respiration and release carbon dioxide gas. This causes the bread dough to rise.

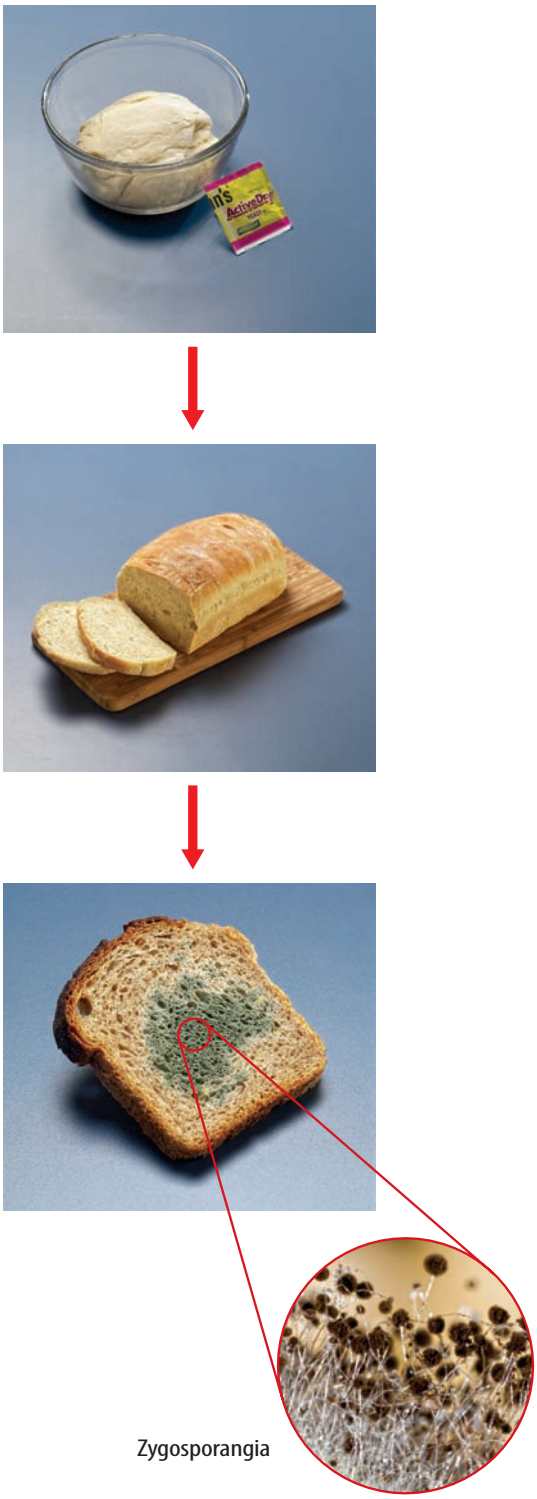
Zygote Fungi

Another type of fungus can cause bread to develop mold. Bread mold, like the type shown in **Figure 12,** is caused by a type of fungus called a zygote fungus. You might also find zygote fungi growing in moist areas, such as a damp basement or on a bathroom shower curtain.

The hyphae of a zygote fungus grow over materials, such as bread, dissolving the material and absorbing nutrients. *Tiny stalks called* **zygosporangia** (zi guh spor AN jee uh) *form when the fungus undergoes sexual reproduction.* The zygosporangia release spores called zygospores. These zygospores then fall on other materials where new zygote fungi might grow.

Reading Check How do sac and zygote fungi differ?

Figure 12 Some fungi can be used to make food, but other fungi can eat the food too.



FOLDABLES®

Fold a sheet of paper to make a four-door book. Label it as shown. Use your book to organize information about the characteristics of the different classifications of fungi.

Imperfect Fungi

How are itchy feet and blue cheese connected? They can both be caused by imperfect fungi. You might have had athlete's foot, an infection that causes flaking and itching in the skin of the feet. The imperfect fungus that causes athlete's foot grows and reproduces easily in the moist environment near a shower or in a sweaty shoe. The blue color you see in blue cheese comes from colonies of a different type of imperfect fungi. They are added to the milk or the curds during the cheese-making process.

Imperfect fungi are named because scientists have not observed a sexual, or "perfect," reproductive stage in their life cycle. Since fungi are classified according to the shape of their reproductive structures, these fungi are left out, or labeled "imperfect." Often after a species of imperfect fungi is studied, the sexual stage is observed. The fungi is then classified as a club, sac, or zygote fungus based on these observations.

Reading Check Why are imperfect fungi classified that way?

Inquiry MiniLab

10 minutes

What do fungal spores look like?

Have you ever seen spores from a mushroom? Some types of fungi reproduce by releasing these structures.

1. Read and complete a lab safety form.
2. Carefully remove the stem of your **mushroom.** Observe the gills, the soft structures on the underside of the cap.
3. Gently place the mushroom cap with the gills down on a sheet of **unlined white paper.**
4. Let the mushroom cap sit undisturbed overnight. Remove it from the paper the next day.

Analyze and Conclude

1. **Describe** your results and sketch them in your Science Journal. What caused this result?
2. **Estimate** the number of mushrooms that could be produced from a single mushroom cap.
3. **Key Concept** What type of fungi (club, sac, zygote, or imperfect) did you use to make the print?

Fungi Products

Figure 13 Products such as bread, cheese, and medicines are made using fungi.

The Importance of Fungi

Do you like chocolate, carbonated sodas, cheese, or bread? If so, you might agree that fungi are beneficial to humans. Fungi are involved in the production of many foods and other products, as shown in **Figure 13.** Some fungi are used as a meat substitute because they are high in protein and low in cholesterol. Other fungi are used to make antibiotics.

Decomposers

Fungi help create food for people to eat, but they are also important because of the things they eat. As you read earlier, fungi are an important part of the environment because they break down dead plant and animal matter, as shown in **Figure 14.** Without fungi and other decomposers, dead plants and animals would pile up year after year. Fungi also help break down pollution, including pesticides, in soil. Without fungi to destroy it, pollution would build up in the environment.

Living things need nutrients. The nutrients available in the soil would eventually be used up if they were not replaced by decomposing plant and animal matter. Fungi help put these nutrients back into the soil for plants to use.

May 8

October 6

Figure 14 Fungi help decompose dead organic matter, such as this rabbit. ▼

Math Skills

Using Fractions

Under certain conditions, 100 percent of the cells in fungus A reproduce in 24 hours. The number of cells of fungus A doubles once each day.

Day 1 = 10,000 cells

Day 2 = 20,000 cells

Day 3 = 40,000 cells

Day 4 = 80,000 cells

When an antibiotic is added to the fungus, the growth is reduced by 50 percent. Only half the cells reproduce each day.

Day 2 = 15,000 cells

Day 3 = 22,500 cells

Day 4 = 33,750 cells

Practice

Without an antibiotic, how many cells of fungus A would there be on day 6?

Review
- Math Practice
- Personal Tutor

Fungi and Plant Roots

Plants benefit from fungi in other ways, too. Many fungi and plants grow together, helping each other. Recall that fungi take in minerals and water through the hyphae, or threadlike structures that grow on or under the surface. *The roots of the plants and the hyphae of the fungi weave together to form a structure called* **mycorrhiza** (mi kuh RI zuh; plural, micorrhizae).

Mycorrhizae can exchange molecules, as shown in **Figure 15.** As fungi break down decaying matter in the soil, they make nutrients available to the plant. They also increase water absorption by increasing the surface area of the plant's roots.

Fungi cannot photosynthesize, or make their own food using light energy. Instead, the fungi in mycorrhizae take in some of the sugars from the plant's photosynthesis. The plants benefit by receiving more nutrients and water. The fungi benefit and continue to grow by using plant sugars. Scientists suspect that most plants gain some benefit from mycorrhizae.

Reading Check How do mycorrhizae benefit both the plant and the fungus?

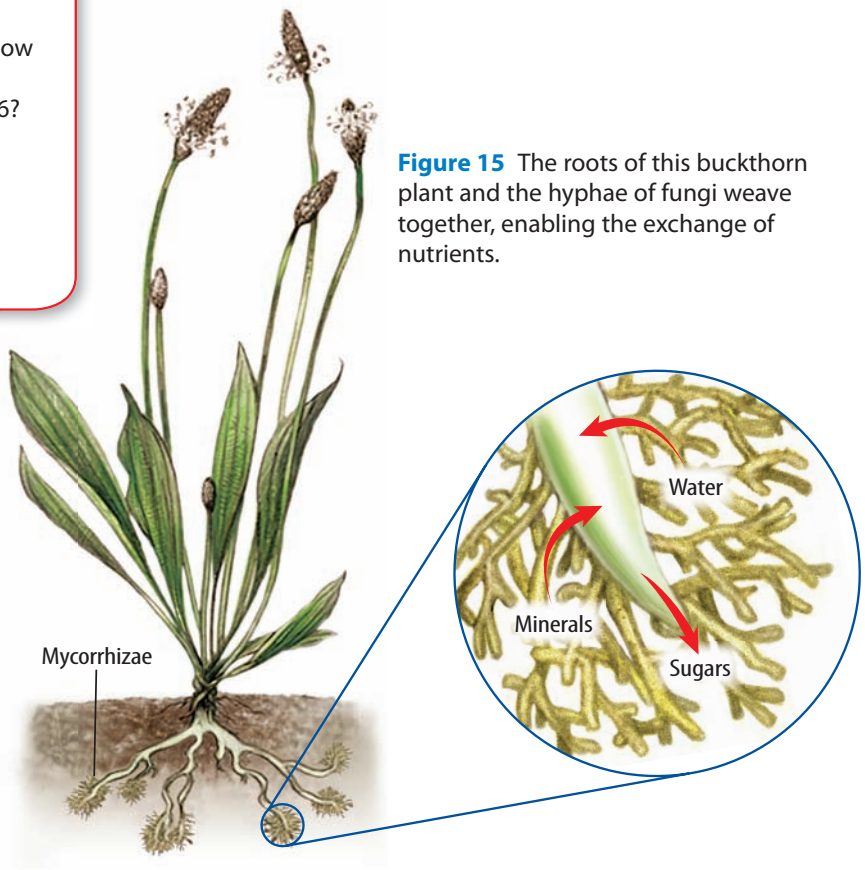


Figure 15 The roots of this buckthorn plant and the hyphae of fungi weave together, enabling the exchange of nutrients.

Health and Medicine

You might recall that many protists can be harmful to humans and the environment. This is true of fungi as well. A small number of people die every year after eating poisonous mushrooms or spoiled food containing harmful fungi.

You do not have to eat fungi for them to make you sick or uncomfortable. You already read that fungi cause athlete's foot rashes and diaper rashes. Some fungi cause allergies, pneumonia, and thrush. Thrush is a yeast infection that grows in the mouths of infants and people with weak immune systems.

Although fungi can cause disease, scientists also use them to make important medicines. Antibiotics, such as penicillin, are among the valuable medications made from fungi. An accident resulted in the discovery of penicillin. Alexander Fleming was studying bacteria in 1928 when spores of *Penicillium* fungus contaminated his experiment and killed the bacteria. After years of research, this fungus was used to make an antibiotic similar to the penicillin used today. **Figure 16** illustrates how penicillin affects bacterial growth.

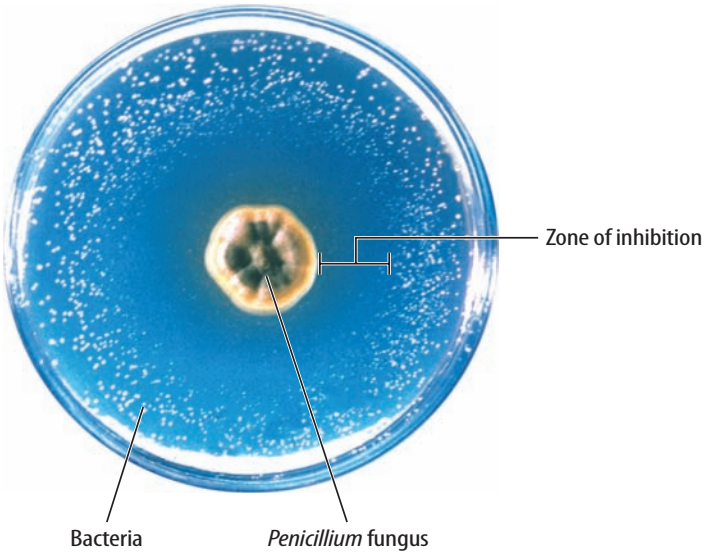


Figure 16 The *Penicillium* fungus that prevents bacteria from growing is used to make penicillin, an antibiotic medicine.
Visual Check How can you tell that the fungi are stopping the bacteria from growing?

Over time, some bacteria have become resistant to the many antibiotics used to fight illness. New antibiotics need to be developed to treat the same diseases. As new species of fungi are discovered and studied, scientists might find new sources of antibiotics and medicines.

Key Concept Check Describe two ways that fungi are important to humans.

What are lichens?

Word Origin
lichen
from Greek *leichen*, means "what eats around itself"

Do you recall the photo at the beginning of the chapter? The structure pictured is a lichen. *A* **lichen** (LI kun) *is a structure formed when fungi and certain other photosynthetic organisms grow together.* Usually, a lichen consists of a sac fungus or club fungus that lives in a partnership with either a green alga or a photosynthetic bacterium. The fungus' hyphae grow in a layer around the algae cells.

Green algae and photosynthetic bacteria are autotrophs, which means they can make their own food using photosynthesis. Lichens are similar to mycorrhizae because both organisms benefit from the partnership. The fungus provides water and minerals while the bacterium or alga provides the sugars and oxygen from photosynthesis.

The Importance of Lichens

Imagine living on a sunny, rocky cliff like the one in **Figure 17.** Not many organisms could live there because there is little to eat. A lichen, however, is well suited to this harsh environment. The fungus can absorb water, help break down rocks, and obtain minerals for the alga or bacterium. They can photosynthesize and make food for the fungus.

Once lichens are established in an area, it becomes a better environment for other organisms. Many animals that live in harsh conditions survive by eating lichens. Plants benefit from lichens because the fungi help break down rocks and create soil. Plants can then grow in the soil, creating a food source for other organisms in the environment.

Key Concept Check Which two organisms make up a lichen?

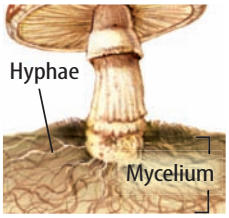
Figure 17 Lichens are structures made of photosynthetic organisms and fungi that can live in harsh conditions.

Lichen Structure

Lesson 2 Review

Assessment Online Quiz

Visual Summary



The body of a fungus is made up of thread-like hyphae that weave together to create a network of mycelium.

Club fungi produce sexual spores in the basidium.

A lichen is made of fungus and a photo-synthetic bacterium or alga.

FOLDABLES®

Use your lesson Foldable to review the lesson. Save your Foldable for the project at the end of the chapter.

What do you think NOW?

You first read the statements below at the beginning of the chapter.

4. Mushrooms and yeasts are two types of fungi.
5. Fungi are always helpful to plants.
6. Some fungi can be made into foods or medicines.

Did you change your mind about whether you agree or disagree with the statements? Rewrite any false statements to make them true.

Use Vocabulary

1. **Distinguish** between a basidium and an ascus.
2. **Identify** the structure formed between fungal hyphae and plant roots.
3. **Define** *ascus* in your own words.

Understand Key Concepts

4. **List** the four groups of fungi.
5. **List** the two organisms that make up lichen.
6. Which disease is caused by a fungus?
   - **A.** athlete's foot
   - **B.** influenza
   - **C.** malaria
   - **D.** pneumonia

Interpret Graphics

7. Review the image below. Describe how this structure helps the fungus survive.

8. **Compare and Contrast** Create a table that compares and contrasts information about sac fungi and zygote fungi.

Sac Fungi	Zygote Fungi

Critical Thinking

9. **Design** a plan for using lichens to convert a harsh cliff environment into a habitat for small plants.
10. **Support** the claim that decomposition is important for the environment.

Math Skills

Review Math Practice

11. The number of cells in fungus X doubles every 2 hours. If you begin with 10 cells, how many would be present after 24 hours?

inquiry **Lab** 40 minutes

What does a lichen look like?

Materials


forceps


lichen sample


paper plate


plastic spoon

slide


dropper


coverslip


microscope

Safety

Lichens come in a wide variety of textures, colors, sizes, and shapes. A lichen is the partnership between a fungus and another organism—usually an alga but sometimes a photosynthetic bacterium. In this relationship, the alga or the bacterium provides the fungus with food through photosynthesis. The fungus provides the other organism with protection. Under magnification you might be able to see structures belonging to both organisms.

Question

What structures can you see in a lichen?

Procedure

1. Read and complete a lab safety form.
2. With your forceps, break off a tiny piece of lichen and place it on a paper plate. Grind the lichen very gently with the back of a plastic spoon until it is broken into small pieces.
3. Using the spoon, place the ground-up lichen into the well of a slide. Use the dropper to add a few drops of water and then place the coverslip over the well.
4. Observe the lichen under the microscope and make a drawing of your observations in your Science Journal.
5. Label the parts of the lichen you observe. Were you able to see any green algal cells? Where are the hyphae? How is the fungus different in color, shape, and texture?

6. Review the structures of the different protists and fungi you have studied so far.
7. Based on your observations from this dissection and your research, determine the ways in which the structures in lichens are similar to and different from those of other organisms.

Analyze and Conclude

8. **Compare** Did you see more fungal structures or algal structures in the slide?
9. **Infer** Based on your observations, do you think a lichen should be classified as a protist, a fungus, neither, or both?
10. **The Big Idea** How do the structures of the algae and fungus benefit each other in a lichen?

Communicate Your Results

Create a poster to represent the data obtained from your investigation. Describe how you used your data to determine the classification of a lichen. Use drawings and photos to support your findings.

Inquiry Extension

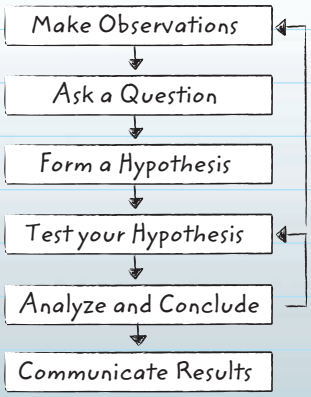
Think of a question about lichen that you might investigate through further observation. Your question might focus on the life cycle of lichen, the best growing conditions, or the lichen as an indicator of air quality. Develop and conduct an experiment to explore your question.

4

Lab Tips

- ☑ Look for differences in the structures you observe. Try to match the characteristics of these structures to those of protists or fungi.
- ☑ Begin observing the samples under low magnification first, and then increase as you identify structures.

Remember to use scientific methods.



Chapter 23 Study Guide

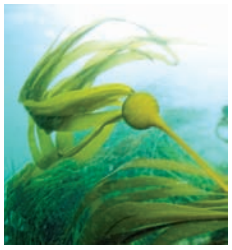
WebQuest

Protists and fungi are diverse groups of organisms. They are classified as neither plant nor animal and serve many functions in the ecosystem.

Key Concepts Summary

Lesson 1: What are protists?

- *Scientists divide* **protists** *into three groups based on the type of organisms they most resemble. There are plantlike, animal-like, and funguslike protists.*
- *Protists are beneficial to humans in many ways. They are used to create many of the useful products you depend on. They also help decompose dead organisms and return nutrients to the environment.*

Plantlike	Animal-like	Funguslike
		

Lesson 2: What are fungi?

- *Scientists divide fungi into four groups, based on the type of structures they use for sexual reproduction. The four groups are club fungi, sac fungi, zygote fungi, and imperfect fungi.*
- *Fungi provide many foods and medicines that people use. In addition, fungi help break down dead organisms and recycle the nutrients into the environment.*
- **Lichens** *are structures made of a fungus and a photosynthetic organism. Both organisms work together to obtain food, water, and nutrients.*

Vocabulary

protist
algae
diatom
protozoan
cilia
paramecium
amoeba
pseudopod

hyphae
mycelium
basidium
ascus
zygosporangia
mycorrhizae
lichen

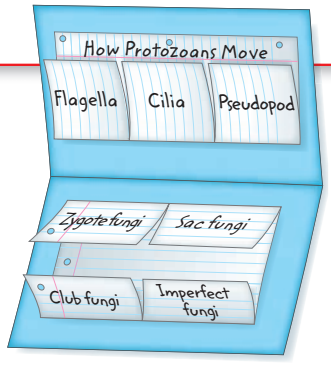
Study Guide

Review
- Personal Tutor
- Vocabulary eGames
- Vocabulary eFlashcards

FOLDABLES®

Chapter Project

Assemble your lesson Foldables as shown to make a Chapter Project. Use the project to review what you have learned in this chapter.



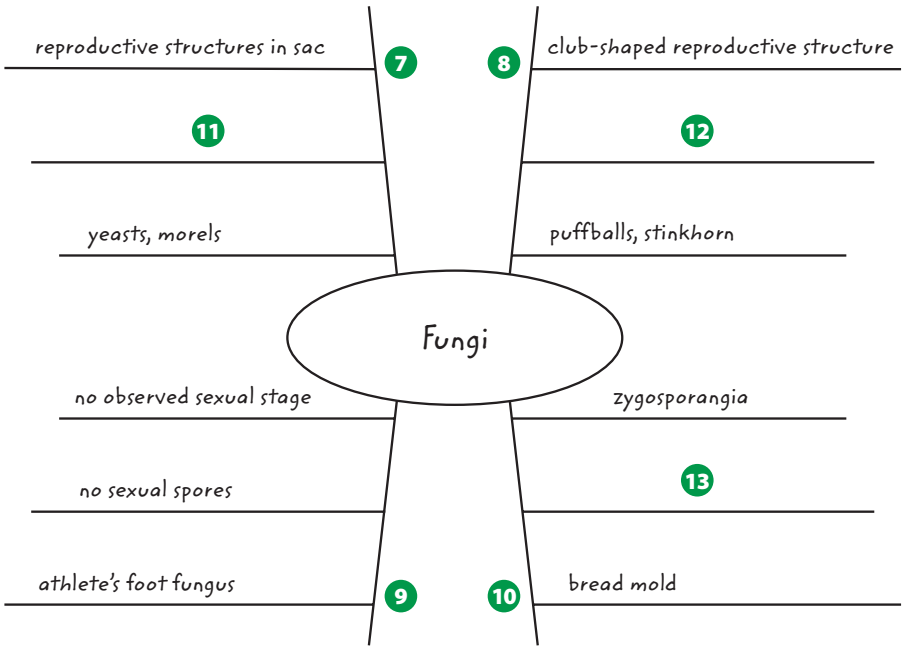
Use Vocabulary

1. A protist that resembles a tiny animal is called a(n) _____.
2. A fungus and the roots of a plant form a structure called _____ that benefits both organisms.
3. The _____ is a saclike structure on a fungus that produces spores.
4. A(n) _____ is a microscopic, plantlike protist that can resemble glass or gems.
5. Short structures that cover the outside of some protists and help them move are called _____.
6. Fungi grow by extending threadlike body structures called _____.

Link Vocabulary and Key Concepts

Concepts in Motion Interactive Concept Map

Copy this concept map, and then use vocabulary terms from the previous page and other terms from this chapter to complete the concept map.



Chapter 23 Review

Understand Key Concepts

1 Which organism causes red tides when found in large numbers?

A. algae
B. amoebas
C. ciliates
D. diatoms

2 Protists are a diverse group of organisms divided into what three categories?

A. animal-like, plantlike, protozoanlike
B. euglenoid, slime-mold, diatoms
C. plantlike, animal-like, and funguslike
D. green algae, red algae, and kelp

3 Which type of protist is commonly used in ice cream, toothpaste, soups, and body lotions?

A. algae
B. amoebas
C. ciliates
D. diatoms

4 The organism in the figure above is a

A. ciliate.
B. diatom.
C. dinoflagellate.
D. kelp.

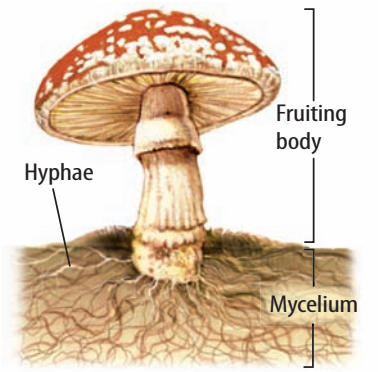
5 The main function of the hairlike structures surrounding the organism above is

A. decomposition.
B. movement.
C. photosynthesis.
D. reproduction.

6 What type of fungus is bread mold?

A. club
B. imperfect
C. sac
D. zygote

7 Which type of fungus is shown below?



A. club fungus
B. sac fungus
C. zygote fungus
D. imperfect fungus

8 Lichens often consist of

A. plants and animals helping each other.
B. animals and fungi helping each other.
C. protozoans living as parasites on animals.
D. fungi and green algae helping each other.

9 An example of a disease caused by a fungus is

A. athlete's foot.
B. malaria.
C. red tide.
D. the common cold.

10 Sac fungi can be

A. capable of both asexual and sexual reproduction.
B. capable of making their own food.
C. protists.
D. unicellular plants.

11 Which is not a common use of fungi?

A. a predator in forest ecosystems
B. decomposing plant and animal material
C. killing bacteria
D. serving as a food source for other organisms

Chapter Review

Assessment
Online Test Practice

Critical Thinking

12 **Compare and contrast** plantlike protists with funguslike protists.

13 **Draw** a diagram to show how a parasitic protist can be transferred from one mammal to another and cause malaria. Imagine you are a doctor in an area where malaria is common. How could you prevent the spread of this disease?

14 **Evaluate** Imagine you are asked to justify removing kelp from an area of the ocean. Based on your knowledge of plantlike protists, what benefits or problems would you consider before you decide if the algae should be removed?

15 **Describe** Complete the table below with characteristics of the different types of animal-like protists.

	Number of nuclei	Method of eating	Method of movement
Ciliates			
Flagellates			
Sarcodines			

16 **Explain** how the movement of an amoeba differs from the movement of a dinoflagellate.

17 **List** several products you have used or seen that were made using fungi.

18 **Evaluate** how Alexander Fleming's experiments helped determine the importance of fungi to medicine.

Writing in Science

19 **Design** a brochure for a tour in which people could see several different types of lichens and fungi. What locations would be included and which organisms would people be likely to observe?

REVIEW THE BIG IDEA

20 Explain how decomposers such as protists and fungi play an important role in the environment.

21 What is the organism shown below and how does it affect the environment?

Math Skills

Review
Math Practice

Calculating Growth

22 *The number of cells of Fungus Q doubles every three hours. If you begin with 1,000 cells, how many will there be after 12 hours?*

23 *Scientists want to know if an antibiotic is effective in treating a fungal infection. They start with two colonies of 100 cells each. The table shows what happens during the first two days.*

	Day 2 Number of Cells	Day 3 Number of Cells
Untreated fungus	*400*	*1600*
Antibiotic A	*200*	*300*

a. *How long does it take the untreated fungus to double?*

b. *What effect does the antibiotic have on the growth rate of the fungus?*

Standardized Test Practice

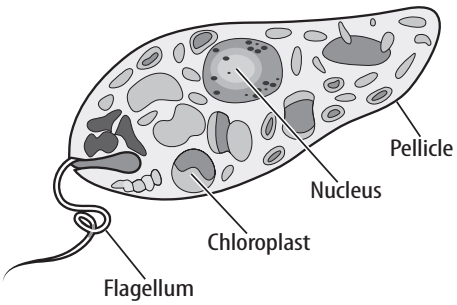
Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

Multiple Choice

1 Which often live on decaying leaves in a forest?

A diatoms
B dinoflagellates
C sarcodines
D slime molds

Use the diagram below to answer question 2.



2 This organism has plant and animal characteristics. Which characteristic makes the organism plantlike?

A chloroplast
B flagellum
C nucleus
D pellicle

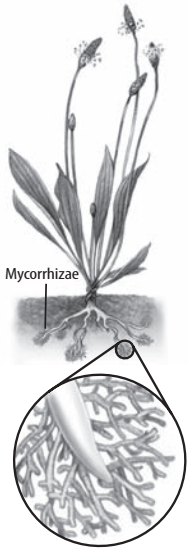
3 Which statement is false?

A Fungi cause bread to rise.
B Fungi cause dead organisms to decay.
C Fungi are sources of antibiotics.
D Fungi use sunlight and produce food.

4 Which protists have cell walls that look like glass?

A algae
B diatoms
C dinoflagellates
D euglenoids

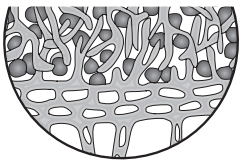
Use the diagram below to answer question 5.



5 What does the plant give the fungus that surrounds its roots?

A antibiotics
B minerals
C sugars
D water

Use the diagram below to answer question 6.



Lichen

6 Which organisms, combined with green algae, form this structure?

A bacteria
B fungi
C plants
D protozoans

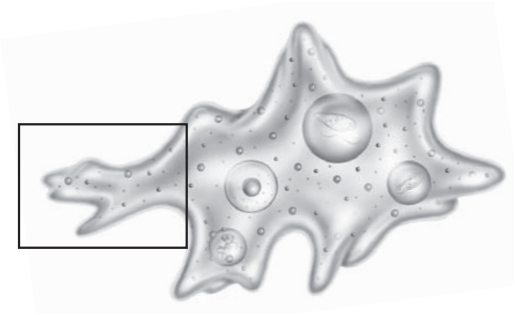
Standardized Test Practice

Assessment
Online Standardized Test Practice

7 Suppose a pond contains no living or decaying organisms. Which could be added to the pond to act as producers?

A algae
B ciliates
C sarcodines
D water molds

Use the diagram below to answer questions 8 and 9.



8 What is the function of the boxed area of this microscopic organism?

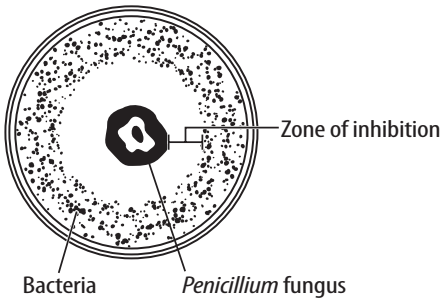
A cellular respiration
B defense
C locomotion
D photosynthesis

9 To which group does this organism belong?

A animal-like protists
B animals
C fungi
D funguslike protists

Constructed Response

Use the diagram below to answer question 10.



10 What is the interaction between the fungus and the bacteria?

11 Copy and complete the table below.

Group of Protists	Beneficial Effects	Harmful Effects
Plantlike		
Animal-like		
Funguslike		

12 For one of the groups of protists you listed in the table in question 11, explain why their beneficial effects are important to other organisms.

13 Identify two ways protists might reproduce. Describe the offspring that result from each method. What is an advantage of each method?

NEED EXTRA HELP?													
If You Missed Question...	1	2	3	4	5	6	7	8	9	10	11	12	13
Go to Lesson...	1	1	2	1	2	2	1	1	1	2	1, 2	1, 2	1