



**Academic Standard—4:** Students recognize that plants and animals obtain energy in different ways, and they can describe some of the internal structures of organisms related to this function. They examine the similarities and differences between humans and other species. They use microscopes to observe cells and recognize cells as the building blocks of all life.

Also covers: Academic Standards 2, 5 (Detailed standards begin on page IN8.)

# Bacteria, Protists, and Fungi

## chapter preview

### sections

- 1** Bacteria
  - 2** Protists  
*Lab Comparing Algae and Protozoans*
  - 3** Fungi  
*Lab Making Yogurt*
-  **Virtual Lab** *What kills germs?*

## Teeming with Life

The pond water appears crystal clear as the scientist uses a dropper to extract a sample for examination. However, in the lab when he examines some of the water under a microscope, he discovers that it contains hundreds of organisms. Some are only one cell, others appear to be groups of cells, and some are many-celled.

**Science Journal** List possible functions of these organisms in a pond environment.

# Start-Up Activities



## Investigate Bacterial Growth

Did you know that millions of microorganisms are living on and inside of you at this moment? What are these organisms? Bacteria. They live nearly everywhere. What affects their growth? Find out by doing this lab.

1. Label six 200-mL beakers 1 through 6. Dissolve two beef bouillon cubes in 600 mL of hot water. Measure then pour 100 mL of this solution into each beaker.
2. Add a teaspoon of salt to 1 and 2, a teaspoon of vinegar to 3 and 4, and add nothing to 5 and 6.
3. Place 1, 3, and 5 in a warm place and 2, 4, and 6 in a refrigerator.
4. Observe the beakers after 48 hours.
5. **Think Critically** A cloudy solution is an indication of bacterial growth. Write a paragraph in your Science Journal comparing the bacterial growth in the six beakers. Infer from your results the growing conditions that favor bacterial growth.

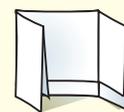
## FOLDABLES™ Study Organizer

**Positive and Negative Effects**  
Make the following Foldable to help you see how some organisms are similar and different.

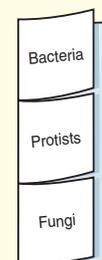
- STEP 1** **Fold** a sheet of paper lengthwise. Make the front edge 1.25 cm shorter than the back edge.



- STEP 2** **Fold** into thirds.



- STEP 3** **Unfold and cut** only the top layer along both folds to make three tabs. **Label** each tab as shown.



**Identify Questions** Before you read the chapter, skim through it and write examples of each type of organism on the front of the tabs. As you read the chapter, list positive effects on the back of the tabs and negative effects under the tabs.



Preview this chapter's content and activities at [in6.msscience.com](http://in6.msscience.com)

# Bacteria

## as you read

### What You'll Learn

- **Identify** the characteristics of bacterial cells.
- **Name** the two major groups of bacteria.
- **Discuss** the overall importance of bacteria.

### Why It's Important

Bacteria are found in all environments and affect all living things.

### Review Vocabulary

**disease:** a condition with symptoms that interferes with body functions

### New Vocabulary

- aerobic
- anaerobe
- endospore
- antibiotic
- pathogen
- vaccine
- pasteurization
- saprophyte

## What are bacteria?

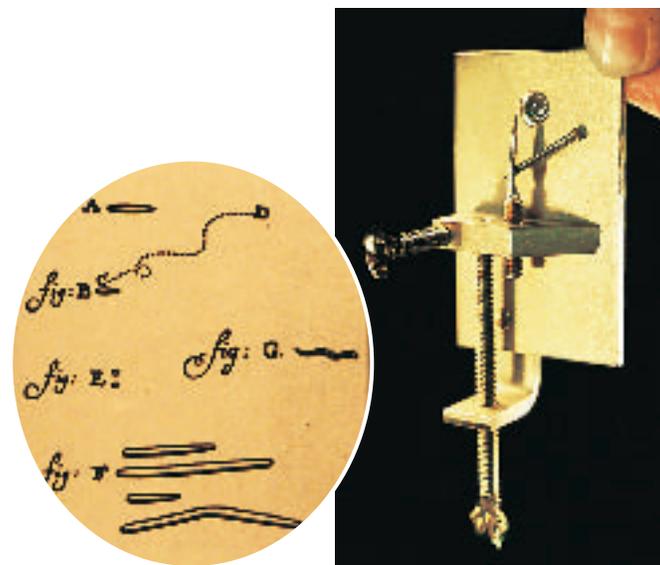
They are found almost everywhere—in the air you breathe, in the food you eat, in the water you drink, and even deep in the ocean. They are on your clothes, on your shoes, and on the family dog or cat. A shovelful of soil contains billions of them. It might be hard to imagine, but you have huge populations of them living in and on your body that are beneficial to you.

For thousands of years, people did not know about bacteria. In the latter half of the seventeenth century, Antonie van Leeuwenhoek, a Dutch merchant, used his simple microscope to look at scrapings from his teeth. Leeuwenhoek did not know that the tiny organisms he observed were bacteria, as shown in **Figure 1**. His drawings were made about 200 years before it was proved that bacteria are living cells.

## Characteristics of Bacteria

All bacteria are one-celled organisms. Their cells are considered to be prokaryotic (proh kar ee AH tihk) because they do not have their genetic material in a nucleus. Some bacteria are found as individual cells. Others grow in groups or in long chains of cells.

**Producers and Consumers** Bacteria obtain their food in a variety of ways. Some bacteria use energy from sunlight to make their own food. Other bacteria use energy from inorganic chemicals to make food. Any organism that can make its own food is called a producer. Organisms that can't make their own food are called consumers. Consumer bacteria obtain food in many ways. Some break down dead organisms to obtain energy, and others live as parasites, absorbing nutrients from living organisms.



**Figure 1** Leeuwenhoek used a simple microscope like this to examine scrapings from his teeth. This drawing shows different types of bacteria that he observed.

**Aerobes and Anaerobes** Most bacteria live in places that have a supply of oxygen. An organism that uses oxygen for respiration is called an **aerobe** (AR ohb). You are an aerobic organism. Some bacteria are called **anaerobes** (A nuh roh bz) and they can live without oxygen.

**Structure and Function** Bacteria cells are usually much smaller than plant and animal cells and do not contain as many internal structures. The general structure of a bacterium can be seen in **Figure 2**. A bacterium contains cytoplasm surrounded by a cell membrane and a cell wall. Bacterial hereditary material is found in the cytoplasm. Some bacteria have a thick, gel-like capsule around the cell wall. The capsule helps protect the bacterium. Many bacteria that live in moist conditions have whiplike tails called flagella that help them move.

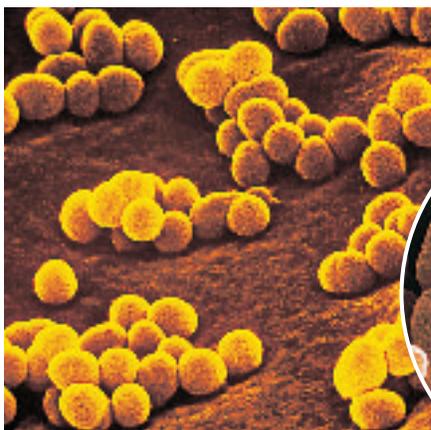
Some bacteria are able to produce a thick wall around themselves when environmental conditions are unfavorable. Inside this thick-walled structure, the bacterium produces a dormant form called an **endospore**. It can survive for hundreds of years this way.

**Reading Check**

*What conditions might cause bacteria to form endospores?*

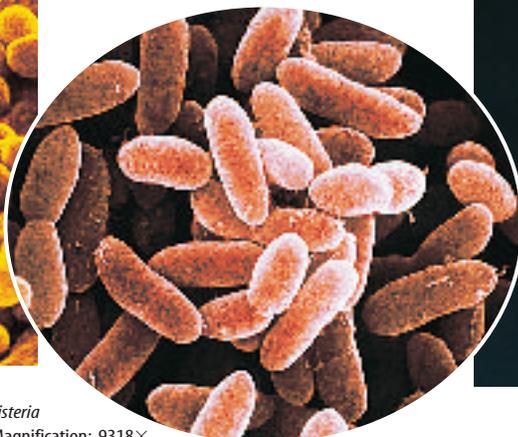
The bacteria that normally inhabit your home and body have three basic shapes—spheres, rods, and spirals—as shown in **Figure 3**. Sphere-shaped bacteria are called cocci (KAW ki) (singular, *coccus*), rod-shaped bacteria are called bacilli (buh SIH li) (singular, *bacillus*), and spiral-shaped bacteria are called spirilla (spi RIH luh) (singular, *spirillum*).

**Cocci**



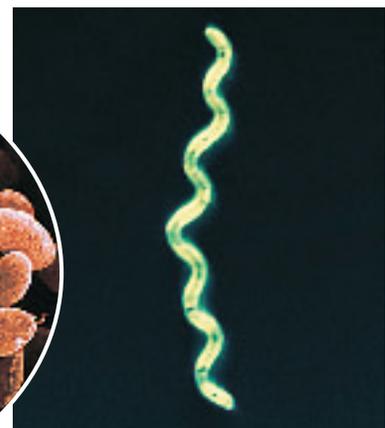
*Micrococcus*  
Magnification: 23100×

**Bacilli**

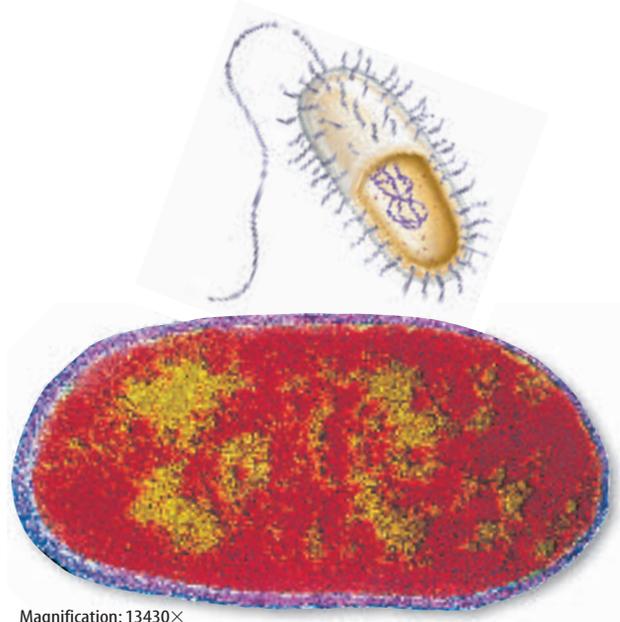


*Listeria*  
Magnification: 9318×

**Spirillum**



*Rhodospirillum rubrum*  
Magnification: 1000×

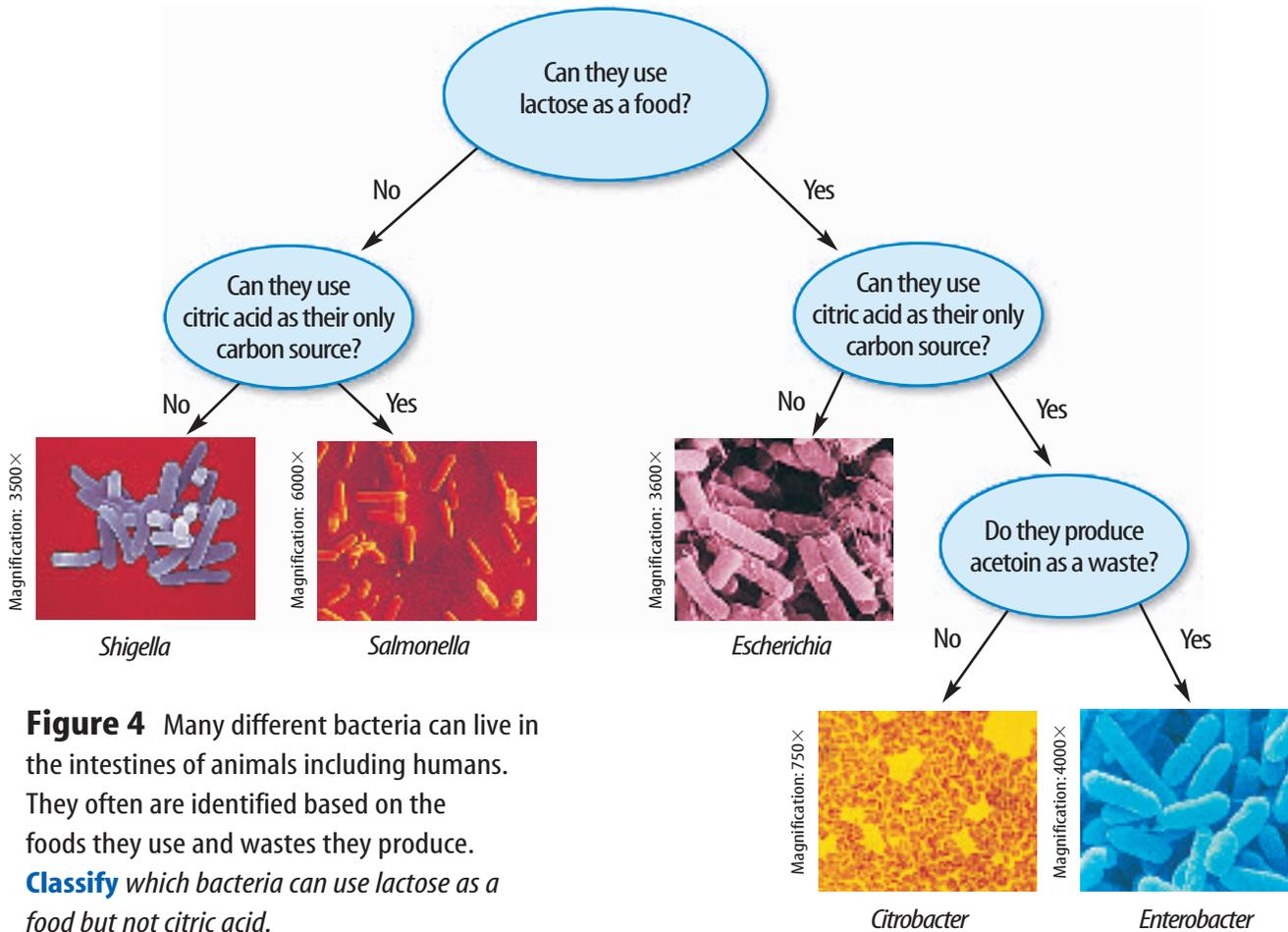


Magnification: 13430×

**Figure 2** Even though their cellular structure is simple, bacteria may be considered the most successful organisms living on Earth.

**Figure 3** Most bacteria can be identified as having one of these three shapes.

**Determine** what shape you think a bacterium called *Streptococcus* would have.



**Figure 4** Many different bacteria can live in the intestines of animals including humans. They often are identified based on the foods they use and wastes they produce.

**Classify** which bacteria can use lactose as a food but not citric acid.



### Indiana Academic Standard Check

**6.4.2:** Give examples of organisms that cannot be neatly classified as either plant or animals, such as . . . bacteria.



How are archaeobacteria usually distinguished from eubacteria?

## Types of Bacteria

Two main groups of bacteria are archaeobacteria (ar kee bak TIHR ee uh) and eubacteria (YOO bak tihr ee uh). Most known archaeobacteria live in harsh environments where few kinds of other organisms can live. Eubacteria usually live in less harsh environments. Archaeobacteria and eubacteria are thought to have existed for billions of years.

**Eubacteria** The larger of the two groups of bacteria is eubacteria. Eubacteria include many diverse groups. Although most eubacteria are consumers, some are producers. Some are aerobes and others are anaerobes. Most bacteria are beneficial. All bacteria that cause known diseases are eubacteria.

Most eubacteria have been classified and identified based upon conditions under which they grow and other chemical characteristics, such as composition of their cell walls, how they obtain food, and which waste products they produce. **Figure 4** shows one way to identify some bacteria that grow in the intestinal tracts of animals.



**Figure 5** Salt-loving bacteria can grow in evaporation ponds used for salt production. These bacteria contain a purple pigment.



Some bacteria grow in hot and acidic environments such as this hot spring in Yellowstone National Park and near deep ocean vents.



Some anaerobic archaeobacteria live in the digestive tracts of animals and produce methane gas as a waste.



**Archaeobacteria** The archaeobacteria usually are grouped according to the extreme environment in which they live, as shown and described in **Figure 5**.

## Applying Math

## Solve a One-Step Equation

**BACTERIA POPULATION** One *E. coli* bacterium has a length of 0.002 mm. How many *E. coli* would fit across the top of an eraser that has a diameter of 10 mm?



### Solution

- |   |  |
|---|--|
| <b>1</b> This is what you know:                 | <ul style="list-style-type: none"> <li>● length of <i>E. coli</i> = 0.002 mm</li> <li>● diameter of eraser = 10 mm</li> </ul>                                |
| <b>2</b> This is what you need to find out:     | The number of <i>E. coli</i> that would fit across eraser.   |
| <b>3</b> This is the procedure you need to use: | Divide the diameter of the eraser by the length of <i>E. coli</i> .<br>$10 \text{ mm} / 0.002 \text{ mm} = 5,000$ <i>E. coli</i> would fit across the eraser |
| <b>4</b> Check your answer:                     | Multiplying your answer by the length of the <i>E. coli</i> . You should get 10 mm.  |

## Practice Problems

1. How many *E. coli* would fit end to end on a paper clip that is 4 cm long? (Hint: Convert centimeters to millimeters.)
2. There are 12,000 *E. coli* cells end to end on a pin. How long is the pin?



For more practice, visit  
[in6.msscience.com/  
math\\_practice](http://in6.msscience.com/math_practice)

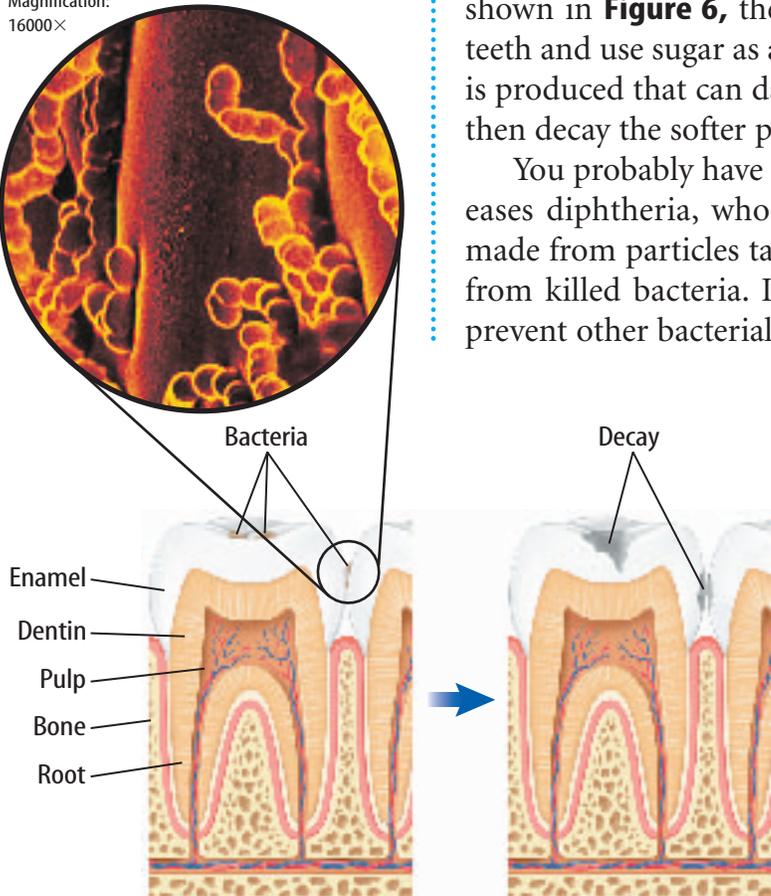
**Topic: Botox**

Visit [in6.msscience.com](http://in6.msscience.com) for Web links to information about the medical uses of the *Clostridium botulinum* toxin in the treatment of cerebral palsy and in cosmetic surgery.

**Activity** Create an advertisement for one of the medical uses that you learned about. Exchange your advertisement with other students in your class.

**Figure 6** One important bacteria that has been found to cause tooth decay is *Streptococcus mutans*.

Magnification:  
16000x



## Bacteria and Your Health

You probably know that some bacteria can cause you to get sick. However, do you know that bacteria can keep you healthy? You cannot survive without some bacteria living in or on your body.

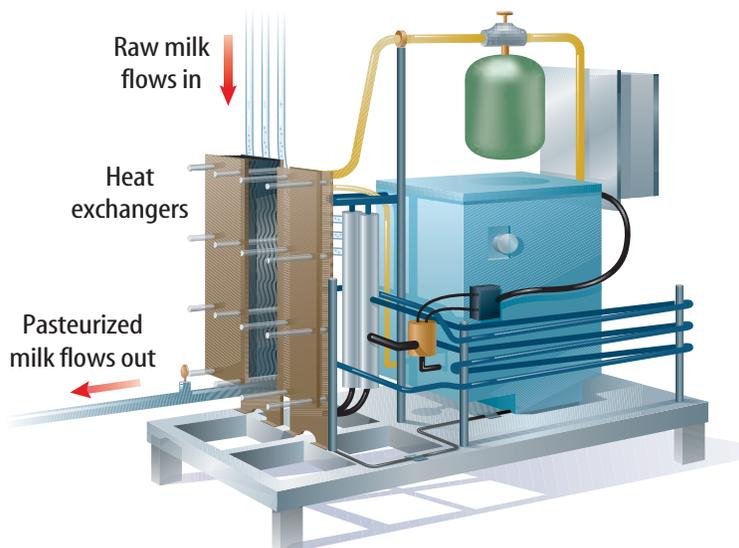
**Helpful Bacteria** Some bacteria produce chemicals called **antibiotics** that limit the growth of or kill other bacteria. For example, one type of bacteria that is commonly found living in soil produces the antibiotic streptomycin. Many diseases in humans and animals can be treated with antibiotics.

Millions of bacteria live on your skin and all other parts of your body that are exposed to the outside world and some parts that are not. Certain types of these bacteria are usually harmless. Because they grow on or in your body, they limit the growth of other harmful bacteria. Most of the bacteria found in your large intestine are harmless to you and help you stay healthy. Some bacteria in your intestine produce vitamin K, which is needed for your blood to clot.

**Harmful Bacteria** Some bacteria are pathogens. A **pathogen** is any organism that causes disease. Bacteria that normally grow in your mouth can cause a common disease—tooth decay. As shown in **Figure 6**, these bacteria grow on the surface of your teeth and use sugar as a food. As they break down sugar, an acid is produced that can damage the enamel of your teeth. Bacteria then decay the softer parts of teeth.

You probably have been vaccinated against the bacterial diseases diphtheria, whooping cough, and tetanus. A **vaccine** is made from particles taken from damaged bacterial cell walls or from killed bacteria. Immunization with certain vaccines can prevent other bacterial diseases.

**Toxins** Many bacteria and other pathogens produce poisons called toxins as they grow in your body or as they grow in food that you might eat. Botulism, a type of food poisoning, is the result of a toxin produced by anaerobic bacteria whose endospores can survive in canned food. Most endospores and other bacteria are destroyed by the long-term heat treatment known as sterilization. Most canned food that you can buy has been sterilized.



**Figure 7** Most milk is pasteurized by heating it to at least  $71.6^{\circ}\text{C}$  for only 15 s. In the process, milk flows continuously past a heat exchanger.

## Bacteria and Industry

Would you want to eat food that contained bacteria and their wastes? Usually not, but many foods that you probably enjoy are produced using bacteria. Even before people understood that bacteria were involved, they used bacteria in the production of foods. One of the first uses of bacteria was in making yogurt, a food that has been eaten in Europe and Asia for hundreds of years. Cheeses, buttermilk, chocolate, vinegar, and sauerkraut all are produced with the aid of bacteria.

Unless it is sterilized, all food contains some bacteria. But heating food to sterilization temperature can change the taste of food. **Pasteurization** is a process that is used to kill most harmful bacteria with a minimum effect on the flavor of the product, as shown in **Figure 7**. Pasteurization also increases the length of time foods can be stored without spoiling. You are probably most familiar with pasteurized milk, but fruit juices and other foods also are pasteurized.

### Reading Check *Why are some foods pasteurized?*

Many industries rely on bacteria. Today, bacteria and their by-products are cultivated in bioreactors. Bioreactors are used to make medicines, vitamins, alcohol, cleansers, adhesives, food thickeners, and other substances. Some landfills are bioreactors.

Some bacteria break down industrial, agricultural, or sewage wastes into simpler, harmless compounds. Sewage-treatment plants and septic systems use bacteria to process waste. The ability of certain bacteria to digest petroleum has been extremely important in helping clean up extensive oil spills in Alaska, California, and Texas.



**Bioremediation** Bacteria exist that can feed on almost any chemical that contains carbon. Using bacteria to break down wastes and clean up spills is called bioremediation. To use this process properly requires matching the correct bacteria with the waste or contaminant to be “eaten.” Find out some wastes that are treated in this way and list them in your Science Journal.



**Figure 8** Nitrogen-fixing bacteria live in the nodules on the roots of this peanut plant. They convert atmospheric nitrogen to a form usable by the plant and animals that eat the plant.

## Bacteria and the Environment

Some consumer bacteria are called saprophytes (SAP ruh fites). A **saprophyte** is any organism that uses dead material as a food and energy source. When saprophytic bacteria digest dead organisms, the nutrients that they contain are made available for use by other organisms. When you compost kitchen, yard, and garden wastes, you put these bacteria to work for you. Without saprophytic bacteria, layers of dead material would be deeper than you are tall all over Earth's surface.

 **Reading Check** *What is a saprophyte?*

**Nitrogen Fixation** All living things need nitrogen for making proteins and nucleic acids, but the nitrogen in Earth's atmosphere isn't in a form that can be used by most organisms. Certain bacteria called nitrogen-fixing bacteria are the only organisms that can combine nitrogen with other chemicals so it can be used by plants. Nitrogen-fixing bacteria live in growths on the roots of plants such as peas, soybeans, and peanuts, as shown in **Figure 8**. Some organisms obtain nitrogen by eating plants that contain the fixed nitrogen. These organisms then might be eaten by other organisms. In this way, nitrogen-fixing bacteria are an essential part of many food chains.

### section 1 review

#### Summary

##### Bacteria

- Bacteria can be producers or consumers.
- Most bacteria are aerobic, others are anaerobic.
- Eubacteria are the largest group of bacteria.
- Archaeobacteria are adapted to extreme environments.

##### Bacteria and Your Health

- Some bacteria can produce antibiotics, others can produce vitamin K in your intestine.
- Bacteria can cause disease or produce toxins.

##### Bacteria and Industry

- Many foods are made using bacteria.
- Some bacteria break down wastes.

##### Bacteria and the Environment

- Saprophytic bacteria digest dead organisms.
- Some bacteria fix nitrogen.

#### Self Check

1. **List** the characteristics of bacteria.
2. **Identify** two reasons why bacteria are important in the environment.
3. **Explain** how some types of bacteria can help you stay healthy and other kinds of bacteria can make you sick.
4. **Describe** the types of environments in which archaeobacteria are found.
5. **Think Critically** Why is botulism associated with canned foods and not with fresh foods?

#### Applying Math

6. **Solve One-Step Equations** Air may have more than 3,500 bacteria per cubic meter. Use this number to estimate the number of bacteria in the air in your classroom.

# Protists

## What is a protist?

A **protist** is a one- or many-celled organism that lives in moist or wet surroundings. Unlike bacteria, protists' cells are eukaryotic. These organisms have a membrane-bound nucleus and other membrane-bound structures in their cytoplasm.

Protists are a diverse group that includes organisms with funguslike, animallike, or plantlike characteristics. To add to the confusion, many protists have characteristics similar to plants and animals. Protists get their food in a variety of ways. Some are producers, and others are predators, parasites, or saprophytes. **Table 1** lists the characteristics of each group. In which group would you place the protist pictured below?

**Funguslike Protists** Many funguslike protists spend part of their lives as one-celled organisms and part of their lives as many-celled organisms. Although many are called molds, they are not the same as the molds you will read about in the next section of this chapter. Slime molds, water molds, and downy mildews are examples of funguslike protists. The funguslike protists are consumers. They are either saprophytes or parasites.

### as you read

#### What You'll Learn

- **Identify** the characteristics common to all protists.
- **Describe** the three protist groups and their characteristics.
- **Compare and contrast** the three groups of protists.

#### Why It's Important

Protists are important sources of food and oxygen for larger organisms. Some types of protists cause disease in humans.



#### Review Vocabulary

**parasites:** consumers that get their food or energy from other living organisms

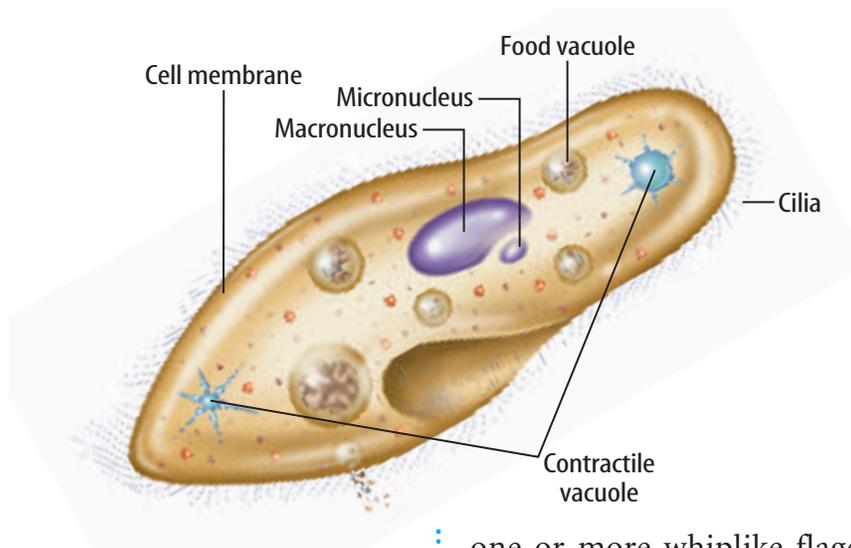
#### New Vocabulary

- protist
- pseudopod
- protozoan
- algae

**Table 1 Characteristics of Protist Groups**

Funguslike	Animal-like	Plantlike
Consumers; most saprophytes or parasites	Consumers; obtain food in many ways	Producers that contain chlorophyll
Most reproduce using spores, like fungi.	Like animals, most do not have cell walls.	Many have cell walls like plants.
	Most can move from place to place using cilia, flagella, or pseudopods.	Many-celled forms remain attached to surfaces with rootlike structures.





**Figure 9** The contractile vacuoles seen in this *Paramecium* act like pumps. As they contract, the vacuoles push water out.

**Animal-like Protists** One-celled, animal-like protists are known as **protozoans**. These complex organisms live in water, soil, and living and dead organisms. Many protozoans contain special structures for getting rid of excess water, as shown in **Figure 9**.

Protozoans often are separated into groups by how they move from place to place. Many protozoans move using one or more whiplike flagella. Others are covered with cilia (SIHL ee uh), which are short, threadlike structures that extend from the cell membrane. The cilia move like tiny oars to propel the protozoan through its watery environment. Another way some protozoans move is by using temporary extensions of their cytoplasm called **pseudopods** (SEW duh pahdz).

## Mini LAB

### Identifying Protists



#### Procedure

1. Fill a **wide-mouthed jar** with **pond water**. Add a **pond rock**.
2. Place the jar in direct sunlight for two weeks. Add new pond water to replace the water that evaporates.
3. Using a **dropper**, place a drop of water on a **slide**. Cover the drop with a **coverslip** and view the drop under a **microscope**.
4. Explore your pond zoo for protists. Identify organisms using a **guide to pond life**.

#### Analysis

1. What protists could you identify in your pond zoo?
2. What did you observe about the pond water during the two-week time period?

### Reading Check

*What are cilia and flagella and how do protozoans use them to move?*

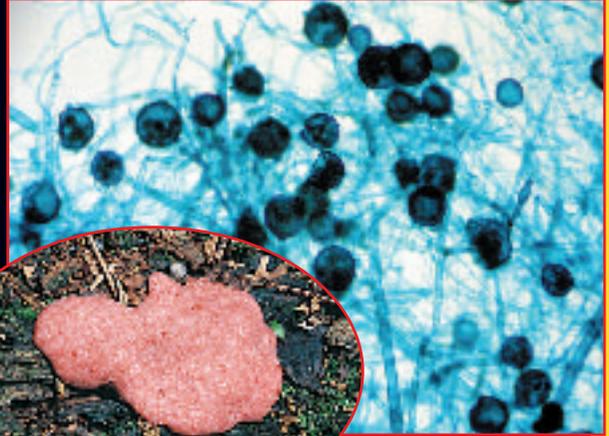
All protozoans are consumers, and many have interesting ways of taking in food. Some, like *Paramecium*, use cilia to sweep food into mouthlike openings. Others, like amoebas, surround and trap food particles, such as a bacterium, with pseudopods. The food is then enclosed in a sphere called a vesicle. Some protozoans are saprophytes, and others are parasites that cause disease in animals and humans.

**Plantlike Protists** Plantlike protists are known as **algae** (AL jee). Some species of algae are one-celled and others are many-celled, as shown in **Figure 10**. One-celled algae have structures that are visible only under the microscope. Many small algae have flagella and can move from place to place. If you visit a beach, you are likely to find many-celled algae, sometimes called seaweed, washed up on the shore. Many-celled algae provide food and shelter for a large number of organisms.

Algae usually are grouped based on their structure and the pigments they contain. There are algae that are red, brown, golden, or different shades of green. All algae can make their own food and produce oxygen because they contain a green pigment called chlorophyll. However, so much of another pigment can be present in some algae that the chlorophyll cannot be observed.

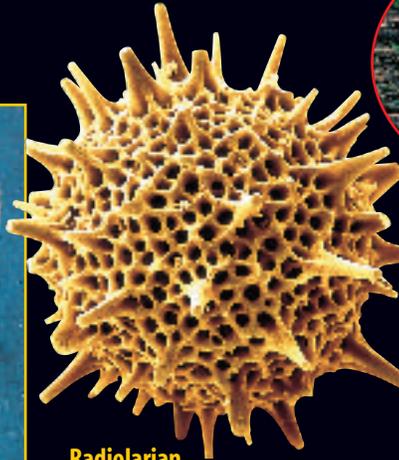
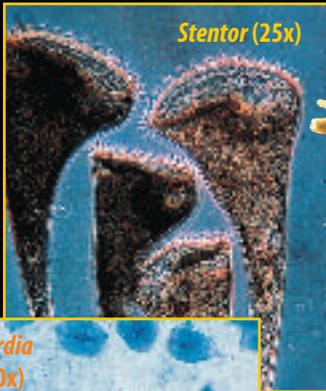
**Figure 10**

The protist kingdom is so diverse that many scientists propose reorganizing it into several smaller kingdoms. In general, the traits of protists are used to group them as either funguslike, animal-like, or plantlike. Examples of each group are shown on this page.



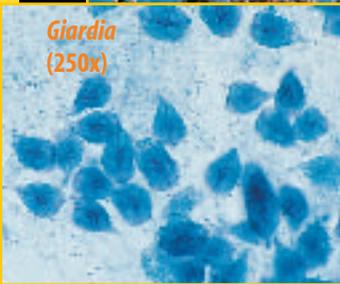
**Water mold (100x)**

▲ **FUNGUSLIKE PROTISTS** Water molds (shown actual size at top) secrete enzymes that digest other organisms. Slime molds (shown actual size in inset) go through a stage in which individual cells come together to form a slimy mass.



**Radiolarian shell (300x)**

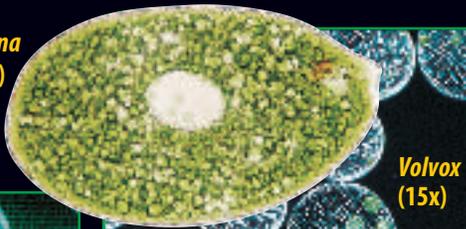
◀ **ANIMAL-LIKE PROTISTS** These are one-celled predators, such as radiolarians and *Stentor*, or parasites, such as *Giardia*.



**Giardia (250x)**

▼ **PLANTLIKE PROTISTS** Diatoms and algae—including giant kelp, which can grow to nearly nine meters—are considered plantlike protists because they have chloroplasts and make their own food.

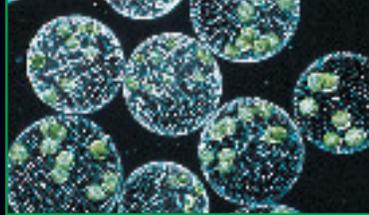
**Euglena (190x)**



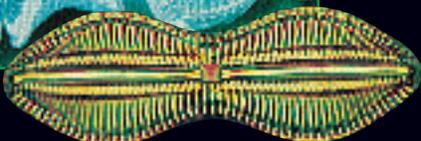
**Diatoms (one-celled, 160x)**



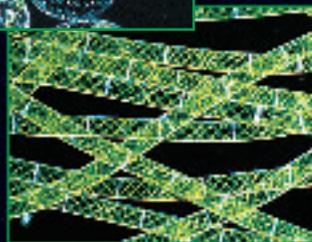
**Volvox (15x)**



**Laminaria longicurris**



**Diatom (one-celled, 200x)**



**Spirogyra (14x)**

**Red algae, Antithamnion (75x)**



**Topic: Malaria**

Visit [in6.msscience.com](http://in6.msscience.com) for Web links to information about malaria.

**Activity** Mark on a map where malaria is a problem. Indicate countries that have the highest number of cases.

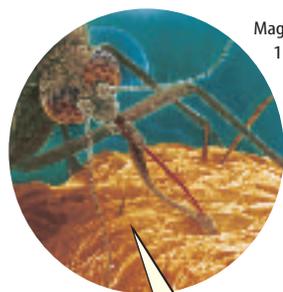


**Indiana Academic Standard Check**

**6.4.9:** Recognize and explain that two types of organisms may interact . . . as . . . parasite/host.

✓ Identify the host and parasite of malaria.

**Figure 11** *Plasmodium*, a protozoan, causes the disease malaria. It spends part of its life cycle in mosquitoes and part in humans.



Magnification: 11x

*Plasmodium* lives in the salivary glands of certain female mosquitoes. The parasite can be transferred to the blood of people if an infected mosquito bites them.

## The Importance of Protists

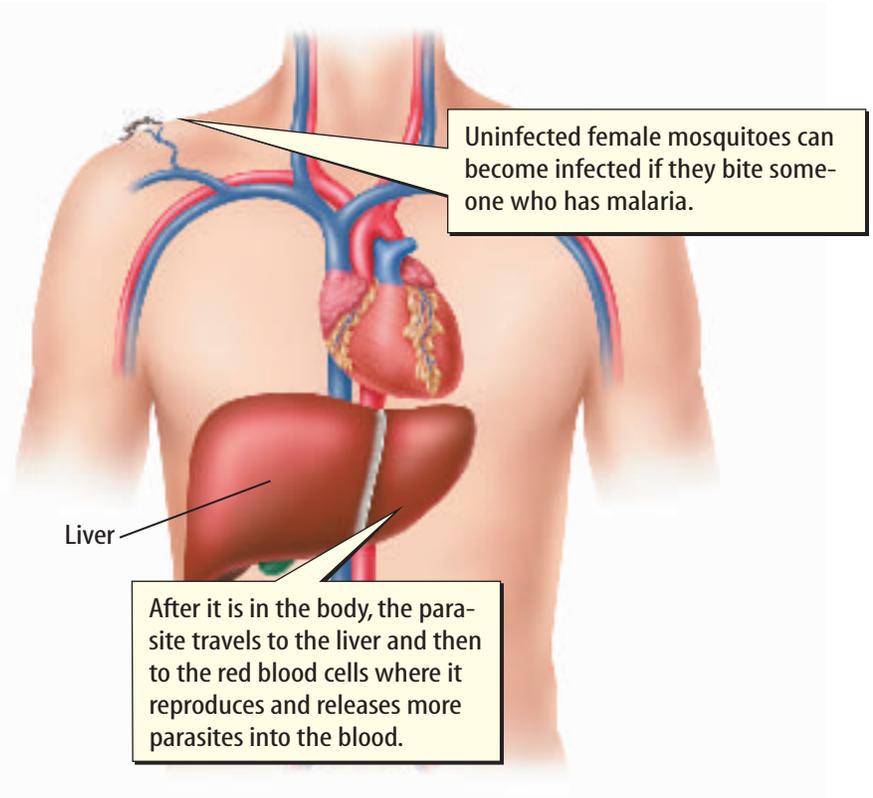
Are these organisms, most of which you can't see without a microscope, important to you or to the environment? The answer is yes. Many animals depend on these organisms for food, some of them cause disease, and many of them or their products are used in industry.

**Protists and Humans** You might use a protist or its product every day and not realize it. Algae or their products are ingredients in toothpaste, pudding, and ice cream. People in many parts of the world eat some algae. Other algae are used to make fertilizers, and some produce the sparkle that makes road lines visible at night.

Many protozoans are parasites that cause disease. One protozoan spends part of its life in an insect called a tsetse fly. People bitten by the fly can get a disease called African sleeping sickness.

Probably the most important disease caused by a protozoan is malaria. **Figure 11** shows how the parasite is carried by mosquitoes and transferred to humans. Malaria kills more than one million people each year.

A water mold caused the Irish potato famine in the 1840s. In a short time, most of the potato crop became diseased and the mold either killed the plants or made the potatoes inedible. More than a million people died in Ireland from the resulting famine. Potato blight continues to be a problem for potato growers, including in the United States.



**Protists in the Environment** Algae are important as food for animals that live in lakes, rivers, oceans, and other bodies of water. Diatoms and one-celled green algae are eaten by protozoans and other small animals. Just like you, animals that live in the water need oxygen. Much of the oxygen dissolved in Earth's water is produced by algae.

However, algae can cause problems in water environments. Sometimes so much algal growth is present that the water becomes the color of the algae. This is called an algal bloom. Blooms in oceans of one type of algae can cause the water to turn red. Algal wastes are produced in such large amounts that fish and other organisms can die, as shown in **Figure 12**. Humans who drink or swim in the water might also get sick.

Have you ever tried to eat wood? If you were a termite, that would be your food source. Protozoans live in a termite's digestive system. The protozoan have bacteria on their surface and inside of them, which produce substances that help the termite digest wood.

**Reading Check** Why are protozoans important to termites?

Many of the slime molds are important decomposers. Other funguslike protists cause disease in plants and animals. If you have an aquarium, you might have seen water molds attack a fish and cause its death.



Magnification:  
7800×

**Figure 12** Blooms of the algae known as dinoflagellates can produce toxins that kill fish and cause clams and mussels to be poisonous when eaten.

## section 2 review

### Summary

#### What is a protist?

- Protists are funguslike, animal-like, or plantlike.

#### The Importance of Protists

- Most protists are microscopic.
- Humans use protists or their products everyday.
- Some protists have caused famines or economic disasters.
- Algae are an important food source for many organisms.
- Some protists form relationships with other organisms such as termites.
- Many protists are decomposers.

### Self Check

1. **List** the main characteristics shared by all protists.
2. **Compare and contrast** three groups of protists.
3. **Identify** some human or plant diseases caused by protozoans.
4. **Define** an algal bloom.
5. **Think Critically** Why might it be a problem for fish and other small organisms in a pond if all the algae die?

### Applying Skills

6. **Use a spreadsheet** to compare protozoans. Include group, example species, method of transportation, and other characteristics.

# LAB

## Comparing Algae and Protozoans

Algae and protozoans share enough characteristics that they usually are placed in the same kingdom. However, protists vary greatly in form. In this lab, you can observe many of the differences that make protists so diverse.

### Real-World Question

What are some of the differences between algae and protozoans?

#### Goals

- **Draw and label** the organisms you examine.
- **Observe** the differences among algae, protozoans, and slime molds.

#### Materials

cultures of *Paramecium*, *Amoeba*, *Euglena*, and *Spirogyra*

\*prepared slides of above organisms

prepared slide of slime mold

coverslips (4)                      dropper  
microscope                        microscope slides (4)  
stereomicroscope                petri dish

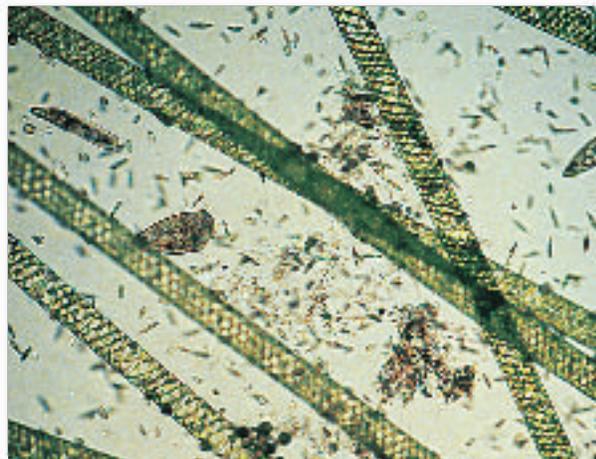
\*Alternate materials

#### Safety Precautions



### Procedure

1. **Design** a data table in your Science Journal for your drawings and observations.
2. Make a wet mount of the *Paramecium* culture. If you need help doing this, refer to the **Reference Handbooks**.
3. **Observe** the wet mount under low power and then under high power. In your Science Journal, make a labeled drawing of the organism.



4. Repeat Steps 2 and 3 with the other cultures. Return all preparations to your teacher and wash your hands.
5. **Observe** the slide of slime mold under low and high power. Record your observations.

### Conclude and Apply

1. **Label** the structure that enabled the movement of each organism that could move.
2. **Infer** which protists make their own food. List facts that support your inference.
3. **Determine** which protist had animal-like and plantlike characteristics. Explain.

### Communicating Your Data

Make a set of cards with drawings of each organism that you examined. On the back of each card, write the organism's name and characteristics. See whether other students in your class can identify your drawings. **For more help, refer to the Science Skill Handbook.**

# Fungi

## What are fungi?

Do you like fungi on your pizza? You do if you like mushrooms. Mushrooms are a type of fungi. You might be surprised to know that a mushroom is only a small part of the organism that produces it. Most of the fungus grows below the mushroom underground, as shown in **Figure 13**, or beneath the surface of the organic material on which it is growing.

**Characteristics of Fungi** Most species of fungi are many-celled. Their cells are eukaryotic and contain membrane-bound cell structures including a nucleus. Some fungi cells contain more than one nucleus.

Fungi once were considered plants. Like plants, their cells have cell walls, and some fungi grow anchored in soil. Unlike plants, fungi do not have specialized tissues and organs such as leaves and roots. Fungi cells don't contain chlorophyll and cannot make their own food. They are not producers. Most fungi are saprophytes, but some are parasites.

Through the production of small, waterproof structures called spores, fungi reproduce. Spores can spread from place to place and grow into a new fungus under the right conditions.

Fungi grow best in warm, humid areas, such as tropical forests or the spaces between your toes. Mildew, a type of fungus, might be growing on the shower curtain in your bathroom.



### as you read

#### What You'll Learn

- **Identify** the characteristics shared by all fungi.
- **Classify** fungi into groups based on their methods of reproduction.
- **Differentiate** among the imperfect fungi and all other fungi.

#### Why It's Important

Fungi are important sources of food and medicines, and they recycle Earth's wastes.

#### Review Vocabulary

**producer:** an organism that can make its own food; usually through photosynthesis

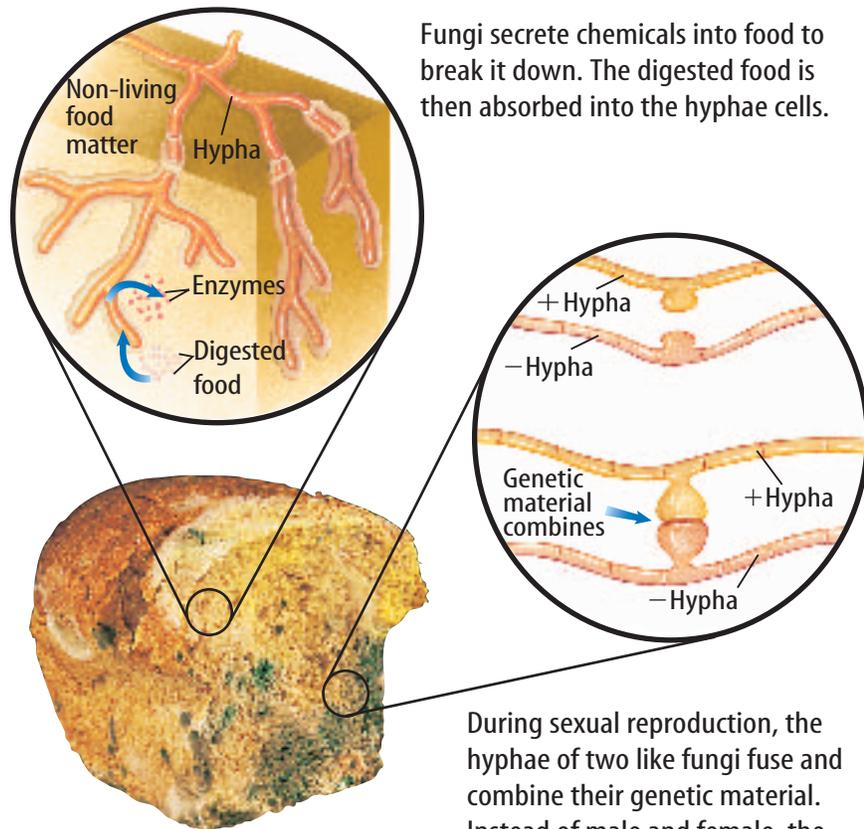
#### New Vocabulary

- hyphae
- sporangia
- lichen
- mycorrhizae

**Figure 13** Often the visible part of a fungus is not the largest part of the organism.

**Identify** the hyphae in this figure.

**Figure 14** Hyphae grow throughout the fungi's food source.



Fungi secrete chemicals into food to break it down. The digested food is then absorbed into the hyphae cells.

During sexual reproduction, the hyphae of two like fungi fuse and combine their genetic material. Instead of male and female, the two fungi are called + and -.

## Mini LAB

### Creating Fungus Art



#### Procedure

1. Find or grow some **blue-green mold** on a piece of **fruit, old bread, or a biscuit**.
2. Tear a slice of **fresh bread** in half.
3. Using a **toothpick** as your brush, lightly touch the mold, which is your paint, and draw a line, a circle, or your initials on each half slice of bread.
4. Wrap each half slice in **plastic wrap** or in separate **plastic bags**.
5. Set one of the wrapped pieces on the counter. Place one wrapped piece in a drawer or other dark place. Wash your hands thoroughly.
6. Examine the bread pieces each day over the next week to see how your fungus art develops.

#### Analysis

1. Describe your artwork on both pieces of the bread.
2. How did the amount of light affect the fungal growth?



**Structure and Function** The body of a fungus is usually a mass of many-celled, threadlike tubes called **hyphae** (HI fee) (singular, *hypha*), as shown in **Figure 14**. Filaments of hyphae form a mat in most fungi. The appearance of a mat of fungal hyphae can be a clue to the kind of fungus you see. Mats of hyphae can be fuzzy like those produced by mold growing on bread.

The hyphae grow throughout the fungus's food source. Enzymes from the fungus help break down the food. The fungal cells in the mat of hyphae then absorb the digested food.

Hyphae are also important in sexual reproduction in fungi. When fungi reproduce sexually, they do not produce sex cells. Instead, the hyphae of two different organisms of the same type of fungus grow close together and fuse, as shown in **Figure 14**. A special reproductive structure grows where the two hyphae join, and spores are produced in it. The type of structure that is produced depends on the type of fungus it is.

## Types of Fungi

Today, fungi are classified by several methods. Comparison of hereditary material provides some answers. However, their structure and the type of reproductive structures produced are still useful in identifying types of fungi.

**Figure 15** Club fungi are identified by their reproductive structures.

Most club fungi are mushrooms. Although many mushrooms are edible, some are poisonous.



Puffball mushrooms break open to release their spores.



You might have seen shelf fungi growing on trees or on rotting wood.

**Club Fungi** Mushrooms, shelf fungi, puffballs, and toadstools are all examples of club fungi, as shown in **Figure 15**. The spores of these fungi are produced in a club-shaped part found on the reproductive structure. On the bottom of the cap of a mushroom, you will see structures called gills. If you use a microscope to look at a gill, you will see spores hanging from these club-shaped parts.

 **Reading Check** *Where are spores produced in mushrooms?*

**Sac Fungi** Yeasts, molds, morels, and truffles are all examples of sac fungi. The spores of these fungi are produced in little sac-like parts of the reproductive structure. This group also includes examples of one-celled fungi, the yeasts. **Figure 16** shows some examples of the sac fungi.

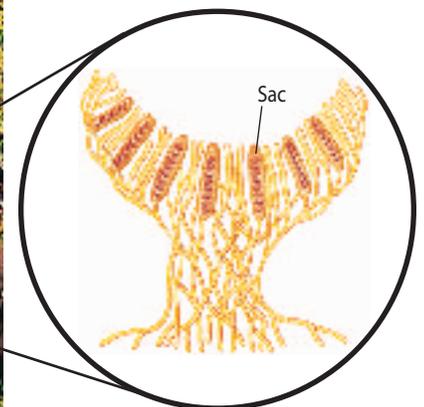
**Figure 16** Sac fungi produce eight spores in each sac.

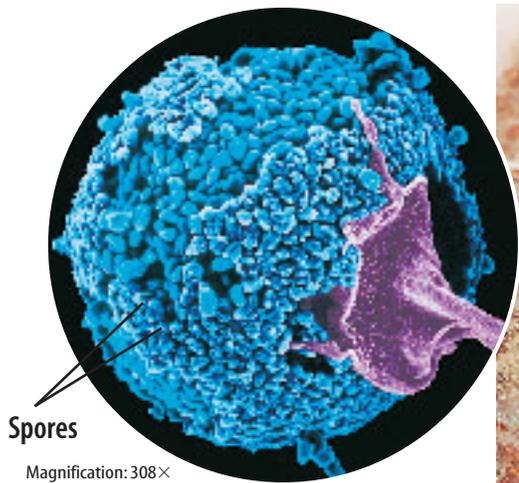


Many morels are edible and appear in early spring. Spore sacs are located in the many folds.



Spore sacs are produced inside the cup-shaped area of the cup fungus.





**Figure 17** The mold growing on these strawberries is a zygosporangium. If you look at the fungus with a microscope, you will see large round sporangia where spores are produced.

**Zygosporangium Fungi** The fuzzy, black mold that you sometimes find growing on old bread or a piece of fruit is a type of zygosporangium fungus. When two hyphae fuse in this group, a cell called a zygosporangium forms. **Sporangium** (spuh RAN jee uh) (singular, *sporangium*) are reproductive structures that grow from the zygosporangium and form on the tips of upright hyphae. Spores are produced in sporangia, as shown in **Figure 17**. As each sporangium splits open, hundreds of spores are released into the air. Each spore will grow into more fungi if it lands where enough moisture, warmth, and food are available.

**Other Fungi** Some fungi never have been observed undergoing sexual reproduction, or they never undergo sexual reproduction. Fungi that do not undergo sexual reproduction are referred to as imperfect because they have an imperfect life cycle. If one of these fungi is observed producing reproductive structures as a result of sexual reproduction, it immediately is classified as one of the other three types of fungi. Several diseases in humans, including athlete's foot, are caused by fungi in this group.

## Fungi in the Environment

Fungi are important in the environment because they break down organic materials. Food scraps, clothing, and dead plants and animals are made of organic material. When fungi decompose, or break down, these materials, energy is released and chemicals are returned to the soil. The chemicals returned to the soil are used by plants. Fungi, along with bacteria, are nature's recyclers.

Fungi can cause diseases in plants and animals. Dutch elm disease and chestnut blight are caused by sac fungi. These diseases killed hundreds of millions of American elm and American chestnut trees in the twentieth century.



### INTEGRATE Career

**Air Quality Engineer** To help assess air quality, some air quality engineers observe lichens. Lichens are called bioindicators because sulfur dioxide, fluorides, heavy metals, and radioactive fallout can affect them. Air quality engineers can monitor changes in the air by studying how lichens react to pollutants. Research to learn what other jobs might be held by an air quality engineer.

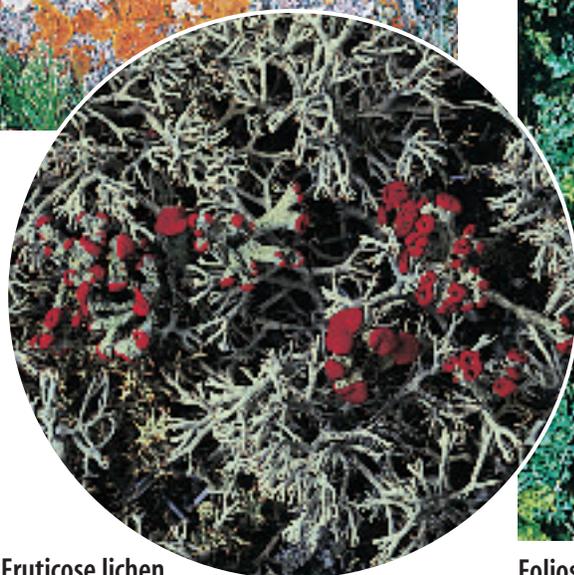
**Lichens** Some fungi live in close associations with other organisms. The fungi and the other organism benefit from the association. A **lichen** (LI kun) is formed when a fungus and either a green alga or a cyanobacterium live together. The alga or the cyanobacterium gets a moist, protected place to live, and the fungus gets food made by the green alga or cyanobacterium. The colorful organisms in **Figure 18** are lichens.

Lichens that grow in the surface cracks of a rock play an important role in the formation of soil. As lichens grow, they release acids as part of their metabolism. The acids help break down the rock. As bits of rock accumulate and lichens die and decay, soil is formed.

 **Reading Check** *How do lichens help form soil?*

Lichens can be used to help monitor pollution levels in an area because they are sensitive to pollutants present in rain and air. The disappearance of lichens from an area can indicate environmental problems.

**Crusty lichen**



Fruticose lichen

**Figure 18** Lichens can grow upright, appear leafy, or look like a crust on bare rock.

**Classify** *How might lichens be classified?*



Foliose lichen



**Indiana Academic Standard Check**

**6.4.8:** Explain that in all environments . . . the growth and survival of organisms depend on the physical conditions.



What environmental factors can harm lichens?

**Figure 19** Mycorrhizae greatly increase the growth of plants. These two groups of plants are the same species. They were planted at the same time and grown under the same conditions.



These plants do not have mycorrhizae associated with their roots.

These plants have mycorrhizae associated with their roots.

**Figure 20** Fungi are economically important to humans. Yeasts are used in the production of bread. As yeast cells feed on carbohydrates in the bread dough, they produce the waste gas carbon dioxide that causes the bread to rise.



**Mycorrhizae** An association similar to that in lichens exists between certain plants and fungi. The fungi form an intricate web called **mycorrhizae** (mi kuh RI zee) (singular *mycorrhiza*) around the roots of the plants. The plants provide the fungi with food and the fungi help the plant roots absorb water and nutrients, as shown in **Figure 19**. Scientists have found mycorrhizae around the roots of 90 percent of the plants they have studied. Some plants cannot grow unless the mycorrhizae are present.

## Fungi and Humans

You already know that many people eat mushrooms, but fungi are important in producing other foods, too. The bread in your sandwich probably was produced using yeast, as shown in **Figure 20**. Yeasts and other fungi also are used in the production of some cheeses.

Fungi can spoil food as well. You might find mold, a type of fungus, growing on an old loaf of bread or leftover food in the back of the refrigerator.



Unrisen bread dough



Risen bread dough



Smuts, like this one growing on corn, cause damage to crops worldwide.



The fungus that causes athlete's foot grows best in warm, damp places.

**Helpful and Harmful Fungi** Many fungi naturally produce antibiotics to prevent bacteria from growing near them. These antibiotics can be produced in bioreactors and used to fight infections. Penicillin is an important antibiotic produced by fungi.

Rust and smuts, shown in **Figure 21**, are types of club fungi that cause billions of dollars worth of damage to corn, wheat, and other major food crops each year. Fungi can grow on or in your body and sometimes they cause disease. For example, athlete's foot and ringworm are caused by fungus.

**Figure 21** Some types of fungi cause disease in plants and animals.

## section 3 review

### Summary

#### What are fungi?

- Fungi have eukaryotic cells, most reproduce through spores, and are many-celled.
- Hereditary material and reproductive structures are used to classify fungi.

#### Fungi in the Environment

- Fungi break down organic materials and can cause disease.
- Lichens can be environmental indicators for pollution.
- Many plants depend on mycorrhizae.

#### Fungi and Humans

- Some fungi are used to produce food. Others cause food to spoil.
- Many fungi produce antibiotics and others harm plants and animals.

### Self Check

1. **Explain** why a particular fungi would be classified as imperfect.
2. **Describe** how their method of sexual reproduction is used to place fungi into groups.
3. **Identify** one way that fungi and plants are alike and two ways that fungi are different from plants.
4. **List** three ways fungi are important to the environment and three ways they are important to humans.
5. **Think Critically** If an imperfect fungus under some circumstances were found to produce spores on clublike structures, how would the fungus be reclassified?

### Applying Skills

6. **Make and Use a Graph** Approximately 30,000 species of sac fungi, 25,000 species each of club and imperfect fungi, 22,000 species of lichens, 5,000 species of mycorrhizae, and 600 species of zygosporangium fungi exist. Construct a circle graph using this information.

## Making Yogurt

### Goals

- **Make** your own yogurt.
- **Describe** the role of bacteria in the process of making yogurt.

### Materials

hot plate  
 saucepan  
 plastic spoon  
 thermometer  
 (nonmercury)  
 plastic container with lid  
 insulated picnic cooler  
 milk (about 0.5 L)  
 live-culture yogurt  
 (about 25 g)  
 \*yogurt culture  
 (1 package)  
 \*Alternate materials

### Safety Precautions



**WARNING:** Use care near heat sources and when handling hot objects. Do not eat anything in the lab unless you are instructed to by your teacher.

### Real-World Question

You probably have eaten yogurt at some point. Do you know how yogurt is made? Live bacteria are combined with milk to produce yogurt. How long does the process of changing milk into yogurt take? Is it healthy to eat food that you know contains bacteria? How can you make yogurt in the lab?



### Procedure

1. Use the hot plate to heat milk to 85°C. When you check the temperature, be sure that the thermometer is not touching the bottom of the saucepan. Stir the milk continuously with the spoon to avoid scorching.



## Using Scientific Methods

2. When the milk reaches 85°C, keep it at that temperature for 30 min.
3. After 30 min. have passed, cool the milk to 45°C. One way to do this is to set the saucepan into a sink partially filled with cold water. Change the water if it becomes warm.
4. Add yogurt or yogurt culture to the cooled milk and stir well.
5. Put the mixture into a plastic container and cover it. Then, place the container in the insulated picnic cooler so that the yogurt will stay warm.
6. Yogurt should be made in 3–7 h. Try not to disturb the equipment while the yogurt is growing.



### Analyze Your Data

1. **Explain** why it is important not to allow the milk to boil.
2. **Determine** why it is important to keep the mixture warm during the yogurt-making process.

### Conclude and Apply

1. **Infer** what was in the yogurt or yogurt culture that helped to change the milk to yogurt. Describe the role of bacteria in making yogurt.
2. **Draw Conclusions** Suppose the milk that is used to make yogurt contains antibiotics. How would that affect the yogurt-making process?

### Communicating Your Data

The next time you see a family member or friend eating yogurt, describe the process of making yogurt and the role that bacteria play in that process.

## SAY CHEESE



**Cheese probably came from milk kept in a pouch made from a sheep's stomach**

**A**lthough no one knows exactly, most authorities believe that cheese was first made in the Middle East, about 4,000 years ago. One story tells of an Arabian traveler carrying milk with him in a pouch made from a sheep's stomach. During his journey across the desert, he opened the pouch and discovered that the milk had separated into thick solids and a watery fluid. The Arabian traveler had accidentally invented cheese.

How did the milk become cheese? First, the Sun warmed the bag of milk. Second, the dried digestive juice in the sheep-stomach pouch caused the milk to coagulate (koh A gyuh layt), separating it into curds and a thin liquid called whey (WAY). The digestive juice contained rennet, an enzyme that still is used to make cheese today. People soon realized that cheese was a good way to preserve milk. Once milk was made into cheese, it could be kept for a longer period of time.

**These test tubes contain *Penicillium roqueforti* that is used to make a French cheese.**



### Bacteria Help

The basis of cheese is milk that has been curdled by the by-products of bacteria. Today, milk is first pasteurized to kill harmful bacteria. Then useful bacteria cultures are added to the milk. The bacteria feed on lactose (sugar) in the milk and produce lactic acid wastes that help curdle or thicken the milk into curd. The major protein in milk, casein, forms the thickened curd.

The curd is then cut to release the whey, leaving the solid mass of curd behind. The curd can become different types of cheese, depending on how cheese makers treat it.

### Types of Cheese

There are more than 2,000 varieties of cheese, with different textures, tastes, and appearances. Cheese can be made from the milk of many animals including cows, goats, sheep, buffalo, and reindeer.

To make cottage cheese, the curd is broken up, rinsed with water, then mixed with cream and salt. Hard cheeses, such as cheddar or Parmesan, are packed into molds and pressed to remove additional whey. Some cheeses are then aged.

**Write** Prepare a report on cheese making in your state. What types are made? Where does your state rank in cheese production? Compare your report with those of your classmates.

Science **online**

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[in6.msscience.com/oops](http://in6.msscience.com/oops)

## Reviewing Main Ideas

### Section 1 Bacteria

1. Bacteria are prokaryotic cells. They contain DNA and cytoplasm but lack membrane-bound organelles.
2. Bacteria have been found living in nearly every environment on Earth and are grouped as either eubacteria or archaeobacteria.
3. Some bacteria are harmful because they can cause disease when they infect organisms.
4. Most bacteria are helpful. They help in recycling nutrients, fixing nitrogen, and food production. They even can be used to break down harmful pollutants.

### Section 2 Protists

1. Protists are one- or many-celled organisms that live in moist or wet environments.
2. The protists are plantlike, animal-like, or funguslike.

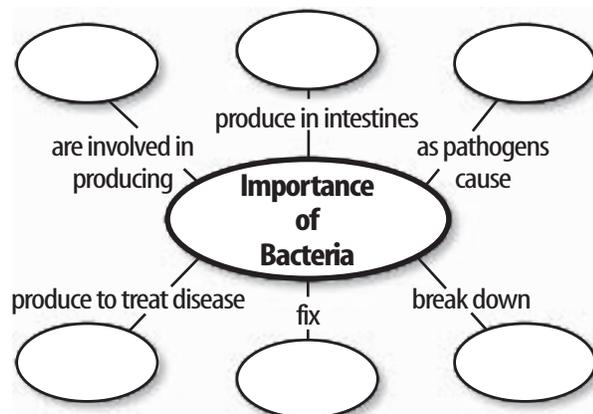
3. Algae are important in freshwater and salt-water environments as food and oxygen producers. They also are used by humans to make many different products.
4. Some protists cause diseases in humans and in plants, such as malaria and potato blight.

### Section 3 Fungi

1. Fungi are composed of eukaryotic cells that grow in long chains called hyphae. They absorb food through the hyphae and are either saprophytes or parasites.
2. Most fungi reproduce sexually by producing spores.
3. Four classifications of fungi exist—club fungi, sac fungi, zygosporangium fungi, and imperfect fungi.
4. One of the most important roles of fungi is to decompose organic material and return nutrients to the soil. They also live in associations with algae and plants, produce antibiotics, and can cause diseases.

## Visualizing Main Ideas

Copy and complete the following spider map to show the importance of bacteria.



## Using Vocabulary

aerobe p.345	pasteurization p.349
algae p.352	pathogen p.348
anaerobe p.345	protist p.351
antibiotic p.348	protozoan p.352
endospore p.345	pseudopod p.352
hyphae p.358	saprophyte p.350
lichen p.361	sporangia p.360
mycorrhizae p.362	vaccine p.348

Fill in the blanks with the correct vocabulary word or words.

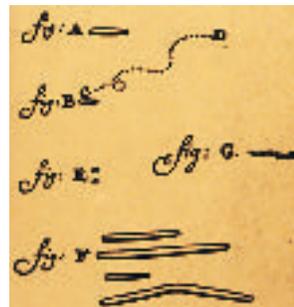
- A(n) \_\_\_\_\_ is an organism that gets nutrition from dead materials.
- A(n) \_\_\_\_\_ can survive without oxygen.
- A(n) \_\_\_\_\_ is a protective structure formed by bacteria.
- \_\_\_\_\_ can prevent some bacterial diseases.
- A one-celled plantlike, animal-like, or funguslike organism is a(n) \_\_\_\_\_.
- An organism composed of an alga and a fungus is a(n) \_\_\_\_\_.
- Fungi grow as a mass of many-celled, threadlike tubes called \_\_\_\_\_.
- What type of consumers use dead material as an energy source?
  - producers
  - flagella
  - saprophytes
  - parasites
- What gas found in Earth's atmosphere is combined with other chemicals by bacteria so that plants can use it?
  - oxygen
  - hydrogen
  - carbon dioxide
  - nitrogen
- Which protist group produces food and the greatest amount of oxygen in water environments?
  - algae
  - lichens
  - protozoans
  - eubacteria
- Decomposition of organic materials is an important role of which organisms?
  - protozoans
  - algae
  - plants
  - fungi
- What name is given to rod-shaped bacteria?
  - bacilli
  - cocci
  - spirilla
  - colonies
- Which group of fungi has not been observed undergoing sexual reproduction?
  - club fungi
  - sac fungi
  - zygospore fungi
  - imperfect fungi

## Checking Concepts

Choose the word or phrase that best answers the question.

- Which organisms usually are grouped according to the extreme environment in which they live?
  - archaeobacteria
  - eubacteria
  - protists
  - fungi
- What are the threadlike tubes by which fungi grow called?
  - spores
  - lichens
  - imperfect fungi
  - hyphae

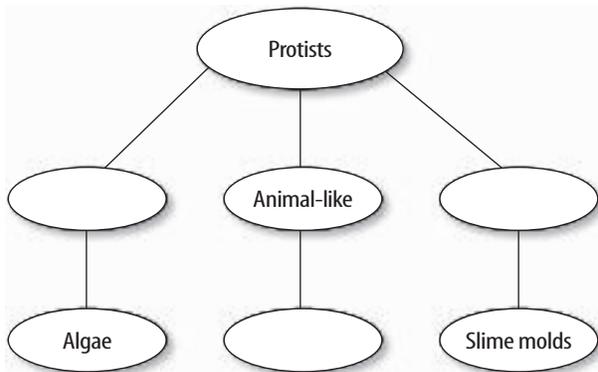
Use the figure below to answer question 16.



- What name would be given to the bacteria Antonie van Leeuwenhoek drew and labeled Fig. G?
  - bacilli
  - cocci
  - spirilla
  - colonies

**Thinking Critically**

17. **Explain** Yeast can use sugar in bread dough as a source of food. As they use the sugar, they produce waste carbon dioxide gas and the dough rises. If yeast are added to dough in very hot or very cold water, why might the dough not rise?
18. **List** some precautions that can be taken to prevent food poisoning.
19. **Compare and contrast** lichens and mycorrhizae.
20. **Infer** why brushing and flossing your teeth help prevent tooth decay.
21. **Interpret Scientific Illustrations** Use **Figure 11** to answer the following question. When the malaria parasite is transferred to the blood from a mosquito bite, what organ does the parasite first infect?
22. **Concept Map** Copy and complete the following concept map that compares the three groups of protists.



23. **Compare and Contrast** Make a chart comparing and contrasting club fungi, sac fungi, zygosporangium fungi, and imperfect fungi.

**Performance Activities**

24. **Make a Poster** Find or draw pictures on a poster to show the importance of bacteria, protists, or fungi to life on Earth. Be sure to include helpful and harmful examples.

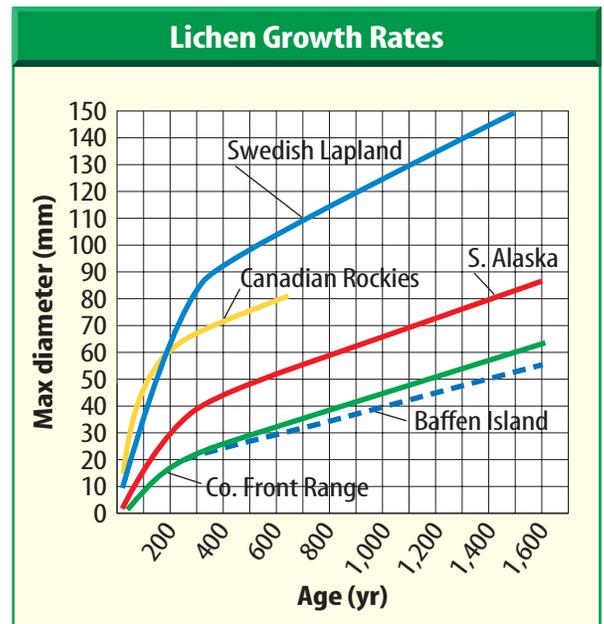
**Applying Math**

Use the table below to answer question 25.

Bacterial Reproduction Rates	
Temperature (°C)	Doubling Rate per Hour
20.5	2.0
30.5	3.0
36.0	2.5
39.2	1.2

25. **Temperature and Growth Rates** What is the effect of temperature on the bacterial growth rates shown in the table above?

Use the graph below to answer question 26.



26. **Growth and Climate** The graph above illustrates that lichens grow at different rates depending on the climate. According to the graph, which climate is the most favorable for lichen growth? What is the difference between the diameter of a 200-year-old colony in the Swedish Lapland compared to a 200-year-old colony on Baffen Island?



The assessed Indiana standard appears above the question.

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

### Part 1 Multiple Choice

- Which type of bacterium uses light energy to make food?
  - consumer
  - pathogen
  - producer
  - saprophyte

#### 6.4.2

- What are the two main groups of bacteria?
  - archaeobacteria and eubacteria
  - pathogens and saprophytes
  - prokaryotes and eukaryotes
  - salt-loving and acid-loving
- The photo below shows a type of fungus.

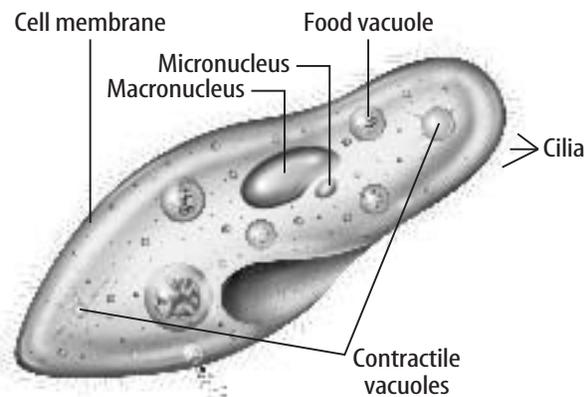


What type of fungi is this?

- club
- imperfect
- sac
- zygospore

- What do some bacteria produce that limits the growth of other bacteria?
  - algae
  - antibiotics
  - antiseptics
  - lichens

The illustration below shows a protist.



- What type of protist is this?
  - algal-like
  - animal-like
  - funguslike
  - plantlike
- What structures would the protist in the illustration above use for motility?
  - cell membrane
  - cilia
  - contractile vacuole
  - micronucleus

#### Test-Taking Tip

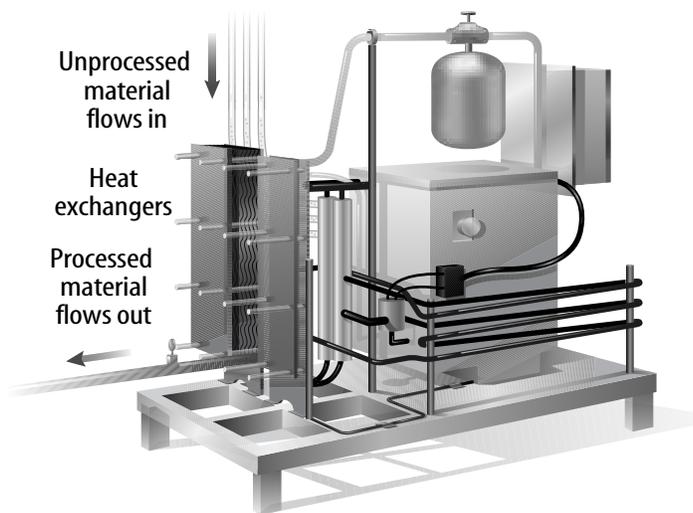
**Mark Answers Carefully** Be sure to ask if it is okay to mark in the test booklet when taking the test, but make sure you mark all answers on your answer sheet.



7. Which disease is caused by a protozoan carried by mosquitoes?
- A African sleeping sickness
  - B botulism
  - C malaria
  - D potato blight

**6.4.2**

8. What is used to classify fungi?
- A hyphae
  - B reproductive strategy
  - C vegetative structures
  - D zygospore
9. The illustration below shows a food-processing machine.

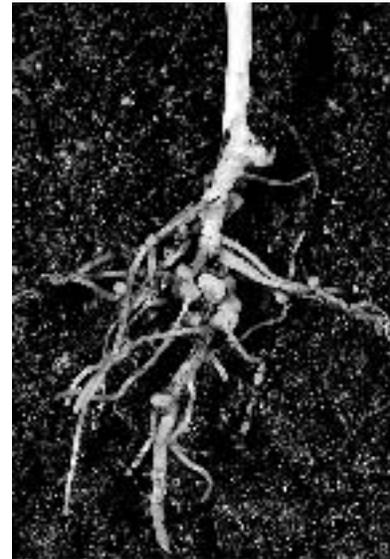


What is the function of this machine?

- A pasteurization
- B refrigeration
- C sanitation
- D sterilization

**Part 2 Critical Response**

10. The photo below shows the roots of a soybean plant.



How are the round structures on these roots critical to the environment?

11. Compare and contrast a one-celled protist and a bacterium.

**6.4.8**

12. What two organisms can form a lichen? How do lichens help form soil?

13. Discuss the ways that bacteria, protists, and fungi can be helpful to humans.

14. How are saprophytes different from parasites?

**6.4.8**

15. What environmental conditions in a refrigerator would slow fungal growth on food?