

# Viruses, Bacteria, Protists, and Fungi

## CALIFORNIA

## Standards Preview

**S 7.1** All living organisms are composed of cells, from just one to many trillions, whose details usually are visible only through a microscope.

- a. *Students know* cells function similarly in all living organisms.

**S 7.2** A typical cell of any organism contains genetic instructions that specify its traits. Those traits may be modified by environmental influences. As a basis for understanding this concept:

- a. *Students know* the differences between the life cycles and reproduction methods of sexual and asexual organisms.

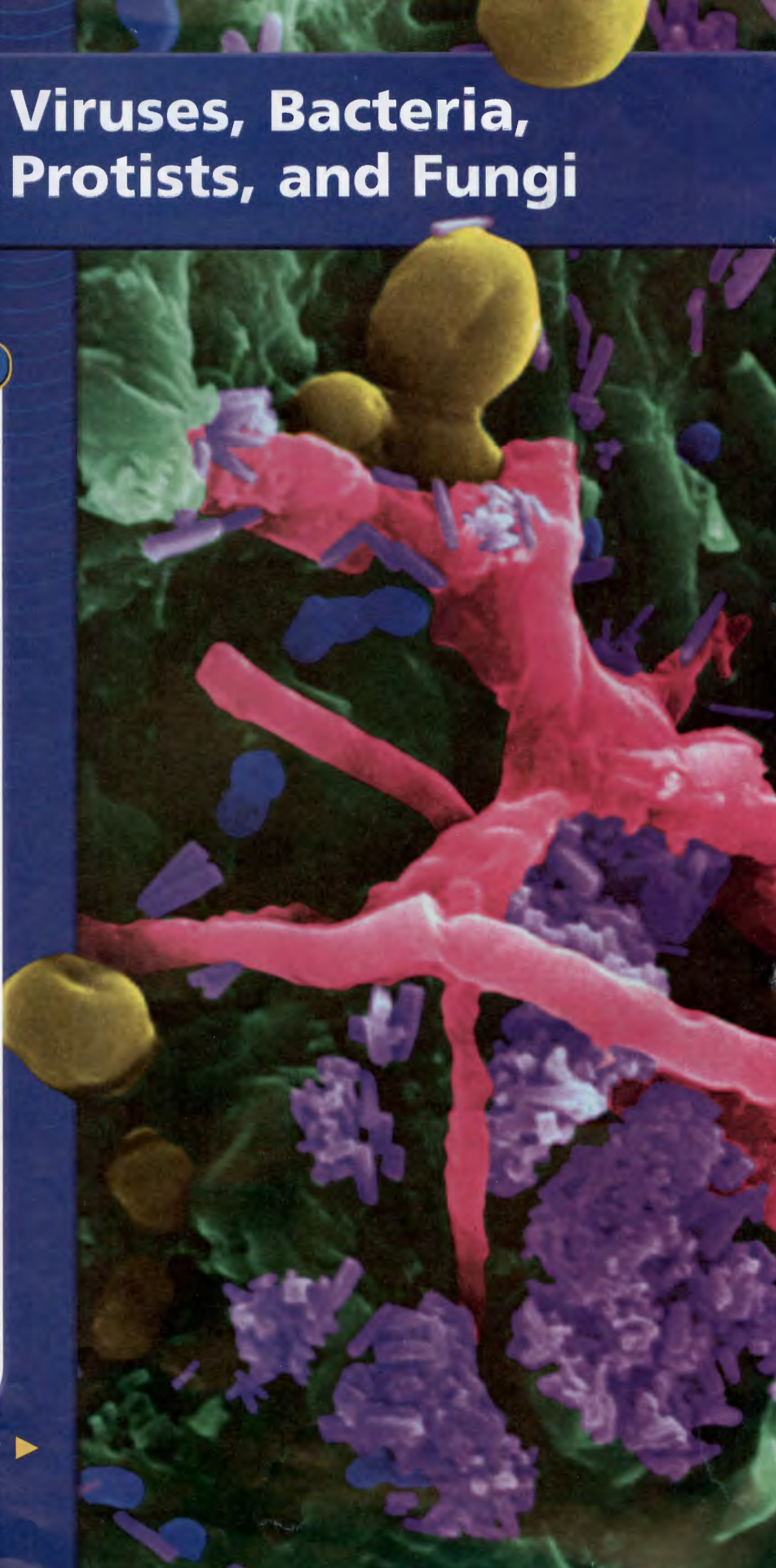
**S 7.5** The anatomy and physiology of plants and animals illustrate the complementary nature of structure and function. As a basis for understanding this concept:

- a. *Students know* plants and animals have levels of organization for structure and function, including cells, tissues, organs, organ systems, and the whole organism.

**S 7.7** Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other three strands, students should develop their own questions and perform investigations. Students will:

- d. Construct scale models, maps, and appropriately labeled diagrams to communicate scientific knowledge (e.g. motion of Earth's plates and cell structure).

Bacteria (blue and purple rods) and other microorganisms lurk in a kitchen sponge. ►





## Video Preview

Discovery Channel School

*Protists and Fungi*



Focus on the  
**BIG Idea**

S 7.5

**How do structure and function vary among organisms in different domains and kingdoms?**

### **Check What You Know**

Suppose you find a seaweed such as the one below. If you were to study one of the leafy structures under a microscope, what would you expect to see? What is the basic unit of structure in seaweeds?

Sea palm, a seaweed ▶

# Build Science Vocabulary

The images shown here represent some of the key terms in this chapter. You can use this vocabulary skill to help you understand the meaning of some key terms in this chapter.

## Vocabulary Skill

### Prefixes

When you talk about word parts, a root is the part of the word that carries the basic meaning. A prefix is a word part placed in front of the root to change the meaning of the root or to form a new word. Look at the examples in the table below.

Prefix	Meaning of Prefix	Example and Meaning of Example
bi-	two, twice	<b>bicolor</b> Having two colors
con-, com-	with, together	<b>compare</b> To look at together to note similarities and differences
de-	down, from, reverse the action of	<b>defrost</b> To remove ice or frost

### Apply It!

Answer the following questions. After reading the chapter, check to see whether your answers are accurate or need to be changed.

1. The word *fission* means "division into parts." When a one-celled organism reproduces by binary fission, how many new organisms are produced?
2. Some bacteria are decomposers. The root *-compose* means "to put together." What do decomposers do to dead organisms?
3. The root *-jugate* means "to join." What might *conjugation* mean?



# Chapter 9 Vocabulary

## Section 1 (page 318)

virus  
host  
parasite  
bacteriophage  
vaccine

.....

## Section 2 (page 325)

bacteria  
flagellum  
binary fission  
asexual reproduction  
sexual reproduction  
conjugation  
endospore  
pasteurization  
decomposer

.....

## Section 3 (page 334)

protist  
protozoan  
pseudopod  
contractile vacuole  
cilia  
symbiosis  
mutualism  
algae  
spore

.....

## Section 4 (page 344)

fungi  
hyphae  
fruiting body  
budding  
lichen



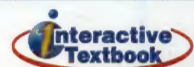
conjugation



fungi



protists



**Build Science Vocabulary  
Online**

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# How to Read Science

## Reading Skill

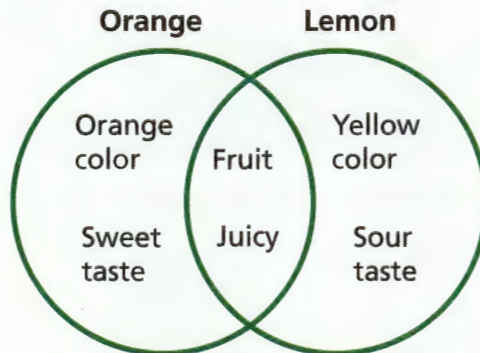


### Compare and Contrast

Science texts often make comparisons. When you compare and contrast, you examine similarities and differences between two things. You can compare and contrast by using a Venn diagram.

Follow these steps to set up a Venn diagram in your notebook.

- Draw two overlapping circles. Label each circle with one of the two items being compared. In the example below, oranges and lemons are being compared.
- In the area where the circles overlap, write the characteristics that the items share.
- Think of how the items are different. Write these differences in the parts of the circles that do not overlap.



### Apply It!

Review the Venn diagram above. Then answer the questions.

1. In the Venn diagram above, what are the similarities between lemons and oranges?
2. What are the differences written in the Venn diagram?

When you read Section 1, draw a Venn diagram comparing viruses and organisms.



## A Mushroom Life Cycle

The fungi you're most familiar with are probably mushrooms. In some ways, mushrooms resemble plants, often growing near plants or even on them like small umbrellas. But mushrooms are very different from plants in some important ways. In this investigation, you'll learn about these differences.

### Your Goal

To determine the conditions needed for mushrooms to grow and reproduce

To complete this investigation, you must

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

### Plan It!

List possible hypotheses about the way variables such as light or moisture could affect the growth and reproduction of mushrooms. Choose one variable and write out a plan for testing that variable. After your teacher approves your plan, start growing your mushrooms!







# Viruses

**CALIFORNIA**
**Standards Focus**

**S 7.2.a** Students know the differences between the life cycles and reproduction methods of sexual and asexual organisms.

**S 7.5** The anatomy and physiology of plants and animals illustrate the complementary nature of structure and function.

-  How are viruses like organisms?
-  What is the structure of a virus?
-  How do viruses multiply?
-  How can you treat a viral disease?

**Key Terms**

- virus
- host
- parasite
- bacteriophage
- vaccine

**Lab zone**
**Standards Warm-Up**
**Which Lock Does the Key Fit?**

1. Your teacher will give you a key.
2. Study the key closely. Think about what shape the keyhole on its lock must have. On a piece of paper, draw the shape of the keyhole.
3. The lock for your key is contained in the group of locks your teacher will provide. Try to match your key to its lock without inserting the key into the keyhole.


**Think It Over**

**Inferring** How might a unique “lock” on its surface help a cell protect itself from invading organisms?

It is a dark and quiet night. An enemy spy slips silently across the border. Invisible to the guards, the spy creeps cautiously along the edge of the road, heading toward the command center. Undetected, the spy sneaks by the center’s security system and reaches the door. Breaking into the control room, the spy takes command of the central computer. The enemy is in control.

**What Is a Virus?**

Although this spy story may read like a movie script, it describes events similar to those that can occur in your body. The spy acts very much like a virus invading an organism.

**Characteristics of Viruses** A **virus** is a tiny, nonliving particle that invades and then multiplies inside a living cell. Viruses are not cells. They do not have the characteristics of organisms.  **The only way in which viruses are like organisms is that they can multiply.** Although viruses can multiply, their reproduction is different than the reproduction of organisms. Viruses can only multiply when they are inside a living cell.

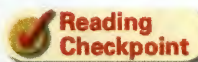
No organisms are safe from viruses. The organism that a virus multiplies inside is called a host. A **host** is a living thing that provides a source of energy for a virus or an organism. Viruses act like **parasites** (PA ruh syts), organisms that live on or in a host and cause it harm. Almost all viruses destroy their host cells.

**The Structure of Viruses** Viruses are smaller than cells and vary in size and shape. Some viruses are round. Others are shaped like rods, bricks, threads, or bullets. There are even viruses that have complex, robot-like shapes, such as the bacteriophage in Figure 1. A **bacteriophage** (bak TEER ee oh fayj) is a virus that infects bacteria. In fact, its name means “bacteria eater.”

Although viruses may look different from one another, they all have a similar structure. 🗑️ **All viruses have two basic parts: a protein coat that protects the virus and an inner core made of genetic material.** A virus’s genetic material contains the instructions for making new viruses. Some viruses are also surrounded by an additional outer membrane, or envelope.

The proteins on the surface of a virus play an important role during the invasion of a host cell. Each virus contains unique surface proteins. The shape of the surface proteins allows the virus to attach to certain cells in the host. Like keys, a virus’s proteins fit only into certain “locks,” or proteins, on the surface of a host’s cells. Figure 2 shows how the lock-and-key action works.

Because the lock-and-key action of a virus is specific, a certain virus can attach only to one or a few types of cells. For example, most cold viruses infect cells only in the nose and throat of humans. These cells are the ones with proteins on their surface that complement or “fit” those on the virus.



**Reading Checkpoint**

What information does a virus’s genetic material contain?

FIGURE 1

**Bacteriophage**

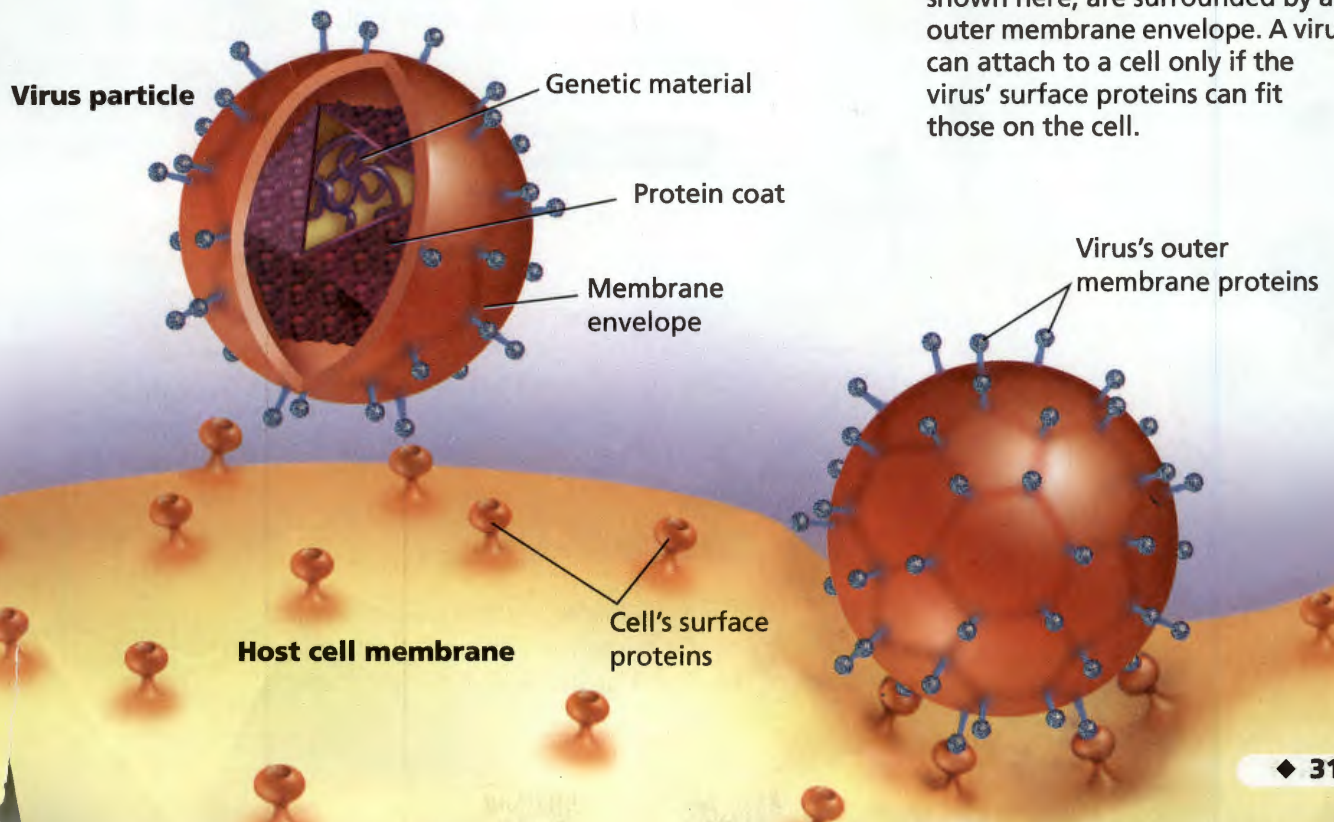
This robot-like virus infects bacteria.



FIGURE 2

**Virus Structure and Infection**

All viruses consist of genetic material surrounded by a protein coat. Some viruses, like the ones shown here, are surrounded by an outer membrane envelope. A virus can attach to a cell only if the virus’ surface proteins can fit those on the cell.





## How Viruses Multiply

After a virus attaches to a cell, it enters the cell. 🟢 Once inside a cell, a virus's genetic material takes over many of the cell's functions. It instructs the cell to produce the virus's proteins and genetic material. These proteins and genetic material then assemble into new viruses. Some viruses take over cell functions immediately. Other viruses wait for a while.

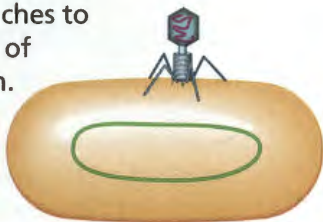
**Active Viruses** After entering a cell, an active virus immediately goes into action. The virus's genetic material takes over cell functions, and the cell quickly begins to produce the virus's proteins and genetic material. Then these parts assemble into new viruses. Like a photocopy machine left in the "on" position, the invaded cell makes copy after copy of new viruses. When it is full of new viruses, the host cell bursts open, releasing hundreds of new viruses as it dies.

FIGURE 3

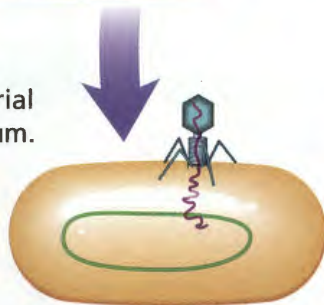
### Active and Hidden Viruses

Active viruses enter host cells and immediately begin to multiply, leading to the quick death of the invaded cells. Hidden viruses "hide" for a while inside host cells before becoming active.

- 1 A virus attaches to the surface of a bacterium.

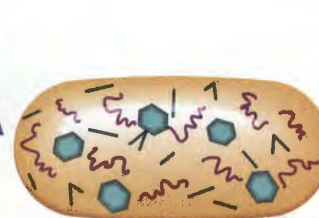


- 2 The virus injects its genetic material into the bacterium.



#### Active Virus

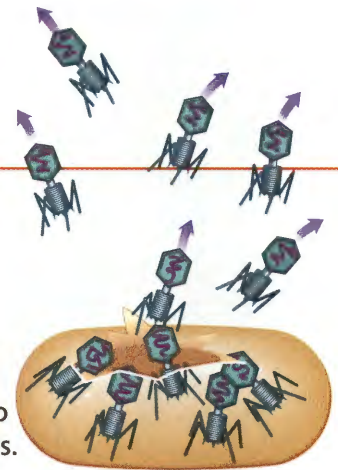
- 3 The virus's genetic material takes over the cell functions of the bacterium. The cell starts to produce the virus's proteins and genetic material.



- 4 The proteins and genetic material assemble into new viruses that fill the bacterium.

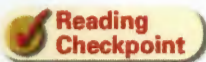


- 5 The bacterium bursts open, releasing new viruses. The viruses go on to infect more cells.



**Hidden Viruses** Other viruses do not immediately become active. Instead, they “hide” for a while. After a hidden virus enters a host cell, its genetic material becomes part of the cell’s genetic material. The virus does not appear to affect the cell’s functions and may stay in this inactive state for years. Each time the host cell divides, the virus’s genetic material is copied along with the host’s genetic material. Then, under certain conditions, the virus’s genetic material suddenly becomes active. It takes over the cell’s functions in much the same way that active viruses do. Soon, the cell is full of new viruses and bursts open.

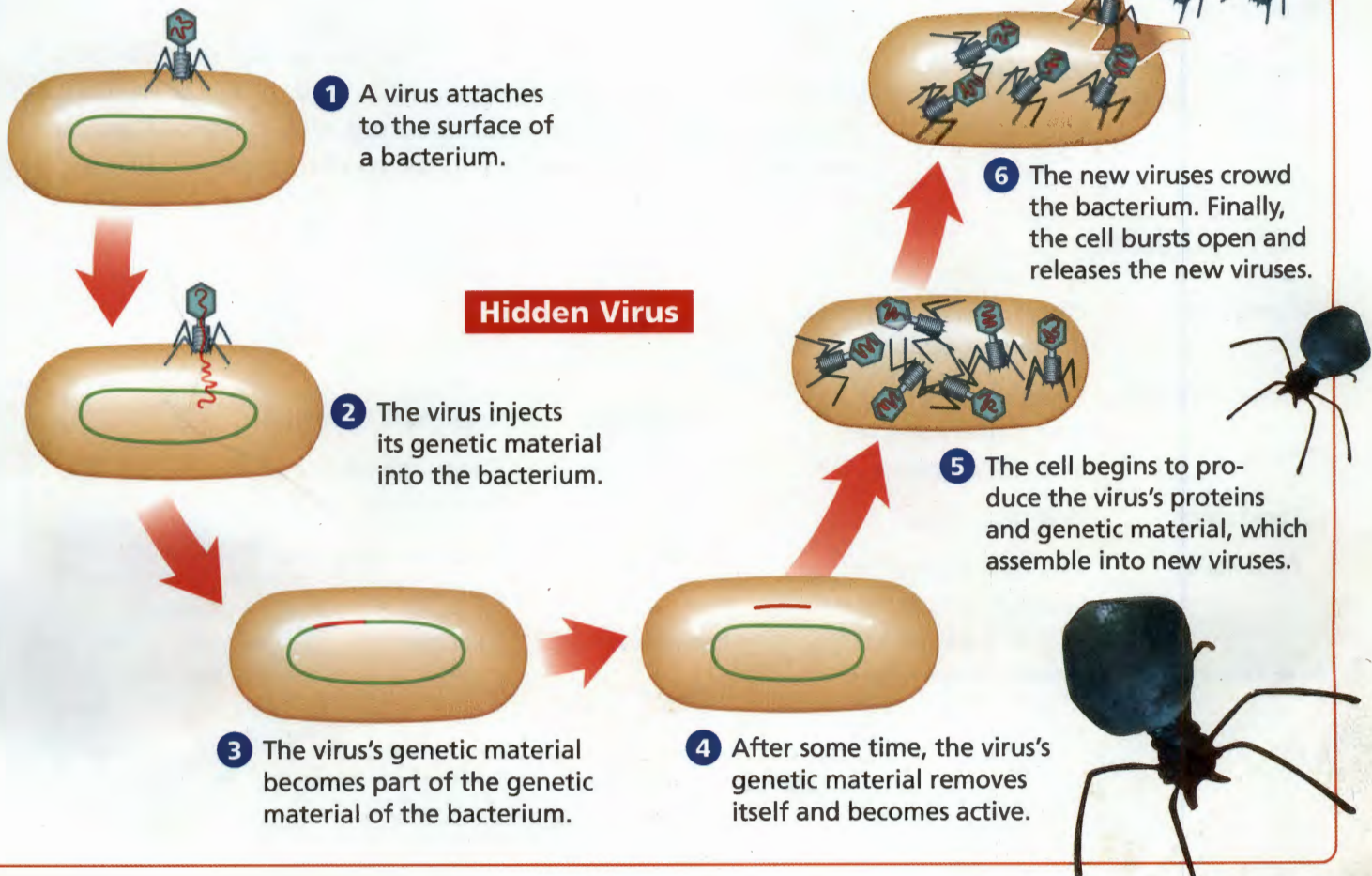
The virus that causes cold sores is an example of a hidden virus. It can remain inactive for months or years inside nerve cells in the face. While hidden, the virus causes no symptoms. When it becomes active, the virus causes a swollen, painful sore to form near the mouth. Strong sunlight and stress are two factors that scientists believe may activate a cold sore virus. After an active period, the virus once again “hides” in the nerve cells until it becomes active again.



**Reading Checkpoint** Where in a host cell does a hidden virus “hide” while it is inactive?

**Go Online**  
**active art**

For: Active and Hidden Viruses activity  
Visit: PHSchool.com  
Web Code: cep-1021



## Viruses and Disease

If you've ever had a cold or been sick with the flu, you know that viruses can cause disease. Some diseases, such as colds, are mild—people are sick for a short time but soon recover. Other diseases, such as acquired immunodeficiency syndrome, or AIDS, have much more serious consequences on the body.

Viruses also cause diseases in organisms other than humans. For example, apple trees infected by the apple mosaic virus may produce less fruit. House pets, such as dogs and cats, can get deadly viral diseases, such as rabies and distemper.

**The Spread of Viral Diseases** Viral diseases can be spread in various ways. For example, some viral diseases can be spread through contact with a contaminated object, while others are spread through the bite of an infected animal. Some viruses, such as cold and flu viruses, can travel in tiny drops of moisture that an infected person sneezes or coughs into the air. Other viruses can spread only through contact with body fluids, such as blood.

**Treating Viral Diseases** There are currently no cures for viral diseases. However, many over-the-counter medicines can help relieve symptoms of a viral infection. While they can make you feel better, these medicines can also delay your recovery if you resume your normal routine while you are still sick. The best treatment for viral infections is often bed rest. 🛌 **Resting, drinking plenty of fluids, and eating well-balanced meals may be all you can do while you recover from a viral disease.**

FIGURE 4

### Viral Diseases

Although there is currently no cure for viral diseases, there are ways to treat the symptoms and prevent their transmission.

**Relating Cause and Effect** *Why does the flu often pass quickly from one family member to another?*

#### INFLUENZA (Flu)

**Symptoms:** High fever; sore throat; headache; cough

**How It Spreads:** Contact with contaminated objects; inhaling droplets

**Treatment:** Bed rest; fluids

**Prevention:** Vaccine (mainly for the high-risk ill, elderly, and young)

#### CHICKENPOX

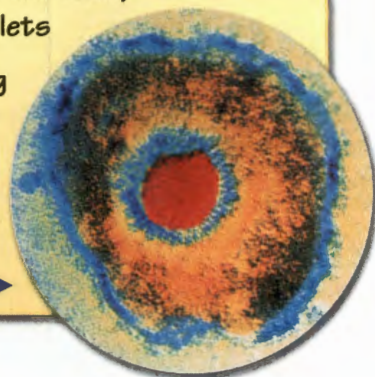
**Symptoms:** Fever; red, itchy rash

**How It Spreads:** Contact with the rash; inhaling droplets

**Treatment:** Antiviral drug (for adults)

**Prevention:** Vaccine

Chickenpox virus ▶



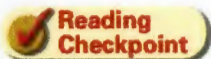
**Preventing Viral Diseases** Of course, you'd probably rather not get sick in the first place. An important tool that helps prevent the spread of many viral diseases is vaccines. A **vaccine** is a substance introduced into the body to stimulate the production of chemicals that destroy specific disease-causing viruses and organisms. A viral vaccine may be made from weakened or altered viruses. Because they have been weakened or altered, the viruses in the vaccine do not cause disease. Instead, they trigger the body's natural defenses. In effect, the vaccine puts the body "on alert." If that disease-causing virus ever invades the body, it is destroyed before it can cause disease. You may have been vaccinated against diseases such as polio, measles, and chickenpox.

Another important way to protect against viral diseases is to keep your body healthy. You need to eat nutritious food, as well as get enough sleep, fluids, and exercise. You can also protect yourself by washing your hands often and by not sharing eating or drinking utensils.

Unfortunately, despite your best efforts, you'll probably get viral infections, such as colds, from time to time. When you do get ill, get plenty of rest, and follow your doctor's recommendations. Also, it's very important to try not to infect others.



**FIGURE 5**  
**Vaccines**  
Veterinarians can give pets vaccine injections that protect the animals against many viral diseases.



**Reading Checkpoint**

Why don't vaccines cause disease themselves?

## Section 1 Assessment

S 7.2.a, 7.5 E-LA: Writing 7.2.4, Reading 7.2.0



### Target Reading Skill **Compare and Contrast**

Complete the Venn diagram comparing viruses and organisms. Use the diagram to help answer Question 1 below.



### Reviewing Key Concepts

- Defining** What is a virus?
  - Comparing and Contrasting** How are viruses similar to organisms?
  - Inferring** Scientists hypothesize that viruses could not have existed on Earth before organisms appeared. Use what you know about viruses to support this hypothesis.
- Identifying** What basic structure do all viruses share?
  - Relating Cause and Effect** What role do the proteins in a virus's outer coat play in the invasion of a host cell?

- Reviewing** How does an active virus multiply?
  - Sequencing** List the additional steps that occur when a hidden virus multiplies.
  - Classifying** Do you think that the cold virus is an active virus or a hidden virus? Explain.
- Reviewing** What is often the best treatment for viral diseases?
  - Explaining** How are vaccines important in preventing viral diseases?

## Writing in Science

**Public Service Announcement** Write a public service announcement for a radio show that teaches young children how to stay healthy during cold and flu season.

# How Many Viruses Fit on a Pin?

S 7.5.a, 7.7.d

## Problem

How can a model help you understand how small viruses are?

## Skills Focus

calculating, making models

## Materials

- straight pin • long strips of paper • pencil
- meter stick • scissors • tape
- calculator (optional)

## Procedure



1. Examine the head of a straight pin. Write a prediction about the number of viruses that could fit on the pinhead. **CAUTION:** Avoid pushing the pin against anyone's skin.
2. Assume that the pinhead has a diameter of about 1 mm. If the pinhead were enlarged 10,000 times, then its diameter would measure 10 m. Create a model of the pinhead by cutting and taping together narrow strips of paper to make a strip that is 10 m long. The strip of paper represents the diameter of the enlarged pinhead.
3. Lay the 10-m strip of paper on the floor of your classroom or in the hall. Imagine creating a large circle that had the strip as its diameter. The circle would be the pinhead at the enlarged size. Calculate the area of the enlarged pinhead using this formula:

$$\text{Area} = \pi \times \text{Radius}^2$$

Remember that you can find the radius by dividing the diameter by 2.

4. A virus particle may measure 200 nm on each side (1 nm equals a billionth of a meter). If the virus were enlarged 10,000 times, each side would measure 0.002 m. Cut out a square 0.002 m by 0.002 m to serve as a model for a virus. (*Hint:* 0.002 m = 2 mm.)



5. Next, find the area in meters of one virus particle at the enlarged size. Remember that the area of a square equals side  $\times$  side.
6. Now divide the area of the pinhead that you calculated in Step 3 by the area of one virus particle to find out how many viruses could fit on the pinhead.
7. Exchange your work with a partner, and check each other's calculations.

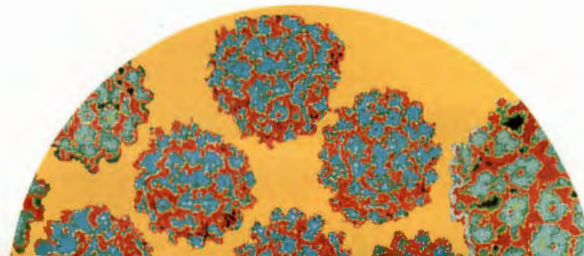
## Analyze and Conclude

1. **Calculating** Approximately how many viruses can fit on the head of a pin?
2. **Predicting** How does your calculation compare with the prediction you made? If the two numbers are very different, explain why your prediction may have been inaccurate.
3. **Making Models** What did you learn about the size of viruses by magnifying both the viruses and pinhead to 10,000 times their actual size?
4. **Communicating** In a paragraph, explain why scientists sometimes make and use enlarged models of very small things such as viruses.

## More to Explore

Think of another everyday object that you could use to model some other facts about viruses, such as their shapes or how they infect cells. Describe your model and explain why the object would be a good choice.

These papilloma viruses, which cause warts, are about 50 nm in diameter. ▼







## Bacteria

## CALIFORNIA

## Standards Focus

**S 7.1** All living organisms are composed of cells, from just one to many trillions, whose details usually are visible only through a microscope.

**S 7.2.a** Students know the differences between the life cycles and reproduction methods of sexual and asexual organisms.

-  How do the cells of bacteria differ from those of eukaryotes?
-  What do bacteria need to survive?
-  Under what conditions do bacteria thrive and reproduce?
-  What positive roles do bacteria play in people's lives?

**Key Terms**

- bacteria
- flagellum
- binary fission
- asexual reproduction
- sexual reproduction
- conjugation
- endospore
- pasteurization
- decomposer

## Lab zone

## Standards Warm-Up

**How Quickly Can Bacteria Multiply?**

1. Your teacher will give you some beans and paper cups. Number the cups 1 through 8. Each bean will represent a bacterial cell.
2. Put one bean into cup 1 to represent the first generation of bacteria. Approximately every 20 minutes, a bacterial cell reproduces by dividing into two cells. Put two beans into cup 2 to represent the second generation of bacteria.
3. Calculate how many bacterial cells there would be in the third generation if each cell in cup 2 divided into two cells. Place the correct number of beans in cup 3.
4. Repeat Step 3 five more times. All the cups should now contain beans. How many cells are in the eighth generation? How much time has elapsed since the first generation?

**Think It Over**

**Inferring** Based on this activity, explain why the number of bacteria can increase rapidly in a short period of time.

They thrive in your container of yogurt. They lurk in your kitchen sponge. They coat your skin and swarm inside your nose. You cannot escape them because they live almost everywhere—under rocks, in the ocean, and all over your body. In fact, there are more of these organisms in your mouth than there are people on Earth! You don't notice them because they are very small. These organisms are bacteria.

**The Bacterial Cell**

Although there are billions of bacteria on Earth, they were not discovered until the late 1600s. A Dutch merchant named Anton van Leeuwenhoek (LAY vun hook) found them by accident. Leeuwenhoek made microscopes as a hobby. One day, while using one of his microscopes to look at scrapings from his teeth, he saw some tiny, wormlike organisms in the sample. However, Leeuwenhoek's microscopes were not powerful enough to see any details inside these organisms.

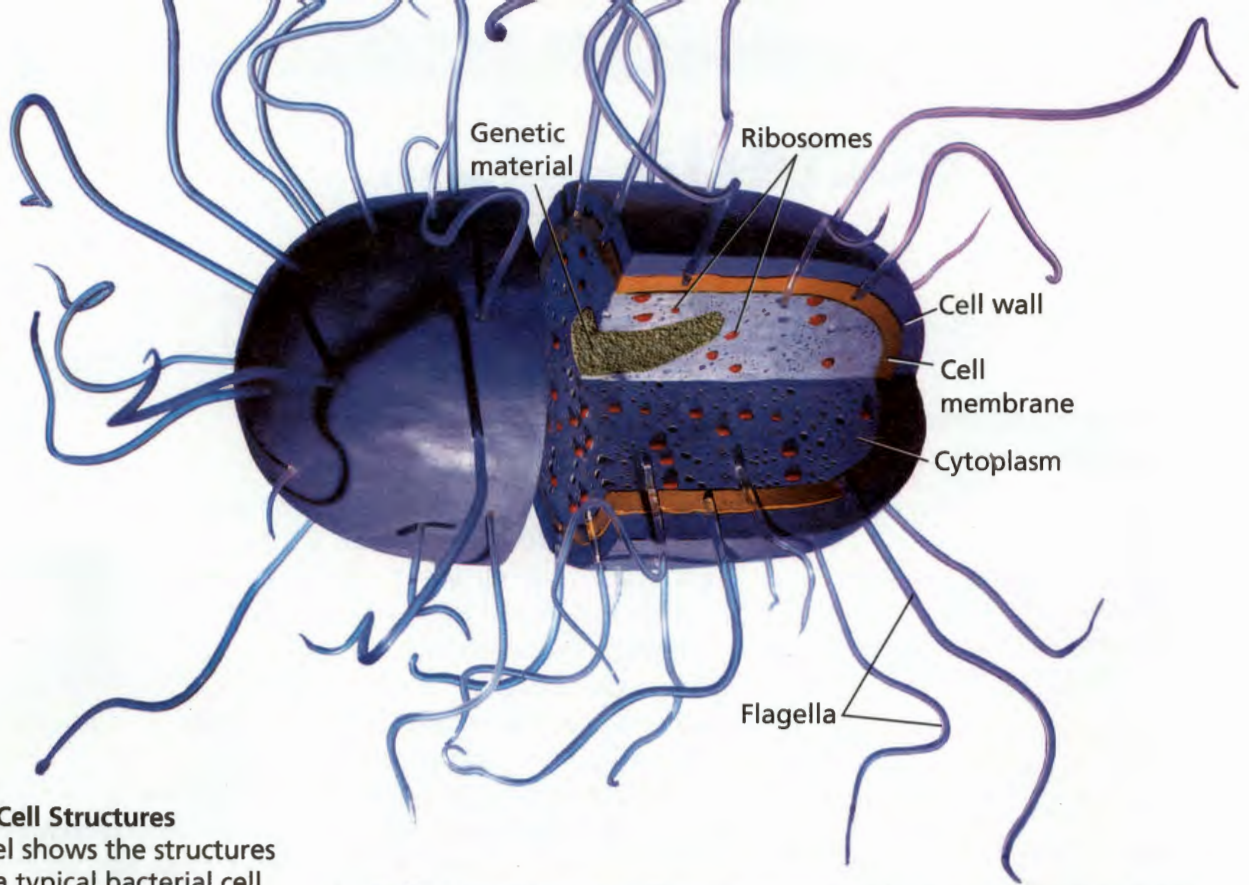


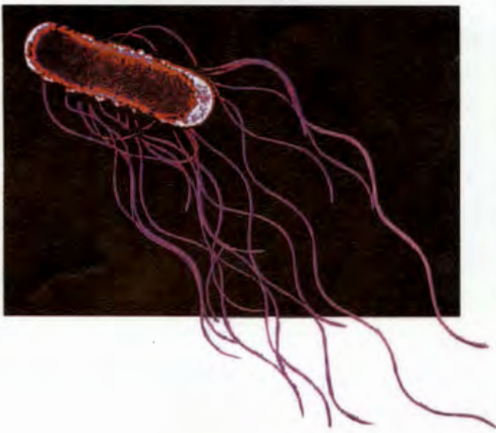
FIGURE 6

### Bacterial Cell Structures

This model shows the structures found in a typical bacterial cell.

#### Relating Diagrams and Photos

What structures does the *Salmonella bacterium* in the photograph use to move?



**Cell Structures** What Leeuwenhoek saw were single-celled organisms called **bacteria** (singular *bacterium*). 🦠 **Bacteria are prokaryotes. The genetic material in their cells is not contained in a nucleus.** A bacterial cell lacks a nucleus and also lacks many other structures, such as mitochondria and Golgi bodies, that are found in the cells of eukaryotes.

Most bacterial cells, like plant cells, are surrounded by a rigid cell wall. Just inside the cell wall is the cell membrane. Located in the cytoplasm are ribosomes and the genetic material, which looks like a tangled string. If you could untangle the genetic material, you would see that it forms a circular shape.

A bacterial cell may also have a **flagellum** (fluh JEL um) (plural *flagella*), a long, whiplike structure that helps a cell to move. A flagellum moves the cell by spinning in place like a propeller. A bacterial cell can have many flagella, one, or none. Most bacteria that do not have flagella cannot move on their own. Instead, they are carried from place to place by the air, water currents, objects, or other methods.

**Cell Sizes and Shapes** Bacteria vary greatly in size. The largest known bacterium is about as big as the period at the end of this sentence. An average bacterium, however, is much smaller. For example, strep throat bacteria are about 0.5 to 1 micrometer in diameter. Most bacterial cells have one of three basic shapes: spherical, rodlike, or spiral. The chemical makeup of the cell wall determines the shape of a bacterial cell.

## Obtaining Food and Energy

Like other organisms, there are significant differences among bacteria that live in different environments. For example, *Thermus thermophilus* bacteria live in extremely hot geysers. They contain enzymes that help them function at high temperatures.

However, no matter how different, all bacteria need certain things to survive. 🚗 **Bacteria must have a source of food and a way of breaking down the food to release its energy.**

**Obtaining Food** Some bacteria are autotrophs and make their own food. Autotrophic bacteria make food in one of two ways. Some capture and use the sun's energy as plants do. Others, such as bacteria that live deep in mud, do not use the sun's energy. Instead, these bacteria use the energy from chemical substances in their environment to make their food.

Some bacteria are heterotrophs and cannot make their own food. Instead, these bacteria consume other organisms or the food that other organisms make. Heterotrophic bacteria consume a variety of foods—from milk and meat, which you might also eat, to the decaying leaves on a forest floor.

**Respiration** Like all organisms, bacteria need a constant supply of energy. This energy comes from breaking down food in the process of respiration. Like many other organisms, most bacteria need oxygen to break down their food. But a few kinds of bacteria, such as *Escherichia coli* living in your intestines, do not need oxygen for respiration. Some kinds of bacteria will even die if exposed to oxygen.




### Reading Checkpoint

What do most bacteria need in order to break down their food?

Lab  
zone

## Try This Activity

### Bacteria for Breakfast

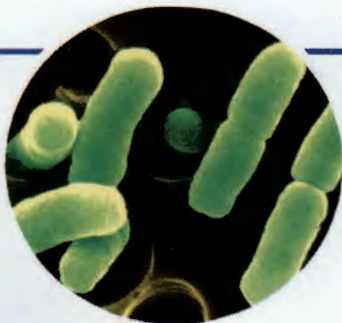
1. Put on your apron. Add water to plain yogurt to make a thin mixture.
2. With a plastic dropper, place a drop of the mixture on a glass slide.
3. Use another plastic dropper to add one drop of methylene blue dye to the slide. **CAUTION:** This dye can stain your skin.
4.  Put a coverslip on the slide. Observe the slide under both the low- and high-power lenses of a microscope.

**Observing** Draw what you see under high power.

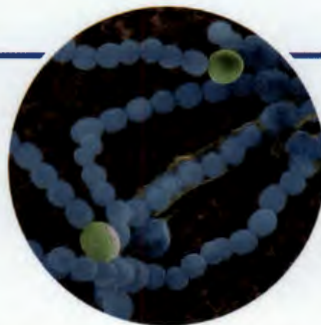
FIGURE 7

### Obtaining Food

Bacteria obtain food in several ways.



▲ These heterotrophic bacteria, found in yogurt, break down the sugars in milk for food.



▲ The autotrophic bacteria that cause the green, cloudy scum in some ponds use the sun's energy to make food.



▲ These autotrophic bacteria, found in hot springs, use chemical energy from their environment to make food.



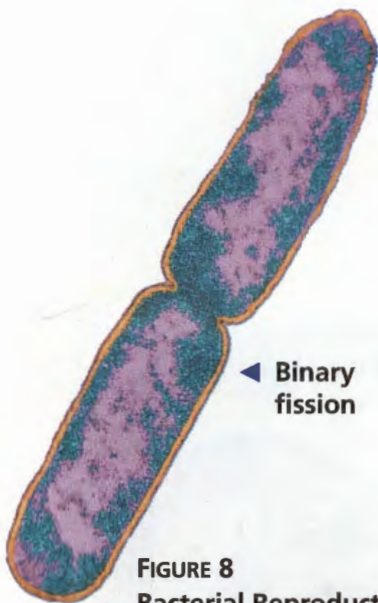
## Reproduction

🇺🇸 When bacteria have enough food, the right temperature, and other suitable conditions, they thrive and reproduce frequently. Under these ideal conditions, some bacteria can reproduce as often as once every 20 minutes. So it's a good thing that growing conditions for bacteria are rarely ideal!

**Asexual Reproduction** Bacteria reproduce by a process called **binary fission**, in which one cell divides to form two identical cells. Binary fission is a form of asexual reproduction. **Asexual reproduction** is a reproductive process that involves only one parent and produces offspring that are identical to the parent. During binary fission, a cell first duplicates its genetic material and then divides into two separate cells. Each new cell gets its own complete copy of the parent cell's genetic material as well as some of the parent's ribosomes and cytoplasm.

**Sexual Reproduction** Some bacteria may at times undergo a form of sexual reproduction. In **sexual reproduction**, two parents combine their genetic material to produce a new organism, which differs from both parents. During a process called **conjugation** (kahn juh GAY shun), one bacterium transfers some genetic material to another bacterium through a threadlike bridge. After the transfer, the cells separate.

Conjugation results in bacteria with new combinations of genetic material. Then, when these bacteria divide by binary fission, the new combinations of genetic material pass to the offspring. Conjugation does not increase the number of bacteria. However, it does result in bacteria that are genetically different.



**FIGURE 8**  
**Bacterial Reproduction**  
In binary fission, one cell divides to form two identical cells. During conjugation, one bacterium transfers genetic material to another bacterium.



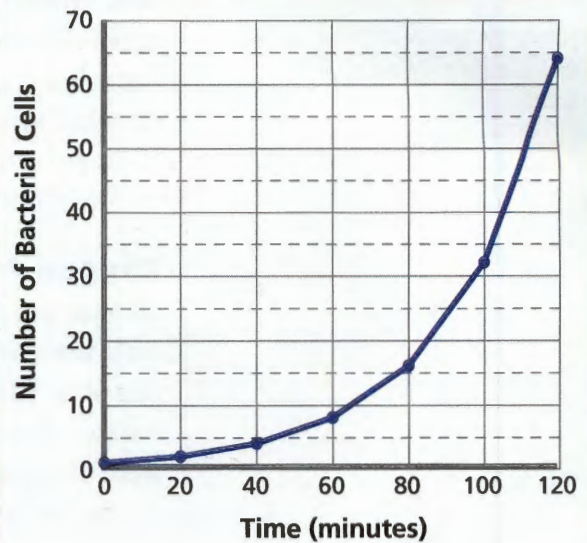
## Math

## Analyzing Data

**Population Explosion**

Suppose a bacterium reproduces by binary fission every 20 minutes. The new cells survive and reproduce at the same rate. This graph shows how the bacterial population would grow from a single bacterium.

- 1. Reading Graphs** What variable is being plotted on the horizontal axis? What is being plotted on the vertical axis?
- 2. Interpreting Data** According to the graph, how many cells are there after 20 minutes? After 1 hour? After 2 hours?
- 3. Drawing Conclusions** Describe the pattern you see in the way the bacterial population increases over 2 hours.

**Bacterial Reproduction by Binary Fission**

**Endospore Formation** Sometimes, conditions in the environment become unfavorable for the growth of bacteria. For example, food sources can disappear, water can dry up, or the temperature can fall or rise dramatically. Some bacteria can survive harsh conditions by forming endospores like those in Figure 9. An **endospore** is a small, rounded, thick-walled, resting cell that forms inside a bacterial cell. It contains the cell's genetic material and some of its cytoplasm.

Because endospores can resist freezing, heating, and drying, they can survive for many years. For example, the bacteria that cause botulism, *Clostridium botulinum*, produce heat-resistant endospores that can survive in improperly canned foods. Endospores are also light—a breeze can carry them to new places. If an endospore lands where conditions are suitable, it opens up. Then the bacterium can begin to grow and multiply.



**Reading Checkpoint**

Under what conditions do endospores form?

**FIGURE 9**

**Endospores**

The red circles within these bacteria are endospores that can survive for years. When conditions in the environment become favorable, the bacteria can begin to grow and multiply.



## The Role of Bacteria in Nature

When you hear the word *bacteria*, you may think about getting sick. After all, strep throat, many ear infections, and other diseases are caused by bacteria. However, most bacteria are either harmless or helpful to people. In fact, in many ways, people depend on bacteria. 🌱 **Bacteria are involved in oxygen and food production, environmental recycling and cleanup, and in health maintenance and medicine production.**

**Oxygen Production** Would it surprise you to learn that the air you breathe depends in part on bacteria? As autotrophic bacteria use the sun's energy to produce food, they also release oxygen into the air. Billions of years ago, there was little oxygen in Earth's atmosphere. Scientists think that autotrophic bacteria were responsible for first adding oxygen to Earth's atmosphere. Today, the distant offspring of those bacteria help keep oxygen levels in the air stable.

## Science and History

### Bacteria and Foods of the World

Ancient cultures lacked refrigeration and other modern methods of preventing food spoilage. People in these cultures developed ways of using bacteria to preserve foods. You may enjoy some of these foods today.

#### 2300 B.C. Cheese

Ancient Egyptians made cheese from milk. Cheese-making begins when bacteria feed on the sugars in milk. The milk separates into solid curds and liquid whey. The curds are processed into cheeses, which keep longer than milk.



2500 B.C.



#### 1000 B.C. Pickled Vegetables

The Chinese salted vegetables and packed them in containers. Naturally occurring bacteria fed on the vegetables and produced a sour taste. The salt pulled water out of the vegetables and left them crisp. These vegetables were part of the food rations given to workers who built the Great Wall of China.

1500 B.C.

#### 500 B.C. Dried Meat

People who lived in the regions around the Mediterranean Sea chopped meat, seasoned it with salt and spices, rolled it, and hung it to dry. Bacteria in the drying meat gave unique flavors to the food. The rolled meat would keep for weeks in cool places.

500 B.C.

**Food Production** Do you like cheese, sauerkraut, or pickles? The activities of helpful bacteria produce all of these foods and more. For example, bacteria that grow in apple cider change the cider to vinegar. Bacteria that grow in milk produce dairy products such as buttermilk, yogurt, sour cream, and cheeses.

However, some bacteria cause food to spoil when they break down the food's chemicals. Spoiled food usually smells or tastes foul and can make you very sick. Refrigerating and heating foods are two ways to slow down food spoilage. Another method, called pasteurization, is most often used to treat beverages such as milk and juice. During **pasteurization** (pas chur ih ZAY shun), the food is heated to a temperature that is high enough to kill most harmful bacteria without changing the taste of the food. As you might have guessed, this process was named after Louis Pasteur, its inventor.

## Writing in Science

**Research and Write** Use the Internet to find out more about one of these ancient food-production methods and the culture that developed it. Write a report about the importance of the food to the culture.



### A.D. 500 Soy Sauce

People in China crushed soybeans into mixtures of wheat, salt, bacteria, and other microorganisms. The microorganisms fed on the proteins in the wheat and soybeans. The salt pulled water out of the mixture. The protein-rich soy paste that remained was used to flavor foods. The soy sauce you may use today is made in a similar manner.

A.D. 500

### A.D. 1500 Chocolate Beverage

People in the West Indies mixed beans from the cocoa plant with bacteria and other microorganisms and then dried and roasted them. The roasted beans were then brewed to produce a beverage with a chocolate flavor. The drink was served cold with honey, spices, and vanilla.



A.D. 1500

### A.D. 1850 Sourdough Bread

Gold prospectors in California ate sourdough bread. The *Lactobacillus sanfrancisco* bacteria gave the bread its sour taste. Each day before baking, cooks would set aside some dough that contained the bacteria to use in the next day's bread.



A.D. 2500



FIGURE 10

### Environmental Recycling

Decomposing bacteria are at work recycling the chemicals in these leaves. **Predicting** What might a forest be like if there were no decomposing bacteria in the soil?

**Environmental Recycling** If you recycle glass or plastic, then you have something in common with some heterotrophic bacteria. These bacteria, which live in the soil, are **decomposers**—organisms that break down large chemicals in dead organisms into small chemicals.

Decomposers are “nature’s recyclers.” They return basic chemicals to the environment for other living things to reuse. For example, the leaves of many trees die in autumn and drop to the ground. Decomposing bacteria spend the next months breaking down the chemicals in the dead leaves. The broken-down chemicals mix with the soil and can then be absorbed by the roots of nearby plants.

Another type of recycling bacteria, called nitrogen-fixing bacteria, help plants survive. Nitrogen-fixing bacteria live in the soil and in swellings on the roots of certain plants, such as peanut, pea, and soybean. These helpful bacteria convert nitrogen gas from the air into nitrogen products that plants need to grow. On their own, plants cannot use nitrogen present in the air. Therefore, nitrogen-fixing bacteria are vital to the plants’ survival.

**Environmental Cleanup** Some bacteria help to clean up Earth’s land and water. Can you imagine having a bowl of oil for dinner instead of soup? Well, some bacteria prefer the oil. They convert the poisonous chemicals in oil into harmless substances. Scientists have put these bacteria to work cleaning up oil spills in oceans and gasoline leaks in the soil under gas stations.



**Reading Checkpoint** What role do bacterial decomposers play in the environment?



FIGURE 11

### Environmental Cleanup

Scientists use bacteria such as these *Ochrobactrum anthropi* to help clean up oil spills.



**Health and Medicine** Did you know that many of the bacteria living in your body actually keep you healthy? In your digestive system, for example, your intestines teem with bacteria. Some help you digest your food. Some make vitamins that your body needs. Others compete for space with disease-causing organisms, preventing the harmful bacteria from attaching to your intestines and making you sick.

Scientists have put some bacteria to work making medicines and other substances. The first medicine-producing bacteria were made in the 1970s. By manipulating the bacteria's genetic material, scientists engineered bacteria to produce human insulin. Although healthy people can make their own insulin, those with some types of diabetes cannot. Many people with diabetes need to take insulin daily. Thanks to bacteria's fast rate of reproduction, large numbers of insulin-making bacteria can be grown in huge vats. The human insulin they produce is then purified and made into medicine.



**FIGURE 12**  
**Bacteria and Digestion**  
Bacteria living naturally in your intestines help you digest food.

## Section 2 Assessment

S 7.2.a, 7.1,  
E-LA: Reading 7.1.0

**Vocabulary Skill Prefixes** The prefix *a-* means “without.” Use the meaning of the prefix to contrast asexual reproduction and sexual reproduction.

### Reviewing Key Concepts

- a. Reviewing** Where is the genetic material located in a bacterial cell?

**b. Describing** What is the role of flagella in a bacterial cell?
- a. Listing** What are the three ways in which bacteria obtain food?

**b. Describing** How do bacteria obtain energy to carry out their functions?

**c. Inferring** You have just discovered a new bacterium that lives inside sealed cans of food. How do you think these bacteria obtain food and energy?
- a. Defining** What is binary fission?

**b. Explaining** Under what conditions do bacteria thrive and reproduce frequently by binary fission?

**c. Inferring** Why might bacteria that undergo conjugation be better able to survive when conditions become less than ideal?
- a. Listing** A friend states that all bacteria are harmful to people. List three reasons why this statement is inaccurate.

**b. Applying Concepts** In what ways might bacteria contribute to the success of a garden in which pea plants are growing?

Lab  
zone

### At-Home Activity

**Edible Bacteria** With a family member, look around your kitchen for foods that are made using bacteria. Read the food labels to see if bacteria are used in the food's production. Discuss with your family member the helpful roles that bacteria play in people's lives.

# Protists

**CALIFORNIA**
**Standards Focus**

**S 7.5.a** Students know plants and animals have levels of organization for structure and function, including cells, tissues, organs, organ systems, and the whole organism.

- What are the characteristics of animal-like, plantlike, and funguslike protists?
- How do algae vary in organization, structure, and function?

**Key Terms**

- protist
- protozoan
- pseudopod
- contractile vacuole
- cilia
- symbiosis
- mutualism
- algae
- spore

**Lab zone**
**Standards Warm-Up**
**What Lives in a Drop of Pond Water?**

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


**Think It Over**

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

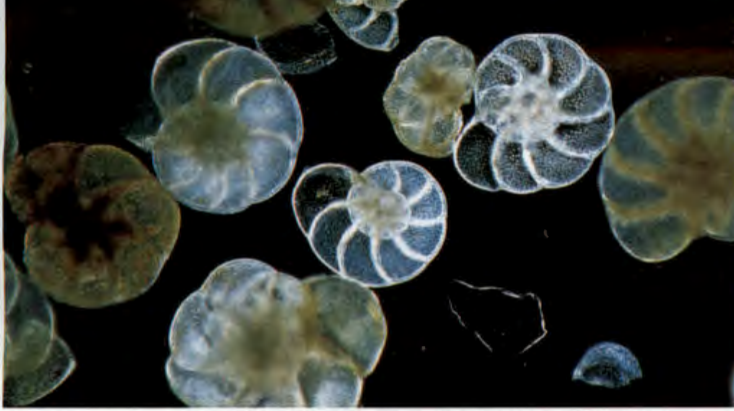
Look at the objects in Figure 13. What do they look like to you? Jewels? Beads? Stained glass ornaments? You might be surprised to learn that these beautiful, delicate structures are the walls of unicellular organisms called diatoms. Diatoms live in both fresh water and salt water and are an important food source for many marine organisms. They have been called the “jewels of the sea.”

**FIGURE 13**

**Diatoms**

These glasslike organisms are classified as protists.





▲ These shells are the remains of unicellular, animal-like protists called foraminifera.

## FIGURE 14 Protists

Protists include animal-like, plantlike, and funguslike organisms.

**Comparing and Contrasting** *In what ways do protists differ from one another?*

## What Is a Protist?

Diatoms are only one of the vast varieties of protists. **Protists** are eukaryotes that cannot be classified as animals, plants, or fungi. The word that best describes protists is *diversity*. For example, most protists are unicellular, but some are multicellular. Some are heterotrophs, some are autotrophs, and others are both. Some protists cannot move, while others can. In fact, protists are so diverse some scientists think that protists belong in separate kingdoms. Biologists continue to study the DNA sequences and evolutionary histories of the various groups of protists.

Despite their diversity, protists do share some characteristics. In addition to being eukaryotes, all protists live in moist surroundings. Most protists reproduce asexually—the cells simply grow and divide. However, some types of protists can reproduce sexually as well. One useful way of grouping protists is to divide them into three categories, based on characteristics they share with organisms in other kingdoms: animal-like protists, plantlike protists, and funguslike protists.

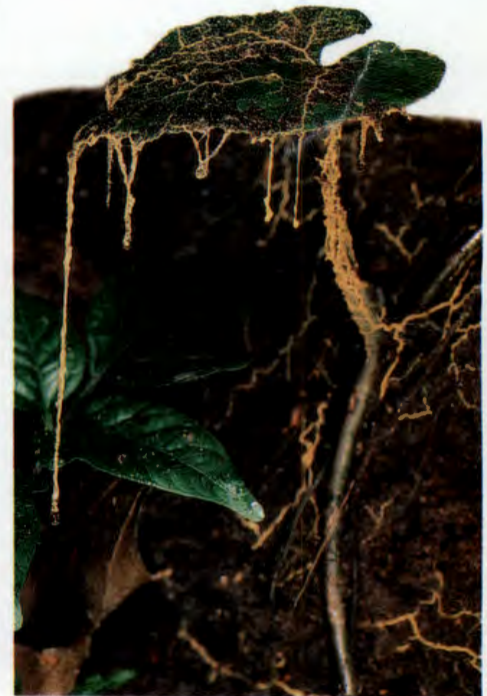
## Animal-Like Protists

What image pops into your head when you think of an animal? A tiger chasing its prey? A snake slithering onto a rock? Most people immediately associate animals with movement. In fact, movement is often involved with an important function of animals—obtaining food. All animals are heterotrophs that must obtain food by eating other organisms.

👉 **Like animals, animal-like protists are heterotrophs, and most are able to move from place to place to obtain food.** But unlike animals, animal-like protists, or **protozoans** (proh tuh ZOH unz), are unicellular. Protozoans can be classified into four groups, based on the way they move and live.



▲ This red alga is a multicellular, plantlike protist found on ocean floors.



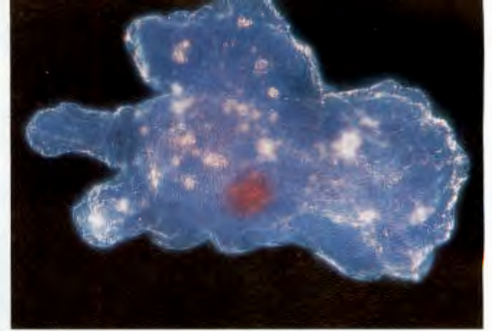
▲ The yellow slime mold oozing off the leaf is a funguslike protist.



FIGURE 15

## Amoeba

Amoebas are sarcodines that live in either water or soil. They feed on bacteria and smaller protists.

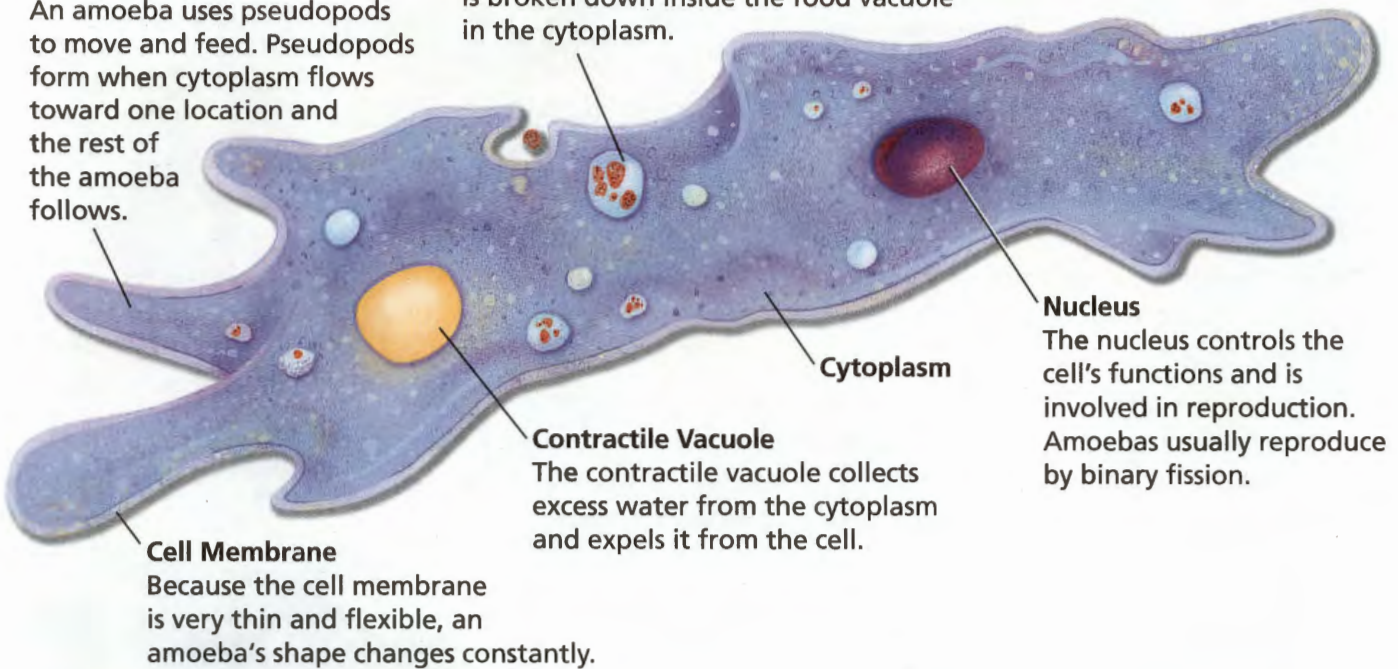


### Pseudopod

An amoeba uses pseudopods to move and feed. Pseudopods form when cytoplasm flows toward one location and the rest of the amoeba follows.

### Food Vacuole

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



### Nucleus

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

### Cell Membrane

Because the cell membrane is very thin and flexible, an amoeba's shape changes constantly.

Go  Online  
**active art**

For: Amoeba and Paramecium activity  
Visit: PHSchool.com  
Web Code: cep-1031

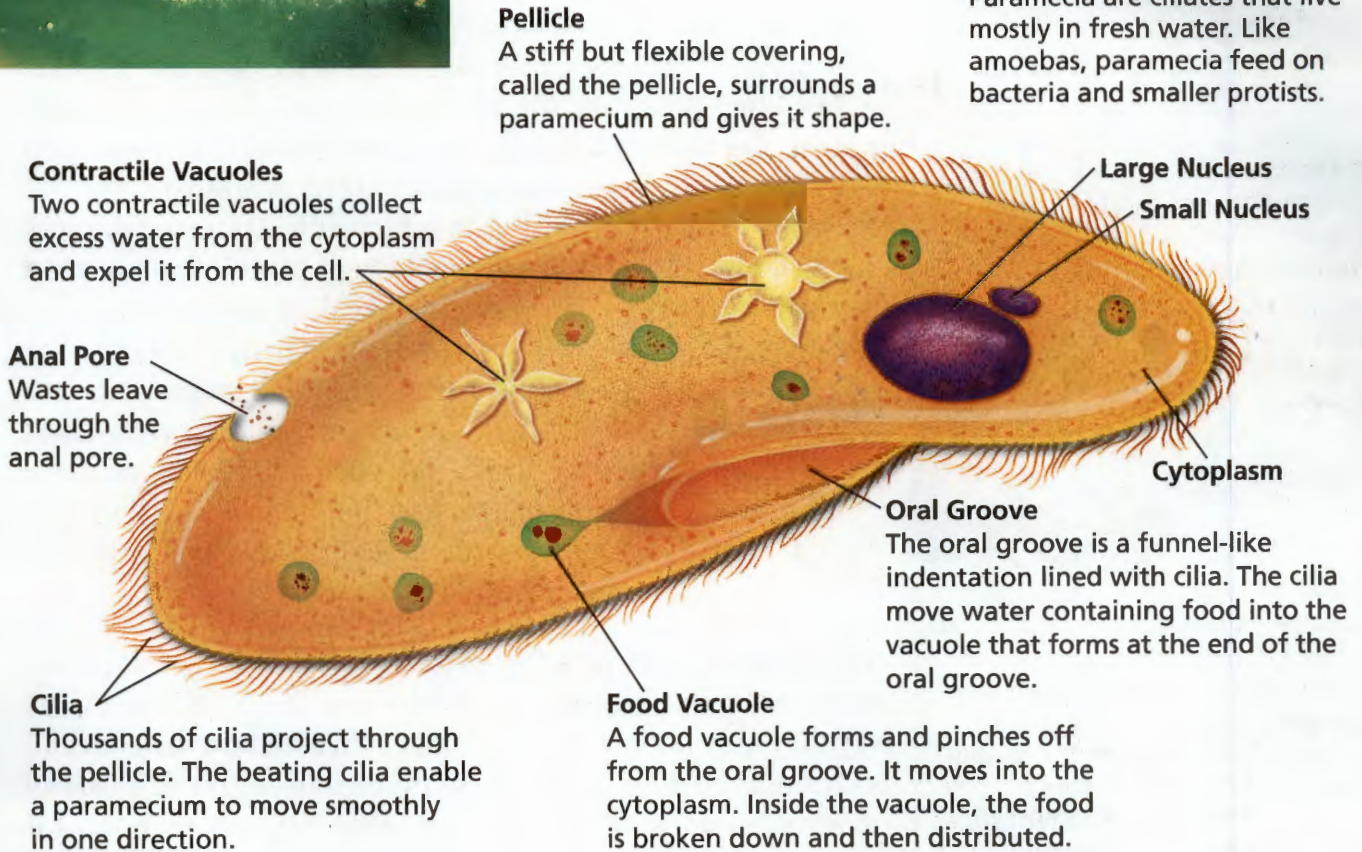
**Protozoans With Pseudopods** The amoeba in Figure 15 belongs to the group of protozoans called sarcodines. Sarcodines move and feed by forming **pseudopods** (SOO duh pahdz)—temporary bulges of the cell. The word *pseudopod* means “false foot.” Pseudopods form when cytoplasm flows toward one location and the rest of the organism follows. Pseudopods enable sarcodines to move. For example, amoebas use pseudopods to move away from bright light. Sarcodines also use pseudopods to trap food. The organism extends a pseudopod on each side of the food particle. The two pseudopods then join together, trapping the particle inside.

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



**FIGURE 16**  
**Paramecium**

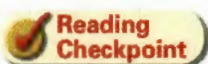
Paramecia are ciliates that live mostly in fresh water. Like amoebas, paramecia feed on bacteria and smaller protists.



**Protozoans With Cilia** The second group of animal-like protists are the ciliates. Ciliates have structures called **cilia** (SIL ee uh), which are hairlike projections from cells that move with a wavelike motion. Ciliates use their cilia to move and obtain food. Cilia act something like tiny oars to move a ciliate. Their movement sweeps food into the organism.

The cells of ciliates, like the paramecium in Figure 16, are complex. Notice that the paramecium has two contractile vacuoles that expel water from the cell. It also has more than one nucleus. The large nucleus controls the everyday tasks of the cell. The small nucleus functions in reproduction.

Paramecia usually reproduce asexually by binary fission. Sometimes, however, paramecia reproduce by conjugation. This occurs when two paramecia join together and exchange some of their genetic material.



**Reading Checkpoint** What are cilia?



**FIGURE 17**  
**Giardia**

When people drink from freshwater streams and lakes, they can get hiker's disease. *Giardia intestinalis* (inset) is the protozoan responsible for this disease.

**Inferring** Why is it important for hikers to filter stream water?



**Protozoans With Flagella** The third group of protozoans are flagellates (FLAJ uh lits), protists that use long, whiplike flagella to move. A flagellate may have one or more flagella.

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

Sometimes, however, a protozoan harms its host. For example, *Giardia* is a parasite in humans. Wild animals, such as beavers, deposit *Giardia* in freshwater streams, rivers, and lakes. When a person drinks water containing *Giardia*, these protozoans attach to the person's intestine, where they feed and reproduce. The person develops a serious intestinal condition commonly called hiker's disease.

**Protozoans That Are Parasites** The fourth type of protozoans are characterized more by the way they live than by the way they move. They are all parasites that feed on the cells and body fluids of their hosts. These protozoans move in a variety of ways. Some have flagella, and some depend on hosts for transport. One even produces a layer of slime that allows it to slide from place to place!

Many of these parasites have more than one host. For example, *Plasmodium* is a protozoan that causes malaria, a disease of the blood. Two hosts are involved in *Plasmodium's* life cycle—humans and a species of mosquitoes found in tropical areas. The disease spreads when a healthy mosquito bites a person with malaria. The mosquito then becomes infected with *Plasmodium*. When the mosquito next bites a healthy person, the mosquito passes the *Plasmodium* to that person. Symptoms of malaria include high fevers that alternate with severe chills.



**Reading  
Checkpoint**

What is symbiosis?

**FIGURE 18**


**Malaria Mosquito**

*Anopheles* mosquitoes can carry the parasitic protozoan *Plasmodium*, which causes malaria in people.

## Plantlike Protists

Plantlike protists, which are commonly called **algae** (AL jee), are extremely diverse. Like plants, algae are autotrophs. Most are able to use the sun's energy to make their own food. They can perform photosynthesis.

Algae play a significant role in many environments. For example, algae that live near the surface of ponds, lakes, and oceans are an important food source for other organisms in the water. In addition, much of the oxygen in Earth's atmosphere is made by these algae.

 **Algae vary greatly in cell organization, structure, and function. Some algae are unicellular. Other algae are multicellular with differentiated tissues and organs. Still others are groups of unicellular organisms that live together in colonies.** Algal colonies can contain from a few cells up to thousands of cells. In a colony, most cells carry out all functions. But, some cells may become specialized to perform certain functions, such as reproduction.

Algae exist in a wide variety of colors because they contain many types of pigments. You may recall that pigments are chemicals that produce color. Depending on their pigments, algae can be green, yellow, red, brown, orange, or even black.

**Diatoms** Diatoms are unicellular protists with beautiful glasslike cell walls. Some float near the surface of lakes or oceans. Others attach to objects such as rocks in shallow water. Diatoms are a food source for heterotrophs in the water. Many diatoms can move by oozing chemicals out of slits in their cell walls. They then glide in the slime.

When diatoms die, their cell walls collect on the bottoms of oceans and lakes. Over time, they form layers of a coarse substance called diatomaceous (dy uh tuh MAY shus) earth. Diatomaceous earth makes a good polishing agent and is used in household scouring products. It is even used as an insecticide—the diatoms' sharp cell walls puncture the bodies of insects.

**Dinoflagellates** Dinoflagellates (dy noh FLAJ uh lits) are unicellular algae surrounded by stiff plates that look like a suit of armor. Because they have different amounts of green, orange, and other pigments, dinoflagellates exist in a variety of colors.


All dinoflagellates have two flagella held in grooves between their plates. When the flagella beat, the dinoflagellates twirl like toy tops as they move through the water. Many glow in the dark. They light up the ocean's surface when disturbed by a passing boat or swimmer.

Lab  
zone

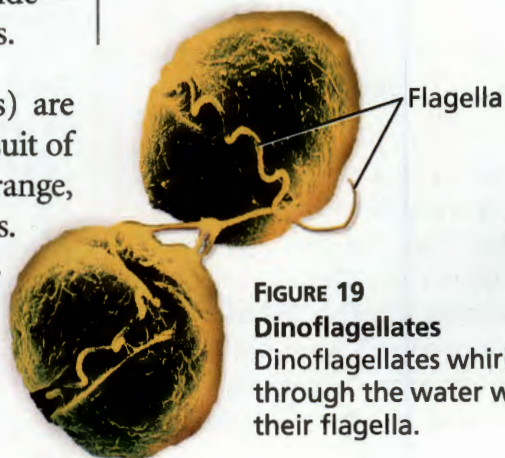
## Try This Activity

### Watching Protists

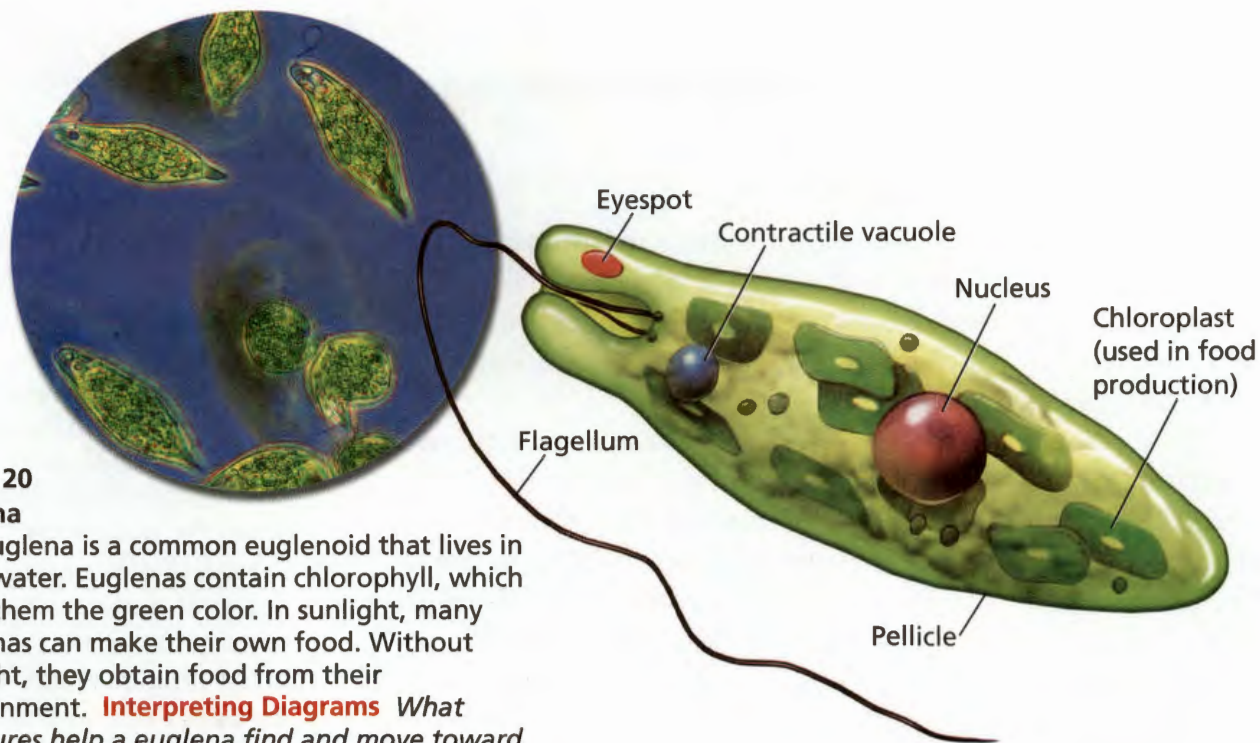
In this activity you will watch the interaction between paramecium, an animal-like protist, and *Chlorella*, a plantlike protist.

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

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



**FIGURE 19**  
**Dinoflagellates**  
Dinoflagellates whirl through the water with their flagella.



**FIGURE 20**  
**Euglena**

The euglena is a common euglenoid that lives in fresh water. Euglenas contain chlorophyll, which gives them the green color. In sunlight, many euglenas can make their own food. Without sunlight, they obtain food from their environment. **Interpreting Diagrams** What structures help a euglena find and move toward light?

**Lab zone**

## Skills Activity

### Predicting

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

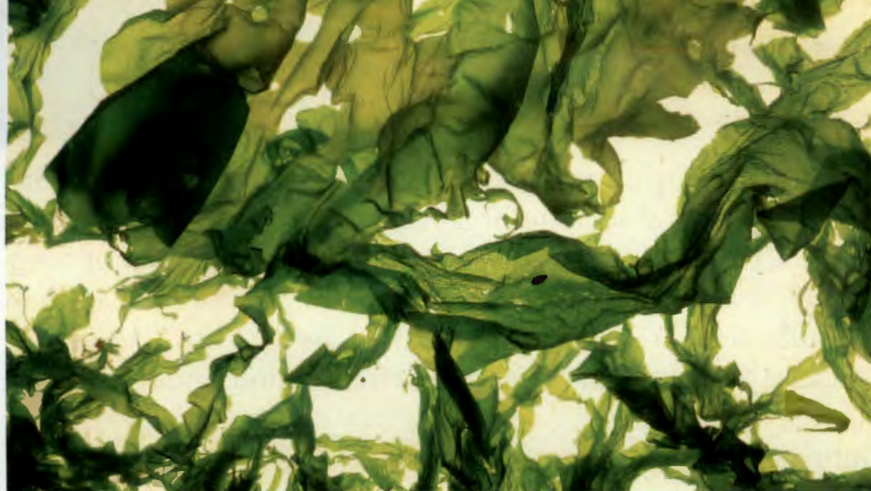
Then carry out the experiment with a culture of euglena in a plastic petri dish. Cover half the dish with aluminum foil. After 10 minutes, uncover the dish. What do you observe? Was your prediction correct? Explain why euglena behave this way.

**Euglenoids** Euglenoids (yoo GLEE noydz) are green, unicellular algae that are found mostly in fresh water. Unlike other algae, euglenoids have one animal-like characteristic—they can be heterotrophs under certain conditions. When sunlight is available, most euglenoids are autotrophs that produce their own food. However, when sunlight is not available, euglenoids will act like heterotrophs by obtaining food from their environment. Some euglenoids live entirely as heterotrophs.

In Figure 20, you see a euglena, which is a common euglenoid. Notice the long, whiplike flagellum that helps the organism move. Locate the eyespot near the flagellum. Although the eyespot is not really an eye, it contains pigments. These pigments are sensitive to light and help the euglena recognize the direction of a light source. You can imagine how important this response is to an organism that needs light to make food.

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

People use red algae in a variety of ways. Carrageenan (ka ruh JEE nun) and agar are substances extracted from red algae. These substances are used in products such as ice cream and hair conditioner. For people in many Asian cultures, red algae are a nutrient-rich food that is eaten fresh, dried, or toasted.



**FIGURE 21**  
**Green Algae**  
Green algae range in size from unicellular organisms to multicellular seaweeds. This multicellular sea lettuce, *Ulva*, lives in oceans.

**Green Algae** Green algae, which contain green pigments, are quite diverse. Most green algae are unicellular. Some, however, form colonies, and a few are multicellular. Most green algae live in either fresh water or salt water. The few that live on land are found on rocks, in the crevices of tree bark, or in moist soils.

Green algae are actually very closely related to plants that live on land. Green algae and plants contain the same type of chlorophyll and share other important similarities. In fact, some scientists think that green algae belong in the plant kingdom.

**Brown Algae** Many of the organisms that are commonly called seaweeds are brown algae. In addition to their brown pigment, brown algae also contain green, yellow, and orange pigments.

All brown algae are multicellular. This group has the most complex structure of all the algae. Some brown algae even have differentiated tissues and organs that resemble structures found in plants. Figure 22 shows a typical brown alga. Holdfasts anchor the alga to rocks. Stalks support the blades, which are the leaflike structures of the alga. Many brown algae also have gas-filled sacs called bladders that allow the algae to float upright.

Brown algae flourish in cool, rocky waters. Brown algae called rockweed live along the Atlantic coast of North America. Giant kelps, which can grow as long as 100 meters, live in some Pacific coastal waters. The giant kelps form large underwater “forests” where many organisms, including sea otters and abalone, live.



**Reading  
Checkpoint**

What color pigments can brown algae contain?

**FIGURE 22 Brown Algae**  
Giant kelps are brown algae that have many plantlike organs.

**Interpreting Diagrams** What plant structures do the kelp’s holdfasts and blades resemble?



## Funguslike Protists

The third group of protists are the funguslike protists. You may recall that fungi include organisms such as mushrooms and yeast. Until you learn more about fungi, you can think of fungi as the “sort of like” organisms. Fungi are “sort of like” animals because they are heterotrophs. They are “sort of like” plants because their cells have cell walls. In addition, most fungi use spores to reproduce. A **spore** is a tiny cell that is able to grow into a new organism.

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

**Slime Molds** Slime molds are often brilliantly colored. They live on forest floors and other moist, shady places. They ooze along the surfaces of decaying materials, feeding on bacteria and other microorganisms. Some slime molds are so small that you need a microscope to see them. Others may cover an area of several meters!

Slime molds begin their life cycle as tiny, individual amoeba-like cells. The cells use pseudopods to feed and creep around. Later, the cells grow bigger or join together to form a giant, jellylike mass. In some species, the giant mass is multicellular and forms when food is scarce. In others, the giant mass is actually a giant cell with many nuclei.

The mass oozes along as a single unit. When environmental conditions become harsh, spore-producing structures grow out of the mass and release spores. Eventually the spores develop into a new generation of slime molds.

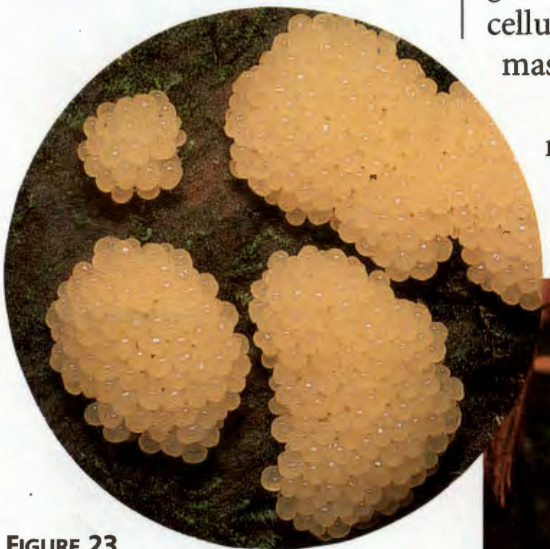


FIGURE 23

### Slime Molds

The chocolate tube slime mold first forms a tapioca-like mass (top). When conditions become harsh, the mass grows spore-producing stalks (right). The stalks, or “chocolate tubes,” are covered with millions of brown spores.



**Water Molds and Downy Mildews** Most water molds and downy mildews live in water or moist places. These organisms often grow as tiny threads that look like fuzz. Figure 24 shows a fish attacked by a water mold and a leaf covered by downy mildew.

Water molds and downy mildews attack many food crops, such as potatoes, corn, and grapes. A water mold impacted history when it destroyed the Irish potato crops in 1845 and 1846. The loss of these crops led to a famine. More than one million people in Ireland died, and many others moved to the United States and other countries.



▲ Water mold on fish

▼ Downy mildew on grape leaf



**FIGURE 24**  
**Water Molds and Downy Mildews**  
Many water molds are decomposers of dead aquatic organisms. Others are parasites of fish and other animals. Downy mildews are parasites of many food crops.



In what environments are water molds found?

## Section 3 Assessment

S 7.5.a, E-LA: Reading 7.1.0

**Vocabulary Skill Prefixes** In the word *pseudopod*, the prefix *pseudo-* means “false.” What do you think the root *-pod* means?

### Reviewing Key Concepts

1. **a. Listing** List the four types of animal-like protists. How does each type move or live?
- b. Comparing and Contrasting** How are these four types of protists similar to animals? How are they different?
- c. Classifying** You observe an animal-like protist under the microscope. It has no hairlike or whiplike structures. It moves by forming temporary bulges of cytoplasm. How would you classify this protist?
2. **a. Reviewing** What characteristics do diatoms, dinoflagellates, and other plantlike protists share?
- b. Making Generalizations** In what ways are plantlike protists different from one another?
- c. Comparing and Contrasting** Describe the similarities and differences in the organization, structure, and function of euglena and brown algae.
3. **a. Listing** What are the three types of funguslike protists?
- b. Describing** How are funguslike protists like fungi?

Lab zone

### At-Home Activity

**Algae Scavenger Hunt** Look around your house with a family member to find products that contain substances made from algae. Look at both food and nonfood items. Before you begin, tell your family member that substances such as diatomaceous earth, algin, and carrageenan are products that come from algae. Make a list of the products and the algae-based ingredients they contain. Share your list with the class.






## Fungi

## CALIFORNIA

## Standards Focus

**S 7.1.a** Students know cells function similarly in all organisms.

**S 7.2.a** Students know the differences between the life cycles and reproduction methods of sexual and asexual organisms.

-  What characteristics do fungi share?
-  How do fungi reproduce?
-  What roles do fungi play in nature?

## Key Terms

- fungi
- hyphae
- fruiting body
- budding
- lichen

## Lab zone

## Standards Warm-Up

## Do All Molds Look Alike?

1. Your teacher will give you two sealed, clear plastic bags—one containing moldy bread and another containing moldy fruit.

**CAUTION:** Do not open the sealed bags at any time.

2. In your notebook, describe what you see.
3. Next, use a hand lens to examine each mold. Sketch each mold in your notebook and list its characteristics.
4. Return the sealed bags to your teacher. Wash your hands.


## Think It Over

**Observing** How are the molds similar? How are they different?

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

## What Are Fungi?

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

Most **fungi** share several important characteristics.  **Fungi are eukaryotes that have cell walls, are heterotrophs that feed by absorbing their food, and use spores to reproduce.** In addition, fungi need moist, warm places in which to grow. They thrive on moist foods, damp tree barks, lawns coated with dew, and even wet bathroom tiles.



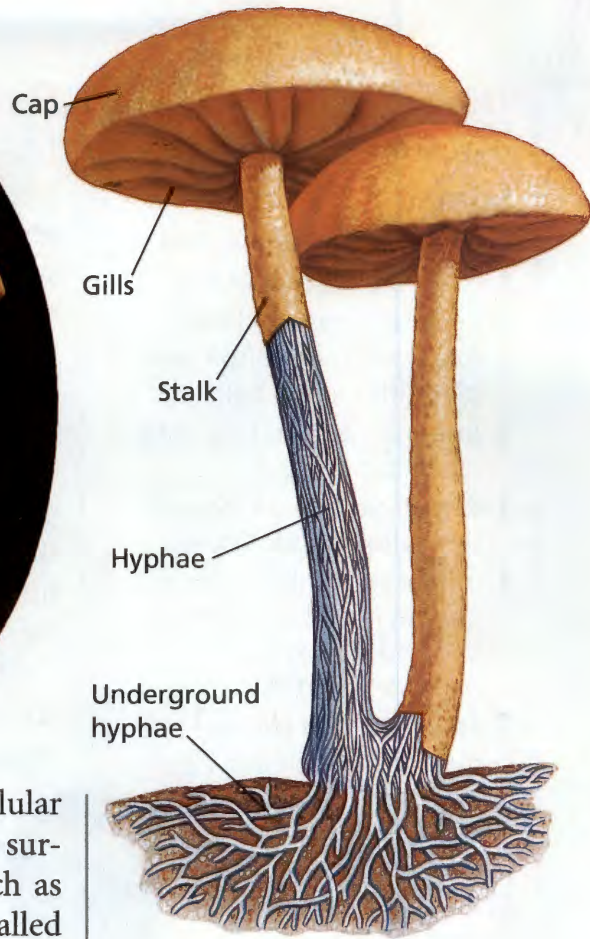
A killer fungus has attacked this bush cricket.

FIGURE 25

### Structure of a Mushroom

The hyphae in the stalk and cap of a mushroom are packed tightly to form firm structures. Underground hyphae are arranged loosely.

**Inferring** What function might underground hyphae perform?



**Cell Structure** Fungi range in size from tiny unicellular yeasts to large multicellular fungi. The cells of all fungi are surrounded by cell walls. Except for the simplest fungi, such as yeast, the cells of most fungi are arranged in structures called hyphae. **Hyphae** (HY fee) (singular hypha) are the branching, threadlike tubes that make up the bodies of multicellular fungi. The hyphae of some fungi are continuous threads of cytoplasm that contain many nuclei. Substances move quickly and freely through the hyphae.

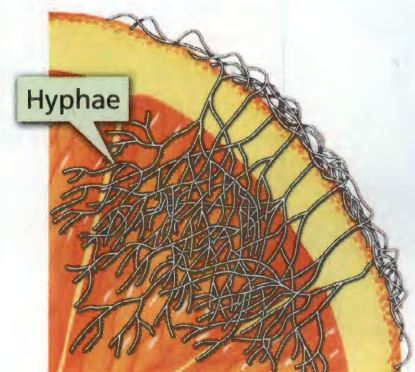
What a fungus looks like depends on how its hyphae are arranged. In some fungi, the threadlike hyphae are loosely tangled. Fuzzy-looking molds that grow on old foods have loosely tangled hyphae. Other fungi have tightly packed hyphae. The stalks and caps of mushrooms are made of hyphae packed so tightly that they appear solid. Underground, however, a mushroom's hyphae form a loose, threadlike maze in the soil.

**Obtaining Food** Fungi absorb food through hyphae that grow into a food source. First, the fungus grows hyphae into the food source. Then digestive chemicals ooze from the hyphae into the food. The chemicals break down the food into small substances that can be absorbed by the hyphae. As an analogy, imagine yourself sinking your fingers down into a chocolate cake and dripping digestive chemicals out of your fingertips. Then imagine your fingers absorbing the digested particles of the cake!

FIGURE 26

### Mold Growing on Food Source

The mold *Penicillium* often grows on old fruits such as oranges. Some of its hyphae grow deep into the food source.




**Reading  
Checkpoint**

What do the bodies of multicellular fungi consist of?

## Spreading Spores

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


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

Observe what happens.

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



## Reproduction in Fungi

Like it or not, fungi are everywhere. The way they reproduce helps guarantee their survival and spread.  **Fungi usually reproduce by making spores. The lightweight spores are surrounded by a protective covering and can be carried easily through air or water to new sites.** Fungi produce millions of spores, more than can ever survive. Only a few spores will fall where conditions are right for them to grow.

Fungi produce spores in reproductive structures called **fruiting bodies**. The appearances of fruiting bodies vary among different fungi. For some fungi, such as mushrooms, the part of the fungus that you see is the fruiting body. In other fungi, such as bread molds, the fruiting bodies are tiny, stalk-like hyphae that grow upward from the rest of the hyphae. A knoblike spore case at the tip of each stalk contains the spores. As you can imagine, the structure of the fruiting body is very important to the fungi's success in reproduction.

**Asexual Reproduction** Most fungi reproduce both asexually and sexually. When there is adequate moisture and food, the fungi make spores asexually. Cells at the tips of their hyphae divide to form spores. The spores grow into fungi that are genetically identical to the parent.

Unicellular yeast cells undergo a form of asexual reproduction called **budding**. In budding, no spores are produced. Instead, a parent cell undergoes mitosis and a small yeast cell grows from the parent cell. This process is somewhat similar to the way a bud forms on a tree branch. The new cell then breaks away and lives on its own.

**Sexual Reproduction** Most fungi can also reproduce sexually, especially when growing conditions become unfavorable. In sexual reproduction, the hyphae of two fungi grow together and genetic material is exchanged. Eventually, a new reproductive structure grows from the joined hyphae and produces spores. The spores develop into fungi that differ genetically from either parent.

**Classification of Fungi** Figure 28 shows three major groups of fungi. The groups are named for the appearance of their reproductive structures. Additional groups include water species that produce spores with flagella and those that form tight associations with plant roots.

FIGURE 27

### Budding Yeast Cells

Budding is a form of asexual reproduction.

#### Applying Concepts

*How is a new yeast cell formed by asexual reproduction similar to its parent cell?*



Reading  
Checkpoint

What is budding?

## The Role of Fungi in Nature

Fungi affect humans and other organisms in many different ways. 🍄 Many fungi provide foods for people. Fungi play important roles as decomposers and recyclers on Earth. Some fungi cause disease while others fight disease. Still other fungi live in symbiosis with other organisms.

**Food and Fungi** Yeasts, molds, and mushrooms are important food sources. Bakers add yeast to bread dough to make it rise. Yeast cells use the sugar in the dough for food and produce carbon dioxide gas as they feed. The gas forms bubbles, which cause the dough to rise. You see these bubbles as holes in a slice of bread. Molds are used to make foods such as some cheeses. The blue streaks in blue cheese, for example, are actually growths of *Penicillium roqueforti*. People enjoy eating mushrooms in salads and on pizza. You should never pick or eat wild mushrooms, however, because some mushrooms are extremely poisonous.

**Video Field Trip**  
Discovery Channel School  
*Protists and Fungi*

FIGURE 28

### Classification of Fungi

Three major groups of fungi include sac fungi, club fungi, and zygote fungi.

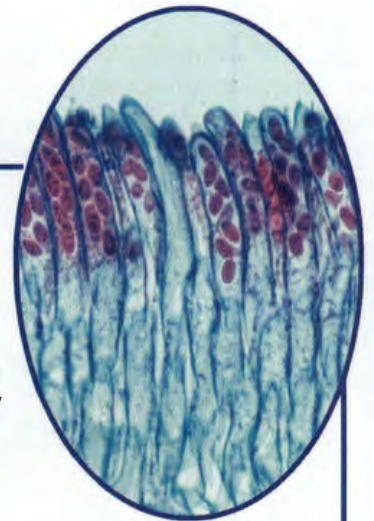


#### ▲ Club Fungi

Club fungi produce spores in tiny clublike structures. This group includes mushrooms, rusts, and puffballs, such as these.

#### ▶ Sac Fungi

Sac fungi produce spores in structures that look like long sacs, such as these. The largest group of fungi, they include yeasts, morels, and truffles.



#### ▲ Zygote Fungi

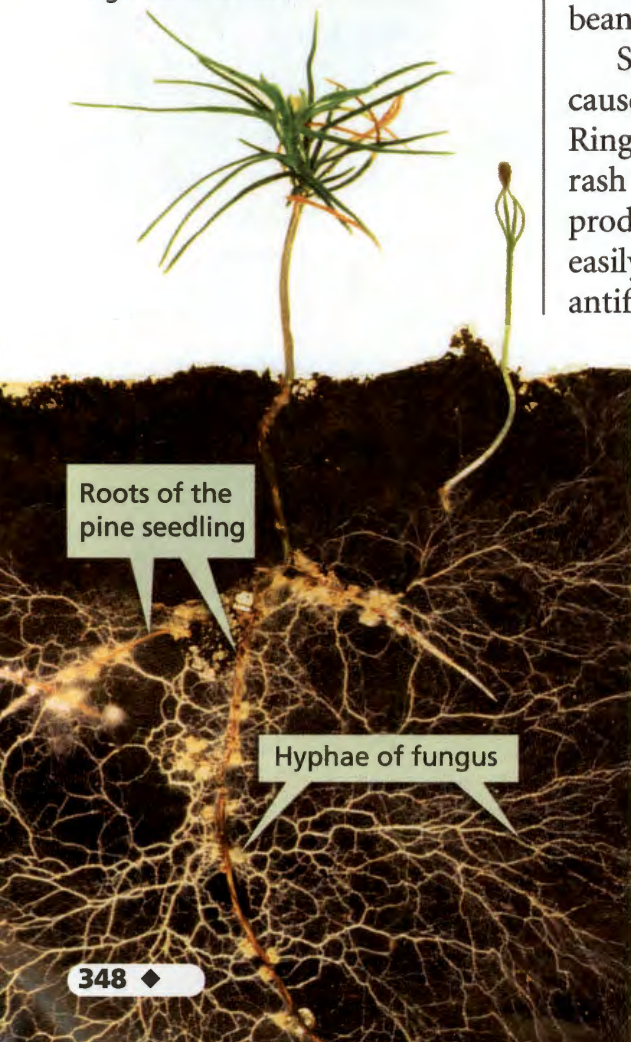
Zygote fungi produce very resistant spores. This group includes many common fruit and bread molds, like this *Rhizopus*.

**FIGURE 29**

**Fungus–Plant Root Associations**

An extensive system of fungal hyphae has grown in association with the roots of the pine seedling in the middle.

**Classifying** What type of symbiosis do these two organisms exhibit?



Roots of the pine seedling

Hyphae of fungus

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

**Disease-Fighting Fungi** In 1928, a Scottish biologist named Alexander Fleming was examining petri dishes in which he was growing bacteria. To his surprise, Fleming noticed a spot of a bluish-green mold growing in one dish. Curiously, no bacteria were growing near the mold. Fleming hypothesized that the mold, a fungus named *Penicillium*, produced a substance that killed the bacteria near it.

Fleming's work contributed to the development of the first antibiotic, penicillin. Since the discovery of penicillin, many antibiotics have been isolated from both fungi and bacteria.

**Disease-Causing Fungi** Many fungi are parasites that cause serious diseases in plants. The sac fungus that causes Dutch elm disease is responsible for killing millions of elm trees in North America and Europe. Corn smut and wheat rust are two club fungi that cause diseases in important food crops. Fungal plant diseases also affect other crops, including rice, cotton, and soybeans, resulting in huge crop losses every year.

Some fungi cause diseases in humans. Athlete's foot fungus causes an itchy irritation in the damp places between toes. Ringworm, another fungal disease, causes an itchy, circular rash on the skin. Because the fungi that cause these diseases produce spores at the site of infection, the diseases can spread easily from person to person. Both diseases can be treated with antifungal medications.

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

Most plants have fungal partners. Many plants are so dependent on the fungi that they cannot survive without them. For example, orchid seeds cannot develop without their fungal partners.

**FIGURE 30 Lichens**  
The British soldier lichen consists of a fungus and an alga. The inset shows how entwined the alga is among the fungus's hyphae.

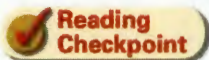


**Lichens** A **lichen** (LY kun) consists of a fungus and either algae or autotrophic bacteria that live together in a mutualistic relationship. You have probably seen some familiar lichens—irregular, flat, crusty patches that grow on tree barks or rocks. The fungus benefits from the food produced by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

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



For: Links on fungi  
Visit: [www.SciLinks.org](http://www.SciLinks.org)  
Web Code: scn-0133



**Reading Checkpoint** What two organisms make up a lichen?

## Section 4 Assessment

S 7.2.a, 7.1.a, E-LA: Writing 7.2.0, Reading 7.2.0

### Target Reading Skill Compare and Contrast

Construct a Venn diagram to help you answer Question 1 below.

### Reviewing Key Concepts

- Listing** List three characteristics that a bread mold shares with a mushroom.
  - Comparing and Contrasting** How are the cells of a bread mold arranged? How are the cells of a mushroom arranged?
  - Summarizing** How does the cell structure of a fungus help it obtain food?
- Reviewing** What role do spores play in the reproduction of fungi?
  - Sequencing** Outline the steps by which fungi produce spores by sexual reproduction.
  - Inferring** Why is it advantageous to a fungus to produce millions of spores?

- Identifying** Name six roles that fungi play in nature.
  - Predicting** Suppose all the fungi in a forest disappeared. What do you think the forest would be like without fungi?

## Writing in Science

**Wanted Poster** Design a “Wanted” poster for a mold that has been ruining food in your kitchen. Present the mold as a “criminal of the kitchen.” Include detailed descriptions of the mold’s physical characteristics, what it needs to grow, how it grows, and any other details that will help your family identify this mold. Propose ways to prevent new molds from growing in your kitchen.

# What's for Lunch?

S 7.1.a

## Problem

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

## Skills Focus

measuring, inferring, drawing conclusions

## Materials

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

## Procedure

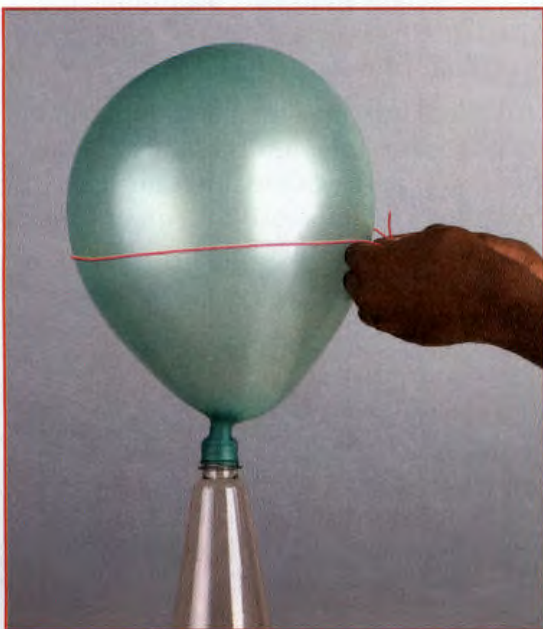
1. Like all other organisms, yeast cells need a source of energy to carry out all their functions. Copy the data table into your notebook. Then read over the entire procedure to see how you will test the respiration activity of the yeast cells in bottles A through E. Write a prediction about what will happen in each bottle.

2. Gently stretch each of the balloons so that they will inflate easily.
3. Using the marking pen, label the bottles A, B, C, D, and E.
4. Use a beaker to fill each bottle with the same amount of warm water. **CAUTION:** Glass is fragile. Handle the beaker gently to avoid breakage. Do not touch broken glass.
5. Put 25 mL of salt into bottle B.
6. Put 25 mL of sugar into bottles C and E.
7. Put 50 mL of sugar into bottle D.
8. Put 6 mL of powdered yeast into bottle A, and stir the mixture with a clean straw. Remove the straw and discard it.
9. Immediately place a balloon over the opening of bottle A. Make sure that the balloon opening fits very tightly around the neck of the bottle.
10. Repeat Steps 8 and 9 for bottle B, bottle C, and bottle D.



Data Table						
Bottle	Prediction	Observations	Circumference			
			10 min	20 min	30 min	40 min
A (Yeast alone)						
B (Yeast and 25 mL of salt)						
C (Yeast and 25 mL of sugar)						
D (Yeast and 50 mL of sugar)						
E (No yeast and 25 mL of sugar)						

- Place a balloon over bottle E without adding yeast to the bottle.
- Place the five bottles in a warm spot away from drafts. Every ten minutes for 40 minutes, measure the circumference of each balloon by placing a string around the balloon at its widest point. Include your measurements in the data table.



## Analyze and Conclude

- Measuring** Which balloons changed in size during this lab? How did they change?
- Inferring** Explain why the balloon changed size in some bottles and not in others. What caused that change in size?
- Interpreting Data** How did the results from bottles C and D compare? Why was it important to include bottle E in this investigation?
- Drawing Conclusions** Do yeast use salt or sugar as a food source? How do you know?
- Communicating** In a paragraph, summarize what you learned about yeast from this investigation. Be sure to support each of your conclusions with the evidence you gathered.

## Design an Experiment

Develop a hypothesis about whether temperature affects the activity of yeast cells. Then design an experiment to test your hypothesis. *Obtain your teacher's permission before carrying out your investigation.*

**Go Online**  
PHSchool.com

For: Data sharing  
Visit: PHSchool.com  
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**The BIG Idea** Organisms in different domains and kingdoms display varying levels of organization, from single cells to more complex structures.

## 1 Viruses

### Key Concepts

S 7.2.a

- The only way in which viruses are like organisms is that they can multiply.
- All viruses have two basic parts: an outer coat that protects the virus and an inner core made of genetic material.
- Once inside a cell, a virus's genetic material takes over many of the cell's functions. The genetic material instructs the cell to produce the virus's proteins and genetic material, which then assemble into new viruses.
- Resting, drinking plenty of fluids, and eating well-balanced meals may be all you can do while you recover from a viral disease.

### Key Terms

virus  
host  
parasite  
bacteriophage  
vaccine



## 2 Bacteria

### Key Concepts

S 7.1, 7.2.a

- Bacteria are prokaryotes. The genetic material in their cells is not contained in a nucleus.
- Bacteria must have a source of food and a way of breaking down the food to release its energy.
- When bacteria have plenty of food, the right temperature, and other suitable conditions, they thrive and reproduce frequently.
- Bacteria are involved in oxygen and food production, environmental recycling and cleanup, and in health maintenance and medicine production.

### Key Terms

bacteria  
flagellum  
binary fission  
asexual reproduction  
sexual reproduction  
conjugation  
endospore  
pasteurization  
decomposer

## 3 Protists

### Key Concepts

S 7.5.a

- Like animals, animal-like protists are heterotrophs, and most are able to move from place to place to obtain food.
- Like plants, algae are autotrophs.
- Like fungi, funguslike protists are heterotrophs, have cell walls, and use spores to reproduce.

### Key Terms

protist  
protozoan  
pseudopod  
contractile vacuole  
cilia  
symbiosis  
mutualism  
algae  
spore

## 4 Fungi

### Key Concepts

S 7.1.a, 7.2.a

- Fungi are eukaryotes that have cell walls, are heterotrophs that feed by absorbing their food, and use spores to reproduce.
- Fungi usually reproduce by making spores. The lightweight spores are surrounded by a protective covering and can be carried easily through air or water to new sites.
- Many fungi provide foods for people. Fungi play important roles as decomposers and recyclers on Earth. Some fungi cause disease while others fight disease. Still other fungi live in symbiosis with other organisms.

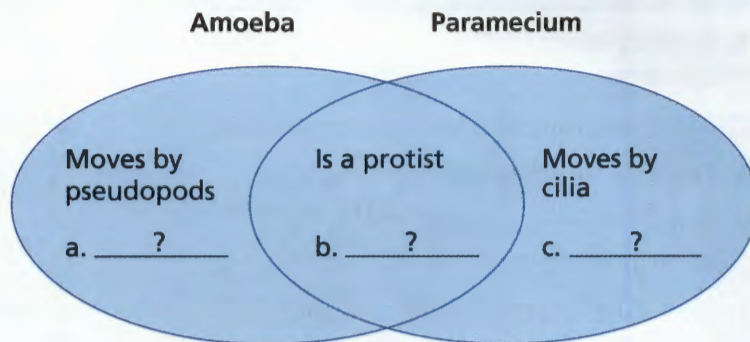
### Key Terms

fungi  
hyphae  
fruiting body  
budding  
lichen



## Target Reading Skill

**Compare and Contrast** To review part of Section 3, copy the Venn diagram, which compares an amoeba to a paramecium. Add at least one additional similarity and one additional difference.



## Reviewing Key Terms

Choose the letter of the best answer.

- Bacteriophages are viruses that attack and destroy
  - other viruses.
  - bacteria.
  - plants.
  - humans.
- A tiny, nonliving particle that invades and then multiplies inside a living cell is a
  - virus.
  - bacterium.
  - protist.
  - fungus.
- Most bacteria are surrounded by a rigid protective structure called the
  - cell wall.
  - cell membrane.
  - protein coat.
  - flagellum.
- Which of the following characteristics describes all protists?
  - They are unicellular.
  - They can be seen with the unaided eye.
  - Their cells have nuclei.
  - They are unable to move on their own.
- A lichen is a symbiotic association between
  - fungi and plant roots.
  - algae and fungi.
  - algae and bacteria.
  - protozoans and algae.

Complete the following sentences so that your answers clearly explain the key terms.

- Viruses act like **parasites**, which are \_\_\_\_\_.
- Binary fission**, a form of asexual reproduction, does not result in genetically different organisms because \_\_\_\_\_.
- When excess water enters an amoeba, the amoeba does not burst because it has a **contractile vacuole**, a structure that \_\_\_\_\_.
- When a protozoan living inside a termite helps the termite digest wood, the relationship is called **mutualism** because \_\_\_\_\_.
- Fuzzy-looking molds have loosely tangled **hyphae**, which are the \_\_\_\_\_.

## Writing in Science

**Informational Pamphlet** Create a pamphlet to teach young children about fungi. Explain where fungi live, how they feed, and their role in the environment. Include illustrations.



### Video Assessment

Discovery Channel School

*Protists and Fungi*

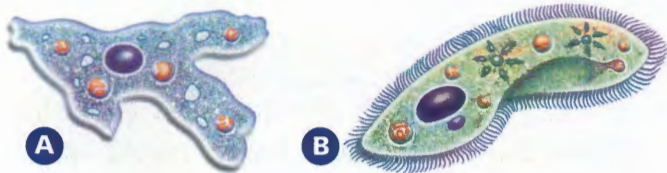
# Review and Assessment

## Checking Concepts

11. Explain why a certain virus will attach to only one type or a few types of cells.
12. Describe how a hidden virus multiplies.
13. Describe how bacteria reproduce.
14. How do the bacteria that live in your intestines help you?
15. How does an amoeba obtain food?
16. Compare how animal-like, plantlike, and funguslike protists obtain food.
17. How does sexual reproduction occur in fungi?

## Thinking Critically

18. **Comparing and Contrasting** Describe the similarities and differences between active and hidden viruses.
19. **Problem Solving** Bacteria will grow in the laboratory on a gelatin-like substance called agar. Viruses will not grow on agar. If you needed to grow viruses in the laboratory, what kind of substance would you have to use? Explain your reasoning.
20. **Comparing and Contrasting** Identify the organisms below. Describe the method by which each obtains food.



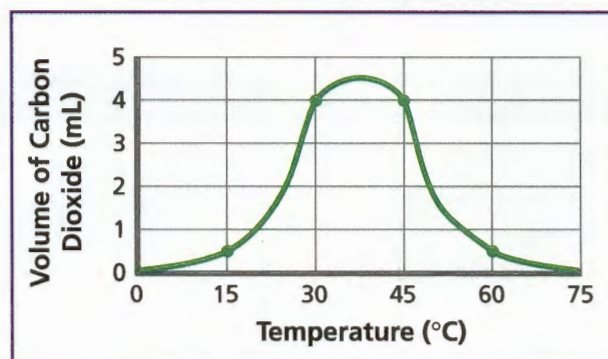
21. **Predicting** If all algae suddenly disappeared from Earth's waters, what would happen to living things on Earth? Explain your answer.
22. **Making Judgments** You see an advertisement for a new, powerful fungicide guaranteed to kill most fungi on contact. What should people take into consideration before choosing to buy this fungicide?

## Applying Skills

Use the graph to answer Questions 23–26.

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

Temperature and Carbon Dioxide Production



23. **Interpreting Data** Based on the graph, at what temperature does yeast produce the most carbon dioxide?
24. **Inferring** Use the graph to explain why yeast is dissolved in warm water, rather than in cold water, when it is used to make bread.
25. **Predicting** Based on the graph, would you expect bread dough to rise if it were placed in a refrigerator (which is kept at about 2° to 5°C)? Explain.
26. **Drawing Conclusions** Explain how temperature affects the amount of carbon dioxide that the yeast cells produce.

Lab zone

## Standards Investigation

**Performance Assessment** Create a poster that summarizes your experiment for the class. In your poster, include your hypothesis and describe the conditions that produced the best mushroom growth. Use diagrams and graphs to display your results. Did the investigation raise any new questions about mushrooms for you? If so, how could you answer those questions?

Choose the letter of the best answer.

- If you know that an organism is a prokaryote, you know that
  - its cell does not contain a nucleus.
  - its cell does not contain ribosomes.
  - the organism is a heterotroph.
  - the organism cannot move on its own.

S 7.1

- Which of the following statements about a paramecium is correct?
  - It has two contractile vacuoles that remove excess water from the cytoplasm.
  - It uses cilia to move.
  - It has two nuclei.
  - all of the above

S 7.5.a

- Which of the following statements about fungus reproduction is true?
  - Fungi reproduce sexually by budding.
  - Fungi reproduce by making spores.
  - Fungi reproduce asexually when two hyphae join together and exchange genetic material.
  - Fungi do not reproduce sexually.

S 7.2.a

Use the diagram below and your knowledge of science to answer Question 4.



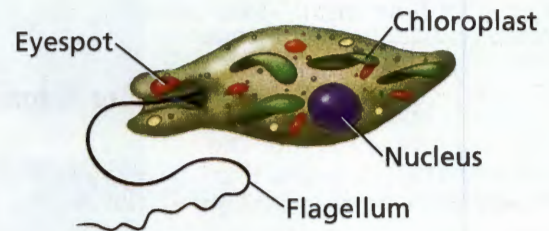
- What will most likely happen after the virus in the diagram attaches to the bacterial cell?
  - The virus will inject its proteins into the bacterial cell.
  - The virus will inject its genetic material into the bacterial cell.
  - The bacterial cell will inject its proteins into the virus.
  - The bacterial cell will inject its genetic material into the virus.

S 7.2.a

- Which of the following statements about viruses is *not* true?
  - Viruses can multiply only inside a living cell.
  - Viruses have genetic material.
  - Virus particles are smaller than bacterial cells.
  - Viruses are composed of cells.

S 7.1

Use the diagram below and your knowledge of science to answer Question 6.



- Which structure tells you that the euglena shown is an autotroph?
  - eyespot
  - flagellum
  - nucleus
  - chloroplast
- Paola grew a new culture of bacteria and measured the population's growth over time. The number of bacteria increased sharply over the first few hours but then tapered off. Which of the following statements about these observations is true?
  - The initial conditions for bacterial growth were favorable.
  - The number of bacteria increased as the bacteria reproduced asexually.
  - After a period of time, the bacteria started to run out of food, space, and other resources.
  - all of the above

S 7.5.a

S 7.2.a

## Apply the BIG Idea

- Compare and contrast viruses and bacteria with respect to their sizes, structures, and methods of reproduction.

S 7.2.a