

## Unit 6

### History & Biology

1500

1600

1700

1761

Wolfgang Amadeus Mozart composes his first musical piece at age 6.

1546

Girolamo Fracastoro theorizes that diseases are caused by invisible organisms.

# Viruses, Bacteria, Protists, and Fungi

## What You'll Learn

### Chapter 18

Viruses and Bacteria

### Chapter 19

Protists

### Chapter 20

Fungi

## Unit 6 Review

BioDigest & Standardized Test Practice

## Why It's Important

Although the world we encounter is largely limited to what we can see, that representation is misleading. Even though the world is filled with plants and animals that are easily distinguishable, much of the real diversity lies in the things we cannot see. We rely on bacteria and fungi to act as decomposers that keep nutrients cycling through the food chain. In addition to bacteria, nonliving things such as viruses act as disease agents on both plants and animals.

### California Standards

The following standards are covered in Unit 6:  
Investigation and Experimentation: 1k, 1m  
Biology/Life Sciences: 1c, 1d

### Understanding the Photo ▶

These *Coprinus* mushrooms grow in thick clumps on the forest floor. The mushrooms are the reproductive forms of the fungus, which lives mostly underground and gets nutrition by decomposing the organisms that fall to the forest floor.



1800

1796

Edward Jenner introduces the first vaccine in order to prevent smallpox.



1861

A funguslike protist causes the Irish potato blight, leading to a mass famine.

◀ A political drawing during the Irish potato blight

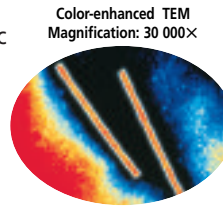
1815

France's armies are defeated at Waterloo.

1900

1892

The first virus, tobacco mosaic virus, is identified.



Tobacco mosaic virus

Color-enhanced TEM  
Magnification: 30 000X



Tobacco mosaic virus

(tl)Hulton/Archive, (tr)Scott Camazine/S.S. Billota Best/Photo Researchers

1903

The Pittsburgh Pirates and the Boston Red Sox play in the first World Series.

2000

1941

Penicillin is first used as an antibiotic for humans.

2002

The genome for the parasite that causes malaria is fully sequenced.



# Viruses and Bacteria

Color-enhanced SEM Magnification 90 000×

### What You'll Learn

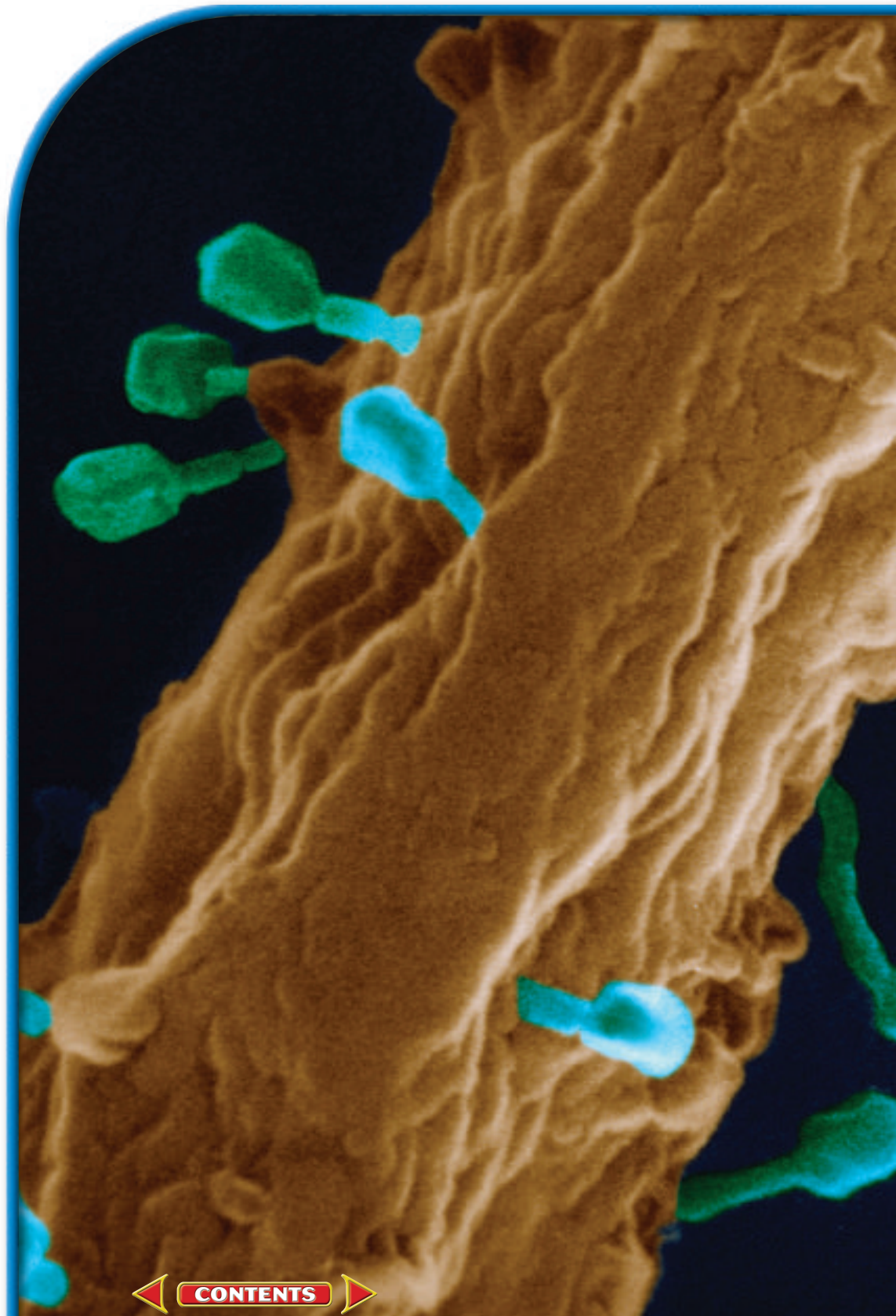
- You will identify the structures and characteristics of viruses and bacteria.
- You will explain how viruses and bacteria reproduce.
- You will recognize the medical and economic importance of viruses and bacteria.

### Why It's Important

Viruses and bacteria are important because many cause diseases in plants and animals. Bacteria play an important role in creating foods and drugs, as well as helping to recycle nutrients.

### Understanding the Photo

Viruses cannot function without a host. This photo, taken with an electron microscope, shows a group of viruses, called phages, infecting an *E. coli* bacterium. The viruses have attached themselves to the outside of the bacterium and are injecting it with their nucleic acid.



### Biology Online

Visit [ca.bdol.glencoe.com](http://ca.bdol.glencoe.com) to

- study the entire chapter online
- access Web Links for more information and activities on viruses and bacteria
- review content with the Interactive Tutor and self-check quizzes

# Section 18.1

## SECTION PREVIEW

### Objectives

**Identify** the different kinds of viruses and their structures.

**Compare and contrast** the replication cycles of viruses.

### Review Vocabulary

**nucleic acid:** a complex macromolecule, either RNA or DNA, that stores genetic information (p. 163)

### New Vocabulary

virus  
host cell  
bacteriophage  
capsid  
lytic cycle  
lysogenic cycle  
provirus  
retrovirus  
reverse transcriptase  
prion  
viroid

# Viruses

**California Standards** Standard 1c Students know how prokaryotic cells, eukaryotic cells, and viruses differ in complexity and general structure.

## Getting a Vaccination

**Using Prior Knowledge** As a child, you probably received several vaccines. Children are regularly vaccinated against diseases that could otherwise be life threatening. Vaccines are injections of particles of viruses or bacteria that provide the human body with a defense against disease. Thanks to vaccines, many devastating diseases of the past are now rarely encountered.

**Research** Make a list of the vaccines you received as a child. Next to each vaccine, list the disease that the vaccine prevents and what microorganism causes the disease.



Children are vaccinated against several diseases.

## What is a virus?

You've probably had the flu—influenza—at some time during your life. Nonliving particles called viruses cause influenza. **Viruses** are composed of nucleic acids enclosed in a protein coat and are smaller than the smallest bacterium. To appreciate how very tiny viruses are, try the *MiniLab* on the next page.

Most biologists consider viruses to be nonliving because they don't exhibit all the criteria for life. They don't carry out respiration, grow, or develop. All viruses can do is replicate—make copies of themselves—and they can't even do that without the help of living cells. A cell in which a virus replicates is called the **host cell**.

Because they are nonliving, viruses were not named in the same way as organisms. Viruses, such as rabies viruses and polioviruses, were named after the diseases they cause. Other viruses were named for the organ or tissue they infect. For example, scientists first found the adenovirus (uh DEN uh vi ruhs), which is one cause of the common cold, in adenoid tissue between the back of the throat and the nasal cavity.

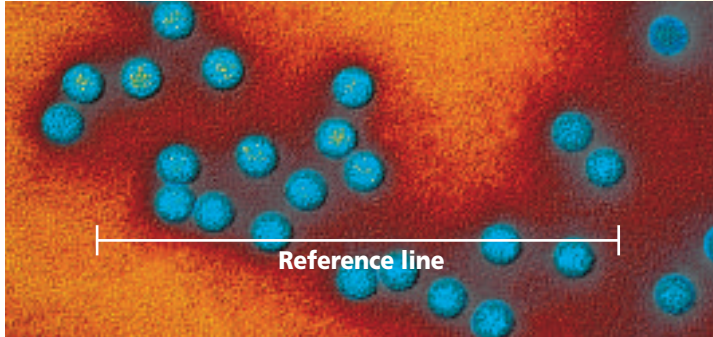
Today, most viruses are given a genus name ending in the word “virus” and a species name. However, sometimes scientists use code numbers to distinguish among similar viruses that infect the same host. For example, seven similar-looking viruses that infect the common intestinal bacteria, *Escherichia coli*, have the code numbers T1 through T7 (*T* stands for “Type”). A virus that infects a bacterium is called a **bacteriophage** (bak TIHR ee uh fayj), or phage for short.

## MiniLab 18.1

### Measure in SI

**Measuring a Virus** Can you use a light microscope to view a virus? Find out by measuring the size of a polio virus in the photo below and then comparing it to  $0.2\ \mu\text{m}$ , the size limit for viewing objects with a light microscope.

Color-enhanced TEM Magnification: 180 000 $\times$



### Procedure

- 1 Copy the data table below.

#### Data Table

Values to Measure and Calculate	Measurement
Length of photo line in mm	
Diameter of poliovirus in mm	
Diameter of poliovirus in $\mu\text{m}$	

- 2 Examine the photo. The horizontal line you see would measure only  $0.4\ \mu\text{m}$  in length if the photo was not magnified  $180\ 000\times$ . Use this line for reference.
- 3 Calculate the diameter of one poliovirus. First, measure the length of the reference line in millimeters. Record the value in the table. Then, measure the diameter of a poliovirus in millimeters. Record the value in the table.
- 4 Use the following equation to calculate the actual diameter of the poliovirus ( $X$ ). Record your answer in the table.

$$\frac{\text{photo line length in mm (A)}}{\text{diameter of virus in mm (B)}} = \frac{0.4\ \mu\text{m}}{\text{diameter of virus in } \mu\text{m (X)}}$$

### Analysis

1. **Interpret Data** Explain why you cannot see viruses with a light microscope. Use specific numbers in your answer.
2. **Use Numbers** An animal cell may be  $100\ \mu\text{m}$  in size. How many polioviruses could fit across the top of such a cell?

### Viral structure

A virus has an inner core of nucleic acid, either RNA or DNA, and an outer protein coat called a **capsid**. Some relatively large viruses, such as human flu viruses, may have an additional layer, called an envelope, surrounding their capsids. Envelopes are composed primarily of the same materials found in the plasma membranes of all cells. You can learn about capsids and envelopes in the *Focus On* on pages 1074–1075.

The core of nucleic acid contains a virus's genetic material. Viral nucleic acid is either DNA or RNA and contains instructions for making copies of the virus. Some viruses have only four genes, while others have hundreds. The arrangement of proteins in the capsid of a virus determines the virus's shape. Four different viral shapes are shown in *Figure 18.1*. The protein arrangement also plays a role in determining what cell can be infected and how the virus infects the cell.

### Attachment to a host cell

Before a virus can replicate, it must enter a host cell. Before it can enter, it must first recognize and attach to a receptor site on the plasma membrane of the host cell.

A virus recognizes and attaches to a host cell when one of its proteins interlocks with a molecular shape that is the receptor site on the host cell's plasma membrane. A protein in the tail fibers of the bacteriophage T4, shown in *Figure 18.1*, recognizes and attaches the T4 to its bacterial host cell. In other viruses, the attachment protein is in the capsid or in the envelope. The recognition and attachment process is like two pieces of a jigsaw puzzle fitting together. The process might also remind you of two spaceships docking.

 **Reading Check** Compare and contrast the structures of viruses to cells.

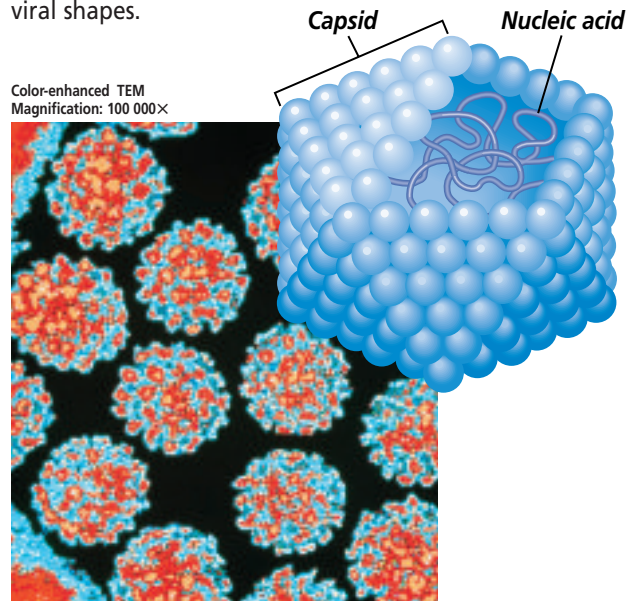
## Attachment is a specific process

Each virus has a specifically shaped attachment protein. Therefore, each virus can usually attach to only a few kinds of cells. For example, the T4 phage can infect only certain types of

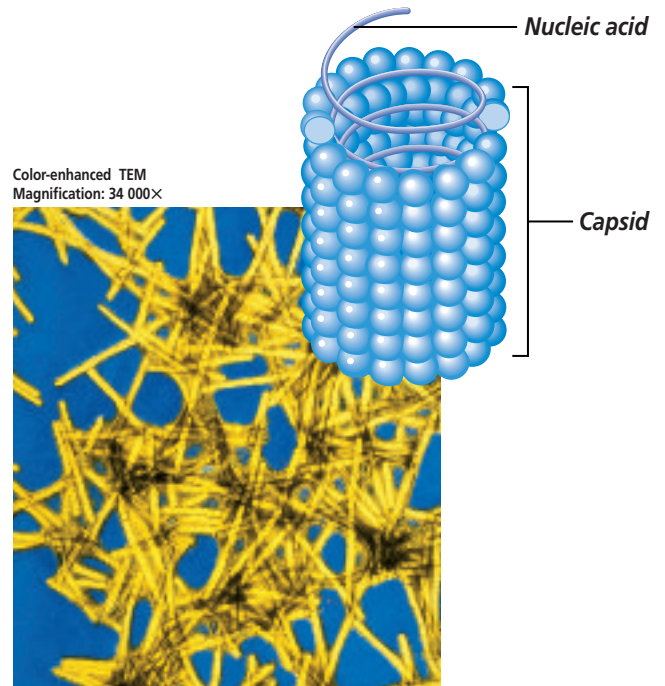
*E. coli* because the T4's attachment protein matches a surface molecule of only these *E. coli*. A T4 cannot infect a human, animal, or plant cell, or even another bacterium. In general, viruses are species specific, and some

**Figure 18.1**

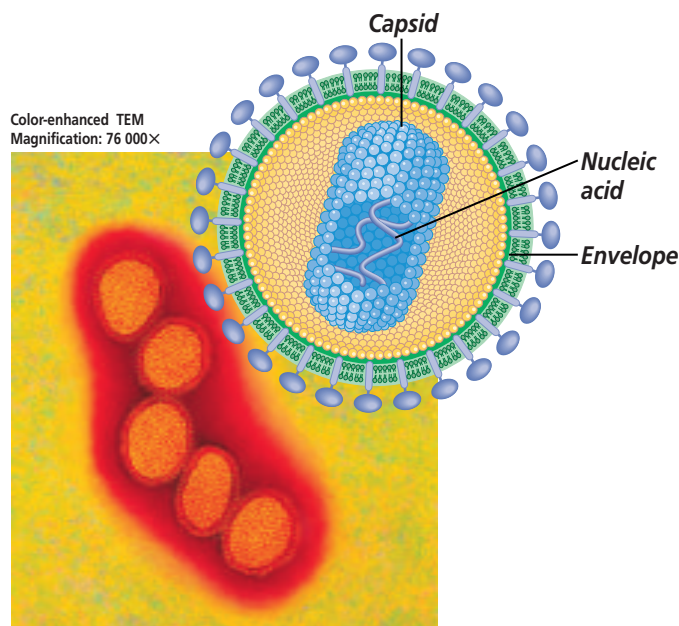
The different proteins in viral capsids produce a wide variety of viral shapes.



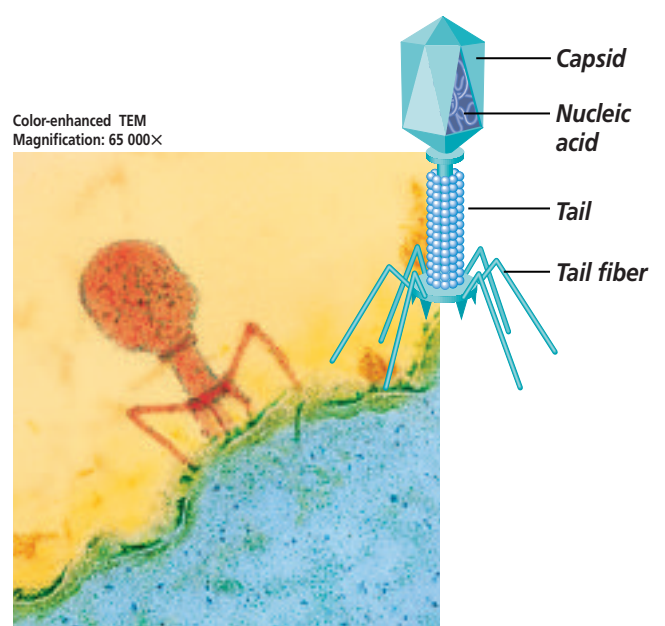
**A** Polyhedral viruses, such as the papilloma virus that causes warts, resemble small crystals.



**B** The tobacco mosaic virus has a long, narrow helical shape.




**C** An envelope studded with projections covers some viruses, including the influenza virus (photo) and the AIDS-causing virus (inset).



**D** This T4 virus, which infects *E. coli*, consists of a polyhedral-shaped head attached to a cylindrical tail with leglike fibers.

also are cell-type specific. For example, polio viruses normally infect only intestinal and nerve cells.

The species specific characteristic of viruses is significant for controlling the spread of viral diseases. For example, by 1980, the World Health Organization had announced that smallpox, which is a deadly human viral disease, had been eradicated. The eradication was possible partly because the smallpox virus infects only humans. A virus such as the one that causes the flu is not species specific and infects animals as well as humans; therefore, it is difficult to eradicate. A virus such as West Nile virus infects mainly birds, horses, and humans.

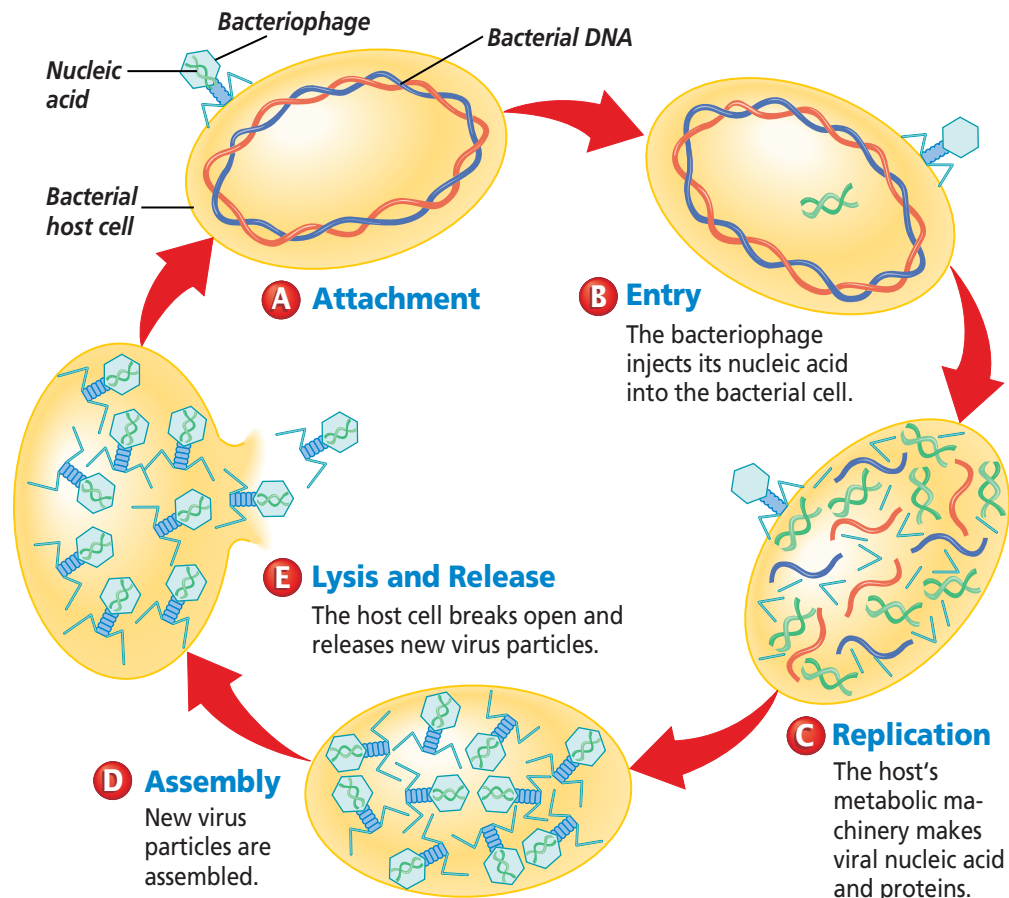
 **Reading Check** Summarize why a virus can attach to only a few specific host cells.

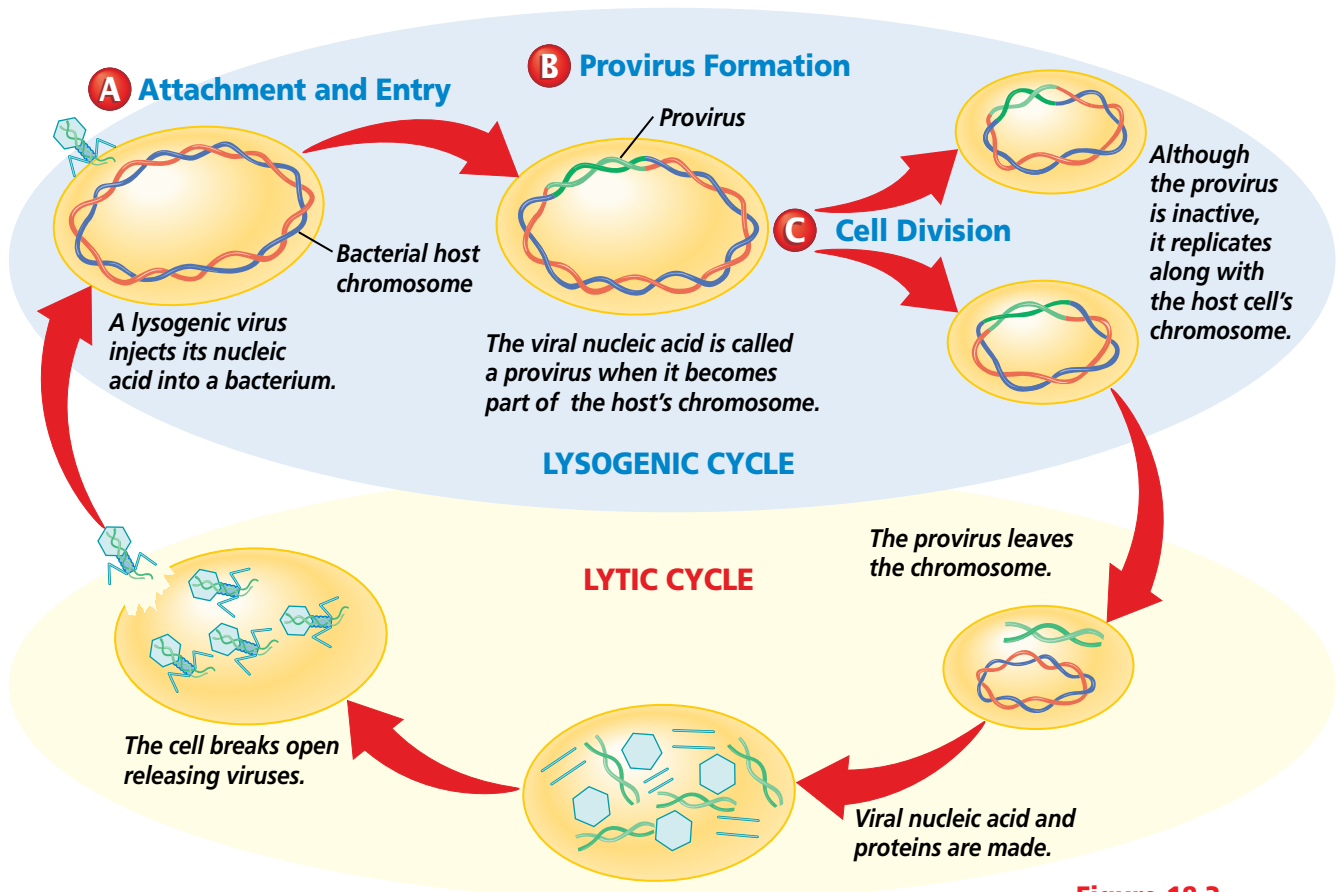
## Viral Replication Cycles

Once attached to the plasma membrane of the host cell, the virus enters the cell and takes over its metabolism. Only then can the virus replicate. Viruses have two ways of getting into host cells. The virus may inject its nucleic acid into the host cell like a syringe injects a vaccine into your arm, as shown in *Figure 18.2*. The capsid of the virus stays attached to the outside of the host cell. An enveloped virus enters a host cell in a different way. After attachment, the plasma membrane of the host cell surrounds the virus and produces a virus-filled vacuole inside the host cell's cytoplasm. Then, the virus bursts out of the vacuole and releases its nucleic acid into the cell.

**Figure 18.2**

In a lytic cycle, a virus uses the host cell's energy and raw materials to make new viruses. A typical lytic cycle takes about 30 minutes and produces about 200 new viruses.





**Figure 18.3**

In a lysogenic cycle, a virus does not destroy the host cell at once. Rather, the viral nucleic acid is integrated into the genetic material of the host cell and replicates with it for a while before entering a lytic cycle.

## Lytic cycle

Once inside the host cell, a virus's genes are expressed and the substances that are produced take over the host cell's genetic material. The viral genes alter the host cell to make new viruses. The host cell uses its own enzymes, raw materials, and energy to make copies of viral genes that along with viral proteins are assembled into new viruses, which burst from the host cell, killing it. The new viruses can then infect and kill other host cells. This process is called a **lytic** (LIH tik) **cycle**. Follow the typical lytic cycle for a bacteriophage shown in *Figure 18.2*.

## Lysogenic cycle

Not all viruses kill the cells they infect. Some viruses go through a **lysogenic cycle**, a replication cycle in which the virus's nucleic acid is

integrated into the host cell's chromosome. A typical lysogenic cycle for a virus that contains DNA is shown in *Figure 18.3*.

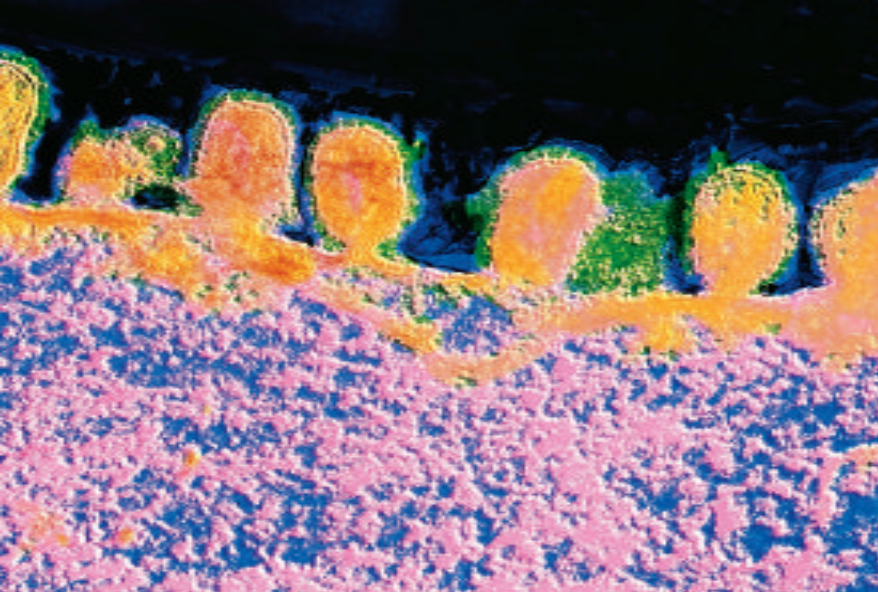
A lysogenic cycle begins in the same way as a lytic cycle. The virus attaches to the host cell's plasma membrane and its nucleic acid enters the cell. However, in a lysogenic cycle, instead of immediately taking over the host's genetic material, the viral DNA is integrated into the host cell's chromosome.

Viral DNA that is integrated into the host cell's chromosome is called a **provirus**. A provirus may not affect the functioning of its host cell, which continues to carry out its own metabolic activity. However, every time the host cell reproduces, the provirus is replicated along with the host cell's chromosome. Therefore, every cell that originates from an infected host

### Word Origin

**lytic** from the Greek word *lyein*, meaning to "break down"; The host cell is destroyed during a lytic cycle.





Color-enhanced TEM Magnification: 17 150X

**Figure 18.4**

Before the influenza virus leaves a host cell, it is wrapped in a piece of the host's plasma membrane, making an envelope with the same structure as the host's plasma membrane.

cell has a copy of the provirus. The lysogenic phase can continue for many years. However, at any time, the provirus can be activated and enter a lytic cycle. Then the virus replicates and kills the host cell. Try to distinguish the human diseases caused by lysogenic viruses from those caused by lytic viruses in the *Problem-Solving Lab* on this page.

**Disease symptoms of proviruses**

The lysogenic process explains the reoccurrence of cold sores, which are caused by the herpes simplex I virus. Even though a cold sore heals, the herpes simplex I virus remains in your cells as a provirus. When the provirus enters a lytic cycle, another cold sore erupts. No one knows what causes a provirus to be activated, but some scientists suspect that physical stress, such as sunburn, and emotional stress, such as anxiety, play a role.

Many disease-causing viruses have lysogenic cycles. Three examples of these viruses are herpes simplex I, herpes simplex II that causes genital herpes, and the hepatitis B virus that causes hepatitis B. Another lysogenic virus is the one that causes chicken pox. Having chicken pox, which usually occurs before age ten, gives lifelong protection from another infection by the virus. However, some chicken pox viruses may remain as proviruses in some of your body's nerve cells. Later in your life, these proviruses may enter a lytic cycle and cause a disease called shingles—a painful infection of some nerve cells.

**Release of viruses**

Either lysis, the bursting of a cell, or exocytosis, shown in *Figure 18.4*, the active transport process by which materials are expelled from a cell, releases new viruses from the host cell.

**Problem-Solving Lab 18.1**

**Analyze Information**

**What type of virus causes disease?** The symptoms and incubation time of a disease can indicate how the virus acts inside its host cell.

**Solve the Problem**

The table below lists symptoms and incubation times for some viral diseases. Use the table to predict which diseases lytic viruses might cause and which diseases lysogenic viruses might cause.

Characteristics of Some Viral Diseases		
Disease	Symptom	Incubation
Measles	Rash, fever	9–11 days
Shingles	Pain, itching on skin	Years
Warts	Bumpy areas on skin	Months
Influenza	Body aches, runny nose, fever	1–4 days
HIV	Fatigue, weight loss, fever	2–5 years

**Thinking Critically**

- 1. Observe** How much time is associated with the replication cycle of a lytic virus? A lysogenic virus?
- 2. Describe** What diseases may lytic viruses cause? Explain your answer.
- 3. Describe** What diseases may lysogenic viruses cause? Explain your answer.
- 4. Infer** What is a possible consequence of the fact that a person infected with HIV may have no symptoms for years?

In exocytosis, a newly produced virus approaches the inner surface of the host cell's plasma membrane. The plasma membrane surrounds the virus, enclosing it in a vacuole that then fuses with the host cell's plasma membrane. Then, the viruses are released to the outside.

## Retroviruses

Many viruses, such as the human immunodeficiency virus (HIV) that causes the disease AIDS, are RNA viruses—RNA being their only nucleic acid. The RNA virus with the most complex replication cycle is the **retrovirus** (reh tro VY rus). How can RNA be integrated into a host cell's chromosome, which contains DNA?

Once inside a host cell, the retrovirus makes DNA from its RNA. To do this, it uses **reverse transcriptase** (trans KRIHP tayz), an enzyme it carries inside its capsid. This enzyme helps produce double-stranded DNA from the viral RNA. Then the double-stranded viral DNA is integrated into the host cell's chromosome and becomes a provirus. If reverse transcriptase is found in a

## CAREERS IN BIOLOGY


### Dairy Farmer

**D**id you grow up on a farm, or do you wish you did? Would you enjoy a chance to work with animals and be outdoors? Perhaps you should be a dairy farmer.

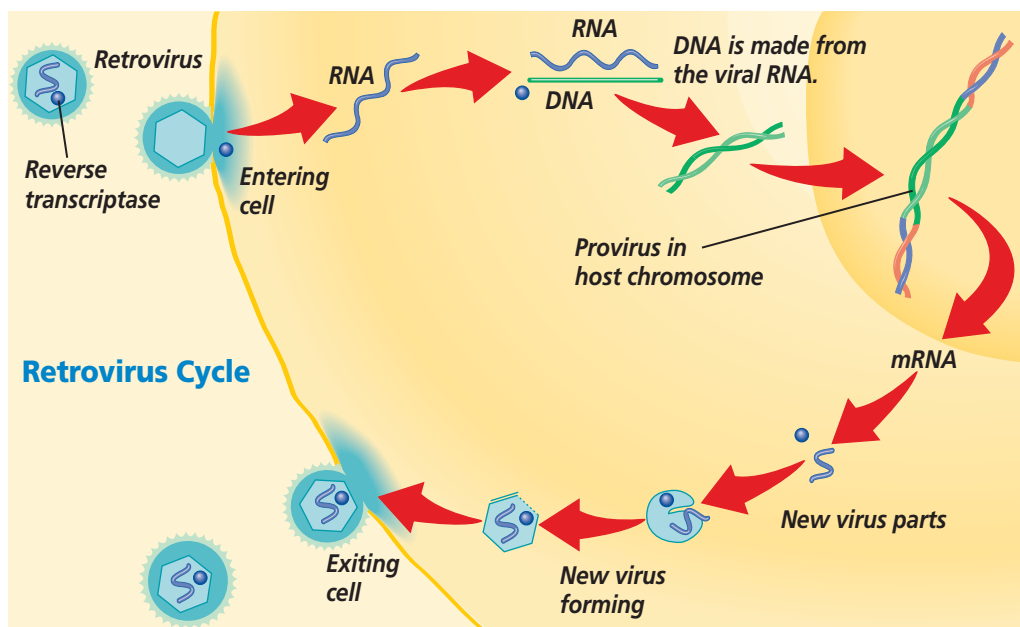
### Skills for the Job

In the past, most dairy farms were family owned, but now corporations own some of these farms. A person can learn dairy farming on the job, or by completing two- and four-year college programs in agriculture. A degree in agriculture can lead to certification as a farm manager. Dairy farmers must keep their herds healthy and producing both milk and calves. Like all farming, dairy farming is a risky business that depends on factors such as the weather, the cost of feed, the amount of milk the herds produce, and the market price for milk and milk products.

For more careers in related fields, visit [ca.bdol.glencoe.com/careers](http://ca.bdol.glencoe.com/careers)



person, it is evidence for infection by a retrovirus. You can see how a retrovirus replicates in its host cell in *Figure 18.5*.



**Figure 18.5**

Retroviruses have an enzyme that transcribes their RNA into DNA. The viral DNA becomes a provirus that steadily produces small numbers of new viruses without immediately destroying the cell. Infer **How do doctors often discover that someone has a retrovirus infection?**

## HIV: An infection of white blood cells

Once inside a human host, HIV infects white blood cells. Newly made viruses are released into the blood stream by exocytosis and infect other white blood cells. Infected host cells still function normally because the viral genetic material is a provirus that produces only a small number of new viruses at a time. Because the infected cells are still able to function normally, an infected person may not appear sick, but they can still transmit the virus in their body fluids.

An HIV-infected person can experience no AIDS symptoms for a long time. However, most people with an HIV infection eventually get AIDS because, over time, more white blood cells are infected and produce new viruses, *Figure 18.6*. People gradually lose white blood cells because proviruses enter a lytic cycle and kill their host cells. Because white blood cells are part of a body's disease-fighting system, their destruction interferes with the body's ability to protect itself from organisms that cause disease, a symptom of AIDS.

## Cancer and Viruses

Some viruses have been linked to certain cancers in humans and animals. For example, the hepatitis B virus has been shown to play a role in causing liver cancer. These viruses disrupt the normal growth and division of cells in a host, causing abnormal growth and creating tumors.

## Prions and viroids

Researchers have recently discovered some particles that behave somewhat like viruses and cause infectious diseases. **Prions** are composed of proteins but have no nucleic acid to carry genetic information. Prions are thought to act by causing other proteins to fold themselves incorrectly, resulting in improper functioning. Prions are responsible for many animal diseases, such as mad cow disease and its human equivalent, Creutzfeldt-Jakob disease.

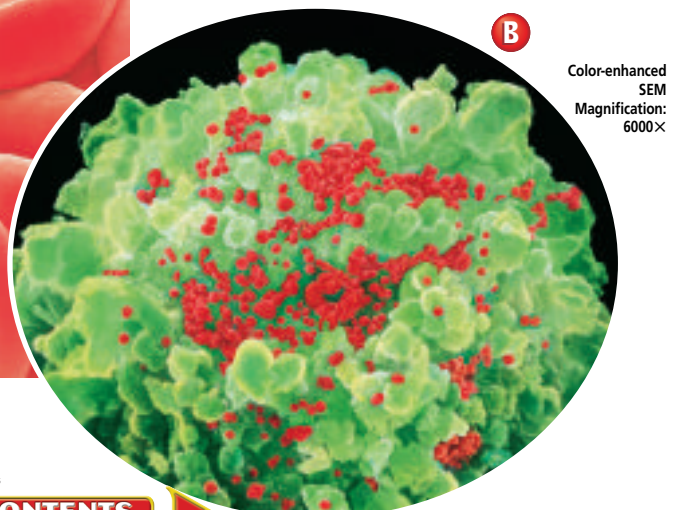
**Viroids** are composed of a single circular strand of RNA with no protein coat. Viroids have been shown to cause infectious diseases in several plants. The amount of viroid RNA is much less than the amount found in viruses.

Color-enhanced SEM Magnification: 3500×



**Figure 18.6**

Normal white blood cells are an essential part of a human's immune system (A). In an HIV-infected person, white blood cells are eventually destroyed by HIV proviruses (shown as red objects) that enter lytic cycles (B).



Color-enhanced SEM Magnification: 6000×



**Figure 18.7**  
Tobacco mosaic virus causes yellow spots on tobacco leaves, making them unmarketable (A). In contrast, another virus causes the beautiful stripes of Rembrandt tulips, making them more desirable (B).

### Plant viruses

The first virus to be identified was a plant virus, called tobacco mosaic virus, that causes disease in tobacco plants. There are more than 400 viruses that infect a variety of plants. These viruses cause as many as 1000 plant diseases and are named according to their host plant. Viruses can cause stunted growth and yield losses in their host plants. Plant viruses require wounds or insect bites to enter and infect a host, and do not use surface recognition. They do not undergo lytic or lysogenic phases.

Not all viral plant diseases are fatal or even harmful. Some mosaic viruses cause striking patterns of color in the flowers of plants. The infected flowers, like the ones shown

in *Figure 18.7B*, have streaks of vibrant, contrasting colors in their petals. These viruses are easily spread among plants when you cut an infected stem and then cut healthy stems with the same tool.

### Origin of Viruses

You might assume that viruses represent an ancestral form of life because of their relatively uncomplicated structure. This is probably not so. For replication, viruses need host cells; therefore, scientists suggest that viruses might have originated from their host cells. Some scientists suggest that viruses are nucleic acids that break free from their host cells while maintaining an ability to replicate parasitically within the host cells.

## Section Assessment

### Understanding Main Ideas

1. Why is a virus considered to be nonliving?
2. What is the difference between a lytic cycle and a lysogenic cycle?
3. What is a provirus?
4. How do retroviruses convert their RNA to DNA?

### Thinking Critically

5. Describe the state of a herpes virus in a person who had cold sores several years ago but who does not have them now.

### SKILL REVIEW

6. **Make and Use Graphs** A microbiologist added some viruses to a bacterial culture. Every hour from noon to 4:00 P.M., she determined the number of viruses present in a sample of the culture. Her data were 3, 3, 126, 585, and 602. Graph these results. How would the graph look if the culture had initially contained dead bacteria? For more help, refer to *Make and Use Graphs* in the *Skill Handbook*.



# Section 18.2

## Archaeobacteria and Eubacteria

**California Standards** Standard 1c Students know how prokaryotic cells, eukaryotic cells (including those from plants and animals), and viruses differ in complexity and general structure.

### SECTION PREVIEW

#### Objectives

**Compare** the types of prokaryotes.

**Explain** the characteristics and adaptations of bacteria.

**Evaluate** the economic importance of bacteria.

#### Review Vocabulary

**prokaryote:** unicellular organism whose cell lacks a nucleus and internal membrane-bound organelles (p. 173)

#### New Vocabulary

chemosynthesis  
binary fission  
conjugation  
obligate aerobe  
obligate anaerobe  
endospore  
toxin  
nitrogen fixation

### FOLDABLES™ Study Organizer

**Viruses and Bacteria** Make the following Foldable to help you organize information about viruses and bacteria.

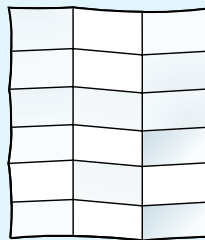
**STEP 1** **Fold** one piece of paper lengthwise into thirds.



**STEP 2** **Fold** the paper widthwise into six sections.



**STEP 3** **Unfold**, lay the paper vertically, and draw lines along the folds.



**STEP 4** **Label** your table as shown.

	Virus	Bacteria
Structure		
Kinds		
Replication		
Harmful		
Beneficial		

**Compare and Contrast** As you read Section 18.2, complete the table by describing the characteristics of viruses and bacteria.

## Diversity of Prokaryotes

Recall that prokaryotes are unicellular organisms that do not have a nucleus or membrane-bound organelles. They are classified in two kingdoms—archaeobacteria and eubacteria. Many biochemical differences exist between these two types of prokaryotes. For example, their cell walls and the lipids in their plasma membranes differ. In addition, the structure and function of the genes of archaeobacteria are more similar to those of eukaryotes than to those of eubacteria.

Because they are so different, many scientists propose that archaeobacteria and eubacteria arose from a common ancestor several billion years ago.

### Archaeobacteria: The extremists

There are three types of archaeobacteria that live mainly in extreme habitats where there is usually no free oxygen available. You can see some of these environments in *Figure 18.8*. One type of archaeobacterium lives

in oxygen-free environments and produces methane gas. These methane-producing archaeobacteria live in marshes, lake sediments, and the digestive tracts of some mammals, such as cows. They also are found at sewage disposal plants, where they play a role in the breakdown of sewage.

A second type of archaeobacterium lives only in water with high concentrations of salt, such as in Utah's Great Salt Lake and the Middle East's Dead Sea. A third type lives in the hot, acidic waters of sulfur springs.

This type of anaerobic archaeobacterium also thrives near cracks deep in the ocean floor, where it is the autotrophic producer for a unique animal community's food chain.

### Eubacteria: The heterotrophs

Eubacteria, the other kingdom of prokaryotes, includes those prokaryotes that live in places more hospitable than archaeobacteria inhabit and that vary in nutritional needs. The heterotrophic eubacteria live almost everywhere and use organic molecules as their food source.

**Figure 18.8**

Archaeobacteria live in extreme environments.



**A** Methane-producing archaeobacteria flourish in this swamp and also live in the stomachs of cows.

**B** Salt-loving archaeobacteria live in these salt pools left after this lake in British Columbia, Canada, evaporated. These pools have high levels of magnesium and potassium salts.



**C** Heat- and acid-loving archaeobacteria live around deep ocean vents where water temperatures are often above 100°C.

## Word Origin

**cyanobacterium** from the Greek words *kyanos*, meaning "blue," and *bakterion*, meaning "small rod"; The cyanobacteria are blue-green bacteria.

Some bacterial heterotrophs are parasites, obtaining their nutrients from living organisms. They are not adapted for trapping food that contains organic molecules or for making organic molecules themselves. Others are saprophytes—organisms that feed on dead organisms or organic wastes. Recall that saprophytes break down and recycle the nutrients locked in the body tissues of dead organisms.

### Eubacteria: Photosynthetic autotrophs

A second type of eubacterium is the photosynthetic autotroph. These eubacteria live in places with sunlight because they need light to make the organic molecules that are their food. Cyanobacteria are photosynthetic autotrophs. They contain the pigment chlorophyll that traps the sun's energy, which they then use in photosynthesis. Most cyanobacteria, like the *Anabaena* shown in **Figure 18.9**,

are blue-green and some are red or yellow in color. Cyanobacteria commonly live in ponds, streams, and moist areas of land. They are composed of chains of independent cells.

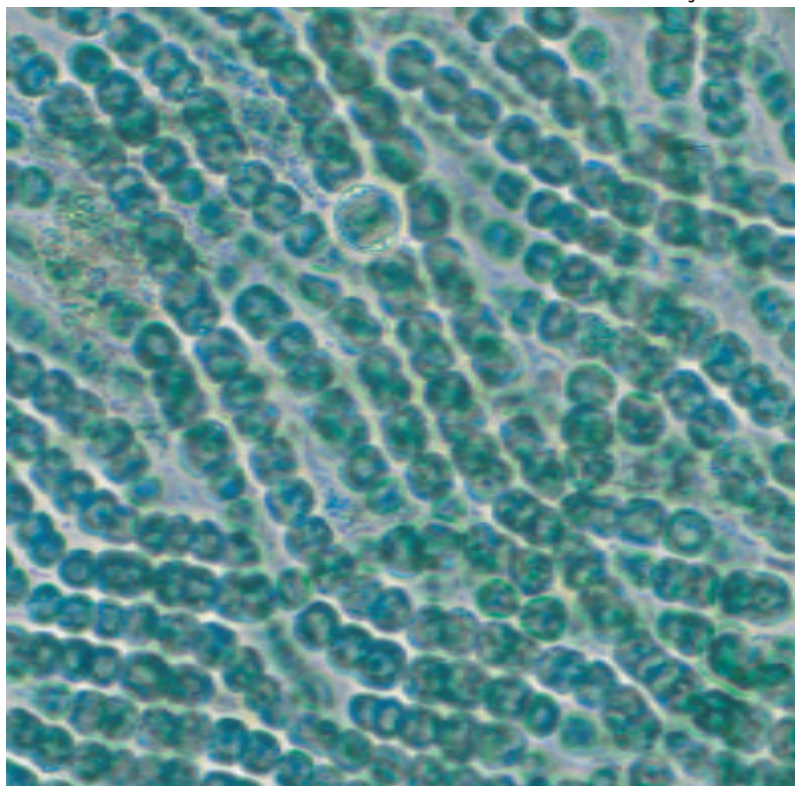
### Eubacteria: Chemosynthetic autotrophs

A third type of eubacterium is the chemosynthetic autotroph. Like photosynthetic bacteria, these bacteria make organic molecules that are their food. However, unlike the photosynthetic bacteria, the chemosynthetic bacteria do not obtain the energy they need to make food from sunlight. Instead, they break down and release the energy of inorganic compounds containing sulfur and nitrogen in the process called **chemosynthesis** (kee moh SIHN tuh sus). Some chemosynthetic bacteria are very important to other organisms because they are able to convert atmospheric nitrogen into the nitrogen-containing compounds that plants need.

**Figure 18.9**

Cyanobacteria, such as *Anabaena*, are photosynthetic and have a blue-green color.

LM Magnification: 250×



## What is a bacterium?

A bacterium consists of a very small cell. Although tiny, a bacterial cell has all the structures necessary to carry out its life functions.

### The structure of bacteria

Prokaryotic cells have ribosomes, but their ribosomes are smaller than those of eukaryotes. They also have genes that are located for the most part in a single circular chromosome, rather than in paired chromosomes. What structures can protect a bacterium? Look at **Figure 18.10** on the next page to learn about other structures located in bacterial cells.

One structure that supports and protects a bacterium is the cell wall. The cell wall protects the bacterium by preventing it from bursting.

## A Typical Bacterial Cell

**Figure 18.10**

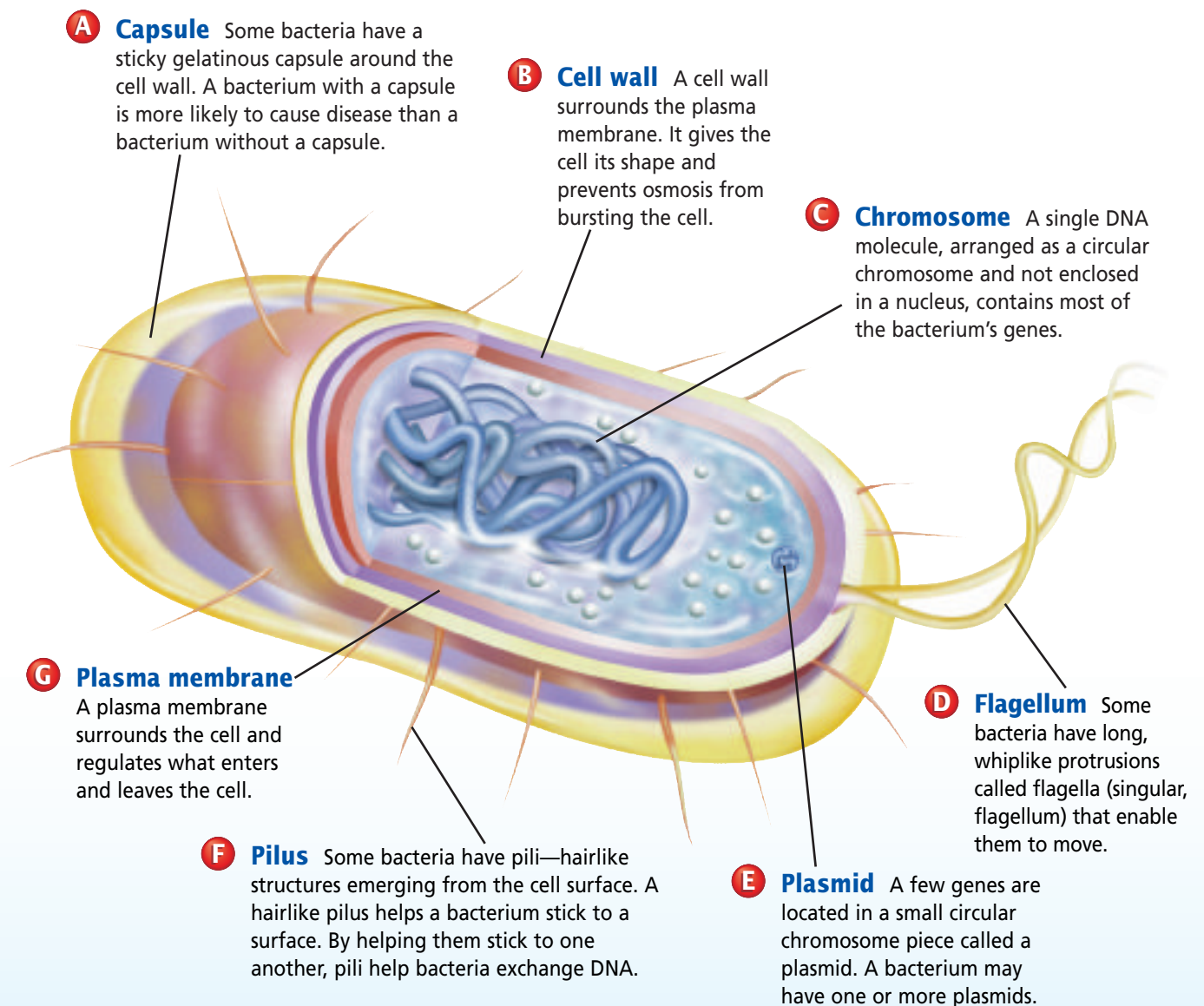
Bacteria are microscopic, prokaryotic cells. Bacteria are unicellular. A typical bacterium, such as *Escherichia coli* shown at the right, would have some or all of the structures shown in this diagram of a bacterial cell.

**Critical Thinking** Which structures of bacteria are involved in reproduction?

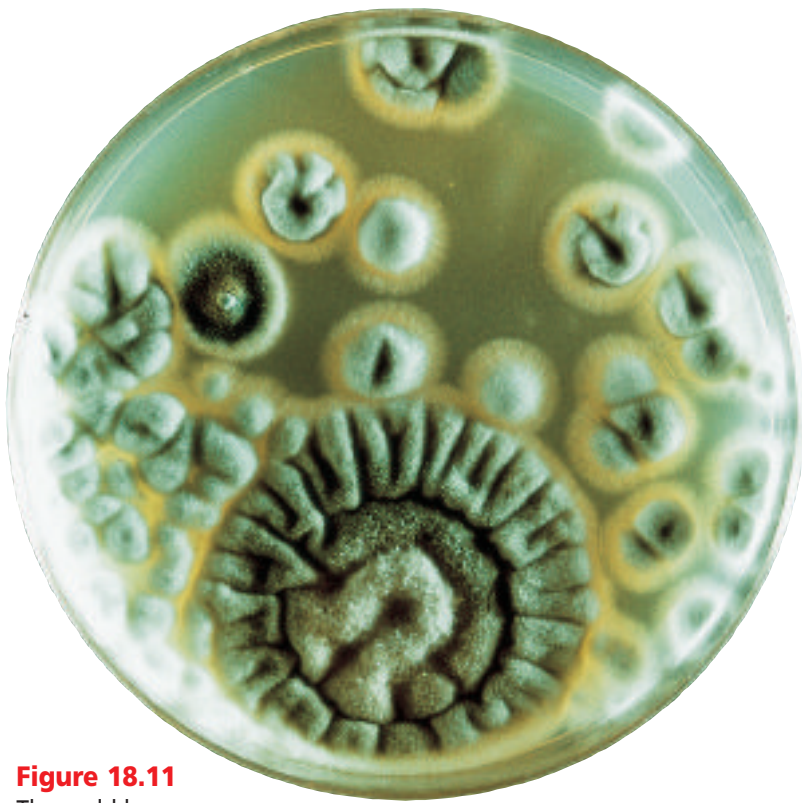
Color-enhanced TEM Magnification: 3000×



*Escherichia coli*







**Figure 18.11**

The mold known as *Penicillium notatum*, shown above in its growth stages, produces the antibiotic penicillin.

Because most bacteria live in a hypotonic environment, one in which there is a higher concentration of water molecules outside than inside the cell, water is always trying to enter a bacterial cell. A bacterial cell remains intact, however, and does not burst open as long as its cell wall is intact. If the cell wall is damaged, water will enter the cell by osmosis, causing the cell to burst. Scientists used a bacterium's need for an intact cell wall to develop a weapon against bacteria that cause disease.


In 1928, Sir Alexander Fleming accidentally discovered penicillin, the first antibiotic—a substance that destroys bacteria—used in humans. He was growing bacteria when an airborne mold, *Penicillium notatum*, contaminated his culture plates. He noticed that the mold, shown in *Figure 18.11*, secreted a substance—now known as the antibiotic penicillin—that killed the bacteria he was growing. Later, biologists discovered that penicillin can interfere with the

ability of some bacteria to make cell walls. When such bacteria grow in penicillin, holes develop in their cell walls, water enters their cells, and they rupture and die.

## Identifying bacteria

Scientists have developed ways to distinguish among bacteria. For example, one trait that helps categorize bacteria is how they react to Gram stain. Gram staining is a technique that distinguishes two groups of bacteria because the stain reflects a basic difference in the composition of bacterial cell walls. The cell walls of all bacteria are made of interlinked sugar and amino acid molecules that differ in arrangement and react differently to Gram stain. After staining, Gram-positive bacteria are purple and Gram-negative bacteria are pink. Gram-positive bacteria are affected by different antibiotics than those that affect Gram-negative bacteria.

Not only do bacterial cell walls react differently to Gram stain, but they also give bacteria different shapes. Shape is another way to categorize bacteria. The three most common shapes are spheres, called cocci; rods, called bacilli; and spirals, called spirilla. An example of each shape is shown in *Figure 18.12*. In addition to having one of these shapes, bacterial cells often grow in characteristic patterns that provide another way of categorizing them. *Diplo-* is a prefix that refers to a paired arrangement of cell growth. The prefix *staphylo-* describes an arrangement of cells that resemble grapes. *Strepto-* is a prefix that refers to an arrangement of chains of cells.

 **Reading Check** Describe what shape and growth pattern you would expect *Staphylococcus* bacteria to have.

Color-enhanced SEM Magnification: 34 000×



**A** These spherical, Gram-positive *Streptococcus pneumoniae* bacteria cause pneumonia.

Color-enhanced SEM Magnification: unavailable



**B** This rodlike, Gram-positive bacterium, *Bacillus anthracis*, commonly exists in the soil. It can cause anthrax in cattle, sheep, and humans.

LM Magnification: 250×



**C** This spiral-shaped, Gram-negative *Spirillum volutans* bacterium has flagella.

## Reproduction by binary fission

Bacteria cannot reproduce by mitosis or meiosis because they have no nucleus, and instead of pairs of chromosomes, they have one circular chromosome and varying numbers of smaller circular pieces of DNA called plasmids. Therefore, they have other ways to reproduce.

Bacteria reproduce asexually by a process known as **binary fission**. To reproduce in this way, a bacterium first copies its chromosome. Then the original chromosome and the copy become attached to the cell's plasma membrane for a while. The cell grows larger, and eventually the two chromosomes separate and move to opposite ends of the cell. Then, a partition forms between the chromosomes, as shown in *Figure 18.13*. This partition separates the cell into two similar cells. Because each new cell has either the original or the copy of the

chromosome, the resulting cells are genetically identical.

Bacterial reproduction can be rapid. In fact, under ideal conditions, some bacteria can reproduce every 20 minutes, producing enormous numbers of bacteria quickly. If bacteria always reproduced this fast, they would cover the surface of Earth within a few weeks. But bacteria don't always have ideal growing conditions. They run out of nutrients and water,

**Figure 18.12**

Bacteria exist in three main shapes.

Color-enhanced TEM Magnification: 16 500×



**Figure 18.13**

This *Escherichia coli* cell is starting to divide. The newly forming partition is visible in the center of the cell.

## MiniLab 18.2

### Observe

**Bacteria Have Different Shapes** Bacteria come in three shapes: spherical (coccus), rodlike (bacillus), and spiral shaped (spirillum). They may appear singly or in pairs, chains, or clusters. Each species has a typical shape and reaction to Gram stain.

Color-enhanced SEM Magnification: 50 000×



*Staphylococcus* bacteria

### Procedure

- 1 Obtain slides of bacteria from your teacher.
- 2 Using low power, locate bacteria of one shape. Switch to high power. Look for individual cells and observe their shape. Also observe the size of the cells and their color. Then look for groups of bacterial cells to determine their arrangement. **CAUTION: Use caution when working with a microscope and microscope slides.**
- 3 Repeat step 2 for bacteria with the other shapes. Then, compare the sizes of the bacteria.
- 4 Draw a diagram of each type of bacteria.

### Analysis

1. **Measure** How do the sizes of the three bacteria compare?
2. **Classify** Which of the bacteria were Gram negative?
3. **Explain** What adaptive advantage might there be for bacteria to form groups of cells?

they poison themselves with their own wastes, and predators eat them.

### Sexual reproduction

In addition to binary fission, some bacteria have a form of sexual reproduction called conjugation. During **conjugation** (kahn juh GAY shun), one bacterium transfers all or part of its chromosome to another cell through or on a bridgelike structure called a pilus (plural, pili) that connects the two cells. In *Figure 18.14*, you can see how this genetic transfer occurs. Conjugation results in a bacterium with a new genetic composition. This bacterium can then undergo binary fission, producing more cells with the same genetic makeup.

Try the *MiniLab* on this page to see some bacterial staining reactions, cell shapes, and patterns of growth.

### Adaptations in Bacteria

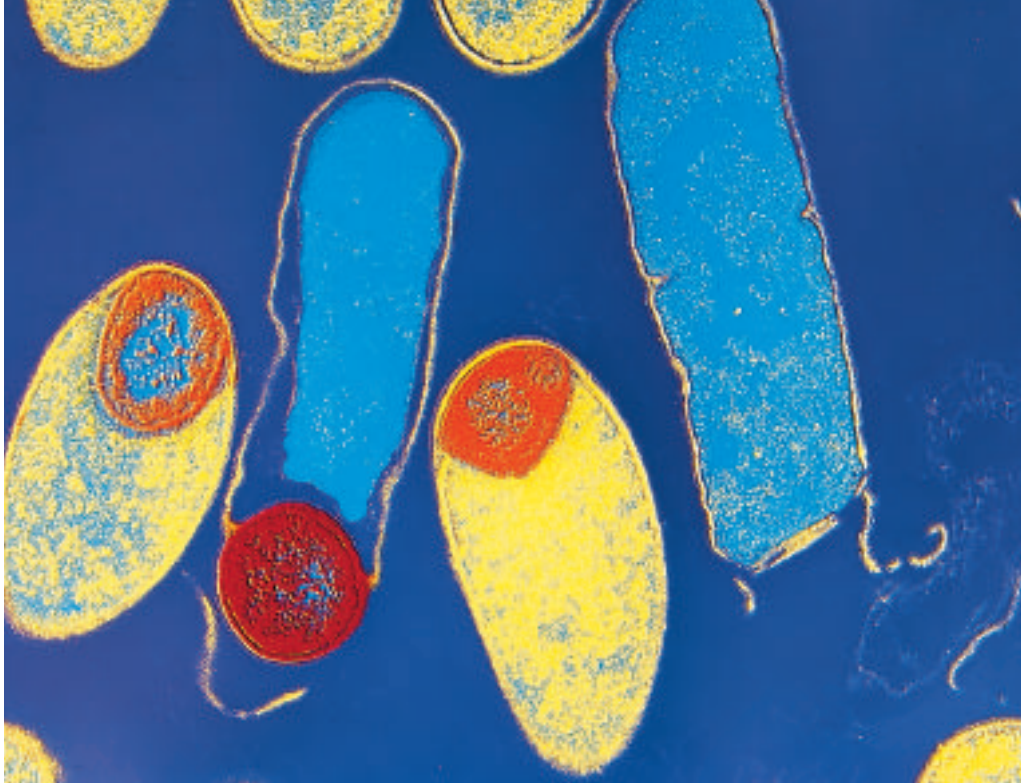
Based on fossil evidence, some scientists propose that anaerobic bacteria were probably among the first photosynthetic organisms, producing not only their own food but also oxygen. As the concentration of oxygen increased

Color-enhanced TEM Magnification: 5000×



### Figure 18.14

The *E. coli* at the bottom is attached to the other bacteria by pili, through or on which genetic material is being transferred. Infer **How would conjugation be a useful addition to binary fission?**



Color-enhanced TEM Magnification: 12 500×

**Figure 18.15**

This TEM magnification shows bacteria in three different stages of endospore production.

in Earth's atmosphere, some bacteria probably adapted over time to use oxygen for respiration.

### Diversity of metabolism

Recall that breaking down food to release its energy is called cellular respiration. Modern bacteria have diverse types of respiration.

Many bacteria require oxygen for respiration. These bacteria are called **obligate aerobes**. *Mycobacterium tuberculosis*, the organism that causes the lung disease called tuberculosis, is an obligate aerobe. There are other bacteria, called **obligate anaerobes**, that are killed by oxygen. Among bacteria that are obligate anaerobes is the bacterium *Treponema pallidum* that causes syphilis, a sexually transmitted disease, and the bacterium that causes botulism, a type of food poisoning that you will learn more about soon. There are still other bacteria that can live either with or without oxygen, releasing the energy in food aerobically by cellular respiration or anaerobically by fermentation.

### A survival mechanism

Some bacteria, when faced with unfavorable environmental conditions, produce endospores, shown in *Figure 18.15*. An **endospore** is a tiny structure that contains a bacterium's DNA and a small amount of its cytoplasm, encased by a tough outer covering that resists drying out, temperature extremes, and harsh chemicals. As an endospore, the bacterium rests and does not reproduce. When environmental conditions improve, the endospore germinates, or produces a cell that begins to grow and reproduce. Some endospores have germinated after thousands of years in the resting state.

Although endospores are useful to bacteria, they can cause problems for people. Endospores can survive a temperature of 100°C, which is the boiling point of water. To kill endospores, items must be sterilized—heated under high pressure in either a pressure cooker or an autoclave. Under pressure, water will boil at a higher temperature than its usual 100°C, and this higher temperature kills endospores.

## Problem-Solving Lab 18.2

### Hypothesize

Can you get food poisoning from eating home-canned foods? *Clostridium botulinum* is a bacterial species that causes food poisoning.

### Solve the Problem

*C. botulinum* is an obligate anaerobic soil bacterium, and it easily spreads onto plants. It forms endospores that are highly heat-resistant and germinate only in anaerobic conditions. The bacterium produces a heat-resistant toxin that can kill humans. Commercially canned foods are heated to 121°C for a minimum of 20 minutes to ensure that all spores are killed.

### Thinking Critically

- Hypothesize** Why don't you get food poisoning if you eat fresh vegetables that are contaminated with the endospores of *C. botulinum*?
- Hypothesize** How do the endospores of *C. botulinum* get into home-canned vegetables?
- Hypothesize** How can *C. botulinum* endospores survive inadequate home-canning procedures?
- Explain** Why do endospores of *C. botulinum* germinate inside canning jars?



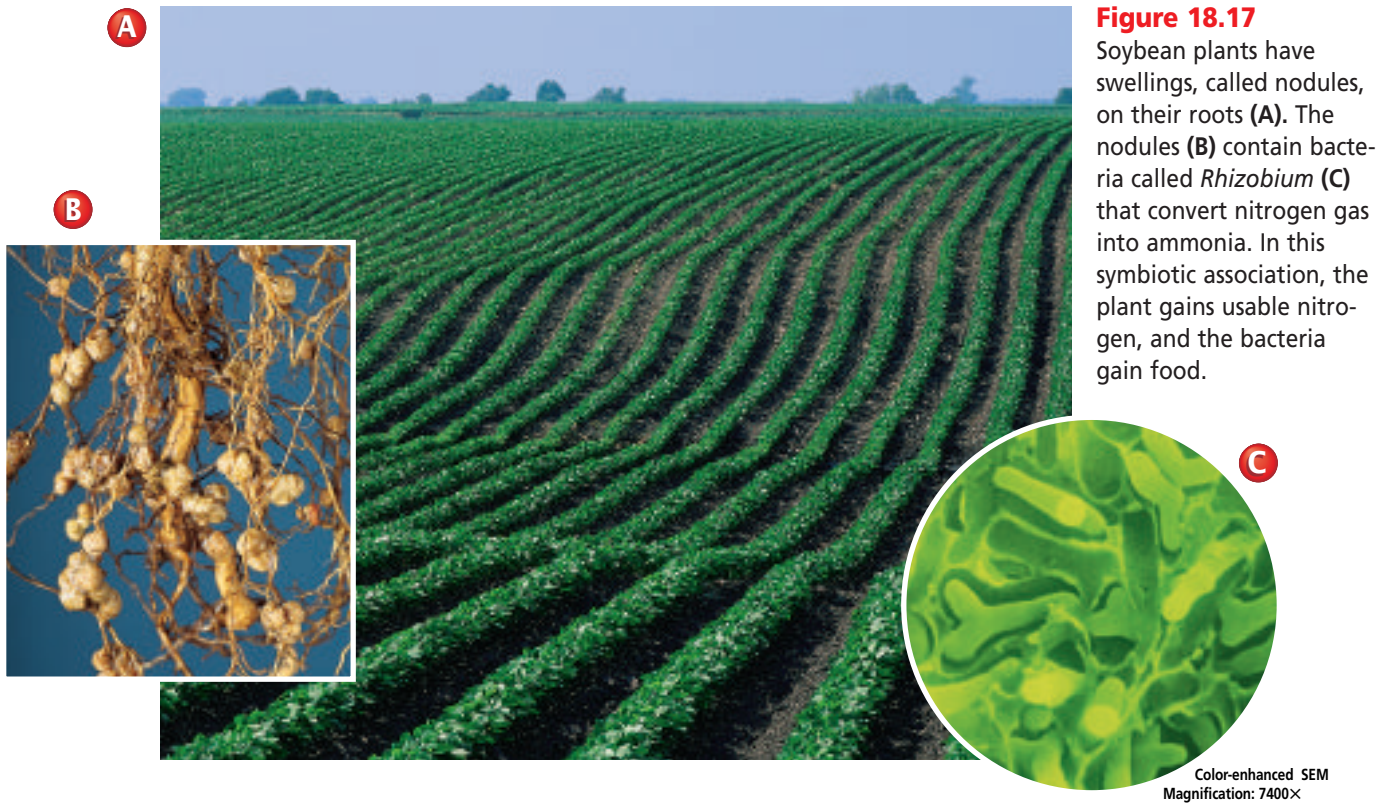
Canned foods must be sterilized and acidified. This is because the endospores of the bacterium called *Clostridium botulinum* easily get into foods being canned. These bacteria belong to the group clostridia—all obligate anaerobic bacteria that form endospores. If the endospores of *C. botulinum* get into improperly sterilized canned food, they germinate. Bacteria grow in the anaerobic environment of the can and produce a powerful and deadly poison, called a **toxin**, as they grow. This deadly toxin saturates the food and, if eaten, causes the disease called botulism. Although rare, botulism is often fatal, and it can be transmitted in many ways other than poorly canned food, as shown in **Figure 18.16**. Try the *Problem-Solving Lab* on this page to learn more about *C. botulinum*.

A different bacterium, *Bacillus anthracis*, lives in the soil. *B. anthracis* causes anthrax, a disease that commonly infects cattle and sheep, but can also infect humans. Most human anthrax infections are fairly harmless and occur on the skin as a result of handling animals. The bacterial spores can become airborne, however, and if inhaled in large amounts, can

**Figure 18.16**

**CAUTION:** When a foil-wrapped potato is baked, any *Clostridium botulinum* spores on its skin can survive. If the potato is eaten immediately, the spores cannot germinate. However, if the still-wrapped potato cools at room temperature, the spores can germinate in the anaerobic environment of the foil, and the bacteria will produce their deadly toxin.





**Figure 18.17** Soybean plants have swellings, called nodules, on their roots (A). The nodules (B) contain bacteria called *Rhizobium* (C) that convert nitrogen gas into ammonia. In this symbiotic association, the plant gains usable nitrogen, and the bacteria gain food.

Color-enhanced SEM  
Magnification: 7400×

germinate in a person's lungs, causing an infection. This infection is more serious than a skin infection and often fatal. The infection harms the lungs by producing toxins that damage lung tissue and the circulatory system. Because anthrax can be easily spread through the air, it has been used to intentionally harm people as a biological weapon.

## The Importance of Bacteria

When you think about bacteria, your first thought may be disease. But disease-causing bacteria are few compared with the number of harmless and beneficial bacteria on Earth. Bacteria help to fertilize fields, to recycle nutrients on Earth, and to produce foods and medicines.

### Nitrogen fixation

Most of the nitrogen on Earth exists in the form of nitrogen gas,  $N_2$ , which makes up about 80 percent of

the atmosphere. All organisms need nitrogen because the element is a component of their proteins, DNA, RNA, and ATP. Yet few organisms, including most plants, can directly use nitrogen from the air.

Several species of bacteria have enzymes that convert  $N_2$  into ammonia ( $NH_3$ ) in a process known as **nitrogen fixation**. Other bacteria then convert the ammonia into nitrite ( $NO_2^-$ ) and nitrate ( $NO_3^-$ ), which plants can use. Bacteria are the only organisms that can perform these chemical changes.

Some nitrogen-fixing bacteria live symbiotically within the roots of some trees and legumes—plants such as peas, peanuts, and soybeans—in swollen areas called nodules. You can see some nodules in *Figure 18.17*. Farmers grow legume crops after the harvesting of crops such as corn, which depletes the soil of nitrogen. Not only do legumes replenish the soil's nitrogen supply, they are an economically useful crop.

### Physical Science Connection

**Classify everyday matter** Elements are substances with the same number of protons in the nucleus of their atoms. For example, all nitrogen atoms (N) in nitrogen gas ( $N_2$ ) have 7 protons. Compounds, such as ammonia ( $NH_3$ ), consist of more than one element present in fixed proportions. The ratio of nitrogen to hydrogen atoms in ammonia always is 1 to 3.

## Recycling of nutrients

You learned that life could not exist if decomposing bacteria did not break down the organic materials in dead organisms and wastes, returning nutrients, both organic materials and inorganic materials, to the environment. Autotrophic bacteria and also plants and algae, which are at the bottom of the food chains, use the nutrients in the food they make.

This food is passed from one heterotroph to the next in food chains and webs. In the process of making food, many autotrophs replenish the supply of oxygen in the atmosphere. You can see from all this that other life depends on bacteria.

## Food and medicines

Some foods that you eat—mellow Swiss cheese, shown in *Figure 18.18*, crispy pickles, tangy yogurt—would not exist without bacteria. During

respiration, different bacteria produce diverse products, many of which have distinctive flavors and aromas. As a result, specific bacteria are used to make different foods, such as vinegar, cheeses, and sauerkraut. Bacteria also inhabit your intestines and produce vitamins and enzymes that help digest food.

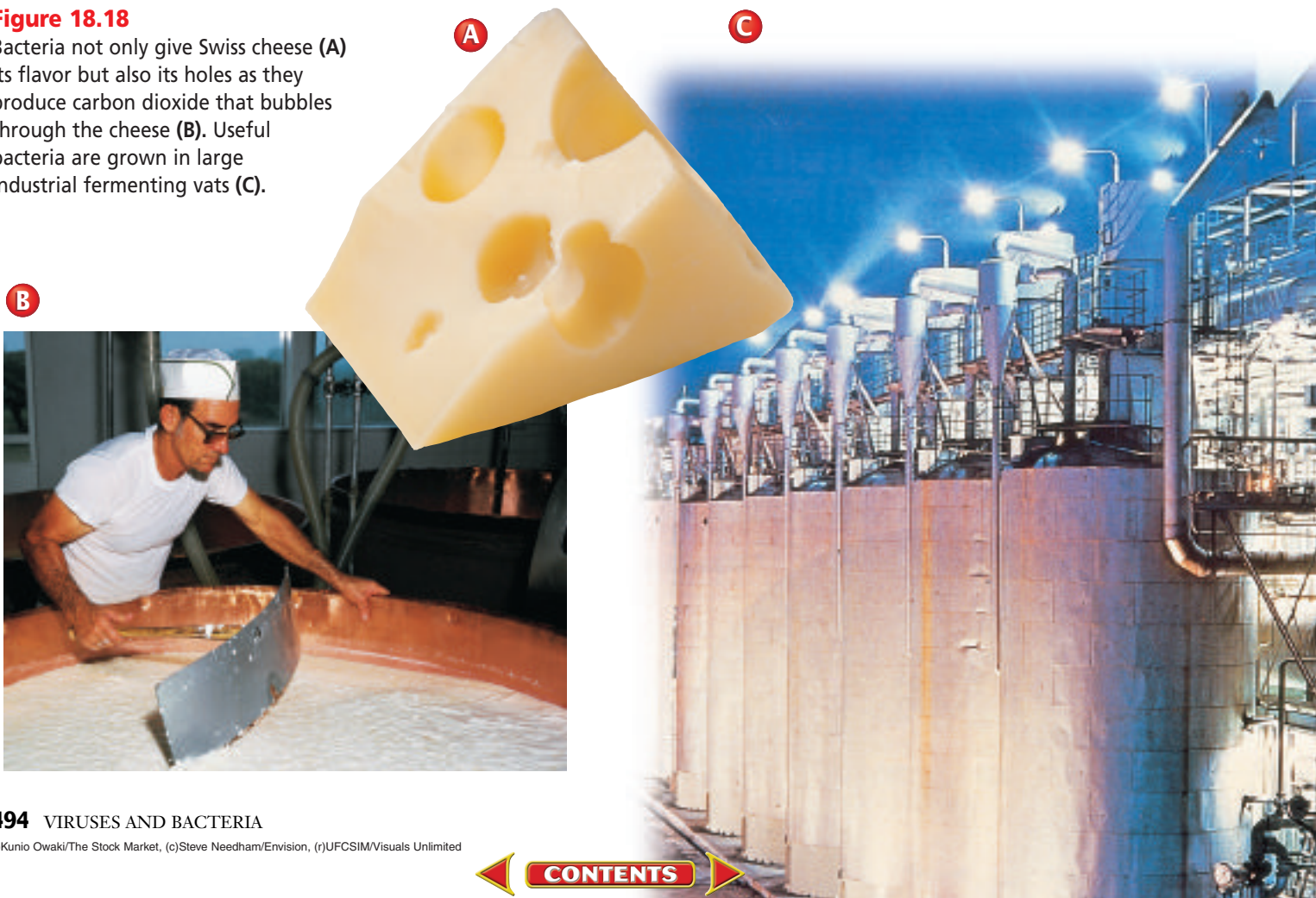
In addition to food, some bacteria produce important antibiotics that destroy other types of bacteria. Streptomycin, erythromycin, bacitracin, and neomycin are some of these antibiotics. How do you know which antibiotic you need when you are sick? The *BioLab* at the end of this chapter will help you learn how scientists have obtained such information.

## Bacteria cause disease

Bacteria cause diseases in plants and animals, causing crops and livestock losses that impact humans indirectly.

**Figure 18.18**

Bacteria not only give Swiss cheese (A) its flavor but also its holes as they produce carbon dioxide that bubbles through the cheese (B). Useful bacteria are grown in large industrial fermenting vats (C).



Disease	Transmission	Symptoms	Treatment
<b>Strep throat (<i>Streptococcus</i>)</b>	Inhale or ingest through mouth	Fever, sore throat, swollen neck glands	Antibiotic
<b>Tuberculosis</b>	Inhale	Fatigue, fever, night sweats, cough, weight loss, chest pain	Antibiotic
<b>Tetanus</b>	Puncture wound	Stiff jaw, muscle spasms, paralysis	Open and clean wound, antibiotic; give antitoxin
<b>Lyme disease</b>	Bite of infected tick	Rash at site of bite, chills, body aches, joint swelling	Antibiotic
<b>Dental cavities (caries)</b>	Bacteria in mouth	Destruction of tooth enamel, toothache	Remove and fill the destroyed area of tooth
<b>Diphtheria</b>	Inhale or close contact	Sore throat, fever, heart or breathing failure	Vaccination to prevent, antibiotics

Bacteria also cause many human diseases, some of which you can see listed in **Table 18.1**. Disease-causing bacteria can enter human bodies through openings, such as the mouth. They are carried in air, food, and water and sometimes invade humans through skin wounds. Bacterial diseases harm people in two ways. The growth of the bacteria can interfere with the normal function of body tissue, or it can release a toxin that directly attacks the host.

In the past, bacterial illnesses had a greater effect on human populations than they do now. As recently as 1900, life expectancy in the

United States was only 47 years. The most dangerous diseases at that time were the bacterial illnesses tuberculosis and pneumonia. In the last 100 years, human life expectancy has increased to about 75 years. This increase is due to many factors, including better public health systems, improved water and sewage treatment, better nutrition, and better medical care. These improvements, along with antibiotics, have reduced the death rates from bacterial diseases to low levels. However, this is starting to change as you can read in the *Biology and Society* feature at the end of this chapter.

## Section Assessment

### Understanding Main Ideas

1. Describe six parts of a typical bacterial cell. State the function of each.
2. What are endospores? How do they help bacteria survive?
3. Explain how penicillin affects a bacterial cell.
4. Explain how bacteria avoid osmotic rupture.

### Thinking Critically

5. Some scientists have proposed that bacterial-like cells were probably among the earliest organisms

to live on Earth. Draw up a list of reasons why such a suggestion is feasible. Then explain each reason on your list.

### Skill Review

6. **Make and Use Tables** Construct a table comparing and contrasting archaeobacteria and eubacteria. Include at least three ways they are alike and three ways they are different. For more help, refer to *Make and Use Tables* in the **Skill Handbook**.







**Before You Begin**

Doctors must know which antibiotic kills each type of disease-causing bacterium. You can use a test similar to the one in this *BioLab* to discover this information. You will use sterile, agar-containing petri dishes and sterile, antibiotic disks. When you place a disk on the agar, the antibiotic diffuses into the agar. A clear ring that develops around a disk—a zone of inhibition—is where the antibiotic killed susceptible bacteria.

# How sensitive are bacteria to antibiotics?

## PREPARATION

### Problem

How can you determine which antibiotic most effectively kills specific bacteria?

### Hypotheses

Decide on one hypothesis that you will test. Your hypothesis might be that the antibiotic with the widest zone of inhibition most effectively inhibits growth of that bacteria.

### Objectives

*In this BioLab, you will:*

- **Compare** how effectively different antibiotics kill specific bacteria.
- **Determine** the most effective antibiotic to treat an infection that these bacteria might cause.

### Possible Materials

- |                        |                           |
|------------------------|---------------------------|
| cultures of bacteria   | marking pen               |
| sterile nutrient agar  | long-handled cotton swabs |
| petri dishes           | forceps                   |
| antibiotic disks       | 37°C incubator            |
| sterile disks of blank | metric ruler              |
| filter paper           |                           |

### Safety Precautions

**CAUTION:** *Always wear goggles in the lab. Although the bacteria you will work with are not disease-causing, do not spill them. Wash your hands with antibacterial soap immediately after handling any bacterial culture. Clean your work area after you finish. Follow your teacher's instructions about disposal of your swabs, cultures, and petri dishes.*

### Skill Handbook

If you need help with this lab, refer to the **Skill Handbook**.



Matt Meadows

## PLAN THE EXPERIMENT

1. Examine the materials provided by your teacher, and study the photos in this lab. As a group, agree on one way that your group could investigate your hypothesis. Design an experiment in which you can collect quantitative data.
2. Make a list of numbered directions and include the amounts of each material you will need. If possible, use no more than one petri dish for each person.
3. Design and construct a table for recording data. To do this, carefully consider what data you need to record and how you will measure the data. For example, how will you measure what happens around the antibiotic disks as the antibiotic diffuses into the agar?

### Check the Plan

Discuss the following points with other group members.

1. How will you set up your petri dishes? How many antibiotics can you test on one petri dish? How will you measure the effectiveness of each antibiotic? What will be your control?
2. Will you add the bacteria or the antibiotic disks first?
3. What will you do to prevent other bacteria from contaminating the petri dishes?
4. How often will you observe the petri dishes?
5. *Make sure your teacher has approved your experimental plan before you proceed further.*
6. Carry out your experiment. **CAUTION:** *Wash your hands with antibacterial soap and water after handling dishes of bacteria.*
7. **CLEANUP AND DISPOSAL** Consult with your teacher in order to make wise choices in the disposal of bacterial cultures and antibiotics.



## ANALYZE AND CONCLUDE

1. **Measure in SI** How did you measure the zones of inhibition? Why did you do it this way?
2. **Draw Conclusions** Suppose you were a physician treating a patient infected with these bacteria. Which antibiotic would you use? Why?
3. **Analyze the Procedure** What limitations does this technique have? If these bacteria were infecting a person, what other tests might increase your confidence about treating the person with the most effective antibiotic?

### Apply Your Skill

**Application** Use a similar procedure to test the effectiveness of four commercial antibacterial soaps and evaluate their promotional claims. Check your plan with your teacher, then prepare your disks by soaking them in the different soap solutions.



**Web Links** To find out more about antibiotics, visit [ca.bdol.glencoe.com/antibiotics](http://ca.bdol.glencoe.com/antibiotics)

## Superbugs Defy Drugs

**A**ntibiotics have prevented millions of deaths from bacterial diseases in the past century. Today, however, many disease-causing bacteria have developed resistance to the antibiotics that used to kill them. The spread of antibiotic-resistant bacteria carries with it the threat of incurable disease. Microbiologists are working to develop new drugs to defeat these “superbugs.”

**Perspectives** During the past 50 years, antibiotics have been used for preventive medical reasons and in agriculture. With the development of resistant bacteria, these uses are being reassessed.

**How much is too much?** Because antibiotics have worked well and had few side effects, some physicians prescribe them for preventive reasons. For example, physicians may prescribe antibiotics before surgery to prevent the chance of infection from bacteria during the surgery. In addition, some physicians prescribe antibiotics for patients with viral infections because a viral infection makes a body vulnerable to a bacterial infection.

Because antibiotics hasten the growth of healthy cattle, chickens, and other domestic animals, many animal feeds contain small amounts of antibiotics. Similarly, antibiotics are used to coat fruit and other agricultural products. These antibiotics may produce resistant bacteria, which pass to people when they eat the food.

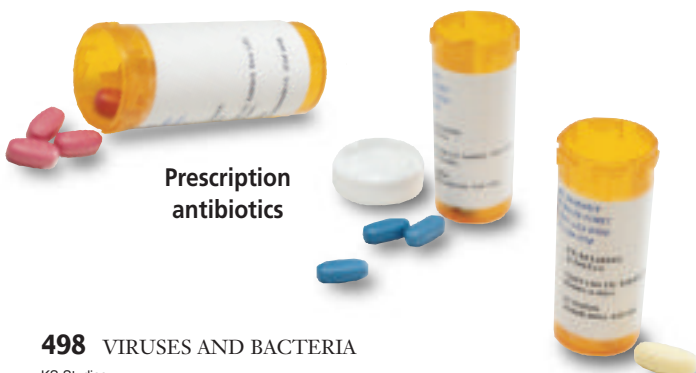
**Emerging resistance** Many antibiotics are available, and several bacteria that they once killed are now resistant to one or more of them.

Tuberculosis, for example, is a deadly, highly contagious disease that a combination of antibiotics usually treats effectively. But strains of resistant tuberculosis bacteria have appeared, and the disease continues to claim lives after once being targeted for elimination through antibiotic use.

Some *Staphylococcus* bacteria, which cause serious infections in hospital patients, were previously resistant to all antibiotics except vancomycin, an antibiotic usually reserved as a last-resort antibiotic. Now vancomycin resistance has turned up in another common “hospital bug,” *Enterococcus*. Resistance genes spread easily among bacteria, and vancomycin-resistant staphylococcus infections have recently appeared.

**Developing better antibiotics** Microbiologists are experimenting with bacterial viruses, or bacteriophages, to develop new antibiotics. Bacteriophages, commonly called phages prevent bacteria from building outer cell walls, weakening and killing the bacteria. Researchers believe phage DNA can be used to produce antibiotics that would attack bacterial cell walls. When bacterial strains develop resistance, the phage’s DNA code could be manipulated to create an antibiotic that attacks a different point in the cell wall.

Genetics may provide another weapon in the fight against disease. One bacterium, *Streptomyces coelicolor*, is used to produce several antibiotics. The recent sequencing of its genome could lead to new antibiotics as researchers mix and match the genes to produce new compounds and medicines.



Prescription antibiotics

### Investigating the Issue

**Think Critically** Not all bacteria are harmful. How might microbiologists use genetics to target specific disease-causing bacteria with new antibiotics?



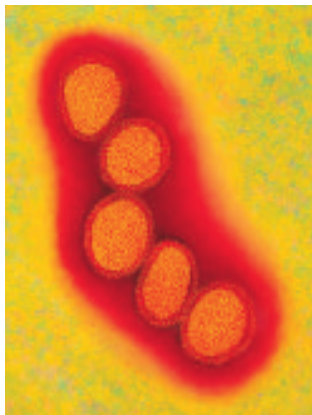
To find out more about bacteria that are antibiotic-resistant, visit [ca.bdol.glencoe.com/biology\\_society](http://ca.bdol.glencoe.com/biology_society)

# Chapter 18 Assessment

## STUDY GUIDE

### Section 18.1

## Viruses



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### Key Concepts

- Viruses are nonliving particles that have a nucleic acid core and a protein-containing capsid.
- To replicate, a virus must first recognize a host cell, then attach to it, and finally enter the host cell and take over its metabolism.
- During a lytic cycle, a virus replicates and kills the host cell. In a lysogenic cycle, a virus's DNA is integrated into a chromosome of the host cell, but the host cell does not die.
- Retroviruses contain RNA. Reverse transcriptase is an enzyme that helps convert viral RNA to DNA, which is then integrated into the host cell's chromosome.
- Prions and viroids are virus-like particles. Prions are composed of only a protein, while a viroid is a singular strand of RNA.
- Viruses probably originated from their host cells.

### Vocabulary

bacteriophage (p. 475)  
capsid (p. 476)  
host cell (p. 475)  
lysogenic cycle (p. 479)  
lytic cycle (p. 479)  
prion (p. 482)  
provirus (p. 479)  
retrovirus (p. 481)  
reverse transcriptase (p. 481)  
viroid (p. 482)  
virus (p. 475)

### Section 18.2

## Archaeobacteria and Eubacteria

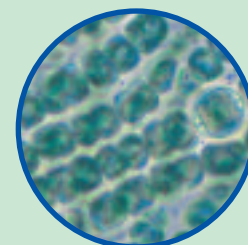


### Key Concepts

- There are two kingdoms of prokaryotes: archaeobacteria and eubacteria. Archaeobacteria inhabit extreme environments. Eubacteria live almost everywhere else. They probably arose separately from a common ancestor billions of years ago.
- Bacteria are varied. Some are heterotrophs, some are photosynthetic autotrophs, and others are chemosynthetic autotrophs. Bacteria can be obligate aerobes, obligate anaerobes, or both aerobic and anaerobic.
- Bacteria usually reproduce by binary fission. Some have a type of sexual reproduction called conjugation. Some bacteria form endospores that enable them to survive when conditions are unfavorable.

### Vocabulary

binary fission (p. 489)  
chemosynthesis (p. 486)  
conjugation (p. 490)  
endospore (p. 491)  
nitrogen fixation (p. 493)  
obligate aerobe (p. 491)  
obligate anaerobe (p. 491)  
toxin (p. 492)



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### FOLDABLES

#### Study Organizer

To help you review viruses and bacteria, use the Organizational Study Fold on page 484.



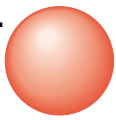
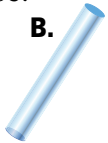
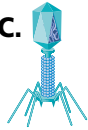

# Chapter 18 Assessment

## Vocabulary Review

Review the Chapter 18 vocabulary words listed in the Study Guide on page 499. Match the words with the definitions below.

- a cell in which a virus replicates
- retrovirus uses this enzyme to make DNA from its RNA
- viral DNA that is integrated into the host cell's chromosome
- method bacteria use to reproduce asexually
- tiny structure that contains bacterial DNA encased by a tough outer covering

## Understanding Key Concepts

- A \_\_\_\_\_ is never a part of a virus.  
A. nucleic acid      C. viral envelope  
B. protein coat      D. cell wall
- Which of the following is NOT a common bacterial shape?  
A.       B.       C.       D. 
- What characteristic do viruses share with all living organisms?  
A. respiration      C. replication  
B. metabolism      D. movement
- During a lytic cycle, after a virus enters the cell, the virus \_\_\_\_\_.  
A. forms a provirus  
B. replicates  
C. dies  
D. becomes inactive
- Prokaryotic cells have \_\_\_\_\_.  
A. organelles  
B. a nucleus  
C. mitochondria  
D. a cell wall
- In \_\_\_\_\_, bacteria convert gaseous nitrogen into ammonia, nitrates, and nitrites.  
A. nitrogen fixation  
B. binary fission  
C. conjugation  
D. attachment

- Bacteria that require \_\_\_\_\_ for respiration are called \_\_\_\_\_.  
A. food—obligate saprophytes  
B. hydrogen—archaeobacteria  
C. oxygen—obligate anaerobes  
D. oxygen—obligate aerobes
- Some bacteria, when faced with unfavorable environmental conditions, produce structures called \_\_\_\_\_.  
A. pili      C. toxins  
B. capsules      D. endospores
- Which of the following would be most likely to live in Utah's Great Salt Lake?  
A. archaeobacteria  
B. staphylococci  
C. eubacteria  
D. viruses

## Constructed Response

- Open Ended** Scientists cannot grow about 99 percent of all bacteria in the laboratory. How might this inability interfere with understanding bacteria?
- Compare and Contrast** What characteristics of life do viruses have? Describe the ways in which viruses differ from living cells.
- Open Ended** Summarize the role of microorganisms such as bacteria in maintaining and disrupting equilibrium, including diseases in plants and animals.

## Thinking Critically

- REAL WORLD BIOCHALLENGE** In addition to viruses, prions, such as bovine spongiform encephalopathy (mad cow disease), can cause diseases. Like viruses, prions are nonliving particles. What restrictions and regulations does the United States government have in place to prevent mad cow disease from coming to the U.S.? Research the answers and report back to your class by making a poster discussing the prevention of this disease in the U.S.



# Chapter 18 Assessment

The assessed California standard appears next to the question.

## California Standards Practice

All questions aligned and verified by

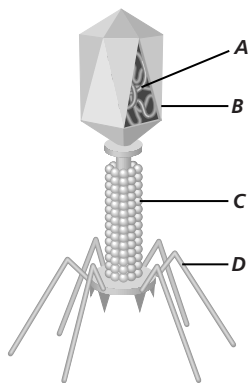


### Part 1 Multiple Choice

Use the diagram to answer questions 19 and 20.

19. Which structure is the genetic material of the virus?

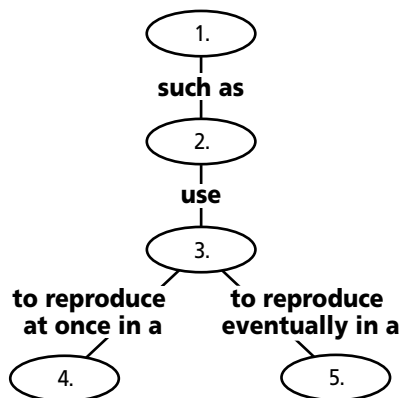
- A. A
- B. B
- C. C
- D. D



20. Which structure is used for attachment to a host bacterium?

- A. A
- B. B
- C. C
- D. D

21. Complete the concept map by using the following vocabulary terms: host cells, viruses, lysogenic cycle, bacteriophages, lytic cycle.



One milliliter of *E. coli* culture was added to each of three petri dishes (I, II, and III). The dishes were incubated for 36 hours, and then the number of bacterial colonies on each were counted.

Petri Dish Number	Medium	Colonies Per Dish
I	Agar and carbohydrates	35
II	Agar, carbohydrates, and vitamins	250
III	Agar and vitamins	0

Study the table and the paragraph above and answer questions 22–24.

22. Which of the above dishes demonstrate that carbohydrates are necessary for the growth of *E. coli*?

- A. dish I alone
- B. dishes I and II
- C. dishes II and III
- D. dish III

23. Which of the above dishes demonstrate that vitamins enhance the growth of *E. coli*?

- A. dishes I and II
- B. dishes II and III
- C. dishes I and III
- D. none of the dishes

24. Which is an independent variable in this experiment?

- A. *E. coli*
- B. agar
- C. carbohydrates
- D. number of colonies

### Part 2 Constructed Response/Grid In

Record your answers on your answer document.

25. **Open Ended** Describe the role of viruses in causing diseases and conditions such as acquired immune deficiency syndrome and smallpox.

26. **Open Ended** Bacteria interact with humans in several ways. Identify and describe the role of bacteria in both maintaining health, such as digestion, and causing disease in humans. Cite specific examples.

