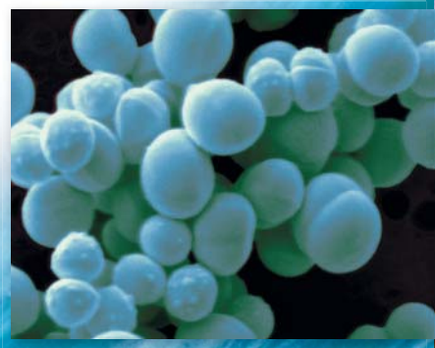
UNIT 6 Microbes

Giant kelp



Staphylococcus xylosus

UNIT 6

Fossilized diatoms

DISCOVERIES IN SCIENCE

Microbiology

1300

The bubonic plague kills 25 million people in Europe. The bacterium that causes the disease is carried by rats and transmitted to humans by fleas.

Rat, a carrier of the bubonic plague

1862

Louis Pasteur and Claude Bernard use heat to eliminate bacteria in liquid for the first time. The process of heating a liquid to kill bacteria is soon called pasteurization and helps prevent milk from spreading bacterial diseases.

1876

A botanical journal publishes Robert Koch's experiments and observations on anthrax bacilli. Koch demonstrates that the bacteria can still cause disease after growing for several generations in pure culture, without animal contact.

1901

Beatrix Potter, an amateur mycologist, finishes a portfolio of about 270 watercolor illustrations of fungi. Potter is best known as an author and illustrator of children's books, such as *The Tale of Peter Rabbit.*

Beatrix Potter with one of her dogs

1928

Alexander Fleming accidentally discovers antibiotics in his laboratory. He observes that *Penicillium notatum,* a mold that was contaminating culture plates, prevents the growth of a bacterium, *Staphylococcus aureus.*

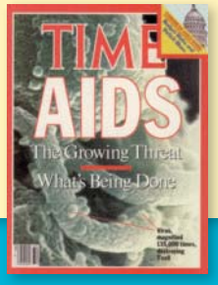
1955

The United States Government permits the widespread use of the polio vaccine developed by Dr. Jonas Salk.

Jonas Salk

1983

Luc Montagnier of the Pasteur Institute in France identifies HIV as the virus that causes AIDS. This discovery made it possible to test blood for HIV.



***Time* magazine cover on AIDS**

2003

In Northeast Oregon, an enormous fungus, *Armillaria ostoyae,* is discovered. The fungus covers 10 km^2, an area the size of 1,600 football fields. This fungus is believed to be the largest single organism on Earth.

Fungi on a moss-covered log

BIOLOGY CAREER

Epidemiologist

Linda Gaul

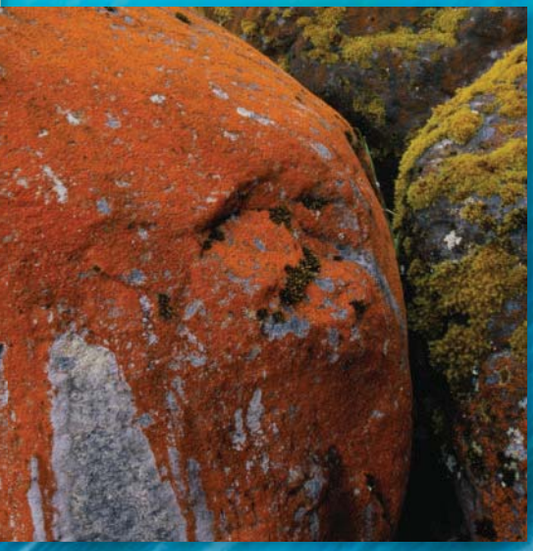
Linda Gaul is an epidemiologist at the Texas Department of State Health Services. She conducts surveillance and epidemiological investigations related to infectious diseases. She has also taught biology and epidemiology at the college level.

Gaul enjoys the process of scientific learning. She especially enjoys discovering connections between seemingly very different organisms that have adapted to a similar environmental constraint.

Gaul also loves teaching and helping others understand and appreciate the living world.

Gaul's father, who is a scientist, and Gaul's mother encouraged Gaul to be inquisitive about the world around her. Gaul credits their encouragement and several enthusiastic college professors for helping her decide to become a scientist.

Gaul also enjoys traveling with her family, gardening, and quilting.



Lichen on rocks

Chapter Planner 20

Bacteria and Viruses

		Standards	Teach Key Ideas
CHAPTER OPENER, pp. 468–469	15 min.	*National Science Education Standards*	
SECTION 1 Bacteria, pp. 471–475 › What are Prokaryotes? › Bacterial Structure › Obtaining Energy and Nutrients › Reproduction and Adaptation	90 min.	LSCell 1, LSCell 2, LSCell 3, LSCell 4, LSGene 1, LSEvol 5, LSMat 2, LSMat 4, UCP1, UCP2, UCP5, SI1, SI2, PS3, ESS1	**Bellringer Transparency** **Transparencies** F2 Three Bacterial Cell Shapes • F3 Gram Staining • F4 Escherichia coli **Visual Concepts** Bacteria• Characteristics of Bacteria • Parts of a Prokaryotic Cell • Comparing Organisms That Are Unicellular and Multicellular • Structure of Cilia and Flagella • Bacterial Capsule • Pilus • Conjugation • Chemoautotroph • Gram Stain
SECTION 2 Viruses, pp. 476–480 › Is a Virus Alive? › Viral Structure › Reproduction › Viroids and Prions	45 min.	LSCell 1, LSCell 2, LSCell 3, LSCell 4, LSGene 1, LSEvol 5, LSInter 3, LSMat 4, UCP1, UCP2, UCP5, SI1, SI2	**Bellringer Transparency** **Transparencies** F7 Structures of the Adenovirus and Bacteriophage • F8 Structures of TMV and Influenza Virus • F9 Viral Replication in Bacteria **Visual Concepts** Virus • Parts of a Virus • Bacteriophage • Lytic Cycle • Lysogenic Cycle • Relationship between the Lytic and Lysogenic Cycles • Pathogen • Prophages and Proviruses
SECTION 3 Bacteria, Viruses, and Humans, pp. 481–489 › Roles of Bacteria and Viruses › Koch's Postulates and Disease Transmission › Bacterial Diseases › Antibiotic Resistance › Viral Diseases › Emerging Diseases	60 min.	LSEvol 5, LSInter 1, LSInter 3, LSInter 5, ST2, SPSP1, SPSP2, SPSP5, SPSP6, HNS2, HNS3	**Bellringer Transparency** **Transparencies** F6 Important Bacterial Diseases • F10 Important Viral Diseases **Visual Concepts** Koch's Postulates • Bacteria and Food • AIDS (Acquired Immune Deficiency Syndrome)
			See also PowerPoint® Resources

Chapter Review and Assessment Resources

- SE Super Summary, p. 490
- SE Chapter Review, p. 491
- SE Standardized Test Prep, p. 493
- Review Resources
- Chapter Tests A and B
- Holt Online Assessment

CHAPTER FastTrack *To shorten instruction, eliminate the labs and cover the three sections over three days.*

Basic Learners

- TE *E. coli* in the Intestine, p. 473
- TE Antibacterial Agents, p. 484
- TE Graphing TB Cases, p. 484
- TE County Health Department, p. 484
- Directed Reading Worksheets*
- Active Reading Worksheets*
- Lab Manuals, Level A*
- Study Guide* ■
- Note-taking Workbook*
- Special Needs Activities and Modified Tests*

Advanced Learners

- TE True or False?, p. 472
- TE AIDS Drug, p. 479
- TE Breakthroughs in Science, p. 481
- Critical Thinking Worksheets*
- Concept Mapping Worksheets*
- Science Skills Worksheets*
- Lab Datasheets, Level C*

Key

SE Student Edition
TE Teacher's Edition
Chapter Resource File
Workbook
Transparency
CD or CD-ROM
* Datasheet or blackline master available
■ Also available in Spanish

All resources listed below are also available on the Teacher's One-Stop Planner.

Why It Matters	Hands-On	Skills Development	Assessment
Build student motivation with resources about high-interest applications.	SE **Inquiry Lab** Bacterial Observation, p. 469* ■	TE **Reading Toolbox** Assessing Prior Knowledge, p. 468 SE **Reading Toolbox,** p. 468	
TE **Food Poisoning,** p. 473 TE **Nitrogen-Fixing Bacteria,** p. 474	SE **Quick Lab** Model Bacterial Growth, p. 474* ■ SE **Skills Practice Lab** Bacterial Staining, p. 488* ■ **Skills Practice Lab** Gram Staining of Bacteria*		SE **Section Review** TE **Formative Assessment** **Spanish Assessment*** ■ **Section Quiz** ■
TE **Demonstration** Viral Characteristics, p. 476 TE **Plant Viruses,** p. 477	SE **Quick Lab** How Small Are Nanometers?, p. 480* ■ **Quick Lab** Modeling Viruses*	SE **Reading Toolbox** Process Chart, p. 478 TE **Reading Toolbox** Process Chart, p. 478 TE **Math Skills** Viral Reproduction, p. 478	SE **Section Review** TE **Formative Assessment** **Spanish Assessment*** ■ **Section Quiz** ■
TE **Demonstration** Yogurt, p. 481 TE **Spread of Disease to Isolated Communities,** p. 482 TE **Bacterial Toxins,** p. 483 TE **Influenza,** p. 485 SE **Tiny Terrors,** p. 487	SE **Quick Lab** Emergence of Bird Flu, p. 486* ■	SE **Reading Toolbox** Cause and Effect, p. 483 TE **Reading Toolbox** Cause and Effect, p. 483 TE **Reading Toolbox** Visual Literacy, p. 487	SE **Section Review** TE **Formative Assessment** **Spanish Assessment*** ■ **Section Quiz** ■
	See also Lab Generator		**See also Holt Online Assessment Resources**

Resources for Differentiated Instruction

English Learners

TE Word Parts, p. 474
TE Paired Summarizing, p. 482
Directed Reading Worksheets*
Active Reading Worksheets*
Lab Manuals, Level A*
Study Guide* ■
Note-taking Workbook*
Multilingual Glossary

Struggling Readers

TE Word Parts, p. 474
TE K-W-L, p. 477
TE Paired Summarizing, p. 482
Directed Reading Worksheets*
Active Reading Worksheets*
Lab Manuals, Level A*
Study Guide*
Note-taking Workbook*
Special Needs Activities and Modified Tests*

Special Education Students

TE Antibacterial Agents, p. 484
Directed Reading Worksheets*
Active Reading Worksheets*
Lab Manuals, Level A*
Study Guide* ■
Note-taking Workbook*
Special Needs Activities and Modified Tests*

Alternative Assessment

TE Design a Virus, p. 478
Science Skills Worksheets*
Section Quizzes* ■
Chapter Tests A, B, and C* ■

Chapter 20

Overview

The purpose of this chapter is to explain the characteristics and processes of bacteria and viruses. Students will also learn how bacteria and viruses are beneficial to humans and how they cause disease.

READING TOOLBOX

Assessing Prior Knowledge Students should understand the following concepts:
- characteristics of living organisms
- DNA and RNA
- cell functions

Visual Literacy Before students read the captions, ask them whether the objects shown in the picture are living or nonliving and why. Then have students read the captions. Ask students to write a short paragraph describing the events in the photo from the bacterium's point of view.
LS Visual

Chapter 20

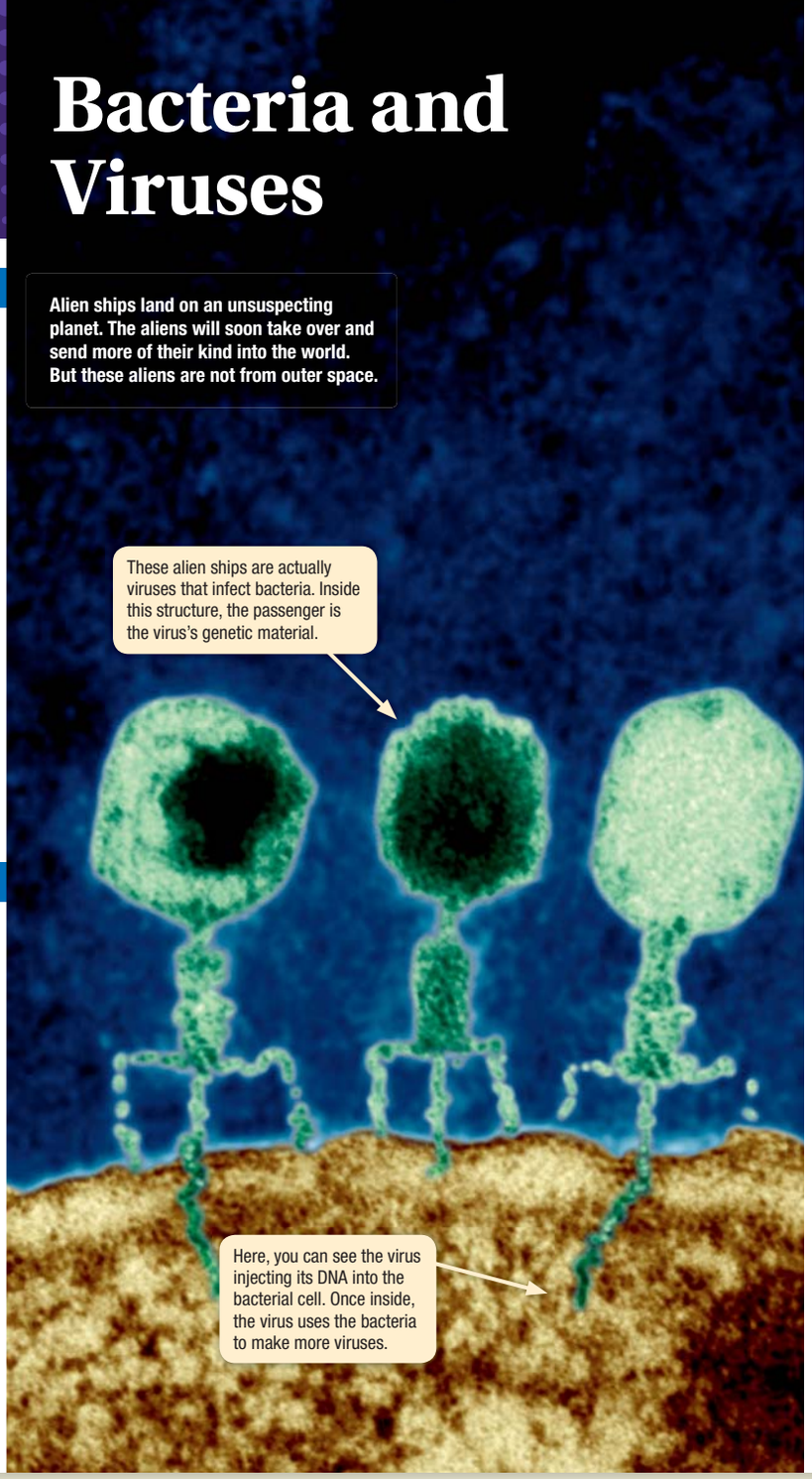
Bacteria and Viruses

Preview

Why It Matters

Most human diseases are caused by bacteria and viruses. Some of these diseases are incurable and others are becoming incurable.

Alien ships land on an unsuspecting planet. The aliens will soon take over and send more of their kind into the world. But these aliens are not from outer space.



Chapter Correlations

National Science Education Standards

LSCell 1 Cells have particular structures that underlie their functions.

LSCell 2 Most cell functions involve chemical reaction.

LSCell 3 Cells store and use information to guide their functions.

LSCell 4 Cell functions are regulated.

LSGene 1 In all organisms, the instructions for specifying the characteristics of the organisms are carried in DNA.

LSEvol 5 Biological classifications are based on how organisms are related.

LSInter 1 The atoms and molecules on earth cycle among the living and nonliving components of the biosphere.

LSInter 3 Organisms both cooperate and compete in ecosystems.

LSInter 5 Human beings live within the world's ecosystems.

LSMat 2 The energy for life primarily derives from the sun.

LSMat 4 The complexity and organization of organisms accommodates the need for obtaining, transforming, transporting, releasing, and eliminating the matter and energy used to sustain the organism.

UCP1 Systems, order, and organization

UCP2 Evidence, models, and explanation

UCP5 Form and function

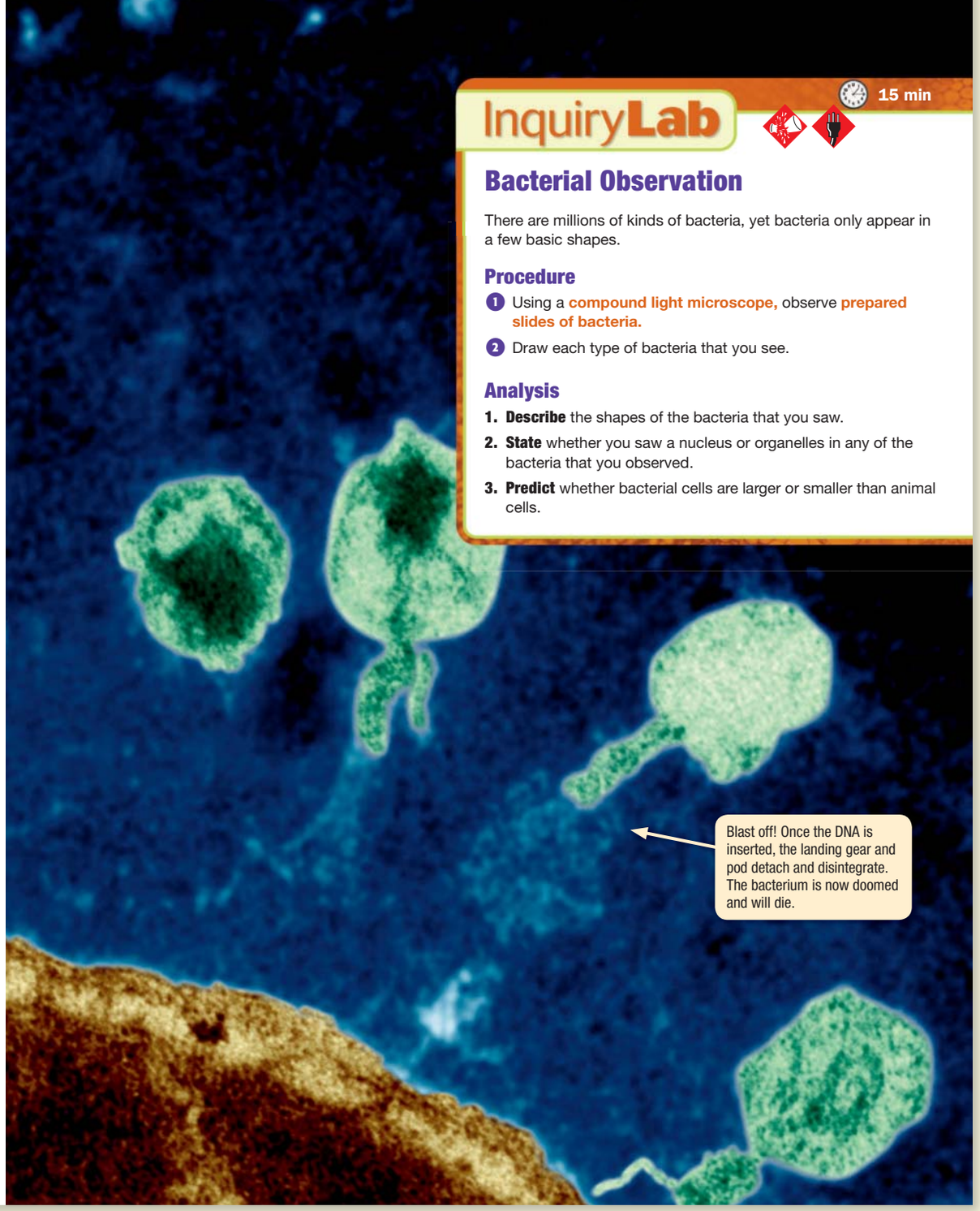
SI1 Abilities necessary to do scientific inquiry

SI2 Understandings about scientific inquiry

PS3 Chemical reactions

ESS1 Energy in the earth system

ST2 Understandings about science and technology



InquiryLab

15 min

Bacterial Observation

There are millions of kinds of bacteria, yet bacteria only appear in a few basic shapes.

Procedure

1. Using a **compound light microscope,** observe **prepared slides of bacteria.**
2. Draw each type of bacteria that you see.

Analysis

1. **Describe** the shapes of the bacteria that you saw.
2. **State** whether you saw a nucleus or organelles in any of the bacteria that you observed.
3. **Predict** whether bacterial cells are larger or smaller than animal cells.

InquiryLab

Teacher's Notes Make sure students use high power to observe the bacteria.

Safety Caution
Remind students to use caution when handling microscopes and microscope slides. Place any broken slides in an appropriate sharps container.

Materials
- microscope
- prepared slides of bacteria

Answers to Analysis

1. Answers may vary depending on the bacteria that students use. They should see rod, round, or spiral shapes.
2. Students should not see a nucleus or organelles in the bacteria.
3. Students should predict that bacterial cells would be smaller than animal cells.

SPSP1 Personal and community health
SPSP2 Population growth
SPSP5 Natural and human-induced hazards
SPSP6 Science and technology in local, national, and global challenges
HNS2 Nature of scientific knowledge
HNS3 Historical perspectives

READING TOOLBOX

Using Words

Students should have a tab for each key term in the chapter.

Using Language

1. Cause: People travel frequently. Effect: Diseases spread from one population to another.
2. Cause: HIV infects white blood cells. Effect: The immune system becomes vulnerable to disease.

Using Science Graphics

One possible answer is shown below.

READING TOOLBOX

These reading tools can help you learn the material in this chapter. For more information on how to use these and other tools, see **Appendix: Reading and Study Skills.**

Using Words

Key-Term Fold A key-term fold is a useful tool for studying definitions of key terms in a chapter. Each tab can contain a key term on one side and its definition on the other.

Your Turn Make a key-term fold to quiz yourself on the definitions of the key terms in this chapter.

1. Fold a sheet of lined notebook paper in half from left to right.
2. Using scissors, cut along every third line from the right edge to the center fold to make tabs.

Using Language

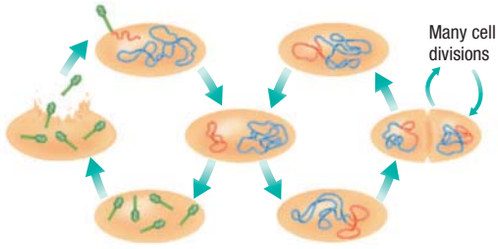
Cause and Effect In biological processes, one step leads to another step. When reading, you can recognize cause-and-effect relationships by words that indicate a cause or a result, such as *because, so, consequently,* and *as a result.*

Your Turn In the following sentences, identify the cause and the effect.

1. Disease spreads easily from one population to another because people travel frequently.
2. HIV infects white blood cells. Consequently, the immune system becomes vulnerable to disease.

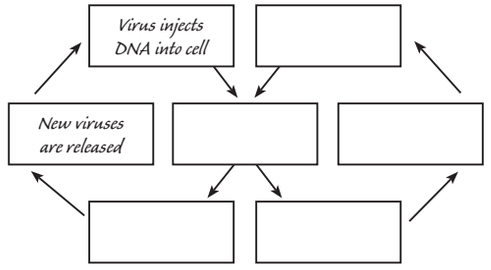
Using Science Graphics

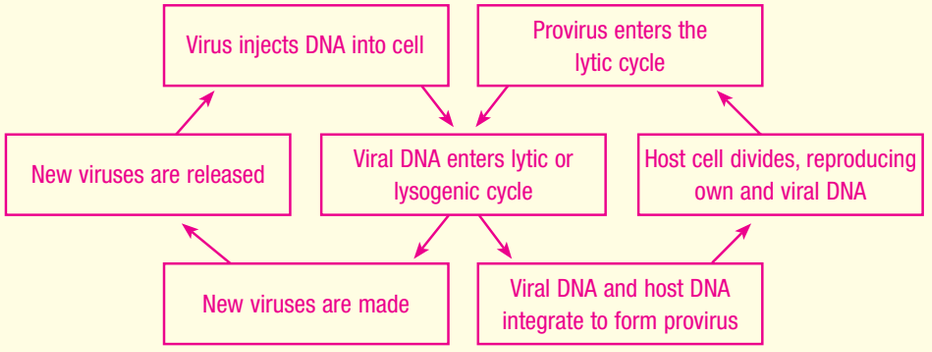
Process Chart Science is full of processes. Some processes are cycles that repeat the same steps. Some processes are two linked cycles. You can use two circular process charts to help you remember the order of the steps and where the cycles meet.



Your Turn Create two linked, circular process charts that illustrate the lytic cycle and the lysogenic cycle.

1. Draw a box. In the box, write the first step of the cycle.
2. To the right and slightly below the first box, draw a second box. Draw an arrow to connect the two boxes. In the second box, write the next step of the cycle.
3. Continue adding boxes in a circular pattern until each step of the cycle is written in a box.
4. Repeat steps 1 through 3 for the second cycle. Draw the second cycle right next to the first cycle.
5. Draw arrows showing where the two cycles are connected.





Section 1

Bacteria

Key Ideas	Key Terms	Why It Matters
What are the two major groups of prokaryotes? How are Gram-positive and Gram-negative bacteria different? How can bacteria be grouped by energy source? What are three ways that bacteria reproduce and adapt?	plasmid peptidoglycan Gram-positive Gram-negative conjugation transformation transduction endospore	Prokaryotes are everywhere, even in boiling hot springs to Antarctic lakes. These small, single-celled organisms can live where nothing else can survive.

Prokaryotes are the oldest living things on Earth. Fossil prokaryotes date back about 3.5 billion years! Over the millennia, prokaryotes have adapted to live in almost every environment.

What Are Prokaryotes?

Prokaryotes are single-celled organisms that do not have membrane-bound organelles. They are generally found in three shapes, as shown in **Figure 1:** a rod shape (*bacillus*), a sphere shape (*coccus*), and a spiral shape (*spirillum*). **Prokaryotes are divided into two major groups: the domain Archaea and the domain Bacteria.** Both groups are commonly referred to as *bacteria*.

Archaea Archaea are found in many places, including extreme environments such as salt lakes and hot springs. Archaea are structurally very different from Bacteria. Some Archaean molecules are more similar to those found in eukaryotes. Others are unique among living organisms.

Bacteria Most known prokaryotes are members of the domain Bacteria. Bacteria can be found virtually everywhere. One square inch of skin plays host to an average of 100,000 bacteria!

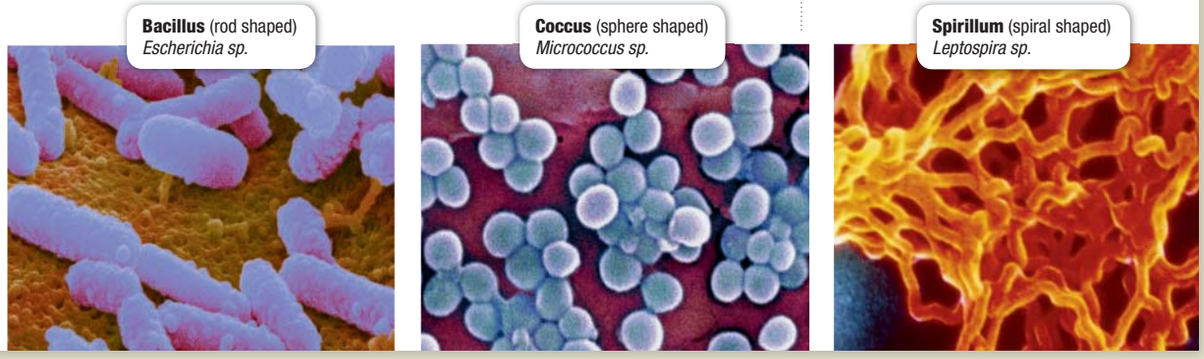


Figure 1 Prokaryotes are generally found in three shapes. The name of a prokaryote can sometimes tell you about its shape. **Which of these prokaryotes have names that reflect their shape?**

Key Resources

Transparencies
F2 Three Bacterial Cell Shapes
F3 Gram Staining
F4 *Escherichia coli*

Visual Concepts
Bacteria
Characteristics of Bacteria
Parts of a Prokaryotic Cell
Comparing Organisms That Are Unicellular and Multicellular
Structure of Cilia and Flagella
Bacterial Capsule
Pilus
Conjugation
Chemoautotroph
Gram Stain

Section 1

Focus

This section describes the two major groups of prokaryotes. It discusses bacteria, their structure, and their methods of obtaining energy and reproducing.

Bellringer
Use the Bellringer transparency to prepare students for this section.

Teach

Teaching Key Ideas

Harmful and Helpful Bacteria Ask students whether bacteria are beneficial or harmful. (Different bacteria can be either beneficial or harmful.) Ask students to think of ways that bacteria are beneficial and harmful. (Some bacteria are harmful to humans and other organisms as disease-causing agents. Bacteria can also be beneficial because they can be used to make medicines and foods, and they help humans perform important metabolic processes.)
LS Verbal

Answers to Caption Questions

Figure 1: *Micrococcus* and *Leptospira* have genus names that reflect their shapes.

Teach, *continued*

Teaching Key Ideas

Peptidoglycan Direct students' attention to **Figure 2,** and have them locate the peptidoglycan in the Gram-positive and Gram-negative diagrams. Tell students that the cell wall is involved in many pathogenic properties of bacteria. Explain that antibiotics, such as penicillin interfere with the formation of the peptidoglycan layer. Gram-positive bacteria are more sensitive than Gram-negative bacteria to penicillin and other antibiotic drugs. The outer membrane of Gram-negative bacteria prevents penicillin from entering the cell. This makes Gram-negative bacteria resistant to penicillin and other similar antibiotics. LS Visual

plasmid a circular DNA molecule in bacteria

peptidoglycan (pep ti doh GLIE kuhn) a protein-carbohydrate compound that makes the cell walls of bacteria rigid

Gram-positive a prokaryote that has a large amount of peptidoglycan in its cell wall and is stained violet during Gram staining

Gram-negative a prokaryote that has a small amount of peptidoglycan in its cell wall, has an outer membrane, and is stained pink during Gram staining

SCILINKS
www.scilinks.org
Topic: Bacteria
Code: HX80133

Bacterial Structure

Although bacteria have no membrane-bound organelles, they do have many internal structures. Bacteria have genetic material in the form of DNA. Bacterial DNA is a single chromosome clustered in a mass called a *nucleoid.* Bacteria often have small extra loops of DNA called **plasmids.** Bacteria have ribosomes and many types of enzymes. Bacteria may also form granules of stored nutrients to be used if nutrients in the environment are in short supply.

Bacterial cell membranes are lipid bilayers. Outside the cell membrane, bacteria have rigid cell walls that can be one or two layers thick. The bacterial cell wall is made of a protein-carbohydrate compound called **peptidoglycan** and may also include a membrane covering the peptidoglycan layer. The presence of this membrane allows biologists to group bacteria into two categories using a technique called the *Gram stain.* **Gram-positive bacteria have a thick layer of peptidoglycan and no outer membrane. Gram-negative bacteria have a thin layer of peptidoglycan and have an outer membrane.**

Gram-Positive Bacteria

The Gram stain involves two colors of dye. The first dye is dark purple. Gram-positive bacteria trap the dark purple dye because their peptidoglycan layer is very thick. The second, pink dye is also absorbed, but it cannot be seen because the purple dye is much darker. As a result, Gram-positive bacteria appear purple after staining, as **Figure 2** shows.

Gram-Negative Bacteria

The thin peptidoglycan layer of Gram-negative bacteria does not trap the purple dye. When the pink dye is added, it is absorbed by the cell. Because the pink dye is the only dye present in Gram-negative bacteria, they appear pink after staining, as **Figure 2** shows. The outer membrane of Gram-negative bacteria makes them more resistant to host defenses and to medicines.

Reading Check ***Is* E. coli *(right) a Gram-positive or Gram-negative bacterium? (See the Appendix for answers to Reading Checks.)***

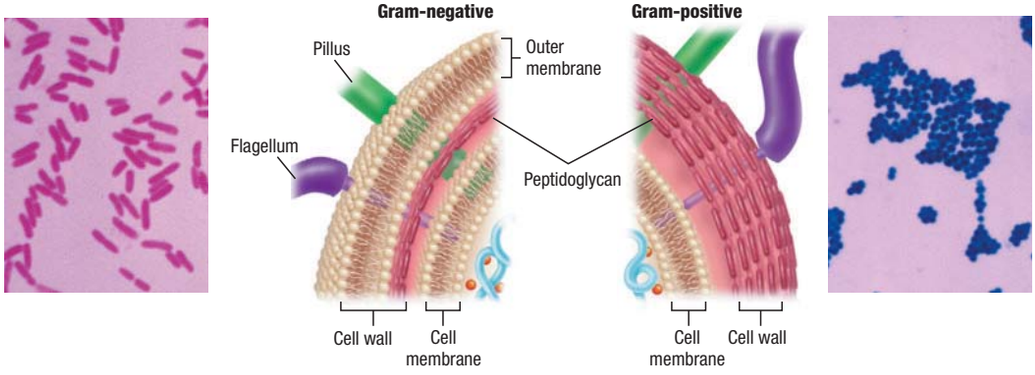


Figure 2 After Gram staining, the Gram-negative bacteria on the left appear pink. The Gram-positive cells on the right appear violet after staining.

Differentiated Instruction

Advanced Learners/GATE

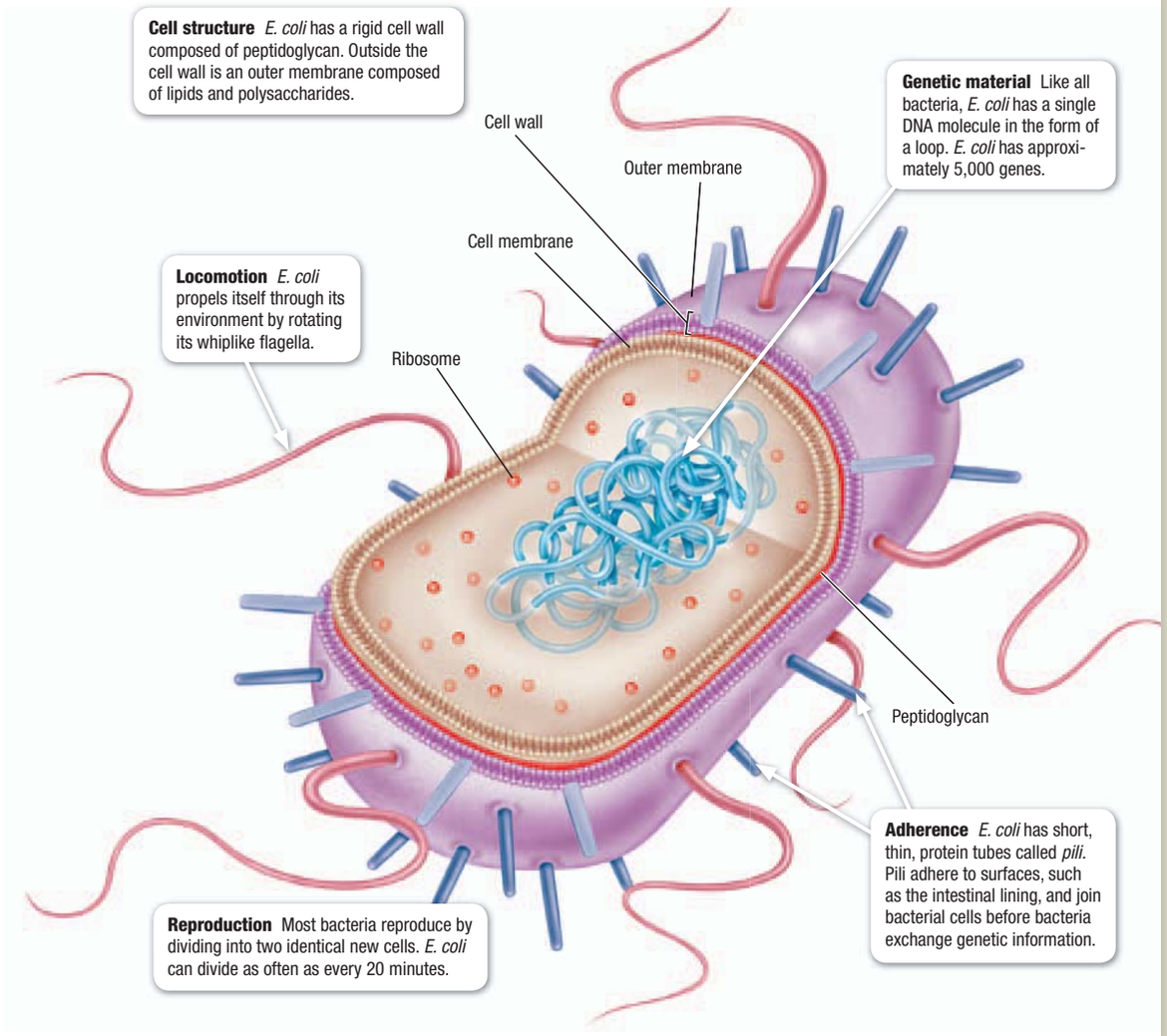
True or False? Ask students whether the following statement is true or false: Bacteria are successful in part because they have cellular structures that enable them to live in a wide variety of environments. (Students should give examples supporting their viewpoints.) LS Intrapersonal

Up Close Bacteria

Escherichia (ESH uh RIK ee uh) *coli* is a Gram-negative bacterium. There are many strains of *E. coli*. Most are harmless residents of healthy human and animal intestines. One strain, *E. coli* O157:H7, produces a powerful toxin and can cause severe illness. About 73,000 people become ill and about 60 people die every year in the United States from *E. coli* O157:H7 poisoning.

E. coli

Scientific name: *Escherichia coli*
Size: up to 1 µm
Habitat: inhabits the intestines of many mammals
Mode of nutrition: heterotrophic
Diet: organic matter from living organisms or from the environment



Differentiated Instruction

Basic Learners

***E. coli* in the Intestine** Tell students that *E. coli* is a normal resident of the human digestive tract, where it performs important functions. Have students research this important bacterium and report on its function in the human body. (*E. coli* helps suppress the growth of harmful bacteria and synthesizes vitamin K and B-complex vitamins.) LS Verbal

Up Close

Teacher's Notes Explain that bacteria have several mechanisms for locomotion, including twisting through fluids and propelling themselves with flagella. However, not all bacteria are motile. Have students discuss how nonmotile bacteria might move from place to place. (transport by other organisms, through the air, through water)

Discussion

1. Is *E. coli* a gram-positive or gram-negative bacterium? (gram-negative)
2. How does *E. coli* reproduce? (binary fission) How fast can the cells divide? (as often as every 20 minutes)
3. Describe the genetic material of an *E. coli* cell. (It has one circular DNA molecule that contains about 5,000 genes.)
4. What is the function of pili? (Pili serve to attach *E. coli* to surfaces and to join bacterial cells in conjugation.)

Why It Matters

Food Poisoning Tell students that symptoms of *E. coli* O157:H7 food poisoning include bloody diarrhea and kidney failure. Severe cases can cause permanent damage to organs or death. Inform students that in 2006 about 200 people across the United States became ill and at least three people died from eating *E. coli* tainted spinach.

Teach, *continued*

QuickLab

Teacher's Notes You may need to begin collecting paper circles from your hole-punch several days in advance in order to have enough circles for this lab. You can also use other objects, such as paper clips or dried beans.

Materials
- paper circles
- plastic cup

Answers to Analysis

1. 16 bacteria
2. 64 bacteria
3. There would be 4,096 bacteria at the end of four hours. (There are 60 minutes in one hour, so the bacteria would divide three times per hour. After four hours, the bacteria will have divided 12 times.)

Why It Matters

Nitrogen-Fixing Bacteria Have students look at the photo and read the caption in **Figure 3.** Ask what would happen if all nitrogen-fixing bacteria were eliminated. (The amount of nitrogen available to plants would fall, plant growth would be reduced, and the amount of organic compounds available at higher trophic levels would decline.) LS Logical

Hands-On

QuickLab

15 min

Model Bacterial Growth

You can estimate how many bacteria are present in a population if you know the growth rate of bacteria and how much time has passed.

Procedure

1. Obtain a **cupful of paper circles** from a **hole punch.**
2. Begin with a single circle, which represents a single bacterium.
3. Add a second circle to indicate one cycle of bacterial cell division.
4. Model another cycle of division by adding another circle for each of the bacteria in your population.
5. Repeat the procedure for four more cycles.

Analysis

1. **State** how many bacteria were present at the end of four cycles.
2. **Calculate** how many bacteria would be present at the end of six cycles.
3. CRITICAL THINKING **Predicting Outcomes** If your bacteria reproduce every 20 min, how many bacteria would you have at the end of 4 h, assuming that you begin with one bacterium?

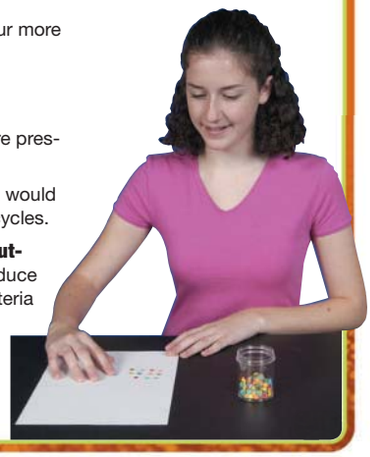
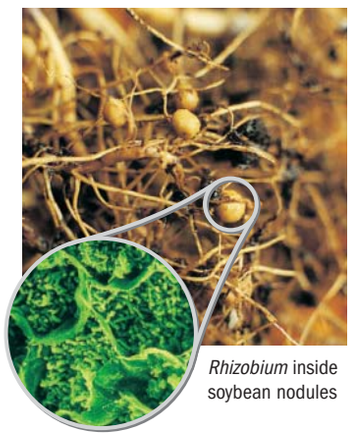


Figure 3 Bacteria of the genus *Rhizobium* live within these soybean root nodules. The bacteria fix nitrogen from the air into a form that both the bacteria and the plants can use.



Rhizobium inside soybean nodules

Obtaining Energy and Nutrients

Bacteria differ in how they obtain energy and nutrients. **Grouping prokaryotes based on their energy source separates them into photoautotrophs, chemoautotrophs, and heterotrophs.**

Photoautotrophs Organisms that get their energy from sunlight through photosynthesis are called *photoautotrophs*. These bacteria include purple sulfur and nonsulfur bacteria, green sulfur bacteria, and cyanobacteria. Green and purple sulfur bacteria can grow only in oxygen-free environments. Cyanobacteria are abundant today and are a major component of the plankton that floats in the oceans. They produce a great deal of our oxygen and probably formed Earth's oxygen atmosphere.

Chemoautotrophs Prokaryotes called *chemoautotrophs* (KEE moh AWT oh TRAHFS) are the only organisms that can get their energy from inorganic sources. They use molecules that contain sulfur or nitrogen and simple organic molecules to obtain energy. In the presence of hydrogen-rich chemicals, chemoautotrophic bacteria can form all of their own amino acids and proteins.

Heterotrophs Most prokaryotes are *heterotrophs* and get both their energy and their nutrients from other organisms. Most absorb nutrients from dead organisms, but some are parasites or pathogens. Many heterotrophic bacteria live in the presence of oxygen, but some can live without it. *Rhizobium*, shown in **Figure 3,** is an important heterotrophic bacterium that converts nitrogen in the air into molecules that can be used by other organisms.

Differentiated Instruction

English Learners/Struggling Readers

Word Parts Write the following word parts and their meanings on the board:

photo: light
chemo: chemical
hetero: other
auto: self
troph: nourishment

Discuss the meanings with students. Then, have them use the word parts and their meanings to write their own definitions of *photoautotroph, chemoautotroph,* and *heterotroph.* LS Verbal

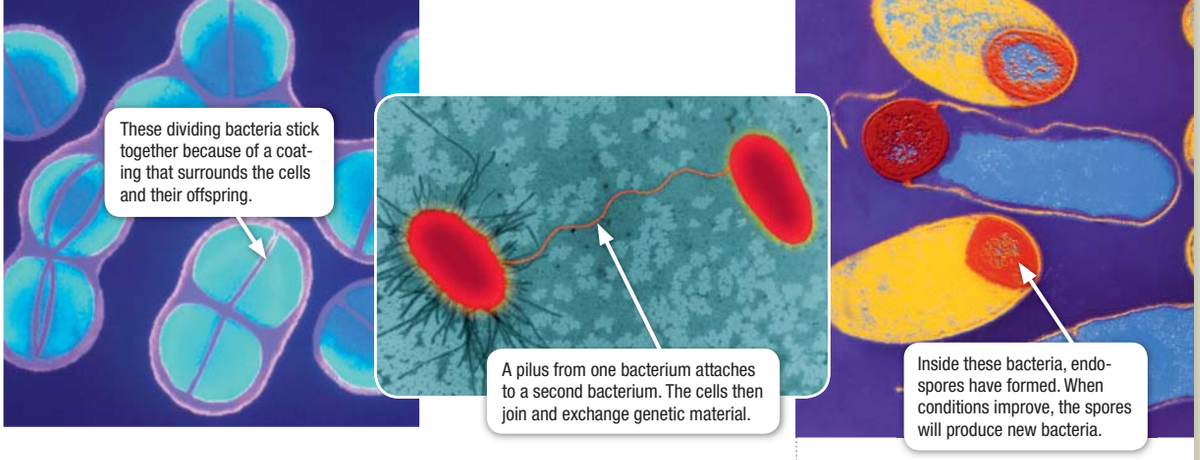


Figure 4 Bacteria can reproduce by binary fission, exchange DNA through conjugation, and survive harsh environments by spore formation.

Reproduction and Adaptation

Prokaryotes reproduce by binary fission; exchange genetic material through conjugation, transformation, and transduction; and survive harsh conditions by forming endospores.

Binary Fission Prokaryotes usually reproduce asexually by binary fission. In this process, a single cell divides into two identical new cells, as **Figure 4** shows. Mutations do occur during prokaryotic reproduction, and new forms emerge frequently.

Genetic Recombination There are three ways that prokaryotes can form new genetic combinations. **Conjugation** occurs when two bacteria exchange genetic material. **Transformation** occurs when bacteria take up DNA fragments from their environment. **Transduction** occurs when genetic material, such as a plasmid, is transferred by a virus. Plasmids often convey antibiotic resistance.

Endospore Formation Some bacteria survive harsh conditions by forming thick-walled structures called **endospores.** Endospores form inside the bacteria. They surround the DNA and a small bit of cytoplasm. Endospores can survive boiling, radiation, and acid. They show no signs of life and can be revived after hundreds of years.

conjugation a type of sexual reproduction in which two cells join to exchange DNA

transformation the transfer of genetic material in the form of DNA fragments

transduction the transfer of DNA from one bacterium to another through a virus

endospore a thick-walled structure that forms inside bacteria and resists harsh conditions

Section 1 Review

KEY IDEAS

1. **Identify** the two major groups of prokaryotes.
2. **Explain** the difference between Gram-positive and Gram-negative bacteria.
3. **Describe** three ways that bacteria can obtain energy.
4. **Describe** how bacteria reproduce, exchange genetic information, and survive harsh conditions.

CRITICAL THINKING

5. **Predicting Outcomes** If Earth suddenly lost its light source but stayed at the same temperature, which organisms might survive?
6. **Applying Information** How do the products of binary fission, conjugation, and endospore germination differ from each other?

ALTERNATIVE ASSESSMENT

7. **Bacterial Meal** Research foods that are made by using prokaryotes. Prepare a menu, including recipes, for a meal made entirely of these foods. If possible, prepare the meal and share with your classmates. Or prepare the ingredients in small groups outside class, and bring the finished products to class to share.

Teaching Key Ideas

CSI Bacteria? Explain to students that forensic genomics can help researchers track natural pathogens such as those that cause tuberculosis, pneumonia, and cholera. Forensic genomics can also be used to distinguish wild strains from lab strains, as in the case of West Nile virus.

Close

Formative Assessment

Which type of bacteria gets energy from inorganic molecules?

A. coccus bacteria (Incorrect. Coccus bacteria are any bacteria that are sphere-shaped.)

B. chemoautotrophs (Correct! Chemoautotrophs obtain energy from breaking down sulfur or nitrogen molecules.)

C. heterotrophs (Incorrect. Heterotrophs get energy from other organisms.)

D. photoautotrophs (Incorrect. Photoautotrophs obtain energy from the sun through photosynthesis.)

Answers to Section Review

1. Archaea and Bacteria
2. Gram-positive bacteria have a thick layer of peptidoglycan and no outer membrane. Gram-negative bacteria have a thin layer of peptidoglycan and an outer membrane.
3. Photoautotrophs obtain energy through photosynthesis; chemoautotrophs obtain energy from sulfur and nitrogen compounds; and heterotrophs obtain energy from other organisms.
4. Prokaryotes reproduce by binary fission; exchange genetic material through conjugation, transformation, and transduction; and survive harsh conditions by forming endospores.
5. All organisms that do not photosynthesize might survive, such as the chemoautotrophs and heterotrophs. However, heterotrophs that rely on photoautotrophs as a food source would eventually die or adapt to use chemoautotrophs as a food source.
6. The products of binary fission are genetically identical to the parent. The products of conjugation are genetically different. The product of endospore germination is genetically identical to the parent, but there is only one product rather than two.
7. Meals may include pickles, sandwich made with sourdough bread, and dessert of yogurt.

Section 2

Section 2 Viruses

Key Ideas	Key Terms	Why It Matters
❯ Why is a virus not considered a living organism? ❯ What two structures are characteristic of viruses? ❯ What are two ways that a virus can reproduce? ❯ What are viroids and prions?	capsid envelope bacteriophage lytic lysogenic	All viruses cause disease, and viral diseases are extremely difficult to treat.

❯ Focus

This section introduces students to the structure of viruses and examines how they replicate. The section also examines how viruses cause disease. Viral characteristics are discussed as they apply to HIV.

Bellringer

Use the Bellringer transparency to prepare students for this section.

❯ Teach

Demonstration

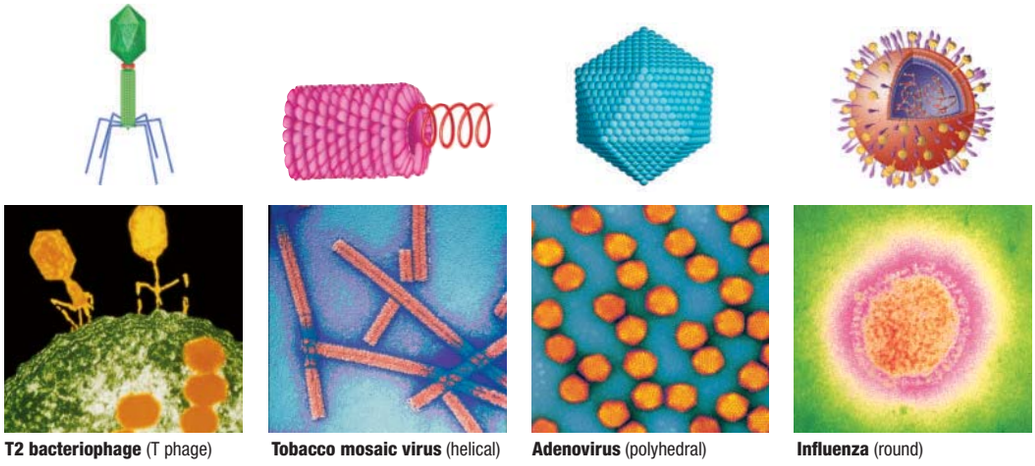
Viral Characteristics Before students begin the lesson, ask them to make a drawing of what they think a virus looks like. Then, have them look at the photos in **Figure 5.** Ask them if they can describe the typical shape of a virus. (Students will probably indicate that they would have difficulty with the task.) Ask if they think the viruses in the picture are living or nonliving and why. (Accept any reasonable answers.) LS Visual

Viruses are so small they can be seen only with an electron microscope. These tiny particles were discovered when material that had passed through a bacteria-trapping filter was found to cause disease.

Is a Virus Alive?

All living things are made of cells, are able to grow and reproduce, and are guided by information stored in their DNA. Viruses, in contrast, are pieces of nucleic acids contained in a protein coat. Biologists do not consider viruses to be living. **❯ Viruses are not considered living because they are missing key characteristics of living organisms.** For example, viruses do have genetic material, but they cannot reproduce on their own. Viruses reproduce by infecting cells. Viruses use the cell's ribosomes, ATP, enzymes, and other molecules to make more viruses. Viruses do not grow. Instead, they are assembled into their full size within a cell. As **Figure 5** shows, viruses can have a variety of interesting shapes. Viruses do not carry out any metabolic activities, do not have any cytoplasm or organelles, and do not maintain homeostasis. However, even though viruses are not alive, they have a major impact on the living world.

Figure 5 Viruses can have a variety of sizes and interesting shapes.



T2 bacteriophage (T phage) **Tobacco mosaic virus** (helical) **Adenovirus** (polyhedral) **Influenza** (round)

Key Resources

Transparencies
F7 Structures of the Adenovirus and Bacteriophage
F8 Structures of TMV and Influenza Virus
F9 The Lytic and Lysogenic Cycles

Visual Concepts
Virus
Parts of a Virus
Bacteriophage
Lytic Cycle
Lysogenic Cycle
Relationship between the Lytic and Lysogenic Cycles
Pathogen
Prophages and Proviruses

Viral Structure

The structure of a virus is relatively simple. There are two structures that are characteristic of all viruses. **All viruses have nucleic acid and a capsid.** In addition to a capsid, viruses may have an envelope or tail fibers.

Nucleic Acids The genetic material of a virus can be either RNA or DNA. Viral genetic material codes for the components of a virus.

DNA Viruses The genetic material of a DNA virus can become inserted into the host cell's DNA or may remain separate. The virus makes copies of its DNA by using the host cell's enzymes and nucleotides. Viral DNA also directs production of mRNA and proteins that are assembled into new viruses.

RNA Viruses When the genetic material of an RNA virus enters a host cell, reproduction can occur by one of two methods. In one method, the viral RNA may be used directly to make more viral RNA. In the second method, the viral RNA is transcribed into DNA, inserted into the host cell's DNA, and then transcribed into viral mRNA. Viruses that use this method of reproduction are called *retroviruses.* In both types of reproduction, viral mRNA is used to make new viral proteins that are assembled into new viruses.

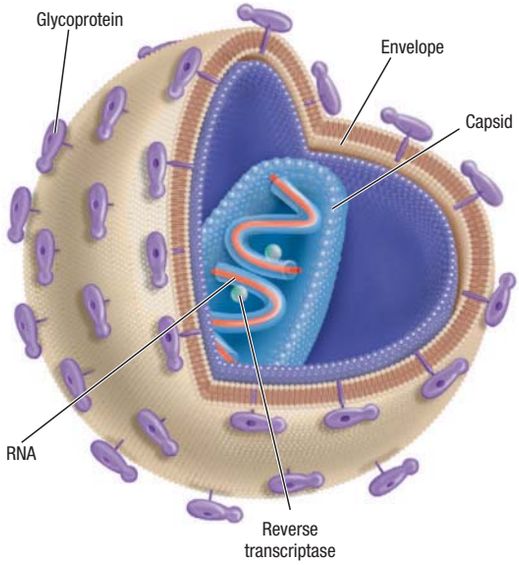


Figure 6 HIV is a spherical virus with an envelope surrounding its capsid. RNA is the genetic material. Along with the RNA, HIV has its own enzymes for converting RNA into DNA inside a cell.

Capsid The protein coat, or **capsid,** of a virus encloses its genetic material. Viruses recognize their hosts by specific proteins on a host cell's surface. The proteins on the host cell have to match proteins on the capsid of the virus, as a key matches a lock. Capsids are made from proteins and have a variety of shapes. **Figure 5** shows T phage, helical, polyhedral, and round viruses.

Envelope Many viruses, such as HIV, shown in **Figure 6,** have a membrane, or **envelope,** surrounding the capsid. The envelope gives the virus an overall spherical shape, but the capsid can have a very different shape. In the case of HIV, for example, the envelope surrounds an oval-shaped capsid. The envelope is studded with receptors that help the virus enter cells. The envelope is made of proteins, lipids, and *glycoproteins* (GLIE koh PROH teenz), which are proteins with attached carbohydrate molecules.

Tail Fibers Viruses that infect bacteria, called **bacteriophages** or just *phages,* have a complicated structure. A T2 bacteriophage, for example, has a capsid attached to a tail with tail fibers, as **Figure 5** shows. A long DNA molecule is coiled within the polyhedron. The tail and tail fibers function like a tiny syringe, which injects the viral DNA into its bacterial host.

Reading Check ***How does reproduction differ between DNA and RNA viruses?***

capsid a protein sheath that surrounds the nucleic acid core in a virus

envelope a membranelike layer that covers the capsids of some viruses

bacteriophage a virus that infects bacteria

SCILINKS
www.scilinks.org
Topic: Viruses
Code: HX81607

Differentiated Instruction

Struggling Readers

K-W-L Before students read this section, have them write short individual lists of all the things they already **K**now (or have heard) about viruses. When students have finished their lists, ask them to contribute their entries to a class list on the board or overhead. Then have students list things they **W**ant to know about viruses. After reading, have them list what they **L**earned in the section.

LS Intrapersonal

Teaching Key Ideas

Viral Structure Use **Figure 6** to point out two important parts of a virus: the capsid (made of protein) and the nucleic acid (RNA or DNA). Ask students what constitutes the membranous envelope surrounding the capsid. (proteins, lipids, and glycoproteins) LS Visual

Why It Matters

Plant Viruses Tell students that tomatoes, white potatoes, and garden peppers are all from the nightshade family, Solanaceae, and are vulnerable to the same viral diseases. Point out that tobacco is also a member of the nightshade family. A virus that plagues this family, the tobacco mosaic virus (TMV), was first recognized in tobacco. Have students speculate why TMV infects only members of this family. (Specific proteins, called receptor sites, on the plants' cell surfaces match proteins on the capsid of the TMV.) LS Logical

Teach, *continued*

Teaching Key Ideas

Capsid Proteins Tell students that only a few different kinds of proteins are found in a viral capsid. For example, the capsid of TMV contains more than 1,000 protein molecules, but they are all copies of the same protein. This means that one gene can code all of the capsid components.

Math Skills

Viral Reproduction Tell students that a single virus that infects a bacterial cell can produce about 100 new viruses in 20 minutes. Have students calculate how many viruses would exist after 1 hour, assuming that there are sufficient cells to support continuous viral replication. (1 million) LS Logical

READING TOOLBOX

Process Chart Advise students to practice their ability to write summaries using the information in **Figure 7.** If they have difficulty, encourage them to paraphrase the steps of each process in their own words. LS Verbal

lytic (LIT ik) viral replication that results in the destruction of a host cell and the release of many new virus particles

lysogenic (lie soh JEN ik) viral replication in which a viral genome is replicated as a provirus without destroying the host cell

READING TOOLBOX

Process Chart Use the information on this page to complete the process chart describing the lytic and lysogenic cycles of viral replication.

Figure 7 T4 is a bacterial virus that reproduces by using the lytic cycle and the lysogenic cycle.

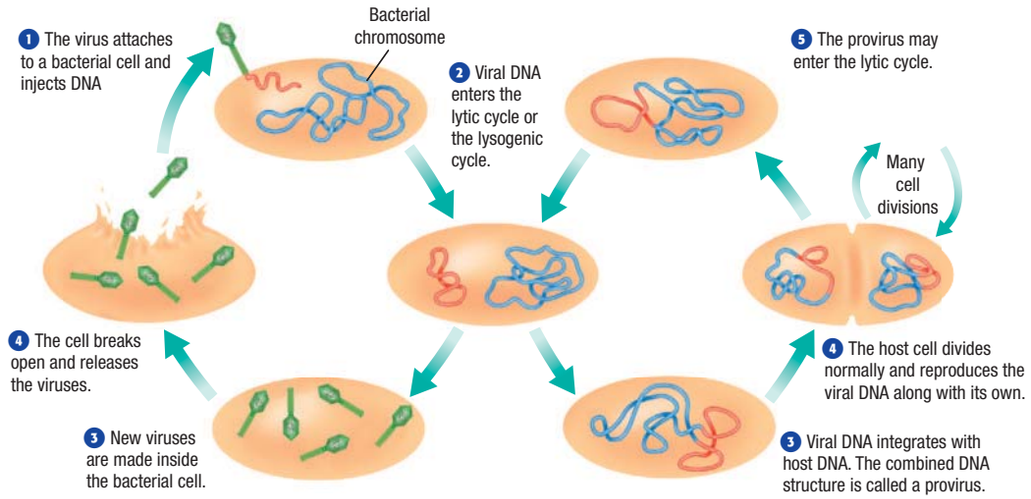
Reproduction

A viral infection begins when the genetic material of a virus enters a host cell. Once inside the cell, a virus can reproduce by two different processes, shown in **Figure 7.** **Viruses can reproduce by a lytic life cycle and a lysogenic life cycle.**

Lytic Cycle The cycle of viral infection, reproduction, and cell destruction is called the **lytic** cycle. Viral genetic material that has entered a cell remains separate from the host cell's DNA. The virus uses the host cell's organelles, enzymes, and raw materials to replicate the virus's DNA and to make viral proteins. The proteins are assembled with the replicated viral DNA to form complete viruses. The host cell breaks open, releases newly made viruses, and dies. The new virus particles can infect other host cells. The virus kills the host cells and further spreads the viral infection. Viruses that reproduce only by the lytic cycle are often called *virulent.*

Lysogenic Cycle When viral DNA becomes part of its host cell's DNA, the virus is called a *prophage.* When the host cell replicates its own DNA, the cell also replicates the provirus. New cells are produced that contain the provirus. New virus particles are not assembled, and the host cell is not destroyed. This process is called the **lysogenic** cycle. Many cells may be produced that contain the viral DNA. After days, months, or even years, the provirus may leave the host's DNA and enter a lytic cycle. If the virus never enters the lytic cycle, it may become a permanent part of its host's genome. A virus whose reproduction includes the lysogenic cycle is called a *temperate* virus.

Viral Replication in Bacteria



Differentiated Instruction

Alternative Assessment

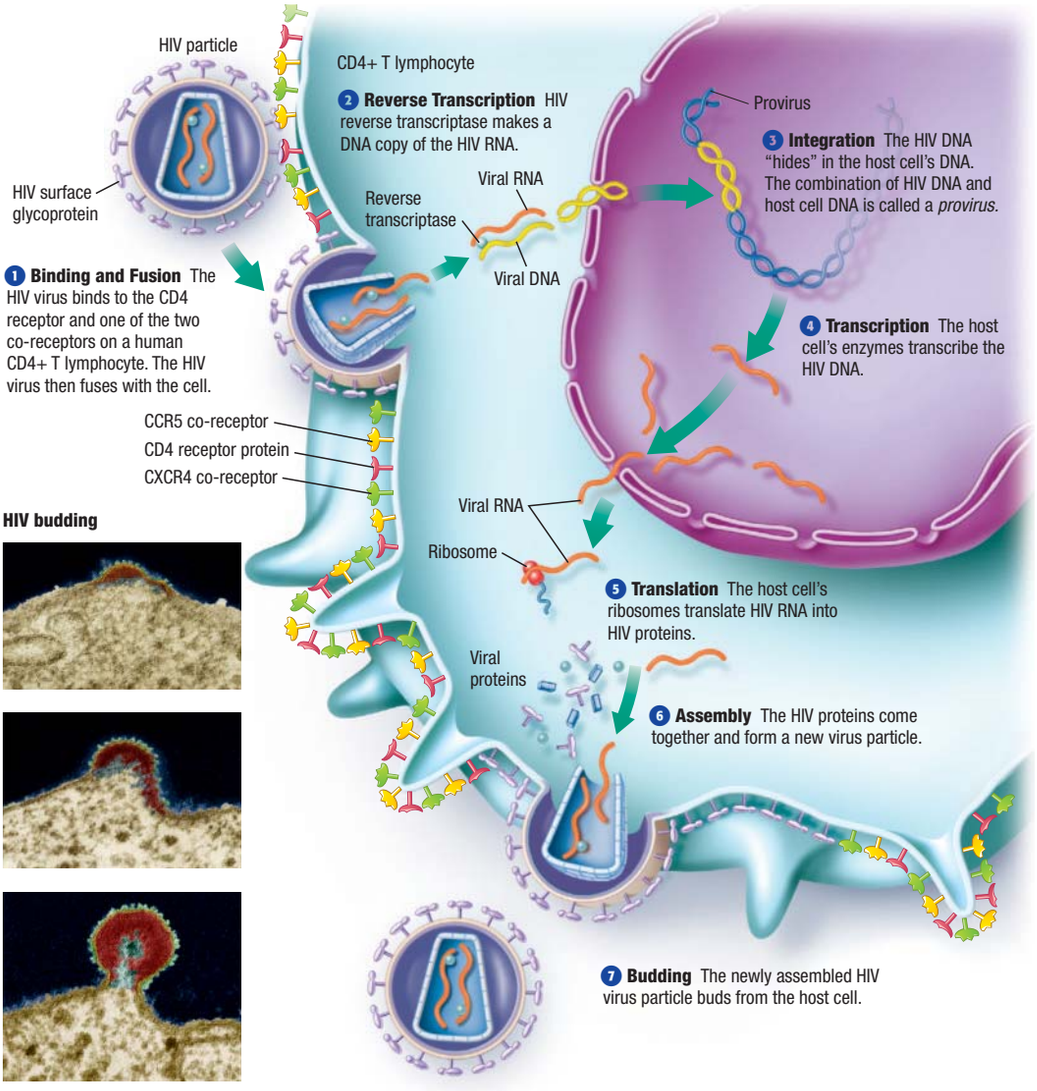
Design a Virus Have students create a fictitious virus. They should produce a drawing or a model of their virus and provide information about its origin, its components, the host it infects, how the virus is transmitted, and the effects of the virus on the host. Have students share their creations with the class. LS Visual

Up Close HIV Reproduction

Human immunodeficiency virus (HIV) is the virus that causes AIDS (acquired immune deficiency syndrome). HIV is considered to be a pandemic, a worldwide epidemic. About 22 million people have died as a result of AIDS. Currently, an estimated 33 million to 46 million people worldwide are living with HIV. There are several drugs used to treat HIV, but there is no cure.

HIV

Full name: human immunodeficiency virus
Size: 110–128 nm
Habitat: human CD4+ T lymphocyte and other cells that have the CD4 receptor including macrophages, B lymphocytes, and brain cells
Mode of nutrition: none



Differentiated Instruction

Advanced Learners/GATE

AIDS Drug Ask student groups to design a hypothetical drug that will disable the infection cycle of HIV. Students' drugs can target any step within the viral replication cycle, such as preventing the virus from attaching to white blood cells, inhibiting endocytosis of the virus, or destroying reverse transcriptase. Ask students to make diagrams of the HIV infection cycle that show their drug at work. LS Logical

MISCONCEPTION ALERT

HIV Infection and AIDS Students may not realize that an individual who has been infected with HIV can pass the virus to others even though he or she shows no symptoms of AIDS. During the long latency period between infection and the appearance of AIDS, typically 8 to 10 years, the virus multiplies in the body but does not kill cells. However, HIV can still be transmitted during this phase.

Up Close

Teacher's Notes The first cases of AIDS were reported in the early 1980s. Have students obtain statistics on the spread of AIDS from its discovery to the present time. Ask students to present the information in brief reports, including a bar graph that compares the number of AIDS-related deaths since the 1980s.

A small number of individuals have a natural resistance to HIV. This resistance seems to be due to their having a defective cell surface receptor for HIV. Researchers are trying to make use of this mutation to develop a vaccine for AIDS.

Discussion

1. What is reverse transcription and how is this process used to reproduce the virus? (The enzyme reverse transcriptase starts the conversion of single-stranded viral RNA to double-stranded DNA.)
2. Where is the translation process occurring? (cell cytoplasm)
3. What is a provirus and where is it found? (The provirus is DNA formed as the result of reverse transcription. The provirus is integrated into the host cell's DNA in the nucleus.)
4. Which cells are targeted by HIV? (CD4+ T lymphocytes)
5. Where is the new virus assembled? (inner surface of the cell membrane)

QuickLab

Teacher's Notes Before students begin the lab, make sure they are familiar with the millimeter scale of the ruler.

Materials
- meter stick
- metric ruler
- paper
- scissors
- tape

Answers to Analysis
1. 1,000
2. 2,000
3. 2 mm

Close

Formative Assessment
All viruses are made up of __ .

A. DNA and a capsid (Incorrect. Some viruses are made up of RNA, not DNA.)

B. a capsid, nucleic acid, and an envelope (Incorrect. Not all viruses have an envelope.)

C tail fibers and RNA (Incorrect. Some viruses use DNA, not RNA, and not all viruses have tail fibers.)

D. nucleic acid and a capsid (Correct! All viruses are made up of nucleic acid enclosed in a capsid.)

Hands-On

QuickLab

15 min

How Small Are Nanometers?

Viruses are extremely small. Most viruses are between 20 and 250 nm in length. One millimeter equals 1,000,000 nanometers. What would it look like if we could visually comparea nanometer to a millimeter?

Procedure
1. Using **scissors,** cut a piece of **paper** into long strips.
2. **Tape** the strips together until you have one strip that is 2 m long.
3. Use a **ruler** to label the strip of paper at the 2 mm, 2 cm, 20 cm, 1 m, and 2 m measurements.

Analysis
1. **Determine** how many millimeters are in 1 m.
2. **Determine** how many millimeters are in 2 m.
3. CRITICAL THINKING **Analyzing Data** If your entire strip of paper represents 2 mm, which mark on your paper represents 2,000 nm?

Figure 8 Mad cow disease damages a cow's brain and results in strange behavior, loss of muscle control, and death.

Viroids and Prions

Two emerging diseases are caused by nonliving particles. **Viroids and prions are molecules that are able to reproduce and cause disease.**

Viroids A *viroid* is a single strand of RNA that has no capsid. The RNA of viroids is much smaller than that of viruses. Viroids can replicate inside a host's cell to make new viroids. They disrupt a host cell's regulation of its own growth. Viroids cause abnormal development and stunted growth in plants. Viroids have affected plants such as cucumbers, potatoes, avocados, and oranges.

Prions *Prions* are misshapen versions of proteins that are found in the brain. They attach to normal proteins and cause them to take on the shape of the prion. As a result, the normal protein stops functioning. The misfolding spreads like a chain reaction and destroys brain tissue. Prion diseases include Creutzfeldt-Jakob disease in humans and mad cow disease, which is described in **Figure 8.** Prions can be transmitted by eating food contaminated with infected brain tissue.

Section 2 Review

KEY IDEAS
1. **Explain** why viruses are not considered to be living organisms.
2. **Describe** the two structures that are characteristic of a virus.
3. **Differentiate** between reproduction by the lytic and lysogenic cycles.
4. **Describe** the structure of viroids and prions.

CRITICAL THINKING
5. **Relating Concepts** Why is it possible for some viral diseases remain undetected for years?
6. **Analyzing Information** The assembly of new viral particles can sometimes take place in the host cell's nucleus. However, such assembly does not occur with phage viruses. Why not?

WRITING FOR SCIENCE
7. **Article** Research mad cow disease. Write an article describing how the disease spread from sheep to cows, how it spread to humans, and what measures have been taken to prevent the disease in sheep, cows, and humans.

Answers to Section Review
1. Viruses are not considered to be living because they cannot reproduce on their own, do not grow, do not carry out metabolic activities, do not have any cytoplasm or organelles, and do not maintain homeostasis.
2. nucleic acid and a capsid
3. The lytic cycle involves rupturing the host cell to produce new viruses. The lysogenic cycle involves viral genetic material becoming embedded in the host cell and being replicated with the host cell.
4. Viroids are single strands of RNA that can replicate inside a host cell. Prions are misshapen versions of proteins that cause normal proteins to change shape and stop functioning.
5. Lysogenic viruses can remain undetected inside a host for years. The viral genetic material is replicated with the host cell and does not cause cells to rupture. As a result, the disease does not cause any symptoms. Eventually, the virus may enter the lytic cycle and cause illness in the host.
6. Phage viruses infect only bacteria. Bacteria do not have a nucleus.
7. Accept any well-researched answer.

Section 3

Bacteria, Viruses, and Humans

Key Ideas	Key Terms	Why It Matters
What are three important roles of bacteria and viruses? What are the steps described in Koch's postulates? What are two ways that bacteria cause disease? How does antibiotic resistance develop? Why are viral diseases difficult to cure? What are four ways that a disease can emerge?	Koch's postulates pathogen toxin antibiotic resistance	Bacteria and viruses have a large impact on humans, from benefiting the environment to causing disease. Our world would not be the same without them.

When we think of bacteria and viruses, we usually think of disease. But bacteria and viruses are not all bad. Bacteria and viruses impact humans in many ways.

Roles of Bacteria and Viruses

Bacteria play important roles in the environment and in industry. Both bacteria and viruses are important in research.

Bacteria and the Environment Bacteria play a vital role in all of Earth's ecosystems. Bacteria produce oxygen, make nitrogen available to other organisms, and help decompose dead organisms. Many form important symbiotic relationships. For example, *E. coli* lives in the large intestines of humans, where it produces vitamin K.

Bacteria and Industry Bacteria are important in a variety of industries. Many of the foods that we eat, such as pickles, soy sauce, and sourdough bread, are made by using bacteria. Bacteria are used to produce chemicals, such as acetone. Mining companies use bacteria to convert sulfur into a form that can be washed away to leave behind valuable minerals, such as copper and uranium. Bacteria are also used in cleaning up oil spills and in sewage treatment plants, as **Figure 9** shows.

Bacteria, Viruses, and Research Bacteria and viruses have been very important in genetic research. Their genetic material can be easily studied. They provide valuable information about DNA replication, transcription, and translation. Viruses are also used in gene therapy as a way to deliver genetic material directly to target cells.

Figure 9 Bubbles pumped into sewage provide oxygen to bacteria that break down organic molecules. Next, anaerobic bacteria break sewage down further and generate methane, which is used to power the plant.

Differentiated Instruction

Advanced Learners/GATE

Breakthroughs in Science Organize students into small groups to discuss the technological uses of bacteria. Have students propose future uses of bacteria and their potential impacts. Encourage students to consider potentially harmful, beneficial, and benign effects of their ideas on quality of life, economy, health, and the environment. Then, have students make a diagram illustrating the topic of their discussion. Diagrams might feature the technological development in the center with its effects on society represented by spokes radiating outward. LS Visual

Section 3

Focus

This section introduces students to the ways that bacteria and viruses affect humans.

Bellringer

Use the Bellringer transparency to prepare students for this section.

Teach

Demonstration

Yogurt Mix a small amount of yogurt with water to make a thin mixture. Use a dropper to place a drop of the mixture on a microscope slide. Use another dropper to place a drop of methylene blue on the slide. Caution students that the dye can stain skin and clothing. Put a coverslip on the slide. Observe the slide under the highest-power lens on the microscope. The bacteria will appear as dark-blue dots against a pale blue background. Explain that the bacteria are used to change milk into yogurt. LS Visual

Key Resources

Transparencies
F6 Important Bacterial Diseases
F10 Important Viral Diseases

Visual Concepts
Koch's Postulates
Bacteria and Food
AIDS (Acquired Immune Deficiency Syndrome)

Why It Matters

Spread of Disease to Isolated Communities Tell students that isolated communities are at particular risk of epidemics when outsiders visit. Diseases spread by travelers can wipe out a small, isolated community. Spanish conqueror Hernán Cortéz was aided in his conquest of the Aztecs by a smallpox epidemic that struck those Native Americans. Prior to the arrival of the Europeans, smallpox had been unknown in the New World. The disease killed millions of Native Americans. Today, the Yanomamo tribe of Brazil and Venezuela is being decimated because of the onslaught of malaria, influenza, measles, and chickenpox brought by miners in search of gold.

go.hrw.com
interact online

Students can interact with "Koch's Postulates" by going to go.hrw.com and typing in the keyword HX8VBCF10.

Answers to Caption Questions

Figure 10: It is important to confirm that the second animal was made ill by the same pathogen that made the first animal ill.

Koch's postulates a four-stage procedure for identifying a pathogen

pathogen an organism or virus that causes disease; an infectious agent

toxin a substance that is produced by one organism that is poisonous to other organisms

Koch's Postulates and Disease Transmission

The German physician Robert Koch developed a technique for diagnosing the cause of an infection. His four-step procedure, described in **Figure 10,** is known as **Koch's postulates.** This technique is still used today to identify a disease-causing agent, or **pathogen.** **The four main steps in Koch's postulates are finding and isolating the pathogen, growing the pathogen, infecting a healthy animal, and then isolating the same pathogen.**

Step 1 The pathogen must be found in an animal with the disease and not in a healthy animal.

Step 2 The pathogen must be isolated from the sick animal and grown in a laboratory culture.

Step 3 When the isolated pathogen is injected into a healthy animal, the animal must develop the disease.

Step 4 The pathogen should be taken from the second animal, grown in the lab, and shown to be the same as the original pathogen.

Diseases that can spread from person to person are considered *contagious.* Some contagious diseases must be transmitted directly from one host to another by contact, such as by kissing or by animal and insect bites. Other diseases can survive outside a host for a period of time. These diseases can be transmitted through the air, in contaminated food or water, or on contaminated objects. Objects that often carry disease include utensils, toothbrushes, computer keyboards, kitchen sponges, and doorknobs.

Reading Check *What are five ways diseases can be transmitted?*

Figure 10 Applying the four principles of Koch's postulates, scientists can identify the pathogen that causes an infectious disease. **Why is it important for the pathogen to be grown from the second animal, as described in step 4?**

go.hrw.com
interact online
Keyword: HX8VBCF10

Koch's Postulates

1. Find and isolate the pathogen from an animal that has the disease.
2. Grow the pathogen in a laboratory.
3. Infect a healthy animal. The healthy animal must develop the same disease.
4. Isolate the same pathogen from the second animal.

MISCONCEPTION ALERT

"Bad" Bacteria Students tend to think of bacteria as "bad" organisms because they are often described as sources of disease. Of the thousands of kinds of bacteria, however, only a few are harmful. Bacteria are nature's recyclers, and scientists are finding ways to use bacteria to produce desirable materials and degrade wastes. Biotechnologists insert genes into bacterial that allow them to make plastics, pharmaceuticals, pesticides, and foods. Bacteria can even be used to mine metals, such as copper and gold, and to clean up industrial wastes.

Differentiated Instruction

English Learners/Struggling Readers

Paired Summarizing Have pairs of students silently read about Koch's postulates and disease transmission. As they read, have them note passages they do not understand. After students finish, ask one member of each pair to summarize the passage, referring to the text as needed. The listener should add anything omitted and continue the discussion by pointing out what he or she did not understand. Partners should work together to clarify what was not clear and to formulate questions to present to the class. LS Intrapersonal

Bacterial Diseases

Bacteria	Disease	Symptoms
Escherichia coli O157:H7	food poisoning associated with undercooked meat	diarrhea, bloody stools; can cause kidney failure and death
Vibrio cholera	cholera	usually mild diarrhea, sometimes profuse watery diarrhea, vomiting, leg cramps, dehydration, death
Borrelia burgdorferi	Lyme disease	fever, headache, fatigue, and characteristic skin rash, untreated it can spread to joints, heart, and nervous system
Clostridium tetani	tetanus 	lockjaw, stiffness in neck and abdomen, difficulty swallowing, fever, high blood pressure, muscle spasms; if left untreated, death
Staphylococcus aureus	food poisoning, staph infections in wounds	nausea, vomiting, diarrhea; rarely fatal
Mycobacterium tuberculosis	tuberculosis	coughing up blood, chest pain, fever, fatigue, weight loss; and if left untreated, death
Helicobacter pylori	stomach ulcers	burning stomach pain; rarely nausea, vomiting, loss of appetite; with bleeding ulcer: anemia, weakness and fatigue
Neisseria meningitidis	bacterial meningitis 	high fever, headache, stiff neck, nausea, vomiting, sensitivity to light, confusion, possibly seizures; untreated may result in brain damage and hearing loss

Figure 11 The scientific study of disease is called *pathology*. The table lists some bacterial pathogens, the disease caused by the bacterium, and symptoms of the disease.

Bacterial Diseases

Pathogenic bacteria cause disease in two ways. **Bacteria can cause disease by producing toxins and by destroying body tissues.**

The most common way that bacteria cause disease is by producing poisonous chemicals, called **toxins.** Toxins may be released or stored inside the bacteria until the bacteria die. Foods contaminated with bacteria or with toxins can cause food poisoning. For example, botulism occurs when canned food is contaminated with endospores of the bacterium *Clostridium botulinum.* The bacteria multiply in the can, causing toxins to build up. Botulinum toxin destroys the tips of nerve cells. Symptoms of botulism include double vision and paralysis. Botulism can be fatal if the muscles involved in breathing become paralyzed. Botulinum toxin is also now used in cosmetic procedures that paralyze nerves in the face and reduce wrinkling of the skin.

A second way that bacteria cause disease is by producing enzymes that break down the host's tissues into nutrients that the bacteria can use. Tuberculosis, described in **Figure 11,** is an example of a bacterium that uses human tissue for nutrients. Group A streptococcus bacteria produce both toxins and digestive enzymes. These bacteria usually cause only mild illnesses, including strep throat and impetigo. However, when these bacteria get into muscle or skin tissue, necrotizing fasciitis can result. This is a severe and often deadly infection in which large areas of flesh die. For this reason, group A strep are sometimes called flesh-eating bacteria!

READING TOOLBOX

Cause and Effect Make a two-column table. Title the left column "Cause" and the right column "Effect." In the "Effect" column, list all of the diseases discussed in this section. In the "Cause" column, list the pathogen that causes the disease, and note whether the pathogen is a bacterium or a virus.

Why It Matters

Bacterial Toxins Some bacterial toxins can be used for medical purposes. Botulinum toxin is used to treat dystonia, an abnormal muscle rigidity that causes painful muscle spasms. The toxin inhibits the release of acetylcholine from the neurons in the neuromuscular junction, allowing the muscles to relax. Dermatologists are using the same toxin to erase wrinkles from the face. Diluted toxin is injected under the skin to relax facial muscles and smooth out the wrinkles. The effect is temporary and must be repeated every six months.

Teaching Key Ideas

Current Infections Ask students to research current newspapers and magazines for articles that discuss any of the bacterial diseases shown in **Figure 11.** Create a class information center, such as a bulletin board, where students can post the latest information about research, outbreaks, controversies, and other details about the diseases.

READING TOOLBOX

Cause and Effect Students should include the information from the first two columns of **Figures 11** and **14.** In addition, the tables should include

- Food poisoning—*Clostridium botulinum* bacteria
- Necrotizing fascititus—group A strep bacteria
- Liver cancer—hepatitis B virus
- Burkett's lymphoma—Epstein-Barr virus
- Cervical cancer—human papilloma virus LS **Verbal, Visual**

Teach, *continued*

Answers to Caption Questions

Figure 12: Sample answer: No. Antibiotics have no effect on viral diseases and should not be used in the treatment of viral diseases. Overuse of antibiotics increases the risk of developing antibiotic resistant strains of bacteria.

Teaching Key Ideas

Preventing Antibiotic Resistance Tell students that according to the Centers for Disease Control and Prevention, antibiotic resistance is one of the world's most pressing public health problems. Nearly all significant bacterial infections in the world are becoming resistant to the most commonly prescribed antibiotic treatments. The CDC offers these suggestions to help prevent antibiotic resistance: 1. Colds, flu, most coughs, bronchitis and sore throats (except strep throat) should not be treated with antibiotics. Do not demand that you doctor provide antibiotics for these diseases. 2. When taking an antibiotic, be sure to take all the medicine as prescribed.

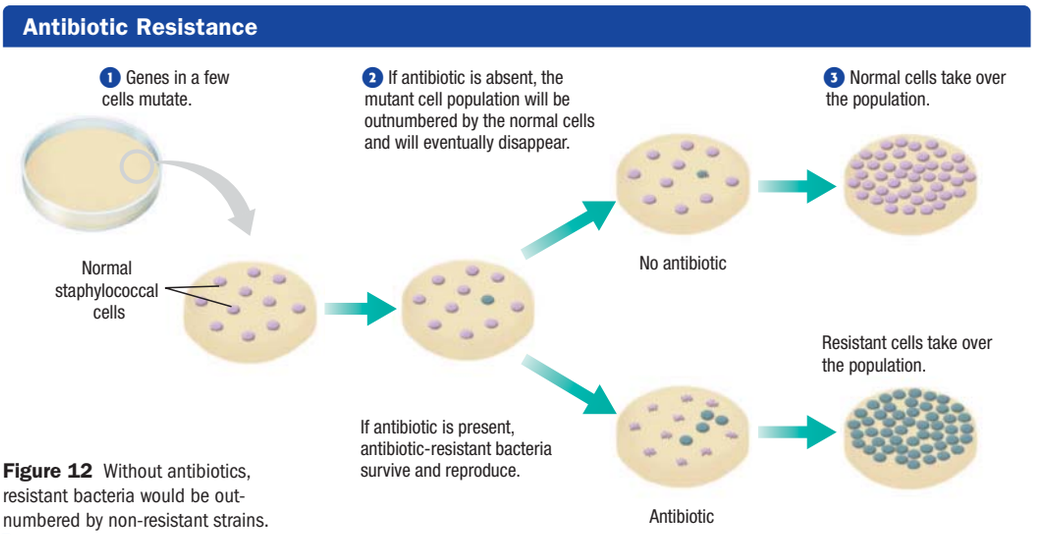


Figure 12 Without antibiotics, resistant bacteria would be outnumbered by non-resistant strains. **Should antibiotics be used in the process of treating viral diseases?**

antibiotic a substance that can inhibit the growth of or kill some microorganisms

resistance the ability of an organism to tolerate a chemical or disease-causing agent

Antibiotic Resistance

Antibiotics are chemicals that inhibit the growth of or kill microorganisms. Since the introduction of antibiotics, these drugs have reduced illness, suffering, and deaths from bacterial diseases.

Development of Resistance Over decades of antibiotic use, bacteria have developed resistance to these drugs. Antibiotic **resistance** is the ability of bacteria to tolerate antibiotics. Mutations for antibiotic resistance arise naturally and often in bacteria. Plasmids containing antibiotic-resistance genes can pass between bacteria during conjugation. When the antibiotic is present, vulnerable bacteria are killed. Resistant bacteria survive and reproduce. In this way, antibiotic-resistant bacteria become the dominant type in the population. **Figure 12** shows how antibiotic resistance can develop in a population of bacteria. **Antibiotic resistance spreads when sensitive populations of bacteria are killed by antibiotics. As a result, resistant bacteria thrive.**

Consequences of Resistance Today, nearly all bacterial pathogens are becoming resistant to one or more antibiotics. Diseases that were once easy to treat with antibiotics, such as staphylococcal infections, are now more difficult to treat because of resistance to multiple antibiotics. Widespread use of antibiotics promotes the spread of antibiotic resistance. As bacteria become resistant, physicians must switch to using different antibiotics. As new antibiotics are used, bacteria will probably develop resistance to those as well. For example, there are strains of tuberculosis in parts of South and Central America against which no antibiotics are effective. Many people fear that bacterial diseases will eventually become impossible to cure.

ACADEMIC VOCABULARY

effective able to have an effect

Differentiated Instruction

Basic Learners/Special Education Students

Antibacterial Agents Have students look for examples of items in their households that contain antibacterial agents. Have each student make a list of the products that they find. In the classroom, compile all the examples into a master list on the board. Ask students if they think these products are necessary and if they have any negative impacts. (Accept all reasonable responses.) LS Intrapersonal

Basic Learners

Graphing TB Cases Tell students that for decades tuberculosis (TB) cases in the United States were in decline. By 1985, the number of reported cases had plunged to only 22,201—one-fourth of the number of cases reported in 1953. However, the number of cases began to rise in 1986. Have students research the causes of the rise in cases. Also, have them research the number of TB cases from the 1940s to the present and make a bar graph showing the number of cases in each decade. LS Logical

Viral Diseases

Viruses cause disease in bacteria, plants, and animals. Because viruses identify host cells by receptors on the cell surface, viruses are very specific. For example, the virus that causes colds infects cells of the upper respiratory tract. The virus that causes chickenpox and shingles, shown in **Figure 13**, affects nerve cells. **Because viruses enter host cells to reproduce, it is difficult to develop a drug that kills the virus without harming the living host.**

Viruses can be transmitted by any action that brings virus particles into contact with a host cell. For this reason, certain viruses can be transmitted only by exchange of body fluids, whereas others can be transmitted through the air. Symptoms of a viral illness can be caused by several factors. Some viruses have toxic parts, such as envelope proteins. Other viruses cause the host cell to produce toxins. Some symptoms are caused by damage to the body's tissues as new viruses burst from host cells. Many symptoms of a viral infection, such as aches and fever, result from the body's response to infection.

Recently, viruses have been shown to cause some types of cancer. Viruses associated with human cancers include hepatitis B (liver cancer), Epstein-Barr virus (Burkitt's lymphoma), and human papilloma virus (cervical cancer). Many viral diseases can be prevented through vaccination. A *vaccine* is a weakened form of a pathogen that prepares the immune system to recognize and destroy the pathogen. **Figure 14** lists several common viruses, the disease caused by the virus, and the symptoms associated with the disease.

Reading Check *What factors cause the symptoms of viral disease?*

Figure 13 Shingles is caused by the same virus that causes chickenpox. It stays dormant until the immune system is stressed. Then, it travels along nerves and causes skin blisters and severe pain.

Figure 14 A virus is often named for the disease it causes. The table lists some viral diseases and their symptoms.

Viral Diseases

Virus	Disease	Symptoms
Influenza virus	flu	fever, headache, fatigue, muscle aches, cough
Varicella zoster virus	chickenpox, shingles	fever, tiredness, itchy or painful blisters
Measles virus	measles	fever, cough, runny nose, pink-eye, and a rash that covers the body
Mumps virus	mumps	fever, headache, muscle aches, tiredness, loss of appetite, swelling of salivary glands
Human immunodeficiency virus	AIDS/HIV	early symptoms: fever, tiredness, swollen lymph nodes; later symptoms: weight loss, Kaposi's sarcoma, opportunistic infections eventually resulting in death
Human papilloma virus	HPV infection, cervical cancer	usually no symptoms; occasionally genital warts; can cause cervical cancer and death
Hepatitis B virus	hepatitis, liver cancer	jaundice, fatigue, abdominal pain, nausea, joint pain, liver disease, liver cancer, death
West Nile virus	West Nile virus infection	fever, headache, bodyache; in rare cases coma, convulsions, numbness and paralysis

Why It Matters

Influenza Commonly called the flu, influenza has been perhaps the most lethal viral disease in human history. Because the influenza virus is airborne, it is highly contagious. A common flu virus can be lethal to people who have respiratory ailments or compromised immune systems, as well as to elderly people and young children. Tell students that every year in the United States about 5 to 20 percent of the population gets influenza and more than 200,000 people are hospitalized because of it. About 36,000 people die from it. Sometimes a new type of flu virus emerges that is very harmful. For example, in 1918 and 1919, a new type of influenza killed 22 million people—more people than were killed in combat during World War I.

Explain that flu spreads from person to person when those infected with the disease cough or sneeze. Ask students how a person can best prevent contracting the flu. (Get a flu vaccine; avoid contact with infected people; wash hands frequently; and avoid touching eyes, nose, or mouth.) LS Intrapersonal

Differentiated Instruction

Basic Learners

County Health Department Ask a county public health official to speak to your class about the kind of work the county public health department does to prevent contagious diseases. Be sure to ask the speaker to discuss viral diseases that are of concern in your county (e.g., mosquito- transmitted viral encephalitis, TB, pertussis, influenza, and HIV). Check with your school's guidelines about the kinds of subject areas that are appropriate. Ask the speaker to bring samples of equipment that the county uses for health work. LS Verbal

Teach, *continued*

QuickLab

Teacher's Notes You may want to make sure that students understand that each colored band represents the total number of human cases of bird flu in that country. For example, in April, there was only one human case of bird flu in Djibouti, not three.

Answers to Analysis

1. Azerbaijan, Cambodia, China, Egypt, Indonesia
2. ten

Close

Formative Assessment

How do *E. coli* that normally live in the human intestines help humans?

A. They produce vitamin K. (Correct! *E. coli* produce vitamin K.)

B. They cause disease. (Incorrect. Diseases do not help humans.)

C. They develop antibiotic resistance. (Incorrect. Antibiotic resistance makes treating diseases difficult.)

D. They insert genetic material into cells. (Incorrect. Viruses, not bacteria, insert genetic material into cells.)

Data

QuickLab

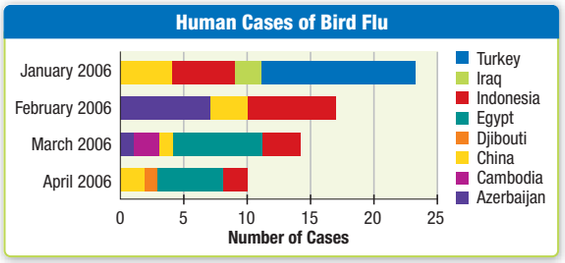
15 min

Emergence of Bird Flu

Although bird flu infection is rare in humans, the disease has emerged in several countries. This graph identifies the onset of new cases in the first half of 2006.

Analysis

1. **Identify** the countries in which new cases of humans infected with bird flu appeared in March 2006.
2. **Calculate** the total number of new cases that appeared in China between January and April 2006.



SCILINKS
www.scilinks.org
Topic: Emerging Viruses
Code: HX80499

Emerging Diseases

Emerging diseases are infectious diseases that are newly recognized, that have spread to new areas or a new host, or that have reemerged when a disease that was once considered under control begins to spread.

In 2005, a new form of bird flu appeared in Asia and spread to other parts of the world. This newly recognized emerging disease was deadly to birds but not to humans. Health officials feared that the bird flu virus could mutate to become highly infectious to humans. The result could be a global flu pandemic.

Diseases can spread to new areas or a new host when people come into contact with a pathogen in a different way than in the past. For example, the use of exotic cats for meat in China resulted in the transmission of SARS (sudden acute respiratory syndrome) to humans.

Environmental changes can cause diseases to emerge. For example, in 1993, an abundance of pine nuts caused a rise in the population of rodents that carry hanta virus. An outbreak of hanta virus resulted. Human behavior plays an important role in emerging disease. Frequent use of antibiotics has resulted in the emergence of antibiotic-resistant pathogens. A decline in vaccination has allowed diseases such as whooping cough, measles, and diphtheria to reemerge. And with the ease of global travel, health officials worry that emerging diseases will spread quickly and easily.

Section 3 Review

KEY IDEAS

1. **Describe** the beneficial roles of bacteria and viruses in the environment, industry, and research.
2. **List** the four steps of Koch's postulates.
3. **Explain** two ways that bacteria cause disease.
4. **Describe** how antibiotic resistance spreads.
5. **Explain** why it is difficult to develop a cure for viral diseases.
6. **Describe** the three types of emerging diseases.

CRITICAL THINKING

7. **Proposing Solutions** In the search for medications to cure viruses, researchers try to find a way to target just the virus without damaging the host's cells. Propose a possible target for antiviral medication.
8. **Recognizing Relationships** The first antibiotic was discovered when the fungus *Penicillium* contaminated a laboratory dish of bacteria. Why might fungi naturally produce antibiotics?

ALTERNATIVE ASSESSMENT

9. **Brochure** Choose an exotic location that you would be interested in visiting on a vacation. Research infectious diseases that are common to the area. Make a travel brochure that will prepare tourists for diseases that they may encounter. Advise them about how they can avoid and recognize these diseases and about available treatment.

Answers to Section Review

1. Answers should reflect information from the chapter.
2. finding and isolating the pathogen, growing the pathogen, infecting a healthy animal, and then isolating the same pathogen
3. Bacteria can cause disease by producing toxins and by destroying body tissues.
4. Antibiotic resistance spreads when sensitive populations of bacteria are killed by antibiotics, allowing resistant bacteria to thrive.
5. Because viruses use host cells in their life cycles, it is difficult to develop a drug that kills the virus without harming the host.
6. Emerging diseases are infectious diseases that are newly recognized, that have spread to new areas or a new host, or that have reemerged when a disease that was once considered under control begins to spread.
7. Answers may vary. Sample answers: medicines that prevent viral assembly, attack capsids, or prevent reverse transcription of RNA
8. Fungi compete with bacteria for food. Fungi may produce antibiotics to prevent bacteria from using food sources.
9. Accept any well-researched brochure.

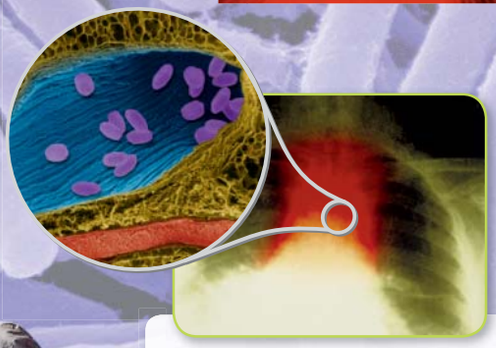
Why It Matters

Tiny Terrors

The use of biological weapons is not new. During the Middle Ages, the dead bodies of plague victims were sent flying over the walls of besieged cities. In the 18th century, British forces decimated Native American populations by intentionally giving them blankets contaminated with smallpox. Today, biological weapons are becoming global news again.

Critical Biological Agents

The Centers for Disease Control and Prevention (CDC) has compiled a list of "critical biological agents." The list is divided into three categories (A, B, and C) based on the level of potential harm to the public. Category A agents have the greatest potential for harm because they can be easily distributed and can cause a large number of deaths. Diseases caused by category A agents include anthrax, smallpox, botulism, plague, and viral hemorrhagic fevers such as Ebola. The most likely way that a biological weapon would be used is as an aerosol, a fine particle released into the air. If a crop duster were used to spread anthrax spores over Washington, D.C., scientists estimate that the spores could cover 300 square miles and could kill 1 million to 3 million people.



Anthrax Inhalation anthrax results from breathing the spores of *Bacillus anthracis.* Once inside the lungs, the spores produce bacterial cells that multiply quickly. Early symptoms are similar to those of a cold and occur within seven days after exposure. If left untreated, anthrax results in suffocating pneumonia and death in only 24–36 hours after symptoms first appear.

Preparing for the Worst As biological weapons become more sophisticated, so must the response. Today, research strategies include enzyme detergents that can dissolve anthrax and aerosol vaccines that can immunize an entire population at once.

Research Research one of the six category A agents, and describe the incubation period, symptoms, and mortality rate of the disease.

Why It Matters

Teacher's Notes Anthrax commonly occurs in both wild and domesticated animals (cattle, sheep, goats, camels, and other herbivores). The disease can spread to humans when they are exposed to infected animals or tissue or by eating undercooked meat from infected animals. However, infected animals are rare in the United States. Anthrax can also be transmitted when spores are used as a bioterrorist weapon. For example, in the fall of 2001, someone caused a panic in the United States by mailing anthrax spores to several politicians and news reporters. The disease in not known to spread from person to person. Antibiotics are the recommended treatment.

READING TOOLBOX

Visual Literacy Have students look at the photos and identify some of the measures that are taken to protect against biological weapons. Point out the biohazard sign, and ask students how this symbol is used as a warning. Then, discuss with students the procedures that your school and city have for biological threats. LS Verbal, Visual

Answer to Research

The CDC Web site has detailed information about biological agents in all six category A agents.

Lab

Time Required

One 45-minute class period

Ratings

Teacher Prep	
Concept Level	
Student Setup	
Cleanup	

Safety Caution

Be sure that students wipe their tables with the rubbing alcohol before and after the lab. Have students wear safety goggles, lab aprons, and disposable gloves before obtaining their bacterial cultures. Remind students to keep methylene blue away from their face, skin, and clothing. Be sure that open flames are isolated from the areas where alcohol is being used. Tell students to dispose of their materials properly and to wash their hands before leaving the lab.

Tips and Tricks

There should be enough wax pencils (or permanent marking pens) to supply every 3 to 4 students with one pen. Standard isopropyl alcohol is sufficient for disinfecting tables. Provide students with sterile cotton swabs that are wrapped individually or in pairs.

Skills Practice

Chapter 20 Lab

Bacterial Staining

Bacteria are prepared for viewing by making a smear. A smear is a slide on which cells have been spread, dried, and usually stained. In this lab, you will practice staining and observing bacteria. To do so, you will make a smear from three cultures of bacteria.

Objectives

- Prepare and stain smears of bacteria.
- Practice using sterile technique to avoid contaminating bacterial cultures.

Materials

- 70% isopropyl alcohol
- paper towels
- pencil, wax
- microscope slides (3)
- Bunsen burner with striker
- culture tubes of bacteria (3)
- test-tube rack
- sterile cotton swabs
- forceps or wooden alligator-type clothespin
- beaker, 150 mL
- water, 75 mL
- methylene blue stain in dropper bottle
- microscope, compound

Safety

Procedure

1. Put on safety goggles, gloves, and a lab apron.
2. **CAUTION: Alcohol is flammable. Do not use alcohol in the room when others are using a Bunsen burner.** Use alcohol and paper towels to clean the surface of your lab table and gloves. Allow the table to air-dry.
3. **CAUTION: Microscope slides are fragile and have sharp edges.** Use a wax pencil to label three microscope slides "A", "B", and "C".
4. **CAUTION: Keep combustibles such as alcohol-soaked paper towels away from flames. Do not light a Bunsen burner when others in the room are using alcohol.** Have your teacher light a Bunsen burner with a striker.

Part A: Making a Smear

5. Remove the cap from culture tube A. **CAUTION: Keep the cap in your hand.** To avoid contaminating your bacterial culture, do not place the cap on the table or other surface.
6. Pass the opening of the tube through the flame of a Bunsen burner to sterilize the end of the culture tube.
7. Use a sterile swab to collect a small sample of bacteria by lightly touching the tip of the swab to the bacterial culture.
8. Pass the opening of the tube through the flame again, and replace the cap.
9. Make a smear of bacterial culture A by rubbing the swab on the slide. Spread a thin layer of culture over the middle area of the slide. Cover about half of the total slide area and allow to dry.
10. Dispose of the swab in a proper container.
11. Repeat steps 5 through 10 for cultures B and C.

Part B: Staining Bacteria

12. Using microscope slide forceps, pick up each slide one at a time, and pass it over the flame several times. Let each slide cool.
13. Using microscope slide forceps, place one of your slides across the mouth of a 150 mL beaker half filled with water.

Obtain and grow bacterial cultures of rod-shaped, round, and spiral-shaped bacteria. Be sure to use non-pathogenic bacteria. Bacterial cultures can be purchased from a biological supply house. Use broth cultures, which will enable students to see chains of cocci. Buy premixed nutrient broth from a biological supply house or prepare culture medium from dehydrated concentrate and sterilize in an autoclave at 120° C at 15 psi for 20 minutes. About one day before the lab, grow the bacteria in nutrient broth at 37° C. Each lab group should be given a set of bacterial cultures. Prepare a sufficient amount of culture broth to provide groups of 3 to 4 students with about 5 mL of each culture. Transfer the culture to each tube with a sterile pipette.

Do not allow students to access your stock cultures. If you allow groups to obtain samples directly from stock cultures, the stocks are likely to become contaminated.

If students' microscopes have an oil immersion lens, you may provide them with immersion oil so that they can view the bacteria at a higher magnification.

14. **CAUTION: Methylene blue will stain your skin and clothing.** Place 2 to 3 drops of methylene blue stain on the dried bacteria. Do not allow the stain to spill into the beaker.
15. Let the stain stay on the slide for 2 min.
16. Dip the slide into the water in the beaker several times to rinse it. Gently blot the slide dry with a paper towel. Do not rub the slide.
17. Repeat steps 14 through 17 for your other two slides.
18. Allow each slide to completely dry before observing your slides under the microscope.

Part C: Observing Bacteria

19. Observe each slide under the microscope on low and high power. Make a sketch of a few cells that you see on each slide.
20. Clean up your lab materials according to your teacher's instructions. Wash your hands before leaving the lab.

SCILINKS
www.scilinks.org
Topic: Antibiotics
Code: HX80082

Analyze and Conclude

1. **Summarizing Results** Describe the shape and grouping of the cells of each type of bacteria that you observed.
2. **Drawing Conclusions** How did you classify the bacteria in cultures A, B, and C: as coccus, bacillus, or spirillum?
3. CRITICAL THINKING **Evaluating Viewpoints** Evaluate the following advice: Always use caution when handling bacteria, even if the bacteria are known to be harmless.

Extensions

4. **Further Inquiry** Write a question about bacteria that could be explored with another investigation using skills that you learned in this lab.
5. **On the Job** Microbiologists are scientists who study organisms too small to be seen by the unaided eye. Do research to find out about the kinds of work that microbiologists do and how microbiologists improve our lives.

Answers to Analyze and Conclude

1. All three types of bacterial cells were observed. Cocci may form pairs, groups of four, chains, or clusters. Bacilli usually appear as single cells, although sometimes they are arranged in pairs or in chains. Spirilla almost always appear singly, and they differ in length and in the number and size of their spirals.
2. Answers will vary according to the type of bacteria placed into the marked tubes.
3. Students should mention that mistakes in identification, contamination, or mutations may result in the presence of harmful bacteria.

Answers to Extensions

4. Sample answer: Are antiseptics equally effective against the three types of bacteria?
5. Microbiologists work closely with doctors and government health agencies to reduce the incidence of diseases caused by microorganisms. They also work in industry and research to develop new applications of bacteria, such as cleaning oil spills.

Key Resources

- Holt Lab Generator
- Lab Datasheet (Levels A, B, C)
- Holt Science Biology Video Labs

Chapter 20

SUPER SUMMARY

Have students connect the major concepts in this chapter through an interactive Super Summary. Visit **go.hrw.com** and type in the keyword **HX8VBCS** to access the Super Summary for this chapter.

Reteaching Key Ideas

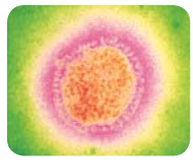
Bacterial Reproduction Have students make simple drawings to show three ways bacteria reproduce. (Drawings should show binary fission, genetic recombination, and endospore formation.) LS Visual

Viral Structure Provide each student with a photocopy of **Figure 6** with the labels deleted. Have students label the major structures shown. Ask them to include one sentence about each structure. LS Visual

Bacterial and Viral Diseases Ask students which of the following diseases are caused by bacteria (b) and which are caused by viruses (v): Lyme disease (b), measles (v), stomach ulcers (b), tetanus (b), Avian flu (v), AIDS (v), cervical cancer (v). Ask whether all the diseases can be cured by antibiotics. (no) Have students give their reasoning. (Antibiotics are not usually effective at curing viral infections.) LS Logical

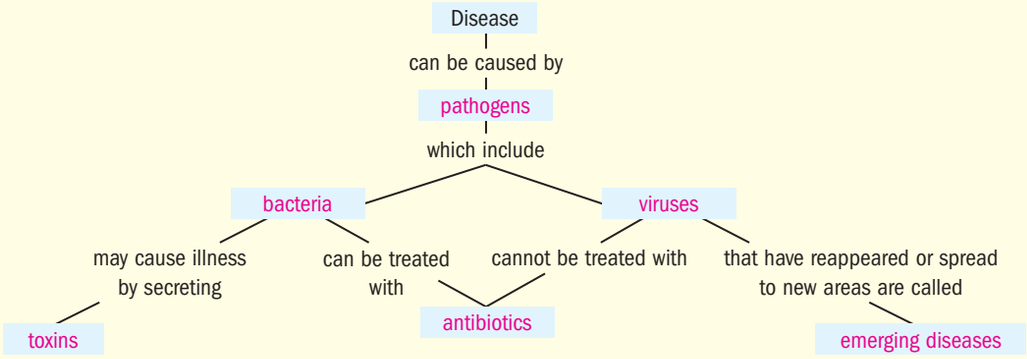
Chapter 20 Summary

go.hrw.com
SUPER SUMMARY
Keyword: HX8VBCS

Key Ideas	Key Terms
1 Bacteria › Prokaryotes are divided into two major groups: the domain Archaea and the domain Bacteria. › Gram-positive bacteria have a thick layer of peptidoglycan and no outer membrane. Gram-negative bacteria have a thin layer of peptidoglycan and have an outer membrane. › Grouping prokaryotes based on their energy source separates them into photoautotrophs, chemoautotrophs, and heterotrophs. › Prokaryotes can reproduce by binary fission, exchange genetic material through conjugation, transformation, and transduction, and survive harsh conditions by forming endospores. 	**plasmid** (472) **peptidoglycan** (472) **Gram-positive** (472) **Gram-negative** (472) **conjugation** (475) **transformation** (475) **transduction** (475) **endospore** (475)
2 Viruses › Viruses are not considered living because they do not grow, metabolize, or maintain homeostasis, and they cannot reproduce without a host cell. › All viruses have nucleic acid and a capsid. › Viruses can reproduce by a lytic life cycle and a lysogenic life cycle. › Viroids and prions are nonliving pathogenic molecules that are able to reproduce. 	**capsid** (477) **envelope** (477) **bacteriophage** (477) **lytic** (478) **lysogenic** (478)
3 Bacteria, Viruses, and Humans › Bacteria play important roles in the environment and in industry. Both bacteria and viruses are important in research. › The steps of Koch's postulates are isolating the pathogen, growing the pathogen, infecting a healthy animal, and isolating the same pathogen. › Bacteria cause disease by producing toxins and by destroying body tissues. › Antibiotic resistance spreads when sensitive populations of bacteria are killed by antibiotics, allowing resistant bacteria to thrive. › Because viruses reproduce inside host cells, it is difficult to develop a drug that kills the virus without harming the living host. › Emerging diseases are infectious diseases that are newly recognized, that have spread to new areas or a new host, or that have reemerged when a disease that was once considered under control begins to spread.	**Koch's postulates** (482) **pathogen** (482) **toxin** (483) **antibiotic** (484) **resistance** (484) 

Answer to Concept Map

The following is one possible answer to Chapter Review question 2.



Chapter 20 Review

READING TOOLBOX

1. **Key-Term Fold** Cut the tabs off your key-term fold. Shuffle the pieces that have the key terms written on them, and then try to match them with their definitions.
2. **Concept Map** Make a concept map that describes the relationships of bacteria and viruses to diseases. Include the following words in your map: *bacteria, viruses, pathogen, emerging diseases, antibiotics,* and *toxin.*

Using Key Terms

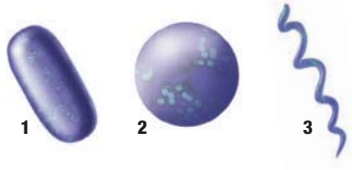
3. Use the following terms in the same sentence: *bacillus, coccus,* and *spirillum.*

For each pair of terms, explain how the meanings of the terms differ.

4. *capsid* and *endospore*
5. *lytic* and *lysogenic*
6. *Gram-positive* and *Gram-negative*

Understanding Key Ideas

7. What characteristic does the Gram stain indicate?
   - **a.** energy source
   - **b.** method of motility
   - **c.** composition of cell wall
   - **d.** form of genetic material
8. Bacteria that do not require sunlight and obtain energy from hydrogen-rich chemicals are called
   - **a.** heterotrophs.
   - **b.** cyanobacteria.
   - **c.** chemoautotrophs.
   - **d.** photosynthetic bacteria.
9. What shape is represented by organism 3?



   - **a.** coccus
   - **b.** bacillus
   - **c.** spirillum
   - **d.** filamentous
10. Genetic recombination in bacteria can occur during which of the following processes?
    - **a.** meiosis
    - **b.** conjugation
    - **c.** binary fission
    - **d.** endospore production
11. Viruses differ from cells because viruses
    - **a.** can grow.
    - **b.** lack nucleic acids.
    - **c.** have homeostasis.
    - **d.** do not metabolize.
12. A virus kills its host cell during
    - **a.** conjugation.
    - **b.** a lytic cycle.
    - **c.** a lysogenic cycle.
    - **d.** assembly of the capsid.
13. Which is a pathogen composed only of protein?
    - **a.** virus
    - **b.** prion
    - **c.** viroid
    - **d.** prokaryote
14. Nitrogen fixation by bacteria is important to all other organisms because
    - **a.** it does not take oxygen away from animals.
    - **b.** it captures more energy than photosynthesis alone captures.
    - **c.** it is necessary in order for dead organisms to be decomposed.
    - **d.** it converts nitrogen gas into a form of nitrogen that plants can take up through their roots.
15. Botulism can be fatal because the toxin
    - **a.** can poison the blood.
    - **b.** can damage the heart.
    - **c.** can paralyze the muscles used in breathing.
    - **d.** can stress the body and enable other infectious agents to grow.
16. Antibiotic resistance arises in a population by
    - **a.** mutation.
    - **b.** crossing-over.
    - **c.** Gram staining.
    - **d.** endospore formation.
17. Viral diseases can be prevented by which of the following techniques?
    - **a.** using antibiotics
    - **b.** hospitalizing people who are infected
    - **c.** using medicines that can destroy viruses
    - **d.** vaccinating people before they become infected

Assignment Guide

Section	Questions
1	1, 2, 3, 5, 6, 7, 8, 9, 10, 18, 21
2	1, 2, 3, 4, 11, 12, 13, 19, 20, 23, 27, 31
3	1, 2, 14, 15, 16, 17, 22, 24, 25, 26, 28, 29, 30

Review

Reading Toolbox

1. Students should be able to match the key term with the correct definition.
2. See previous page for answer to concept map.

Using Key Terms

3. Bacteria come in three different shapes, which are *bacillus, coccus,* and *spirillum.*
4. A *capsid* is the outer protein coating of a virus. An *endospore* is a protective outer coating of a bacterial cell.
5. The *lytic cycle* is a type of viral replication that involves rupture of the host cell. The *lysogenic cycle* does not cause rupture of the host cell.
6. *Gram-positive bacteria* stain purple in the Gram stain. *Gram-negative bacteria* stain pink.

Understanding Key Ideas

7. c	8. c	9. c	10. b
11. d	12. b	13. b	14. d
15. c	16. a	17. d	

Explaining Key Ideas

18. Archaea have proteins similar to those found in eukaryotes, and they can be found in many places, including extreme environments. Bacteria have peptidoglycan in their cell walls and can be found almost everywhere.
19. Viruses have genetic material, but they cannot reproduce. Viruses do not grow, carry out any internal processes, or maintain homeostasis as living organisms do.
20. Viruses are composed of both proteins and nucleic acids. Viroids are made only of the nucleic acid RNA. Prions are made only of protein.

Critical Thinking

21. Gram-negative bacteria are more resistant to antibiotics. If the bacteria is Gram-negative, the doctor might prescribe a different antibiotic than might be prescribed for Gram-positive bacteria.

22. The viruses that the body is not able to destroy will reproduce, resulting in a population of viruses that the immune system cannot combat. In this way, the immune system acts as an agent of natural selection.
23. HIV is an RNA virus that relies on its own enzyme, reverse transcriptase, to transcribe the HIV RNA into DNA. If AZT blocks reverse transcriptase, it can prevent the HIV RNA from being transcribed into DNA and embedded in an infected cell's DNA.
24. The bacteria get a sheltered living environment that has relatively constant moisture and nutrients supplied by photosynthesis by the plant.
25. The Native Americans had no natural immunity to the virus because they had never been exposed to it. Many Europeans were immune because they had been exposed to the virus either through contact with it or by having and recovering from smallpox.

Why It Matters

26. Students should recognize that an insect-borne virus might be difficult to produce on a large scale, hard to disseminate in a population, and complicated to produce, so it would be unlikely to be an agent that a bioterrorist would use.

Alternative Assessment

27. Accept any correctly constructed model that includes a polyhedral capsid, a helical tail, and a DNA strand in the capsid. The model may or may not have tail fibers.

Interpreting Graphics

28. b
29. d

Methods of Science

30. Accept any well-researched answer.

Math Skills

31. 25,000 cm; 2.5 m

Explaining Key Ideas

18. Describe the two major groups of prokaryotes.

19. Compare the characteristics of viruses with those of living organisms.

20. Describe how viruses, viroids, and prions differ from each other.

Critical Thinking

21. Relating Concepts Why might your doctor try to determine if the bacteria infecting your throat were Gram positive or Gram negative?

22. Making Inferences If cold viruses invade your body, your body's immune system may destroy most but not all of these viruses. How does your body's immune system affect the evolution of the cold virus?

23. Evaluating Information The drug azidothymidine (AZT) works by blocking the enzyme reverse transcriptase. Explain how AZT can help patients infected with HIV.

24. Making Inferences *Rhizobium* bacteria live inside the roots of certain plants. The bacteria provide the plants with nitrogen that the bacteria have fixed from the air. What benefit do the bacteria get from this association?

25. Evaluating Results In the 1520s, the Spanish explorer Cortez and his armies introduced smallpox to the Americas. The death rate among the Native Americans ranged from 50% to 90%, but the death rate was about 10% among people in Europe. What accounts for the difference in death rates?

Why It Matters

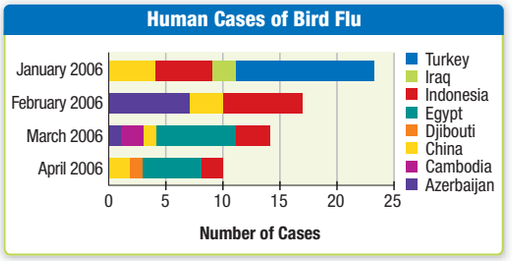
26. Making Predictions Would a virus that is transmitted through the bite of an insect be an agent that a bioterrorist would be likely to use? Explain your answer.

Alternative Assessment

27. Phage Model Use common household materials, such as hardware items or craft materials, to prepare a model of a bacteriophage. Your model must depict all of the structural characteristics of a bacteriophage. Display your model in the classroom.

Using Science Graphics

The diagram below shows human cases of bird flu from January to April 2006. Use the diagram to answer the following questions.



Source: European Union Communicable Diseases Network

28. Which country had the fewest cases of bird flu?

a. China **c.** Cambodia
b. Djibouti **d.** Azerbaijan

29. What was the total number of human cases of bird flu reported in Indonesia?

a. 5 **c.** 12
b. 7 **d.** 17

Methods of Science

30. Germ Theory Doctors have not always known that bacteria and viruses cause disease. Research the development of germ theory. Describe one or more alternative theories that explain the cause of disease. Discuss the research that scientists performed and how researchers proved that pathogens are the cause of disease.

Math Skills

31. Unit Conversion To convert a measurement from one unit to another, you need to know the relationship between the units. For example, there are 100 centimeters in a meter. So, to convert a measurement from meters to centimeters, you would multiply by 100. To convert a measurement from centimeters to meters, you would divide by 100.

How many centimeters are in 250 meters?

How many meters are in 250 centimeters?

Chapter 20 Standardized Test Prep

TEST TIP When using a diagram to answer a question, study the diagram closely for evidence that supports your potential answer.

Science Concepts

1. Chemoautotrophic prokaryotes get their energy
- **A** from carbon dioxide.
- **B** from other organisms.
- **C** from inorganic molecules.
- **D** from fixing nitrogen.

2. *E. coli* is a
- **F** Gram-positive bacterium.
- **G** Gram-negative bacterium.
- **H** Gram-sensitive bacterium.
- **J** Gram-peptidoglycan bacterium.

3. In harsh conditions, *Clostridium bacteria* form
- **A** envelopes.
- **B** conjugation.
- **C** endospores.
- **D** endocapsids.

4. A virus is made up of
- **F** only protein.
- **G** only nucleic acid.
- **H** nucleic acid plus protein.
- **J** nucleic acid, protein, and organelles.

5. Viroids contain
- **A** only RNA.
- **B** only DNA.
- **C** only protein.
- **D** DNA and protein.

6. Environmental spills of petroleum are sometimes cleaned up by using
- **F** viroids.
- **G** prions.
- **H** bacteria.
- **J** bacteriophages.

7. HIV infects and destroys
- **A** skin cells.
- **B** bacterial cells.
- **C** red blood cells.
- **D** white blood cells.

Writing Skills

8. Short Response Write a paragraph that describes the process of Gram staining and the results obtained when staining Gram-positive and Gram-negative bacteria.

Using Science Graphics

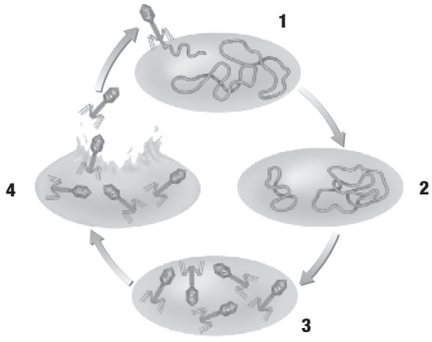
The table below lists the response of bacteria to several antibiotics. A score of 0 means that the bacteria were not sensitive. Sensitivity increases as the score increases. Use the table to answer the following question(s).

Antibiotic	Sensitivity
Ampicillin	3
Bacitracin	0
Cephalosporin	0
Penicillin	0
Pifampin	0
Streptomycin	3
Tetracycline	2

9. Which of the following antibiotics killed bacteria most effectively?
- **F** penicillin
- **G** bacitracin
- **H** tetracycline
- **J** streptomycin

10. Which of the following antibiotics had no effect on the bacteria?
- **A** ampicillin
- **B** tetracycline
- **C** streptomycin
- **D** cephalosporin

The diagram shows the life cycle of a bacteriophage. Use the diagram to answer the following question(s).



11. This bacteriophage would be considered
- **F** viral.
- **G** virulent.
- **H** temperate.
- **J** tempestuous.

State Resources

For specific resources for your state, visit go.hrw.com and type in the keyword **HSHSTR**.

Test Practice with Guided Reading Development

Answers

1. C **2.** G **3.** C
4. H **5.** A **6.** H
7. D
8. The Gram stain involves two colors of dye. The first dye is dark purple. The second dye is pink. Gram-positive bacteria trap the purple dye in their peptidoglycan membranes. They also trap the pink dye, but it cannot be seen because the purple dye is much darker. So Gram-positive bacteria appear purple after staining. Gram-negative bacteria do not trap the purple dye because their peptidoglycan layer is thin. They absorb the pink dye only and appear pink after staining.
9. J **10.** D **11.** G

TEST DOCTOR

Question 1 Chemoautotropic prokaryotes get their energy from inorganic molecules, so the correct answer is **C. A** is incorrect because carbon dioxide is not a source of energy for organisms. **B** is incorrect because organisms that get energy from other organisms are heterotrophs. **D** is incorrect because bacteria do not obtain energy from nitrogen.

Question 4 A virus is made up of a protein coat and nucleic acid. Therefore, **H** is correct. **F** and **G** are incorrect because they are incomplete descriptions. **J** is incorrect because a virus does not contain organelles.

Question 7 **D** is correct because HIV infects only white blood cells. Answers **A, B,** and **C** are incorrect because HIV does not infect skin cells, bacterial cells, or red blood cells.