Chapter 7

Bacteria and Viruses

THE BIG IDEA

What are bacteria and viruses and why are they important?

Color-enhanced TEM Magnification: 63,000×

Inquiry

Are robots attacking?

You might think this photo shows robots landing on another planet. Actually, this is a picture of viruses attacking a type of unicellular organism called a bacterium (plural, bacteria). Many viruses can attach to the surface of one bacterium.

- Do you think the bacterium is harmful? Are the viruses?
- What do you think happens after the viruses attach to the bacterium?
- What are viruses and bacteria and why are they important?

Lesson 1

Reading Guide

Key Concept

ESSENTIAL QUESTION

- What are bacteria?

Vocabulary

bacterium p. 231
flagellum p. 234
fission p. 234
conjugation p. 234
endospore p. 235

Multilingual eGlossary

BrainPOP®

What are bacteria?

Color-enhanced SEM Magnification: 560×

Inquiry **How clean is this surface?**

This photo shows a microscopic view of the point of a needle. The small orange things are bacteria. Bacteria are everywhere, even on surfaces that appear clean. Do you think bacteria are living or nonliving?

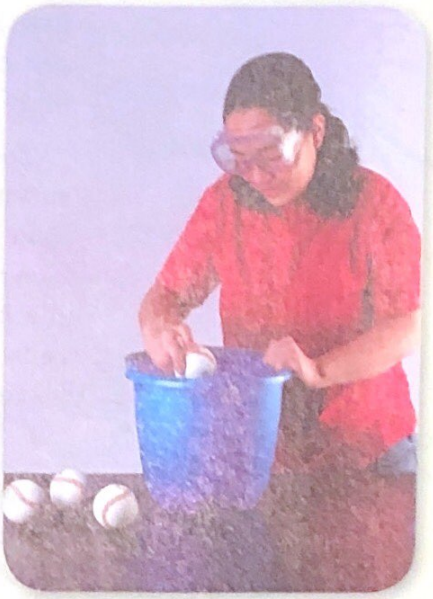
Launch Lab

10 minutes

How small are bacteria?

Bacteria are tiny cells that can be difficult to see, even with a microscope. You might be surprised to learn that bacteria are found all around you, including in the air, on your skin, and in your body. One way of understanding how small bacteria are is to model their size.

1. Read and complete a lab safety form.
2. Examine the size of a **baseball** and a **2.5-gal. bucket.** Estimate how many baseballs you think would fit inside the bucket.
3. As a class, count how many baseballs it takes to fill the bucket.



Think About This

1. How much larger is the bucket than a baseball?
2. If your skin cells were the size of the bucket and bacteria were the size of the baseballs, how many bacterial cells would fit on a skin cell?
3. **Key Concept** Why do you think you cannot see bacteria on your skin or on your desk?

Characteristics of Bacteria

Did you know that billions of tiny organisms too small to be seen surround you? These organisms, called bacteria, even live inside your body. **Bacteria** (singular, bacterium) *are microscopic prokaryotes.* You might recall that a prokaryote is a unicellular organism that does not have a nucleus or other membrane-bound organelles.

Bacteria live in almost every habitat on Earth, including the air, glaciers, the ocean floor, and in soil. A teaspoon of soil can contain between 100 million and 1 billion bacteria. Bacteria also live in or on almost every organism, both living and dead. Hundreds of species of bacteria live on your skin. In fact, your body contains more bacterial cells than human cells! The bacteria in your body outnumber human cells by 1.3 to 1.

Key Concept Check What are bacteria?

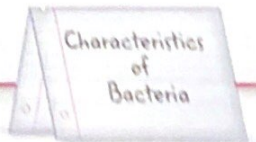
Other prokaryotes, called archaea (ar KEE uh; singular, archaean), are similar to bacteria and share many characteristics with them, including the lack of membrane-bound organelles. Archaea can live in places where few other organisms can survive, such as very warm areas or those with little oxygen. Both bacteria and archaea are important to life on Earth.

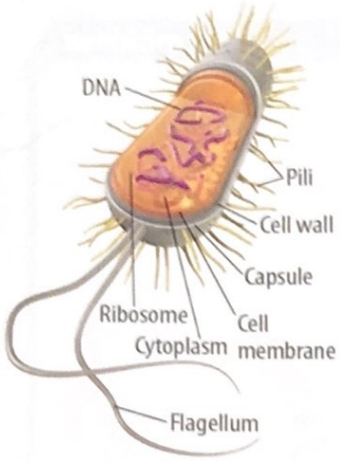
WORD ORIGIN

bacteria
from Greek *bakterion,* means "small staff"

FOLDABLES

Make a folded book from a sheet of notebook paper. Label it as shown. Use your book to organize your notes on the characteristics of bacteria.





▲ **Figure 1** Bacteria have a cell membrane and contain cytoplasm.

Structure of Bacteria

A typical bacterium, such as the one shown in **Figure 1**, consists of cytoplasm and DNA surrounded by a cell membrane and a cell wall. The cytoplasm also contains ribosomes. Most bacteria have DNA that is one coiled, circular chromosome. Many bacteria also have one or more small circular pieces of DNA called plasmids that are separate from its other DNA.

Some bacteria have specialized structures that help them survive. For example, the bacterium that causes pneumonia (noo MOH nyuh), an inflammation of the lungs, has a thick covering, or capsule, around its cell wall. The capsule protects the bacterium from drying out. It also prevents white blood cells from surrounding and antibiotics from entering it. Many bacteria have capsules with hairlike structures called pili (PI li) that help the bacteria stick to surfaces.

Size and Shapes of Bacteria

Bacteria are much smaller than plant or animal cells. Bacteria are generally only 1-5 micrometers (µm) (1 m = 1 million µm) wide, while an average eukaryotic cell is 10-100 µm wide. Scientists estimate that as many as 100 bacteria could be lined up across the head of a pin. As shown in **Figure 2**, bacteria generally have one of three basic shapes.

Shapes of Bacteria

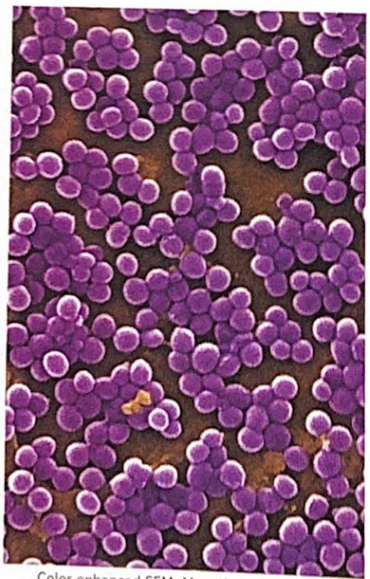
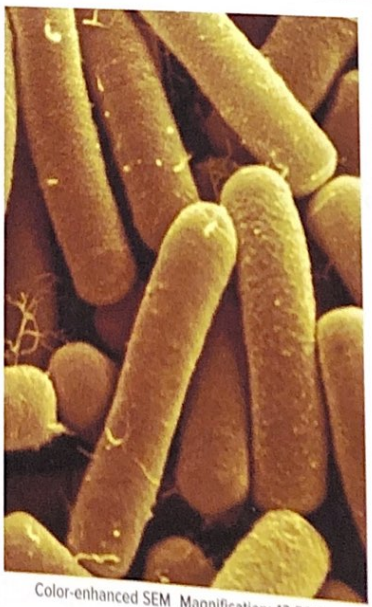
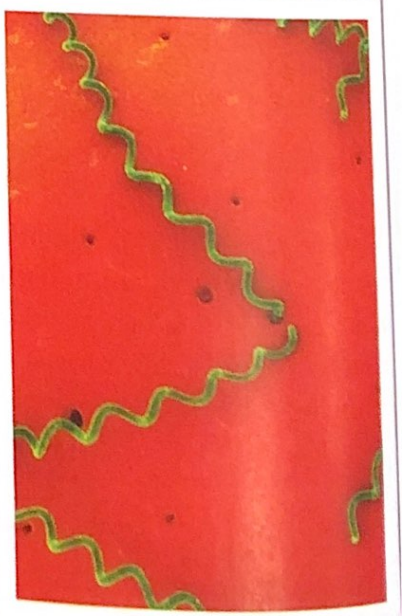
Round or Sphere-Shaped	Rod-Shaped	Spiral-Shaped
		
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Figure 2 Bacteria are generally shaped like a sphere, a rod, or a spiral.

Visual Check What are the three basic shapes of bacteria?

MiniLab

15 minutes

How does a slime layer work?

Bacteria have a gelatinlike, protective coating called a slime layer on the outside of their cell walls. A slime layer can help a bacterium attach to surfaces or reduce water loss.

1. Read and complete a lab safety form.
2. Cut two 2-cm-wide strips from the long side of a **synthetic kitchen sponge**.
3. Soak both strips in **water**. Remove them from the water and squeeze out the excess water. Both strips should be damp.
4. Completely coat one strip with **hair-styling gel** to simulate a slime layer.
5. Place both strips on a **plate** and let them sit overnight.

Analyze and Conclude

1. **Describe** the appearance of the two strips in your Science Journal. How do they differ?
2. **Key Concept** Explain how a slime layer might be beneficial to a bacterium when moving or finding food.

Obtaining Food and Energy

Bacteria live in many places. Because these environments are very different, bacteria obtain food in various ways. Some bacteria take in food and break it down and obtain energy. Many of these bacteria feed on dead organisms or organic waste, as shown in **Figure 3.** Others take in their nutrients from living hosts. For example, bacteria that cause tooth decay live in dental plaque on teeth and feed on sugars in the foods you eat and the beverages you drink.

Some bacteria make their own food. These bacteria use light energy and make food, like most plants do. These bacteria live where there is a lot of light, such as the surface of lakes and streams. Other bacteria use energy from chemical reactions and make their food. These bacteria live in places where there is no sunlight, such as the dark ocean floor.

Key Concept Check How do bacteria obtain food?

Most organisms, including humans, cannot survive without oxygen. However, certain bacteria do not need oxygen to survive. These bacteria are called anaerobic (a nuh ROH bihk) bacteria. Bacteria that need oxygen are called aerobic (er OH bihk) bacteria. Most bacteria in the environment are aerobic.

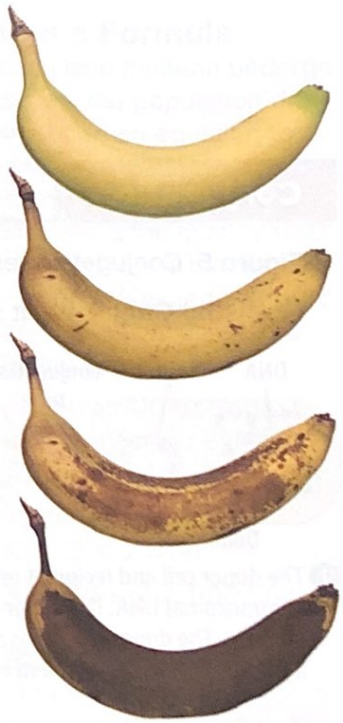
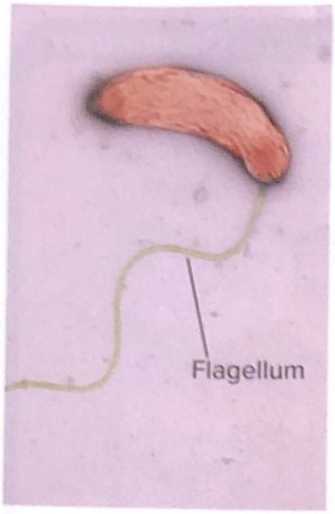


Figure 3 This banana is rotting because bacteria are breaking it down to use it for food.



▲ **Figure 4** Some bacteria move using a flagellum.

Movement

Some bacteria are able to move around to find the resources that they need to survive. These bacteria have special structures for movement. *Many bacteria have long whiplike structures called* **flagella** (fluh JEH luh; singular, flagellum), as shown in **Figure 4.** Others twist or spiral as they move. Still other bacteria use their pili like grappling hooks or make threadlike structures that enable them to push away from a surface.

Reproduction

You might recall that organisms reproduce asexually or sexually. Bacteria reproduce asexually by fission. **Fission** *is cell division that forms two genetically identical cells.* Fission can occur quickly–as often as every 20 minutes under ideal conditions.

Bacteria produced by fission are identical to the parent cell. However, genetic variation can be increased by a process called conjugation, shown in **Figure 5.** *During* **conjugation** (kahn juh GAY shun), *two bacteria of the same species attach to each other and combine their genetic material.* DNA is transferred between the bacteria. This results in new combinations of genes, increasing genetic diversity. New organisms are not produced during conjugation, so the process is not considered reproduction.

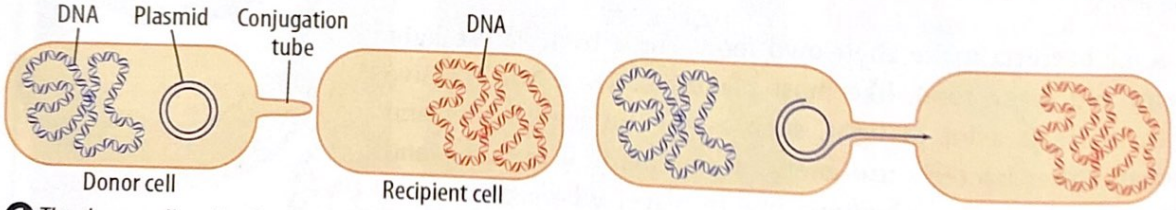
Reading Check How does conjugation increase the genetic diversity of bacteria?

Conjugation

Personal Tutor

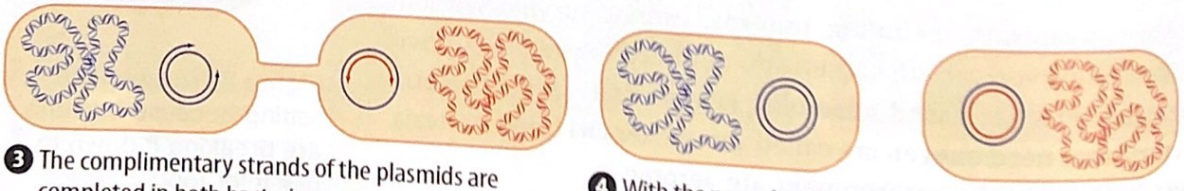
Figure 5 Conjugation results in genetic diversity by transferring DNA between two bacteria cells.

Visual Check What structure does the donor cell use to connect to the recipient cell?



❶ The donor cell and recipient cell both have circular chromosomal DNA. The donor cell also has DNA as a plasmid. The donor cell forms a conjugation tube and connects to the recipient cell.

❷ The conjugation tube connects both cells. The plasmid splits in two and one plasmid strand moves through the conjugation tube into the recipient cell.



❸ The complimentary strands of the plasmids are completed in both bacteria.

❹ With the new plasmids complete, the bacteria separate from each other. The recipient cell now contains plasmid DNA from the donor cell as well as its own chromosomal DNA.

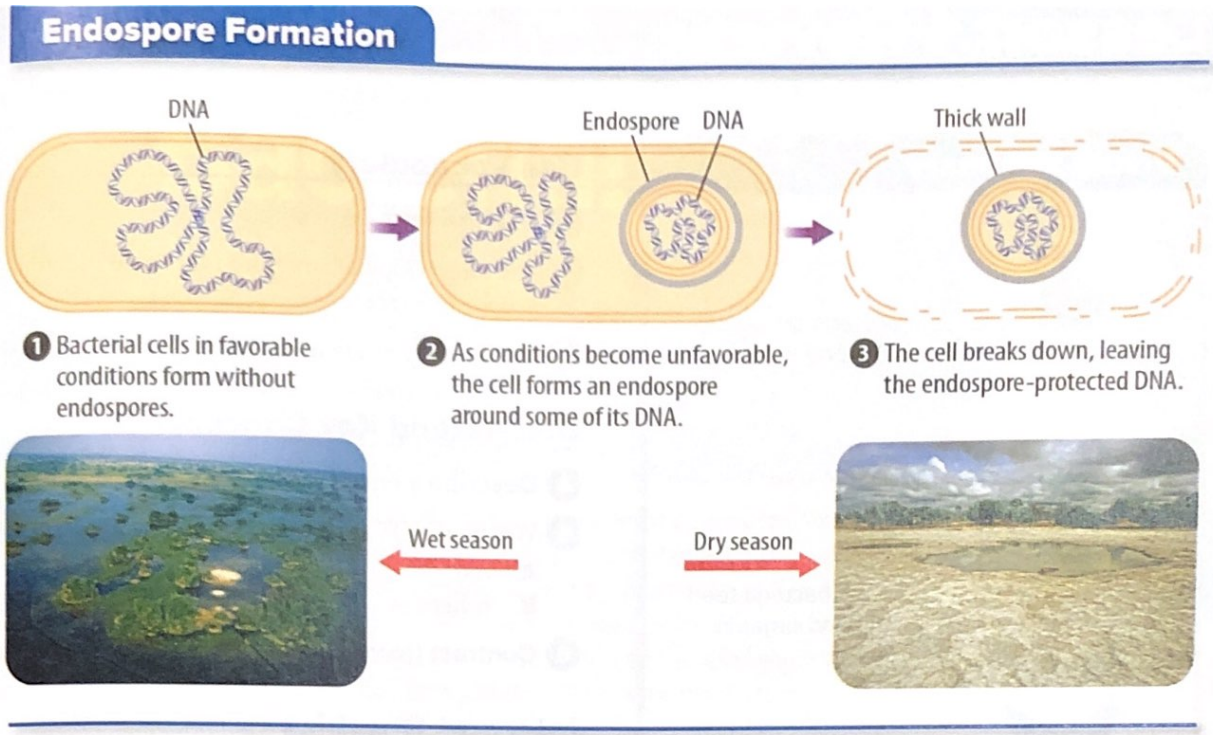


Figure 6 An endospore protects a bacterium.

Endospores

Sometimes environmental conditions are unfavorable for the survival of bacteria. In these cases, some bacteria can form endospores. *An* **endospore** (EN doh spor) *forms when a bacterium builds a thick internal wall around its chromosome and part of the cytoplasm,* as shown in **Figure 6.** An endospore can protect a bacterium from intense heat, cold, or drought. It also enables a bacterium to remain dormant for months or even centuries. The ability to form endospores enables bacteria to survive extreme conditions that would normally kill them.

Archaea

Prokaryotes called archaea were once considered bacteria. Like a bacterium, an archaean has a cell wall and no nucleus or membrane-bound organelles. Its chromosome is also circular, like those in bacteria. However, there are some important differences between archaea and bacteria. The ribosomes of archaea more closely resemble the ribosomes of eukaryotes than those of bacteria. Archaea also contain molecules in their plasma membranes that are not found in any other known organisms. Archaea often live in extreme environments, such as hot springs and salt lakes. Some scientists refer to archaea as extremophiles (ik STREE muh filez)–a term that means "those that love extremes."

Math Skills

Use a Formula

Each time bacteria undergo fission, the population doubles. Use an equation to calculate how many bacteria there are: $n = x \times 2^f$ where n is the final number of bacteria, x is the starting number of bacteria, and f is the number of times that fission occurs.

Example: 100 bacteria undergo fission 3 times.

$f = 3$, so 2^f is 2 multiplied by itself 3 times. $(2 \times 2 \times 2 = 8)$

$n = 100 \times 8 = 800$ bacteria

Practice

How many bacteria would there be if 1 bacterium underwent fission 10 times?

Math Practice

Personal Tutor

Lesson 1 Review

Online Quiz

Visual Summary

Bacteria are unicellular prokaryotes.

Many bacteria feed on dead organic matter.

Bacteria can increase genetic diversity by sharing DNA through conjugation.

FOLDABLES

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

What do you think NOW?

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

1. A bacterium does not have a nucleus.

2. Bacteria cannot move.

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

Use Vocabulary

1 **Use the term** *bacteria* in a sentence.

2 The long whiplike structure that some bacteria use for movement is a(n) _____.

3 **Define** *conjugation* in your own words.

Understand Key Concepts

4 **Describe** a typical bacterium.

5 Which is NOT a common bacteria shape?

A. rod **C.** spiral

B. sphere **D.** square

6 **Contrast** fission and conjugation.

Interpret Graphics

7 **Identify** Copy and complete the table below to identify shapes of bacteria.

Bacterial Shapes	Illustration

Critical Thinking

8 **Describe** how a bacterium's small size could be an advantage or a disadvantage for its survival.

9 **Explain** how bacteria might find food and survive in an environment where few other organisms live.

10 **Analyze** how bacteria that can form endospores would have an advantage over bacteria that cannot form endospores.

Math Skills

Math Practice

11 How many bacteria would there be if fission occurred 4 times with 1,000 bacteria?

Cooking Bacteria!

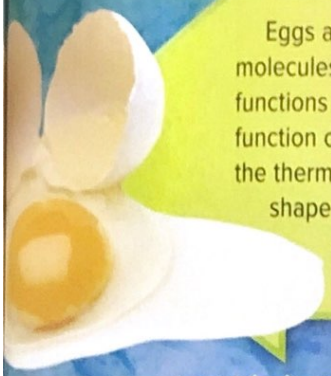
HOW NATURE WORKS

How Your Body Is Like Bleach

When it comes to killing germs, few things work as well as household bleach. How does bleach kill bacteria? Believe it or not, killing bacteria with bleach and boiling an egg involve similar processes.

▼ After cooking, egg proteins become a tangled mass.

Eggs are made mostly of proteins. Proteins are complex molecules in all plant and animal tissues. Proteins have specific functions that are dependent on the protein's shape. A protein's function changes if its shape is changed. When you cook an egg, the thermal energy transferred to the egg causes changes to the shape of the egg's proteins. Think of the firm texture of a cooked egg. When the egg's proteins are heated, they become a tangled mass.



▲ Before cooking, the proteins in eggs remain unfolded and change shape easily.

▼ Bacteria also contain proteins that change shape when exposed to heat.

Like eggs, bacteria also contain proteins. When bacteria are exposed to high temperatures, their proteins change shape, similar to those in a boiled egg. But what is the connection with bleach? Scientists have discovered that an ingredient in bleach, hypochlorite (hi puh KLOR ite), also causes proteins to change shape. The bacterial proteins that are affected by bleach are needed for the bacteria's growth. When the shape of those proteins changes, they no longer function properly, and the bacteria die.

A common ingredient in bleach is also found in your body's immune cells. ▶

Scientists also know now that your body's immune cells produce hypochlorite. Your body protects itself with the same chemical you can use to clean your kitchen!

It's Your Turn

RESEARCH AND REPORT A bacterial infection often causes inflammation, or a response to tissue damage that can include swelling and pain. Research and report on what causes inflammation.