13.1 Prokaryotes

Lesson objectives

- Outline the classification and evolution of prokaryotes.
- Describe the structure of prokaryotes.
- Identify different types of metabolism found in prokaryotes.
- Describe the range of prokaryote habitats.
- Explain how prokaryotes reproduce.
- Identify important relationships between bacteria and humans.

Vocabulary

antibiotic drug drug that kills bacteria and cures bacterial infections and diseases

antibiotic resistance ability to withstand antibiotic drugs that has evolved in some bacteria

Archaea one of two prokaryote domains that includes organisms that live in extreme environments

Bacteria domain of prokaryotes, some of which cause human diseases

biofilm colony of prokaryotes that is stuck to a surface such as a rock or a host's tissue

cyanobacteria Gram-positive blue-green photosynthetic bacteria of the type that added oxygen to Earth's early atmosphere and evolved into chloroplasts of eukaryotic cells

endospore spores that form inside prokaryotic cells when they are under stress, enclosing the DNA and helping it survive conditions that may kill the cell

extremophile any type of Archaea that lives in an extreme environment, such as a very salty, hot, or acidic environment

flagella long, thin protein extensions of the plasma membrane in most prokaryotic cells that help the cells move

genetic transfer method of increasing genetic variation in prokaryotes that involves cells "grabbing" stray pieces of DNA from their environment or exchanging DNA directly with other cells

Gram-negative bacteria type of bacteria that stain red with Gram stain and have a thin cell wall with an outer membrane

Gram-positive bacteria type of bacteria that stain purple with Gram stain and have a thick cell wall without an outer membrane

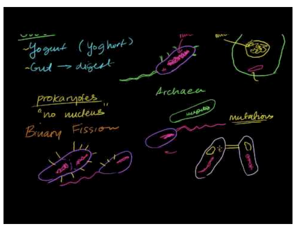
plasmid small, circular piece of DNA in a prokaryotic cell

vector organism such as an insect that spreads pathogens from host to host

Introduction

No doubt you've had a sore throat before, and you've probably eaten cheese or yogurt. If so, then you've encountered the fascinating world of prokaryotes. Prokaryotes are single-celled organisms that lack a nucleus. They also lack other membrane-bound organelles. Prokaryotes are tiny and sometimes bothersome, but they are the most numerous organisms on Earth. Without them, the world would be a very different place.

An overview of bacteria can be seen at http://www.youtube.com/user/khanacademy#p/c/7A9646BC5110CF64/16/TDoGrbpJJ14.



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Evolution and Classification of Prokaryotes

Prokaryotes are currently placed in two domains. A domain is the highest taxon, just above the kingdom. The prokaryote domains are **Bacteria** and **Archaea** (see **Figure** 13.1). The third domain is Eukarya. It includes all eukaryotes. Unlike prokaryotes, eukaryotes have a nucleus in their cells.

Prokaryote Evolution

It's not clear how the three domains are related. Archaea were once thought to be offshoots of Bacteria that were adapted to extreme environments. For their part, Bacteria were considered to be ancestors of Eukarya. Scientists now know that Archaea share several traits with Eukarya that Bacteria do not share (see **Table** 13.1). How can this be explained? One hypothesis is that Eukarya arose when an Archaean cell fused with a Bacterial cell. The two cells became the nucleus and cytoplasm of a new Eukaryan cell. How well does this hypothesis fit the evidence in **Table** 13.1?

TABLE 13.1: **Comparison of Bacteria, Archaea, and Eukarya**

Characteristic	Bacteria	Archaea	Eukarya
Flagella	Unique to Bacteria	Unique to Archaea	Unique to Eukarya
Cell Membrane	Unique to Bacteria	Like Bacteria and Eukarya	Unique to Eukarya
Protein Synthesis	Unique to Bacteria	Like Eukarya	Like Archaea
Introns	Absent in most	Present	Present

TABLE 13.1: (continued)

Characteristic	Bacteria	Archaea	Eukarya
Peptidoglycan (in cell wall)	Present	Absent in most	Absent

Domain Bacteria

Bacteria are the most diverse and abundant group of organisms on Earth. They live in almost all environments. They are found in the ocean, the soil, and the intestines of animals. They are even found in rocks deep below Earth's surface. Any surface that has not been sterilized is likely to be covered with bacteria. The total number of bacteria in the world is amazing. It's estimated to be 5×10^{30}, or five million trillion trillion. You have more bacteria in and on your body than you have body cells!

Bacteria called **cyanobacteria** are very important. They are bluish green in color (see **Figure** 13.2) because they contain chlorophyll. They make food through photosynthesis and release oxygen into the air. These bacteria were probably responsible for adding oxygen to the air on early Earth. This changed the planet's atmosphere. It also changed the direction of evolution. Ancient cyanobacteria also may have evolved into the chloroplasts of plant cells.

Thousands of species of bacteria have been discovered, and many more are thought to exist. The known species can be classified on the basis of various traits. One classification is based on differences in their cell walls and outer membranes. It groups bacteria into **Gram-positive** and **Gram-negative** bacteria, as described in **Figure** 13.3.

Domain Archaea

Scientists still know relatively little about Archaea. This is partly because they are hard to grow in the lab. Many live inside the bodies of animals, including humans. However, none are known for certain to cause disease.

Archaea were first discovered in extreme environments. For example, some were found in hot springs. Others were found around deep sea vents. Such Archaea are called **extremophiles**, or "lovers of extremes." **Figure** 13.4 describes three different types of Archaean extremophiles. The places where some of them live are thought to be similar to the environment on ancient Earth. This suggests that they may have evolved very early in Earth's history.

Archaea are now known to live just about everywhere on Earth. They are particularly numerous in the ocean. Archaea in plankton may be one of the most abundant types of organisms on the planet. Archaea are also thought to play important roles in the carbon and nitrogen cycles. For these reasons, Archaea are now recognized as a major aspect of life on Earth.

Prokaryote Structure

Most prokaryotic cells are much smaller than eukaryotic cells. Although they are tiny, prokaryotic cells can be distinguished by their shapes. The most common shapes are helices, spheres, and rods (see **Figure** 13.5).

Plasma Membrane and Cell Wall

Like other cells, prokaryotic cells have a plasma membrane (see **Figure** 13.6). It controls what enters and leaves the cell. It is also the site of many metabolic reactions. For example, cellular respiration and photosynthesis take place in the plasma membrane.

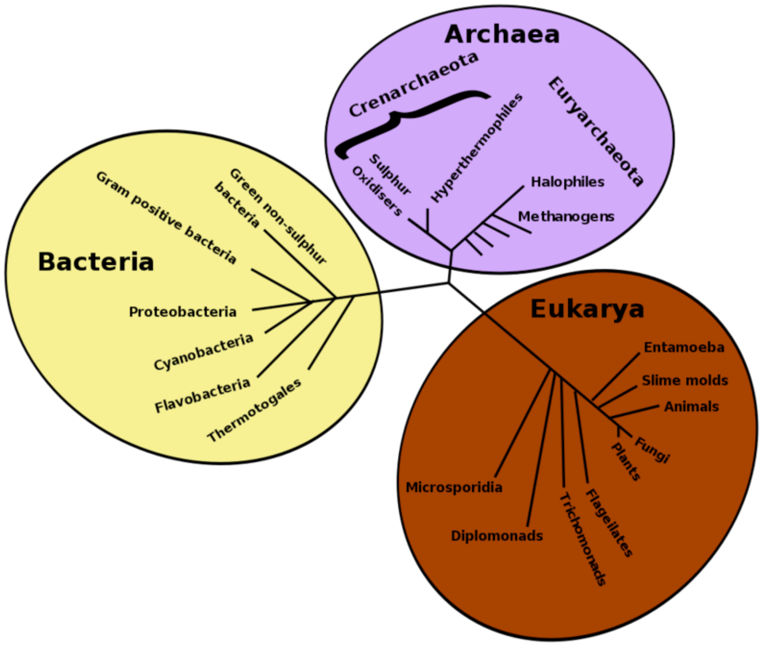


FIGURE 13.1
The Three Domains of Life. All living things are grouped in three domains. The domains Bacteria and Archaea consist of prokaryotes. The Eukarya domain consists of eukaryotes.

FIGURE 13.2
Cyanobacteria Bloom. The green streaks in this lake consist of trillions of cyanobacteria. Excessive nutrients in the water led to overgrowth of the bacteria.

Most prokaryotes also have a cell wall. It lies just outside the plasma membrane. It gives strength and rigidity to the cell. Bacteria and Archaea differ in the makeup of their cell wall. The cell wall of Bacteria contains peptidoglycan (composed of sugars and amino acids). The cell wall of most Archaea lacks peptidoglycan.

Cytoplasm and Cell Structures

Inside the plasma membrane of prokaryotic cells is the cytoplasm. It contains several structures, including ribosomes, a cytoskeleton, and genetic material. Ribosomes are sites where proteins are made. The cytoskeleton helps the cell keeps its shape. The genetic material is usually a single loop of DNA. There may also be small, circular pieces of DNA, called **plasmids**. (see **Figure** 13.7). The cytoplasm may contain microcompartments as well. These are tiny structures enclosed by proteins. They contain enzymes and are involved in metabolic processes.

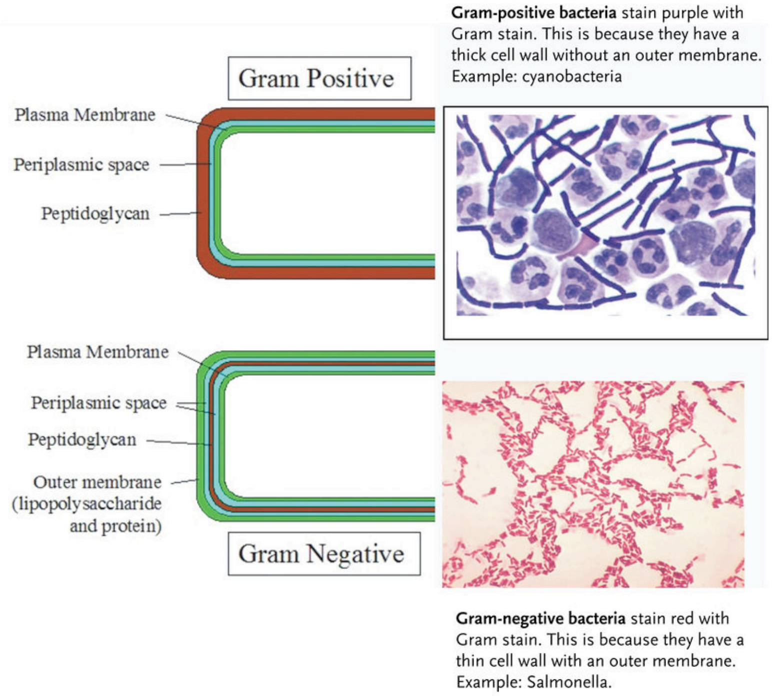


FIGURE 13.3

Classification of Bacteria. Different types of bacteria stain a different color when stained with Gram stain. This makes them easy to identify.

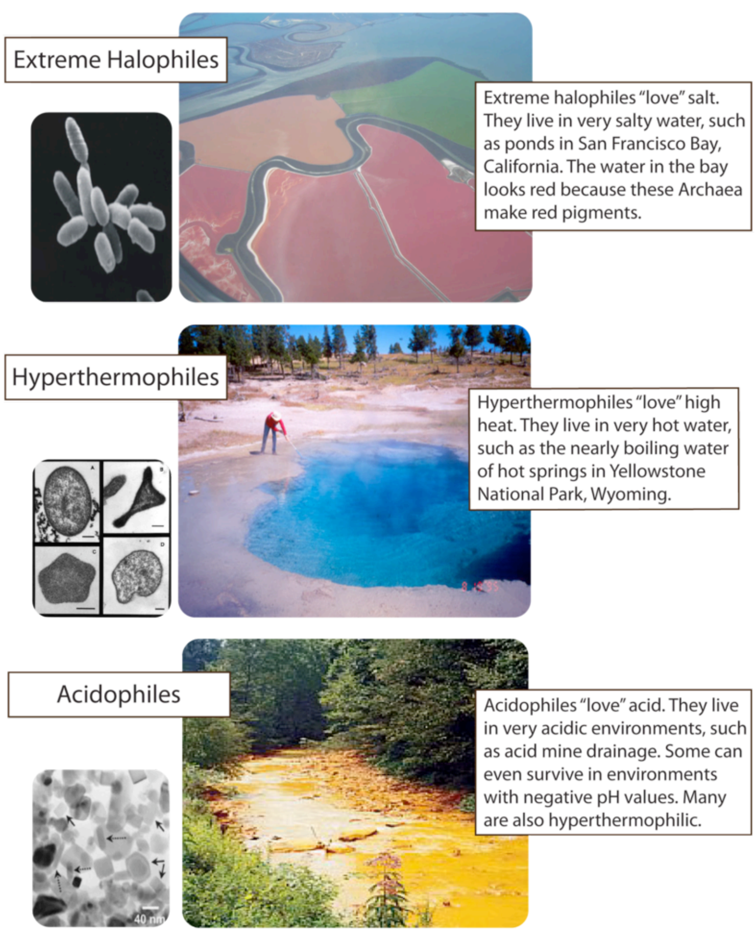


FIGURE 13.4

Extremophile Archaea. Many Archaea are specialized to live in extreme environments. Just three types are described here.

FIGURE 13.5
Prokaryotic Cell Shapes. The three most common prokaryotic cell shapes are shown here.

Extracellular Structures

Many prokaryotes have an extra layer, called a capsule, outside the cell wall. The capsule protects the cell from chemicals and drying out. It also allows the cell to stick to surfaces and to other cells. Because of this, many prokaryotes can form biofilms, like the one shown in **Figure** 13.8. A **biofilm** is a colony of prokaryotes that is stuck to a surface such as a rock or a host's tissues. The sticky plaque that collects on your teeth between brushings is a biofilm. It consists of millions of bacteria.

Most prokaryotes also have long, thin protein structures called **flagella** (singular, flagellum). They extend from the plasma membrane. Flagella help prokaryotes move. They spin around a fixed base, causing the cell to roll and tumble. As shown in **Figure** 13.9, prokaryotes may have one or more flagella.

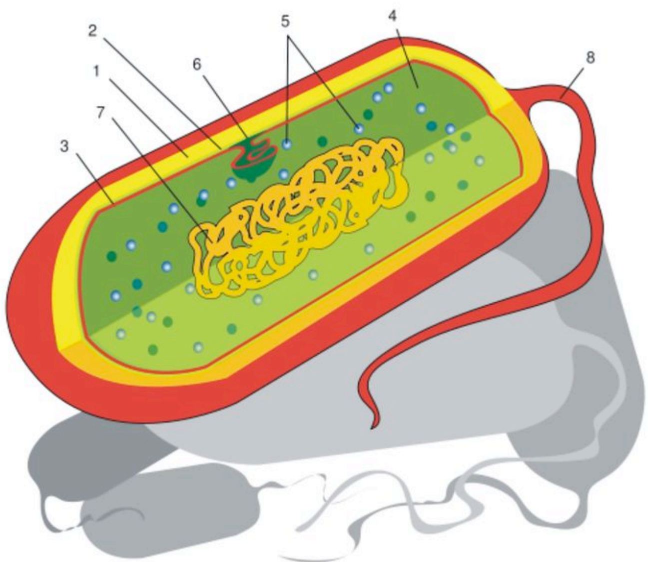


FIGURE 13.6
Prokaryotic Cell. The main parts of a prokaryotic cell are shown in this diagram. The structure called a mesosome was once thought to be an organelle. More evidence has convinced most scientists that it is not a true cell structure at all. Instead, it seems to be an artifact of cell preparation. This is a good example of how scientific knowledge is revised as more evidence becomes available.

Endospores

Many organisms form spores for reproduction. Some prokaryotes form spores for survival. Called **endospores**, they form inside prokaryotic cells when they are under stress (see **Figure** 13.10). The stress could be UV radiation, high temperatures, or harsh chemicals. Endospores enclose the DNA and help it survive under conditions that may kill the cell. Endospores are commonly found in soil and water. They may survive for long periods of time.

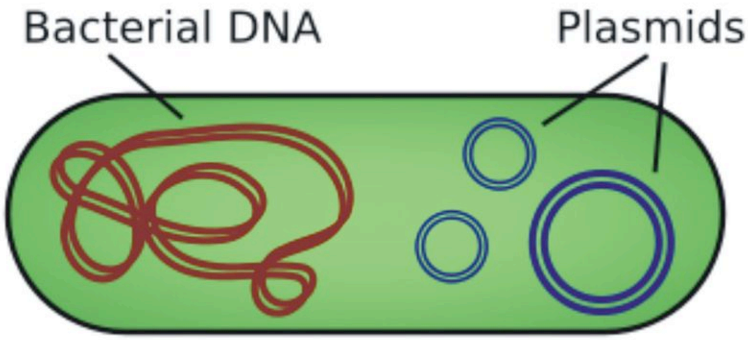


FIGURE 13.7

Prokaryotic DNA. The DNA of a prokaryotic cell is in the cytoplasm because the cell lacks a nucleus.

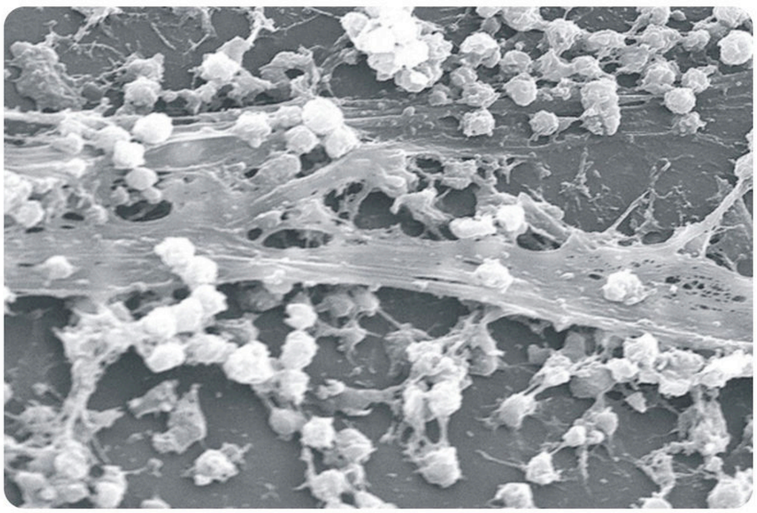


FIGURE 13.8

Bacterial Biofilm. The greatly magnified biofilm shown here was found on a medical catheter (tubing) removed from a patient's body.

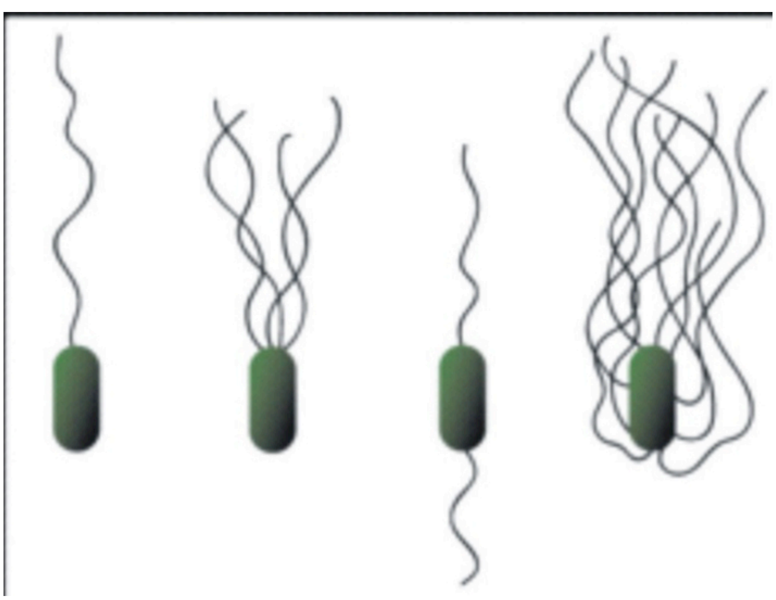


FIGURE 13.9

Variations in the Flagella of Bacteria. Flagella in prokaryotes may be located at one or both ends of the cell or all around it. They help prokaryotes move toward food or away from toxins.

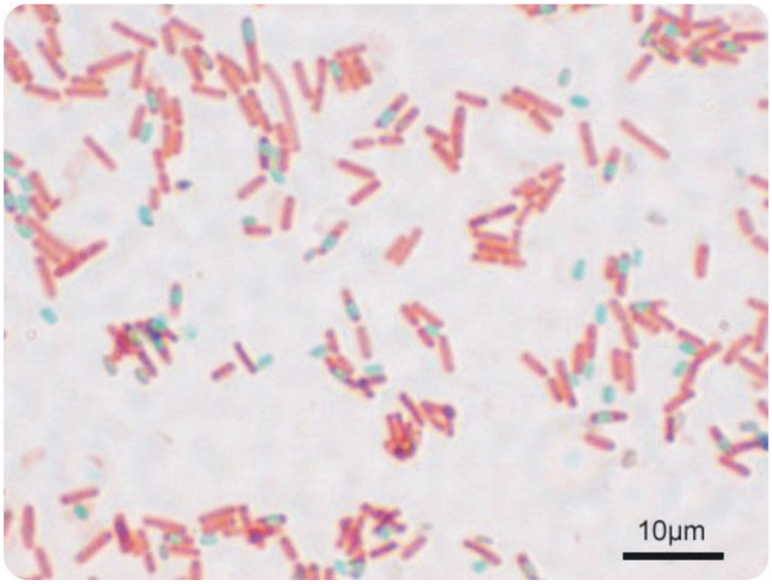


FIGURE 13.10
Prokaryotic Endospores. The red shapes are bacterial cells. The blue-green shapes are endospores.

Prokaryote Metabolism

Like all living things, prokaryotes need energy and carbon. They meet these needs in a variety of ways. In fact, prokaryotes have just about every possible type of metabolism. They may get energy from light (photo) or chemical compounds (chemo). They may get carbon from carbon dioxide (autotroph) or other living things (heterotroph). **Table** 13.2 shows all the possible types of metabolism. Which types of prokaryotes are producers? Which types are consumers?

TABLE 13.2: **Metabolism in Prokaryotes**

Type of Energy	Source of Carbon: carbon dioxide	Source of Carbon: other organisms
Light	Photoautotroph	Photoheterotroph
Chemical Compounds	Chemoautotroph	Chemoheterotroph

Most prokaryotes are chemoheterotrophs. They depend on other organisms for both energy and carbon. Many break down organic wastes and the remains of dead organisms. They play vital roles as decomposers and help recycle carbon and nitrogen. Photoautotrophs are important producers. They are especially important in aquatic ecosystems.

Prokaryote Habitats

Prokaryote habitats can be classified on the basis of oxygen or temperature. These factors are important to most organisms.

- Aerobic prokaryotes need oxygen. They use it for cellular respiration. An example is the bacterium that causes the disease tuberculosis (TB). It infects human lungs.
- Anaerobic prokaryotes do not need oxygen. They use fermentation or other methods of respiration that don't require oxygen. In fact, some cannot tolerate oxygen. An example is a bacterium that infects wounds and kills tissues, causing a condition called gangrene.

Temperature

Reproduction in Prokaryotes

Prokaryote cells grow to a certain size. Then they divide through binary fission. For a discussion of exponential growth and bacteria see http://www.youtube.com/watch?v=-3MI0ZX5WRc (10:43).

Binary Fission

Binary fission is a type of asexual reproduction. It occurs when a parent cell splits into two identical daughter cells. This can result in very rapid population growth. For example, under ideal conditions, bacterial populations can double every 20 minutes. Such rapid population growth is an adaptation to an unstable environment. Can you explain why?

Genetic Transfer

In asexual reproduction, all the offspring are exactly the same. This is the biggest drawback of this type of reproduction. Why? Lack of genetic variation increases the risk of extinction. Without variety, there may be no organisms that can survive a major change in the environment.

Prokaryotes have a different way to increase genetic variation. It's called **genetic transfer**. It can occur in two ways. One way is when cells "grab" stray pieces of DNA from their environment. The other way is when cells directly exchange DNA (usually plasmids) with other cells. Genetic transfer makes bacteria very useful in biotechnology. It can be used to create bacterial cells that carry new genes.

Bacteria and Humans

Bacteria and humans have many important relationships. Bacteria make our lives easier in a number of ways. In fact, we could not survive without them. On the other hand, bacteria can also make us sick.

Benefits of Bacteria

Bacteria provide vital ecosystem services. They are important decomposers. They are also needed for the carbon and nitrogen cycles. There are billions of bacteria inside the human intestines. They help digest food, make vitamins, and play other important roles. Humans also use bacteria in many other ways, including:

- Creating products, such as ethanol and enzymes.
- Making drugs, such as antibiotics and vaccines.
- Making biogas, such as methane.
- Cleaning up oil spills and toxic wastes.
- Killing plant pests.
- Transferring normal genes to human cells in gene therapy.
- Fermenting foods (see **Figure** 13.11).

Bacteria and Disease

You have ten times as many bacteria as human cells in your body. Most of these bacteria are harmless. However, bacteria can also cause disease. Examples of bacterial diseases include tetanus, syphilis, and food poisoning.

FIGURE 13.11
Fermented Foods. Fermentation is a type of respiration that doesn't use oxygen. Fermentation by bacteria is used in brewing and baking. It is also used to make the foods pictured here.

Bacteria may spread directly from one person to another. For example, they can spread through touching, coughing, or sneezing. They may also spread via food, water, or objects.

Another way bacteria and other pathogens can spread is by vectors. A **vector** is an organism that spreads pathogens from host to host. Insects are the most common vectors of human diseases. **Figure** 13.12 shows two examples.

FIGURE 13.12
Bacterial Disease Vectors. Ticks spread bacteria that cause Lyme disease. Deerflies spread bacteria that cause tularemia.

Humans have literally walked into some new bacterial diseases. When people come into contact with wild populations, they may become part of natural cycles of disease transmission. Consider Lyme disease. It's caused by bacteria that normally infect small, wild mammals, such as mice. A tick bites a mouse and picks up the bacteria. The tick may then bite a human who invades the natural habitat. Through the bite, the bacteria are transmitted to the human host.

Controlling Bacteria

Bacteria in food or water usually can be killed by heating it to a high temperature (generally, at least 71°C, or 160°F). Bacteria on many surfaces can be killed with chlorine bleach or other disinfectants. Bacterial infections in people can be treated with **antibiotic drugs**. For example, if you ever had "strep" throat, you were probably treated with an antibiotic.

Antibiotics have saved many lives. However, misuse and over-use of the drugs have led to **antibiotic resistance** in bacteria. **Figure** 13.13 shows how antibiotic resistance evolves. Some strains of bacteria are now resistant to most common antibiotics. These infections are very difficult to treat.

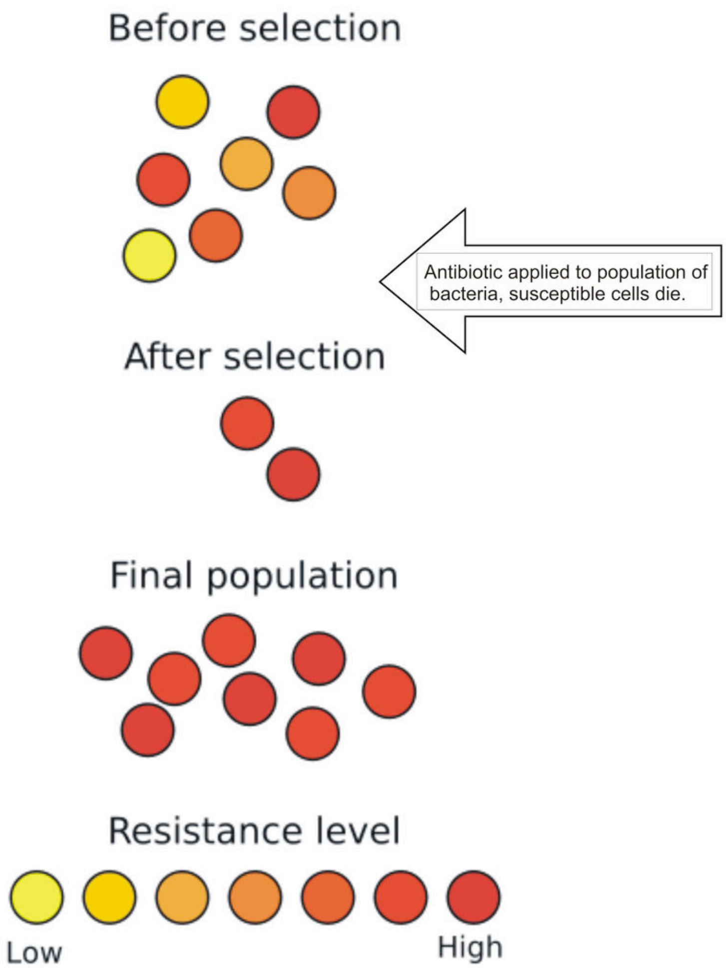


FIGURE 13.13
Evolution of Antibiotic Resistance in Bacteria. This diagram shows how antibiotic resistance evolves by natural selection.

Lesson Summary

- Prokaryotes include Bacteria and Archaea. An individual prokaryote consists of a single cell without a nucleus. Bacteria live in virtually all environments on Earth. Archaea live everywhere on Earth, including extreme environments.
- Most prokaryotic cells are much smaller than eukaryotic cells. They have a cell wall outside their plasma membrane. Prokaryotic DNA consists of a single loop. Some prokaryotes also have small, circular pieces of DNA called plasmids.
- Prokaryotes fulfill their carbon and energy needs in various ways. They may be photoautotrophs, chemoautotrophs, photoheterotrophs, or chemoheterotrophs.
- Aerobic prokaryotes live in habitats with oxygen. Anaerobic prokaryotes live in habitats without oxygen.

Prokaryotes may also be adapted to habitats that are hot, moderate, or cold in temperature.
- Prokaryotic cells grow to a certain size. Then they divide by binary fission. This is a type of asexual reproduction. It produces genetically identical offspring. Genetic transfer increases genetic variation in prokaryotes.
- Bacteria and humans have many important relationships. Bacteria provide humans with a number of services. They also cause human diseases.

Lesson Review Questions

Recall

1. What are prokaryotes?

2. Distinguish between Gram-positive and Gram-negative bacteria, and give an example of each.

3. Summarize the evolutionary significance of cyanobacteria.

4. What are extremophiles? Name three types.

5. Identify the three most common shapes of prokaryotic cells.

6. Describe a typical prokaryotic cell.

7. What are the roles of flagella and endospores in prokaryotes?

8. List several benefits of bacteria.

Apply Concepts

9. Assume that a certain prokaryote is shaped like a ball, lives deep under the water on the ocean floor, and consumes dead organisms. What traits could you use to classify it?

10. Apply lesson concepts to explain why many prokaryotes are adapted for living at the normal internal temperature of the human body.

Think Critically

11. Compare and contrast Archaea and Bacteria.

12. Why might genetic transfer be important for the survival of prokaryote species?

13. Why might genetic transfer make genetic comparisons of prokaryotes difficult to interpret in studies of their evolution?

Points to Consider

In this lesson, you read that some bacteria cause human diseases. Many other human diseases are caused by viruses.

- What are viruses? Do they belong in one of the three domains of life?
- Can you name any diseases that are caused by viruses? Do you know how viruses spread from one person to another?

13.2 Viruses

Lesson Objectives

- Describe the structure of viruses.
- Outline the discovery and origins of viruses.
- Explain how viruses replicate.
- Explain how viruses cause human disease.
- Describe how viruses can be controlled.
- Identify how viruses are used in research and medicine.

Vocabulary

capsid protein coat that surrounds the DNA or RNA of a virus particle

latency period of dormancy of a virus inside a living body that may last for many years

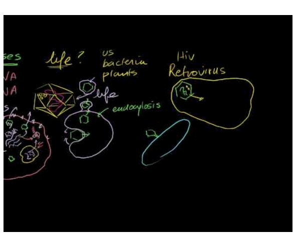
vaccine substance containing modified pathogens that does not cause disease but provokes an immune response and results in immunity to the pathogen

virion individual virus particle that consists of nucleic acid within a protein capsid

Introduction

At the end of the last lesson, you were asked which of the three domains of life do viruses belong to. Did you figure it out? None. Why? Viruses are usually considered to be nonliving. Viruses do not meet most of the criteria of life. They are not even cells.

An overview of viruses can be seen at http://www.youtube.com/user/khanacademy#p/c/7A9646BC5110CF64/17/0h5Jd7sgQWY.



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Characteristics of Viruses

An individual virus is called a **virion.** It is a tiny particle much smaller than a prokaryotic cell. Because viruses do not consist of cells, they also lack cell membranes, cytoplasm, ribosomes, and other cell organelles. Without these structures, they are unable to make proteins or even reproduce on their own. Instead, they must depend on a host cell to synthesize their proteins and to make copies of themselves. Viruses infect and live inside the cells of living organisms. When viruses infect the cells of their host, they may cause disease. For example, viruses cause AIDS, influenza (flu), chicken pox, and the common cold.

Although viruses are not classified as living things, they share two important traits with living things. They have genetic material, and they can evolve. This is why the classification of viruses has been controversial. It calls into question just what it means to be alive. What do you think? How would you classify viruses?

Structure and Classification of Viruses

Viruses vary in their structure. The structure of a virus is one trait that determines how it is classified.

Structure of Viruses

A virus particle consists of DNA or RNA within a protective protein coat called a **capsid.** The shape of the capsid may vary from one type of virus to another, as shown in **Figure** 13.14.

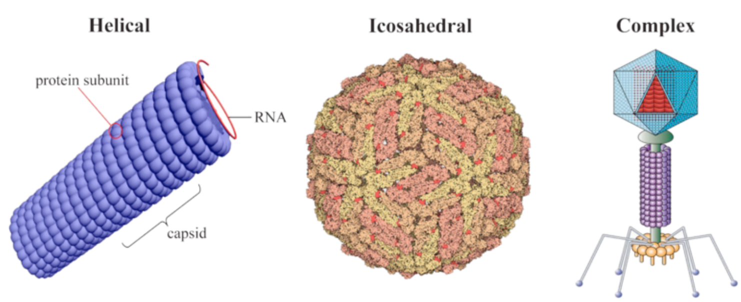

FIGURE 13.14

Capsid Shapes in Viruses. Three shapes of viral capsids are shown here. They are helical (spiral), icosahedral (20-sided), and complex. Viruses with complex shapes may have extra structures such as protein tails.

Some viruses have an envelope of phospholipids and proteins. The envelope is made from portions of the host's cell membrane. It surrounds the capsid and helps protect the virus from the host's immune system. The envelope may also have receptor molecules that can bind with host cells. They make it easier for the virus to infect the cells.

Classification of Viruses

Viruses are classified on the basis of several traits. For example, they may be classified by capsid shape, presence or absence of an envelope, and type of nucleic acid. Most systems of classifying viruses identify at least 20 virus families. **Table** 13.4 shows four examples of virus families and their traits. Have any of these viruses made you sick?

TABLE 13.4: Virus Classification: Four Examples

Virus Family	Capsid Shape	Envelope Present?	Type of Nucleic Acid	Disease Caused by a Virus in this Family
Adenovirus	icosahedral	no	DNA	acute respiratory disease
Herpesviruses	icosahedral	yes	DNA	chicken pox
Orthomyxoviruses	helical	yes	RNA	influenza
Coronaviruses	complex	yes	RNA	common cold

Discovery and Origin of Viruses

Viruses are so small that they can be seen only with an electron microscope. Before electron microscopes were invented, scientists knew viruses must exist. How did they know? They had demonstrated that particles smaller than bacteria cause disease.

Discovery of Viruses

Researchers used special filters to remove bacteria from tissues that were infected. If bacteria were causing the infection, the filtered tissues should no longer be able to make other organisms sick. However, the filtered tissues remained infective. This meant that something even smaller than bacteria was causing the infection.

Scientists did not actually see viruses for the first time until the 1930s. That's when the electron microscope was invented. The virus shown in **Figure** 13.15 was the first one to be seen.

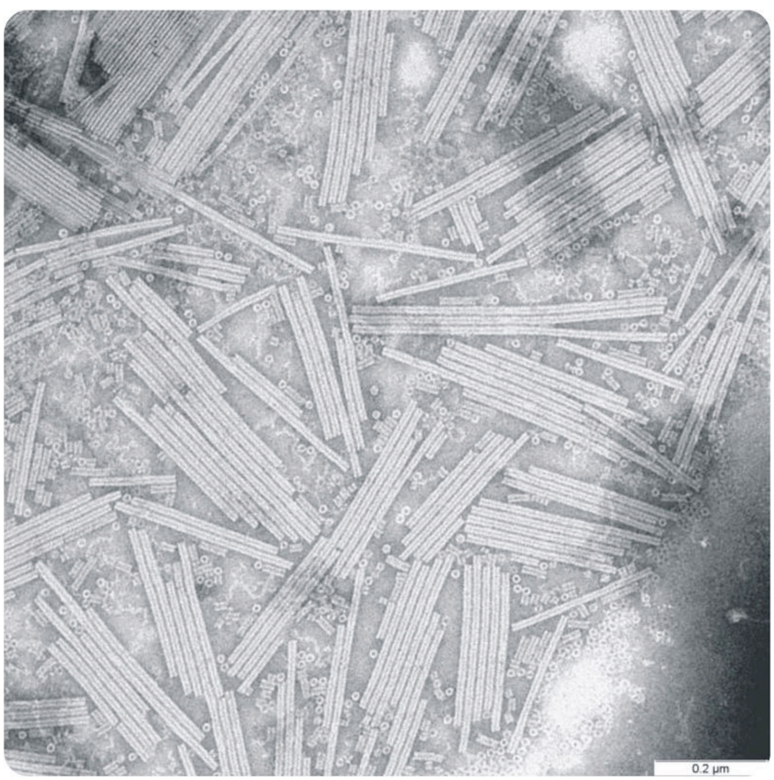

FIGURE 13.15

Tobacco Mosaic Virus. This tobacco mosaic virus was the first virus to be discovered. It was first seen with an electron microscope in 1935.

Origin of Viruses

Where did viruses come from? How did the first viruses arise? The answers to these questions are not known for certain. Several hypotheses have been proposed. The two main hypotheses are stated below. Both may be valid and explain the origin of different viruses.

- Small viruses started as runaway pieces of nucleic acid that originally came from living cells such as bacteria.
- Large viruses were once parasitic cells inside bigger host cells. Over time, genes needed to survive and reproduce outside host cells were lost.

Replication of Viruses

Populations of viruses do not grow through cell division because they are not cells. Instead, they use the machinery and metabolism of a host cell to produce new copies of themselves. After infecting a host cell, a virion uses the cell's ribosomes, enzymes, ATP, and other components to replicate. Viruses vary in how they do this. For example:

- Some RNA viruses are translated directly into viral proteins in ribosomes of the host cell. The host ribosomes treat the viral RNA as though it were the host's own mRNA.
- Some DNA viruses are first transcribed in the host cell into viral mRNA. Then the viral mRNA is translated by host cell ribosomes into viral proteins.

In either case, the newly made viral proteins assemble to form new virions. The virions may then direct the production of an enzyme that breaks down the host cell wall. This allows the virions to burst out of the cell. The host cell is destroyed in the process. The newly released virus particles are free to infect other cells of the host.

Viruses and Human Disease

Viruses cause many human diseases. In addition to the diseases mentioned above, viruses cause rabies, measles, diarrheal diseases, hepatitis, polio, and cold sores (see **Figure** 13.16). Viral diseases range from mild to fatal. One way viruses cause disease is by causing host cells to burst open and die. Viruses may also cause disease without killing host cells. They may cause illness by disrupting homeostasis in host cells.

Some viruses live in a dormant state inside the body. This is called **latency**. For example, the virus that causes chicken pox may infect a young child and cause the short-term disease chicken pox. Then the virus may remain latent in nerve cells within the body for decades. The virus may re-emerge later in life as the disease called shingles. In shingles, the virus causes painful skin rashes with blisters (see **Figure** 13.17).

Some viruses can cause cancer. For example, human papillomavirus (HPV) causes cancer of the cervix in females. Hepatitis B virus causes cancer of the liver. A viral cancer is likely to develop only after a person has been infected with a virus for many years.

Control of Viruses

Viral diseases can be difficult to treat. They live inside the cells of their host, so it is hard to destroy them without killing host cells. Antibiotics also have no effect on viruses. Antiviral drugs are available, but only for a limited number of viruses.

FIGURE 13.16
Cold Sore. Cold sores are caused by a herpes virus.

FIGURE 13.17
Shingles. Shingles is a disease caused by the same virus that causes chicken pox.

Many viral diseases can be prevented by giving people vaccines (see **Figure** 13.18). A **vaccine** is a substance that contains pathogens such as viruses. The pathogens have been changed in some way so they no longer cause disease. However, they can still provoke a response from the host's immune system. This results in immunity, or the ability to resist the pathogen. Vaccines have been produced for the viruses that cause measles, chicken pox, mumps, polio, and several other diseases.

Viruses in Research and Medicine

Viruses are important tools in scientific research and medicine. Viral research has increased our understanding of fundamental biological processes involving DNA, RNA, and proteins. Viruses that infect cancer cells are being studied for their use in cancer treatment. Viruses are also being used in gene therapy to treat genetic disorders, as

FIGURE 13.18
Vaccination. A child receives a vaccine to prevent a viral disease. How does the vaccine prevent the disease?

explained in **Figure** 13.19.

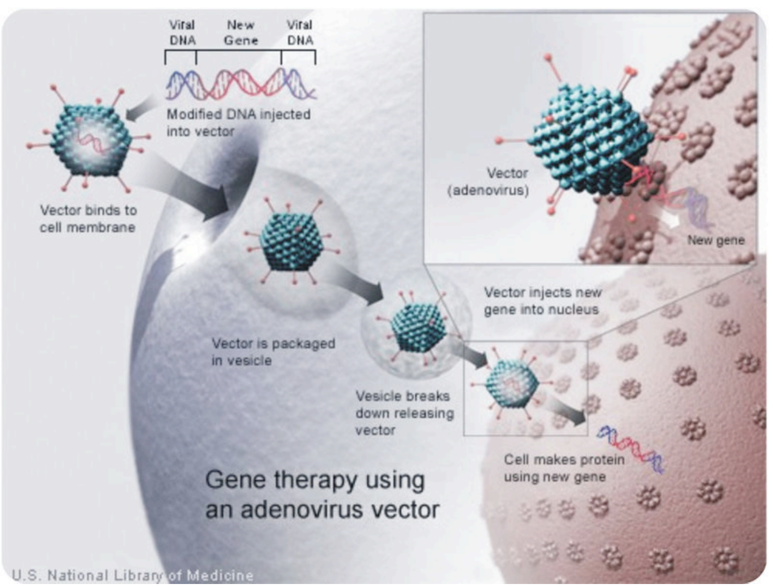

FIGURE 13.19
Using a Virus in Gene Therapy. A normal human gene is inserted into a virus. The virus carries the gene into a human host cell. The gene enters the nucleus and becomes part of the DNA. The normal gene can then be used to make normal proteins. It can also be copied and passed to daughter cells in the host.

Lesson Summary

- Viruses are tiny particles, smaller than prokaryotic cells. They are not cells and cannot replicate without help, but they have nucleic acids and can evolve.
- Viruses can be classified on the basis of capsid shape, presence or absence of an envelope, and type of nucleic acid.

- Viruses were assumed to exist before they were first seen with an electron microscope in the 1930s. Multiple hypotheses for viral origins have been proposed.
- After infecting a host cell, a virus uses the cell's machinery and metabolism to produce new copies of itself.
- Viruses cause many human diseases by killing host cells or disturbing their homeostasis. Viruses are not affected by antibiotics. Several viral diseases can be treated with antiviral drugs or prevented with vaccines.
- Viruses are useful tools in scientific research and medicine. Viruses help us understand molecular biology. They are also used in gene therapy.

Lesson Review Questions

Recall

1. How do viruses differ from living things? How are they similar to living things?

2. Describe variation in capsid shape in viruses.

3. State two hypotheses for the origin of viruses.

4. Describe how viruses replicate.

5. How do viruses cause human disease?

Apply Concepts

6. Apply lesson concepts to decide how strep throat and flu can be treated or prevented. Create a chart to summarize your ideas.

7. Viruses often infect bacteria. Some of them destroy the bacterial cells they infect. How could this information be applied to finding a cure for bacterial infections?

Think Critically

8. Why did scientists think viruses must exist even before they ever saw them with an electron microscope?

9. Why are viruses especially useful tools for understanding molecular biology? What might scientists learn by studying how viruses invade and use host cells?

Points to Consider

In this chapter, you read about two of the three domains of life: Bacteria and Archaea. The next chapter introduces the simplest, smallest members of the third domain, the Eukarya.

- Some Eukarya are single-celled organisms. What do you think they are?
- How might single-celled eukaryotes differ from single-celled prokaryotes? How might they be the same?

13.3 References

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2. Jesse Allen/NASA. . Public Domain
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