

● Before You Read

When you hear the word *bacteria*, what comes to mind? On the lines below, describe places you think bacteria might live. Then read the section to learn about some surprising places where bacteria thrive.

● Read to Learn

Diversity of Prokaryotes

Scientists think the first organisms on Earth were small, unicellular organisms called prokaryotes (proh KE ree ohts). Today, prokaryotes are the most numerous organisms on Earth. Prokaryotic cells do not have organelles or a nucleus. Instead, their DNA is found in a region of the cell. Prokaryotes are grouped into two domains—Bacteria and Archaea.

Where are bacteria found?

Bacteria live almost everywhere except in the most extreme environments. They have strong cell walls which contain peptidoglycan.

Where do archaea live?

Archaea live in extreme environments. One type lives in hot, acidic environments such as sulfur hot springs, thermal vents on the ocean floor, and around volcanoes. A second type lives in salty environments such as the Dead Sea. This type photosynthesizes using a substance other than chlorophyll. A third type cannot live in an environment that has oxygen. They use carbon dioxide during respiration and give off methane gas as waste. They live in swamps and in human intestines. They make the gases that are released from the lower digestive tract.

MAIN Idea

Bacteria are prokaryotic cells.

What You'll Learn

- how archaea differ from bacteria
- how prokaryotes can survive environmental challenges
- ways that bacteria benefit humans

Study Coach

Make an Outline Make an outline of the information you learn in this section. Start with the headings. Include the boldface terms.



Think it Over

1. **Apply** Prokaryotes that live in the Great Salt Lake belong to which domain? (Circle your answer.)
 - a. Bacteria
 - b. Archaea

Picture This

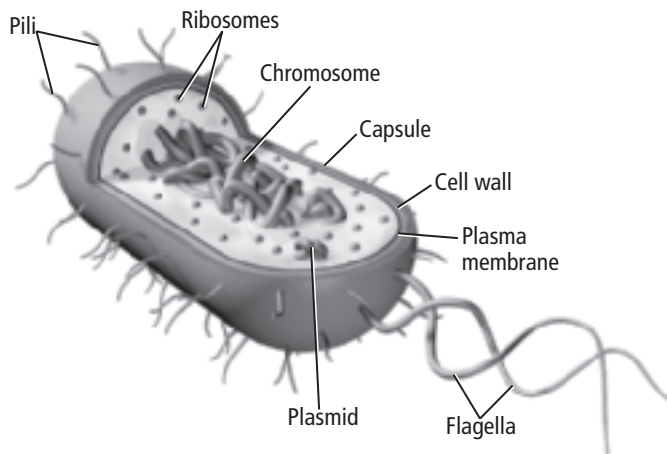
2. **Highlight** each structure in the figure as you read about it.

How do bacteria and archaea differ?

The cell walls of bacteria contain peptidoglycan. The cell walls of archaea do not contain peptidoglycan. Also, the two groups of organisms have different lipids, ribosomal proteins, and RNA. They are as different from each other as they are from eukaryotes.

Prokaryote Structure

A prokaryotic cell shares some characteristics with all cells such as DNA and ribosomes. Prokaryotic cells do not have membrane-bound organelles such as mitochondria and chloroplasts. The figure below shows the structure of a prokaryotic cell.



How are the chromosomes arranged?

The genes of a prokaryotic cell are on a circular chromosome in an area of the cell called the **nucleoid**. Many prokaryotes also have at least one smaller, circular piece of DNA. It is called a plasmid.

What are the functions of the capsule?

Some prokaryotic cells form a **capsule** by secreting a layer of polysaccharides around the cell wall. The capsule keeps the cell from drying out and helps it attach to surfaces. It also protects the cell from white blood cells and antibiotics.

How do pili help a prokaryotic cell?

Some prokaryotes have pili on their outer surface. **Pili** (singular, pilus) are hairlike structures that are made of protein. Pili help a prokaryotic cell attach to a surface. Pili can also serve as a bridge between prokaryotes. Copies of plasmids can cross the bridge, providing new genetic characteristics. Resistance to antibiotics can be transferred this way.

Reading Check

3. **Explain** how pili are helpful during reproduction.

How do prokaryotes benefit from their size?

Prokaryotes are small, even when viewed with a microscope. Small cells have a larger surface-area-to-volume ratio than larger cells. As a result, nutrients and other important substances can diffuse to all parts of the cell easily.

Identifying Prokaryotes

Scientists can identify prokaryotes by their shape, cell walls, and movement.

What shapes do prokaryotes display?

There are three main shapes of prokaryotes. Those shaped like spheres are called cocci (KAHK ki) (singular, coccus). Bacilli (buh SIH li) (singular, bacillus) are rod shaped. Spiral-shaped spirilli (spi RIH li) (singular, spirillum) are called spirochetes (SPI ruh keets).

Why is the Gram stain test important?

All bacteria have peptidoglycan in their cell walls. Biologists add dyes to the bacteria cells to identify the two major types of bacteria—those with and those without an outer layer of lipid. The dye technique is called a Gram stain. Bacteria without a lipid layer have a lot of peptidoglycan and appear dark purple. They are called gram positive. Bacteria with a lipid layer have less peptidoglycan and appear light pink. They are called gram negative. Some antibiotics attack the cell walls of bacteria. The Gram stain identifies the type of cell wall so doctors can prescribe the right antibiotic.

How do prokaryotes move?

Some prokaryotes do not move. Others use a flagellum (plural, flagella) to move toward light, oxygen, or sources of nutrients. Others glide over a layer of secreted slime.

Reproduction of Prokaryotes

Prokaryotes reproduce either by binary fission or by conjugation. The figure on the next page shows both.

What is binary fission?

Binary fission is the division of a cell into two cells with identical genes. In binary fission, the prokaryote's chromosome replicates. The cell gets longer as the chromosome copies separate. A new plasma membrane and cell wall form, separating the cell into two identical cells.

Reading Check

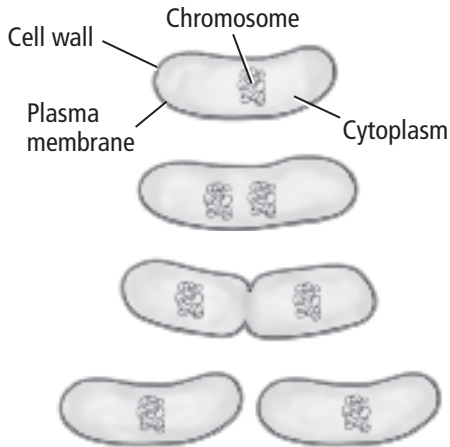
4. Describe the three shapes of prokaryotes.

Reading Check

5. Apply Why do doctors use Gram stains?

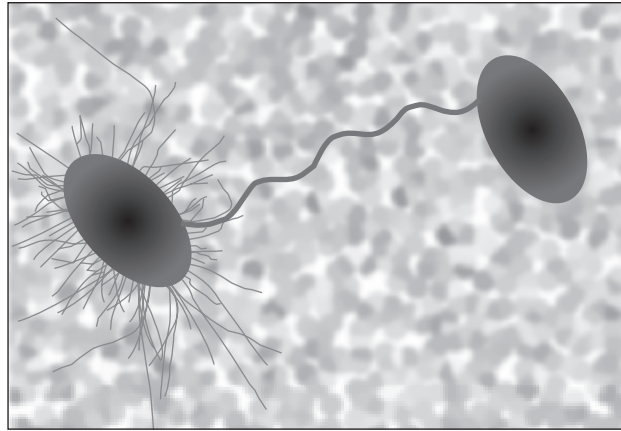
Picture This

6. Label Write the labels *genetic information exchanged* and *identical cells formed* next to the appropriate reproduction diagram in the figure.



How do prokaryotes reproduce by conjugation?

In **conjugation**, two prokaryotes attach to each other and exchange genetic material. As shown in the figure below, the two cells attach using their pili. The transfer of genetic material from one cell to the other creates new gene combinations. This increases the diversity of prokaryotes.



Metabolism of Prokaryotes

Obligate aerobes are bacteria that need oxygen to live. Obligate anaerobes cannot live in the presence of oxygen. They obtain energy by fermentation. Facultative anaerobes can live with or without oxygen. Besides how they use oxygen, prokaryotes are classified by how they obtain energy.

How do heterotrophs obtain energy?

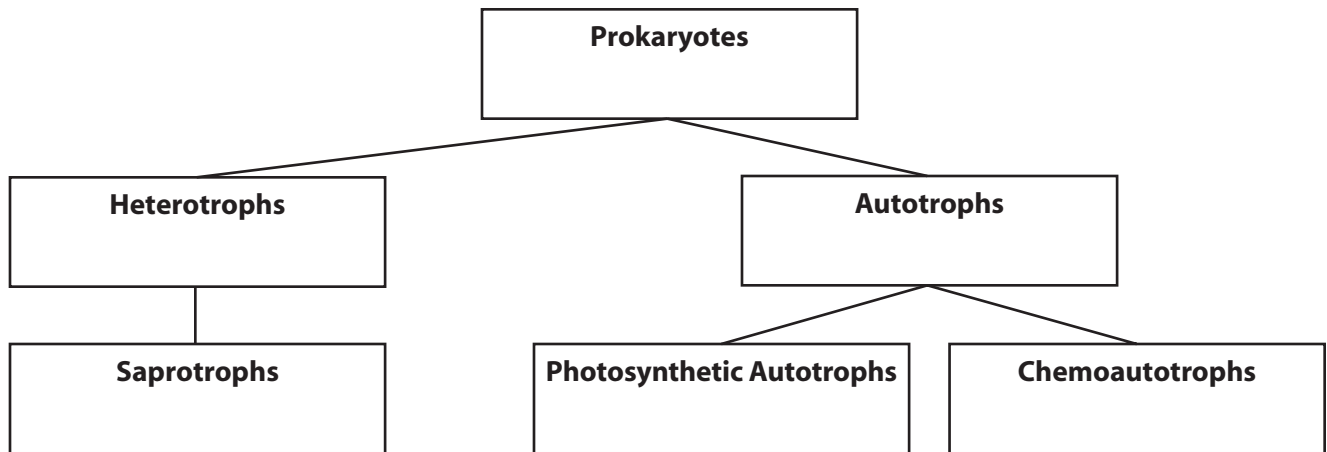
Heterotrophs cannot make their own food. They need to take in nutrients. As shown in the figure on the next page, many heterotrophic bacteria are saprotrophs. They obtain nutrients by decomposing organic materials associated with dead organisms or organic waste.

In what ways are photoautotrophs like plants?

Autotrophs (AW tuh trohfs) can make their own food. Photoautotrophs, or cyanobacteria, carry out photosynthesis. Like plants, these bacteria live in areas where there is light, such as shallow ponds and streams, in order to make organic molecules to use as food. Also like plants, they are at the base of some food chains and they release oxygen into the environment

Reading Check

7. Compare What is the main difference between heterotrophs and autotrophs?



Scientists once thought that these organisms were eukaryotes and called them blue-green algae. Later discoveries showed that they were prokaryotes. Scientists call these organisms cyanobacteria. Cyanobacteria might have been the first organisms to release oxygen into Earth's early atmosphere.

What do chemoautotrophs use to make food?

Chemoautotrophs do not need light. They use the process of chemosynthesis to break down and release inorganic materials that contain nitrogen or sulfur. They help cycle nitrogen and other inorganic materials through ecosystems.

Survival of Bacteria

Bacteria have several ways that they can survive if their environment becomes unfavorable.

When environmental conditions are harsh, some types of bacteria produce a structure called an **endospore**. A spore coat surrounds a copy of the bacterial cell's chromosome and a small part of the cytoplasm. The bacterial cell dies, but the endospore can survive for long periods. An endospore might be able to survive conditions that would kill a bacterium such as extreme heat, cold, or dehydration. When conditions improve, the endospore grows into a new bacterial cell.

How do mutations benefit bacteria?

Mutations are changes or random errors in a DNA sequence. They lead to new genes, new gene combinations, new characteristics, and genetic diversity. Because bacteria reproduce quickly, gene mutations occur quickly. If the environment changes, some bacteria might have the right combination of genes that will enable them to survive and repopulate.

Picture This

8. Label each type of heterotroph and autotroph in the figure with the way it obtains nutrients.

Think it Over

9. Draw Conclusions

What might happen if bacteria did not mutate and the environment changed?

Reading Check

10. Describe how nitrogen fixation benefits plants.


Picture This

11. Explain Suppose a friend showed you this table and said, "See, bacteria are bad." How would you respond?

Ecology of Bacteria

Bacteria are decomposers. They get energy from dead organisms and return nutrients to the environment. Most bacteria do not cause disease. In fact, many benefit humans.

How do bacteria benefit plants?

All organisms use nitrogen to make proteins, DNA, and RNA. Most of Earth's nitrogen is gas in the atmosphere. Some bacteria can use nitrogen gas directly. In a process called **nitrogen fixation**, these bacteria convert nitrogen gas into nitrogen compounds that plants can use. Some of these bacteria live in soil. Others live in root nodules of plants. Nitrogen is passed on to organisms that eat the plants. 

Why are bacteria important to humans?

Your body is covered with harmless bacteria called normal flora. Normal flora help prevent harmful bacteria from infecting your body and causing disease.

Some *Escherichia coli* (*E. coli*) bacteria can cause food poisoning. Other *E. coli* bacteria live symbiotically in the digestive tracts of humans and other mammals. These *E. coli* make vitamin K, which humans use for blood clotting. In exchange, the *E. coli* get a warm place with food to live.

Bacteria are used to make many foods such as cheese, yogurt, and pickles. Bacteria break down the covering of cocoa beans during the production of chocolate. Some vitamin pills are made with the help of bacteria. Several common antibiotics were originally made by bacteria.

How do bacteria cause disease?

The small percentage of bacteria that cause disease do so in two ways. Some bacteria multiply at an infection site and can spread to other parts of the body. Other bacteria secrete a toxin or other substances such as the acid that causes tooth decay. The table below lists some diseases caused by bacteria.

Category	Human Diseases
Sexually transmitted diseases	syphilis, gonorrhea, chlamydia
Respiratory diseases	strep throat, pneumonia, whooping cough, anthrax
Skin diseases	acne, boils, infections of wounds or burns
Digestive tract diseases	gastroenteritis, many types of food poisoning, cholera
Nervous system diseases	botulism, tetanus, bacterial meningitis