Bacteria

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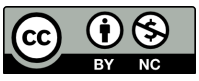

CHAPTER 1 Bacteria

Lesson Objectives

- Describe the cellular features of bacteria.
- Explain the ways in which bacteria can obtain energy.
- Explain how bacteria reproduce themselves.
- Identify some ways in which bacteria can be helpful.
- Identify some ways in which bacteria can be harmful.

Check Your Understanding

- How do prokaryotic and eukaryotic cells differ?
- What are some components of all cells, including bacteria?

Vocabulary

- bacilli
- chemotroph
- cocci
- conjugation
- cyanobacteria
- decomposer
- flagella
- nucleoid
- peptidoglycan
- spirilli
- transduction

Characteristics of Bacteria

Even though life is much more diverse on Earth today, bacteria (singular, bacterium) are still the most abundant organisms on Earth. Recall that prokaryotes are single-celled organisms that lack a nucleus, and that the prokaryotes include bacteria and archaea.

Size and Shape

Bacteria are so small that they can only be seen with a microscope. When viewed under the microscope, they have three distinct shapes (**Figure** 1.1). Bacteria can be classified by their shape:

1. **Bacilli** are rod-shaped.
2. **Cocci** are sphere-shaped.
3. **Spirilli** are spiral-shaped.

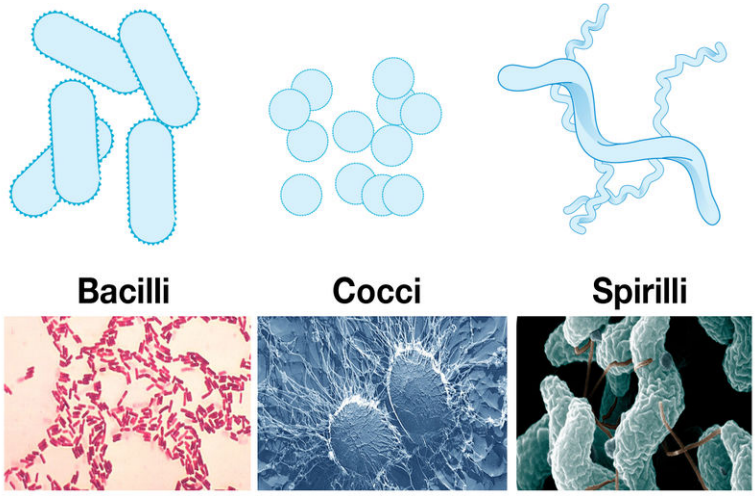

FIGURE 1.1

Bacteria come in many different shapes. Some of the most common shapes are bacilli (rods), cocci (spheres), and spirilli (spirals). Bacteria can be identified and classified by their shape. Bottom left: Escherichia coli is an example of bacteria that are rod-shaped, or bacilli. Bottom center: Staphylococcus aureus is an example of bacteria that are sphere-shaped, or cocci. Bottom right: Campylobacter is an example of bacteria that are spiral, or spirula.

The Cell Wall

Bacteria are surrounded by a cell wall consisting of **peptidoglycan**, a complex molecule consisting of sugars and amino acids. The cell wall is important for protecting bacteria. The cell wall is so important that some antibiotics, such as penicillin, kill bacteria by preventing the cell wall from forming.

Another type of bacteria, called parasitic bacteria, depends on a host organism for energy and nutrients. If the host starts attacking the bacteria, the bacteria release a layer of slime that surrounds the cell wall for an extra layer of protection.

Differences between Eukaryotes and Prokaryotes

Recall that all prokaryotes, including bacteria, lack many of the things that eukaryotes contain, such as membrane-bound organelles (like mitochondria or chloroplasts) or a nucleus (**Figure** 1.2).

Similarities to Eukaryotes

Like eukaryotic cells, prokaryotic cells do have:

1. Cytoplasm, the fluid inside the cell.
2. A plasma membrane, which acts as another barrier.
3. Ribosomes, where proteins are assembled.
4. DNA, contained in a large circular strand, forming a single chromosome, that is compacted into a structure called the **nucleoid**. Many bacteria also have additional small rings of DNA known as **plasmids**.

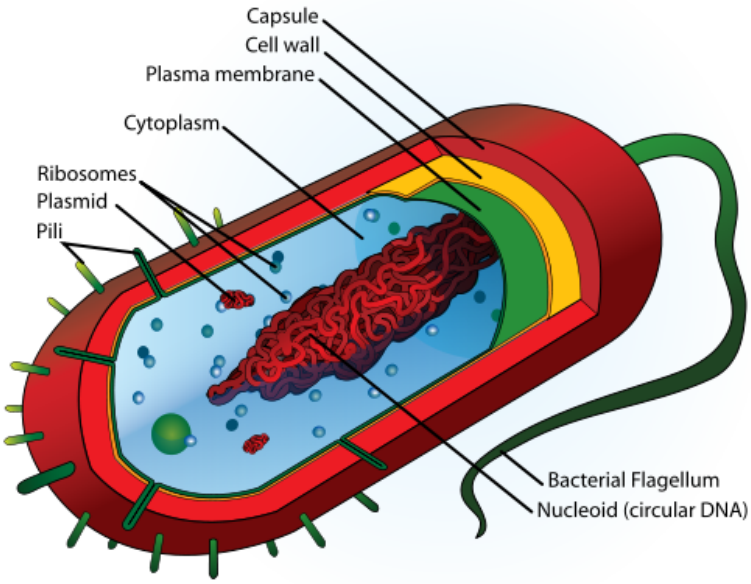

FIGURE 1.2

The structure of a bacterial cell is distinctive from a eukaryotic cell because of features such as an outer cell wall and the circular DNA of the nucleoid, and the lack of membrane-bound organelles.

Flagella

Some bacteria also have tail-like structures called **flagella** (**Figure** 1.3). Flagella help bacteria move. As the flagella rotate, they spin the bacteria and propel them forward.

FIGURE 1.3

The flagella facilitate movement in bacteria. Bacteria may have one, two, or many flagella - or none at all.

Obtaining Food and Energy

Bacteria obtain energy and nutrients in a variety of different ways:

- Bacteria known as decomposers break down wastes and dead organisms into smaller molecules to get the

energy they need to survive.

- Photosynthetic bacteria use the energy of the sun, together with carbon dioxide, to make their own food. Briefly, in the presence of sunlight, carbon dioxide and water is turned into glucose and oxygen. The glucose is then turned into usable energy. Glucose is like the "food" of the bacteria. An example of photosynthetic bacteria is **cyanobacteria**, as seen in **Figure** 1.4.

FIGURE 1.4

Cyanobacteria are photosynthetic bacteria. These bacteria carry out all the reactions of photosynthesis within the cell membrane and in the cytoplasm; they do not need chloroplasts.

- Bacteria can also be chemotrophs. **Chemotrophs** obtain energy by breaking down chemical compounds in their environment, such as nitrogen-containing ammonia. They do not use the energy from the sun. Nitrogen cannot be made by living organisms, so it must be continually recycled. The bacteria help cycle the nitrogen through the environment for other living things to use. Organisms need nitrogen to make organic compounds, such as DNA.
- Some bacteria depend on other organisms for survival. For example, mutualistic bacteria live in nutrient-rich part of the roots of legumes, such as pea plants. The bacteria turn nitrogen-containing molecules into nitrogen that the plant can use. In this relationship, both the bacteria and the plant benefit.
- Other bacteria are parasitic and can cause illness. In a parasitic relationship, the bacteria benefit and the other organism is harmed. Harmful bacteria will be discussed later in the lesson.

Reproduction in Bacteria

Bacteria reproduce through a process called binary fission. During binary fission, the chromosome copies itself, forming two genetically identical copies. Then, the cell enlarges and divides into two new daughter cells. The two daughter cells are identical to the parent cell (**Figure** 1.5). Binary fission can happen very rapidly. Some species of bacteria can double their population in less than ten minutes (**Figure** 1.6)!

Sexual reproduction does not occur in bacteria. But not all new bacteria are clones. This is because bacteria can still combine and exchange DNA. This exchange occurs in three different ways:

1. **Conjugation**: In conjugation, DNA passes through an extension on the surface of one bacterium and travels to another bacterium.
2. Transformation: In transformation, bacteria pick up pieces of DNA from their environment.
3. **Transduction**: In transduction, viruses that infect bacteria carry DNA from one bacterium to another.

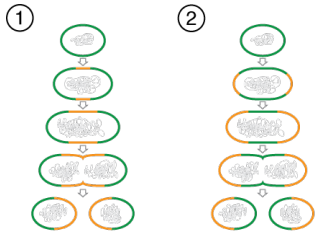

FIGURE 1.5

Bacteria cells reproduce by binary fission, resulting in two daughter cells identical to the parent cell.

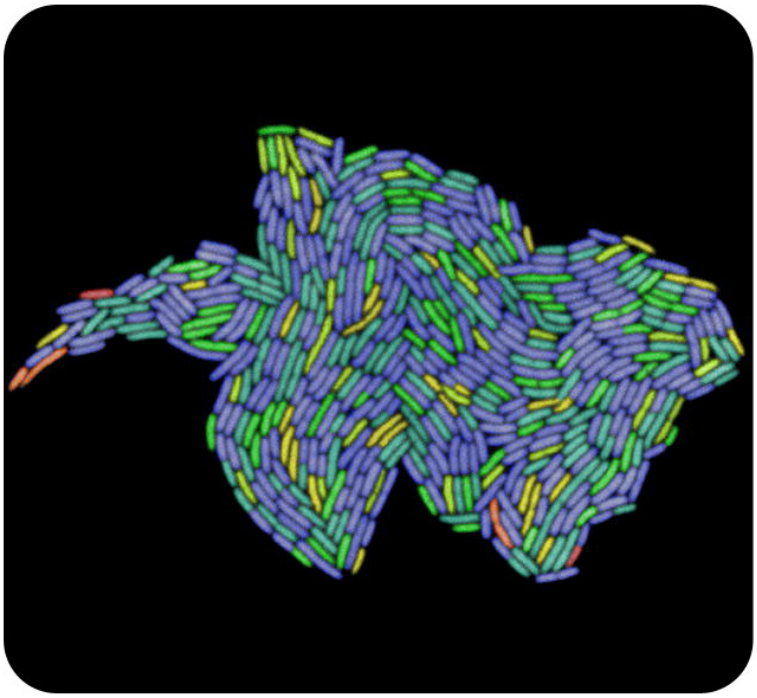

FIGURE 1.6

Bacteria can divide rapidly. This image is of a growing colony of E. coli bacteria. In the right environment the growth and division of two *E. coli* can form a colony of hundreds of bacteria in just a few hours.

Helpful Bacteria

Bacteria are helpful to humans and to other living things because they can:

1. Recycle essential nutrients in the soil.
2. Aid in animal digestion.
3. Produce food for consumption.
4. Produce chemicals used in medicines.

Decomposers

Bacteria are important because many bacteria are decomposers. They break down dead materials and waste products and recycle nutrients back into the environment. This recycling of nutrients, such as nitrogen, is essential for living organisms. Organisms cannot produce nutrients, so they must come from other sources.

We get nutrients from the food we eat; plants get them from the soil. How do these nutrients get into the soil? One

way is from the actions of decomposers. Without decomposers, we would eventually run out of the materials we need to survive. We also depend on bacteria to decompose our wastes in sewage treatment plants.

Digestion

Bacteria also help you digest your food. Several species of bacteria, such as *E. coli*, are found in your digestive tract. In fact, bacteria cells outnumber your own cells in your gut!

Food Production

Bacteria are involved in producing some foods. Yogurt is made by using bacteria to ferment milk. Cheese can also be made from milk with the help of bacteria (**Figure** 1.7). Fermenting cabbage with bacteria produces sauerkraut.

FIGURE 1.7

Yogurt is made from milk fermented with bacteria. The bacteria ingest natural milk sugars and release lactic acid as a waste product, which causes proteins in the milk to form into a solid mass, which becomes the yogurt.

Medicines

In the laboratory, bacteria can be changed to provide us with a variety of useful materials. Bacteria can be used as tiny factories to produce desired chemicals and medicines. For example, insulin, which is necessary to treat people with diabetes, can be produced using bacteria.

Through the process of transformation, the human gene for insulin is placed into bacteria. The bacteria then use that gene to make a protein. The protein can be separated from the bacteria, and then used to treat patients. The mass production of insulin by bacteria made this medicine much more affordable.

Harmful Bacteria

There are also ways that bacteria can be harmful to humans and other animals.

Diseases

Bacteria are responsible for many types of human illness, including:

- Strep throat.
- Tuberculosis.
- Pneumonia.
- Leprosy.
- Lyme disease.

The Black Death, which killed at least one third of Europe's population in the 1300s, is believed to have been caused by the bacterium *Yersinia pestis*.

Food Contamination

Bacterial contamination can also lead to outbreaks of food poisoning. Raw eggs and undercooked meats can contain bacteria that can cause digestive problems. Foodborne infection can be prevented by cooking meat thoroughly and washing surfaces that have been in contact with raw meat. Washing of hands before and after handling food also helps stop contamination.

Weapons

Some bacteria also have the potential to be used as biological weapons by terrorists. An example is anthrax, a disease caused by the bacterium *Bacillus anthracis*. Since inhaling the spores of this bacterium can lead to a deadly infection, it is a dangerous weapon. In 2001, an act of terrorism in the United States involved *B. anthracis* spores sent in letters through the mail.

Lesson Summary

- Bacteria contain a cell wall containing peptidoglycan and a single chromosome contained in the nucleoid.
- Bacteria can obtain energy through several means including photosynthesis, decomposition, and parasitism, symbiosis, and chemosynthesis.
- Bacteria reproduce through binary fission.
- Bacteria are important decomposers in the environment and aid in digestion.
- Some bacteria can be harmful when they contribute to disease, food poisoning, or biological warfare.

Review Questions

Recall

1. What are prokaryotes?
2. What are the possible shapes that bacteria can have?
3. What is the purpose of the flagella?
4. What is a chemotroph?

Apply Concepts

5. How is the DNA in prokaryotes different from the DNA in eukaryotes?
6. How do bacteria reproduce without having sex?
7. What are the ways bacteria can go through genetic recombination?
8. How are cyanobacteria similar to plants?
9. How are bacteria important in nature?
10. How can you avoid becoming sick from bacteria that cause food poisoning?

Think Critically

11. If a species of bacteria lives in the roots of a plant and supplies the plant with nitrogen, is this a parasitic bacteria? Explain why or why not.
12. How might you genetically modify bacteria so that they produce a chemical they do not normally produce?

Further Reading / Supplemental Links

- http://www.bt.cdc.gov/agent/anthrax
- http://www.cdc.gov/ncidod/dvbid/plague/index.htm
- http://www.cdc.gov/nczved/dfbmd/disease_listing/salmonellosis_gi.html
- http://www.ucmp.berkeley.edu/bacteria/bacteria.html
- http://commtechlab.msu.edu/sites/dlc-me/zoo
- http://www.cellsalive.com/cells/bactcell.htm

Points to Consider

- In the next section we will discuss the Kingdom Archaea. “Archae” shares the same root word as “archives” and “archaic,” so what do you think it means?
- What do you think the earliest life forms on Earth looked like?
- How do you think these early life forms obtained energy?

References

1. Diagrams: Mariana Ruiz Villarreal (User:LadyofHats/Wikimedia Commons); Bottom left: Courtesy of Dr. William A. Clark/CDC; Bottom center: Courtesy of Eric Erbe and Christopher Pooley/USDA; Bottom right: Courtesy of De Wood and Christopher Pooley/USDA. Diagrams: http://commons.wikimedia.org/wiki/File:Bacteria_morphologic_forms_simplified.svg; Bottom left: http://commons.wikimedia.org/wiki/File:Bacillus_coagulans_01.jpg; Bottom center: http://commons.wikimedia.org/wiki/File:Staphylococcus_aureus,_50,000x,_USDA,_ARS,_EMU.jpg; Bottom right: http://commons.wikimedia.org/wiki/File:Campylobacter.jpg . Public Domain
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