SECTION 1

The Characteristics of Cells

Key Concept Cells function similarly in all living organisms.

What You Will Learn

- The cell theory explains why cells are important for living things.
- All cells have a cell membrane, cytoplasm, and DNA.
- Prokaryotic cells and eukaryotic cells differ in how their genetic information is contained.

Why It Matters

Understanding how cells function makes it easier to learn how organisms function.

Vocabulary

- cell
- cell membrane
- organelle
- nucleus
- prokaryote
- eukaryote

READING STRATEGY

Asking Questions Read this section silently. In your **Science Journal,** write down questions that you have about this section. Discuss your questions in a small group.

cell (SEL) the smallest functional and structural unit of all living organisms; usually consists of a nucleus, cytoplasm, and a membrane

Most cells are so small that they can't be seen with the naked eye. So, how did scientists find cells? They found cells by accident! The first person to see cells wasn't looking for them.

All living things are made of cells. A **cell** is the smallest structural and functional unit of living things. Because of their size, cells weren't discovered until microscopes were invented in the mid-1600s.

Cells and the Cell Theory

Robert Hooke was the first person to describe cells. In 1665, he built a microscope to look at tiny objects. One day, he looked at a thin slice of cork. Cork is found in the bark of cork trees. The cork looked as if it were made of little boxes. Hooke named these boxes *cells,* which means "little rooms" in Latin. Hooke's cells were really the outer layers of dead cork cells. His microscope and his drawing of the cork cells are shown in **Figure 1.**

Hooke also looked at thin slices of living plants. He saw that they too were made of cells. Some cells were even filled with "juice." The "juicy" cells were living cells.

Hooke also looked at feathers, fish scales, and the eyes of houseflies. But he spent most of his time looking at plants and fungi. The cells of plants and fungi have cell walls. Thus, they are easy to see. Animal cells do not have cell walls. The lack of cell walls makes seeing the outline of animal cells harder. Because Hooke couldn't see their cells, he thought that animals weren't made of cells.

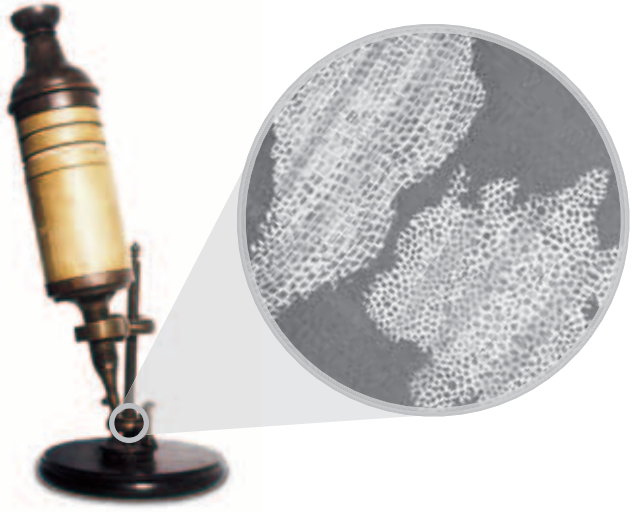


Figure 1 *Hooke discovered cells by using this microscope. His drawing of cork cells is shown to the right of his microscope.*

7.1.a Students know cells function similarly in all living organisms.
7.1.c Students know the nucleus is the repository for genetic information in plant and animal cells.

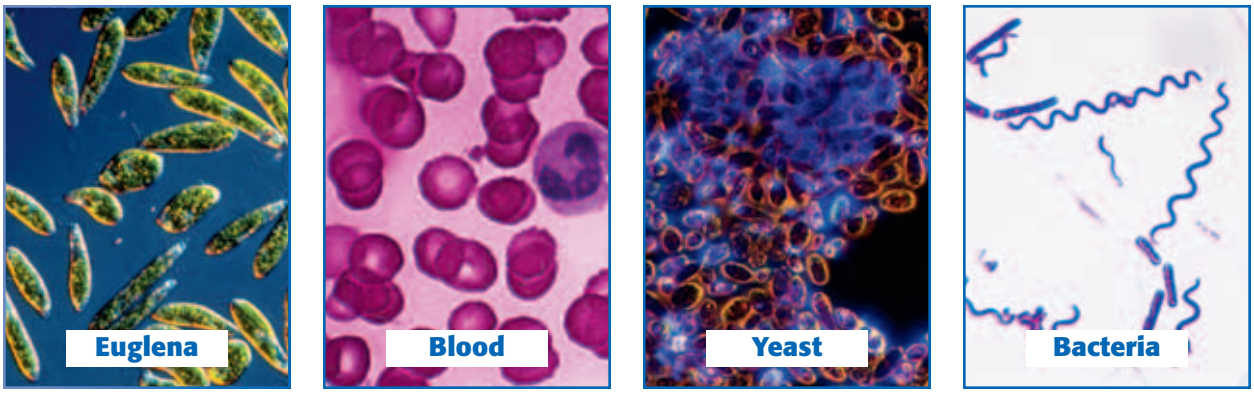


Figure 2 *Leeuwenhoek examined many types of cells, including protists of the genus* Euglena *and the other types of cells shown above. The bacteria in the photo have been enlarged more than the other cells. Bacterial cells are much smaller than most other types of cells.*

Finding Cells in Other Organisms

In 1673, Anton van Leeuwenhoek (LAY vuhn HOOK), a Dutch merchant, made his own microscopes. He used one of his microscopes to look at pond scum. Leeuwenhoek saw small organisms in the water. He named these organisms *animalcules,* which means "little animals." Today, we call these single-celled organisms *protists* (PROH tists).

Leeuwenhoek also looked at animal blood. He saw differences in blood cells from different kinds of animals. For example, blood cells in fish, birds, and frogs are oval. Blood cells in humans and dogs are round and flat. Leeuwenhoek was also the first person to see bacteria. And he discovered that yeasts that make bread dough rise are single-celled organisms. Examples of the types of cells that Leeuwenhoek examined are shown in **Figure 2.**

The Cell Theory

Almost 200 years passed before scientists concluded that cells are present in all living things. Matthias Schleiden (muh THIE uhs SHLIE duhn) studied plants. In 1838, he concluded that all plant parts were made of cells. Theodor Schwann (THEE oh DAWR SHVAHN) studied animals. In 1839, Schwann concluded that all animal tissues were made of cells. Shortly thereafter, he wrote the first two parts of what is now known as the *cell theory:*

- All organisms are made up of one or more cells.
- The cell is the basic unit of all living things.

In his book published in 1858, doctor Rudolf Virchow (ROO DAWLF FIR koh), stated that all cells could form only from other cells. He then added the third part of the cell theory:

- All cells come from existing cells.

Standards Check **What are the three parts of the cell theory?** 7.1.a

Quick Lab

Observing Cells

7.1.a
7.7.d

1. Follow your teacher's directions on how to set up and operate a **microscope.**
2. Examine **prepared microscope slides** from a variety of living things.
3. Record your observations of the samples on the slides. Draw pictures of what you see, and label your drawings.
4. What similarities between the samples do you observe?
5. How do the samples differ?

20 min

Cell Size

Most cells are too small to be seen without a microscope. It would take 50 human cells to cover the dot on this letter *i*.

Figure 3 *The white and yolk of this chicken egg provide nutrients for the development of a chick.*

A Few Large Cells

Most cells are small. A few, however, are big. The yolk of a chicken egg, shown in **Figure 3,** is one big cell. The size of most cells is controlled by the relationship between the surface area and the volume of the cell.

Many Small Cells

There is a reason why most cells are so small. Cells take in food and get rid of wastes through their outer surface. As a cell gets larger, it needs more food and produces more waste. Therefore, more materials pass through its outer surface.

As the cell's volume increases, its surface area grows, too. But the cell's volume grows faster than its surface area. If a cell gets too large, the cell's surface area will not be large enough to take in enough nutrients or pump out enough wastes. So, the surface area of a cell—relative to the volume of the cell—limits the cell's size. The ratio of the cell's surface area to the cell's volume is called the *surface area–to–volume ratio*. It can be calculated by using the following equation:

$$\text{surface area–to–volume ratio} = \frac{\text{surface area}}{\text{volume}}$$

MATH FOCUS

Surface Area–to–Volume Ratio Calculate the surface area–to–volume ratio of a cube whose sides measure 2 cm.

Step 1: Calculate the surface area.

$\text{surface area of cube} = \text{number of sides} \times \text{area of side}$

$\text{surface area of cube} = 6 \times (2\text{ cm} \times 2\text{ cm})$

$\text{surface area of cube} = 24\text{ cm}^2$

Step 2: Calculate the volume.

$\text{volume of cube} = \text{side} \times \text{side} \times \text{side}$

$\text{volume of cube} = 2\text{ cm} \times 2\text{ cm} \times 2\text{ cm}$

$\text{volume of cube} = 8\text{ cm}^3$

Step 3: Calculate the surface area–to–volume ratio.

$$\text{surface area–to–volume ratio} = \frac{\text{surface area}}{\text{volume}} = \frac{24}{8} = \frac{3}{1}$$

Now It's Your Turn

1. Calculate the surface area–to–volume ratio of a cube whose sides are 3 cm long.
2. Calculate the surface area–to–volume ratio of a cube whose sides are 4 cm long.
3. Of the cubes from questions 1 and 2, which has the greater surface area–to–volume ratio?
4. What is the relationship between the length of a side and the surface area–to–volume ratio of a cell?

Parts of a Cell

Cells have many different functions and come in many shapes and sizes. But all cells have some parts in common.

The Cell Membrane and Cytoplasm

All cells are surrounded by a cell membrane. The **cell membrane** is a protective layer that covers the cell's surface and acts as a barrier. It separates the cell's contents from its environment. The cell membrane also controls materials going into and out of the cell. Inside the cell is a fluid. This fluid and almost all of its contents are called the *cytoplasm* (SIET oh PLAZ uhm).

Organelles

Cells have organelles that carry out many life processes. **Organelles** are structures that have specific jobs inside the cell. Different kinds of cells have different organelles. Most organelles are surrounded by membranes. For example, the algal cell in **Figure 4** has membrane-bound organelles. Some organelles float in the cytoplasm. Other organelles are attached to membranes or other organelles.

Genetic Material

All cells have DNA (**d**eoxyribo**n**ucleic **a**cid) at some point in their lives. DNA is genetic material. It carries information needed to make new cells and new organisms. DNA is passed on from parent cells to new cells and directs the activities of a cell. **Figure 5** shows the DNA of a bacterium.

In cells such as plant and animal cells, DNA does not float around the cell. The *repository,* or storage area, for DNA is an organelle called the **nucleus.** Other cells, such as bacterial cells, do not have a nucleus.

Some cells can live without DNA. When human red blood cells are first made, they have a nucleus with DNA. But as red blood cells mature, they lose their nucleus and DNA. Most cells, however, always need to have DNA. DNA gives these cells instructions on how to make proteins.

Standards Check **Where is DNA located in plant and animal cells?**

7.1.c

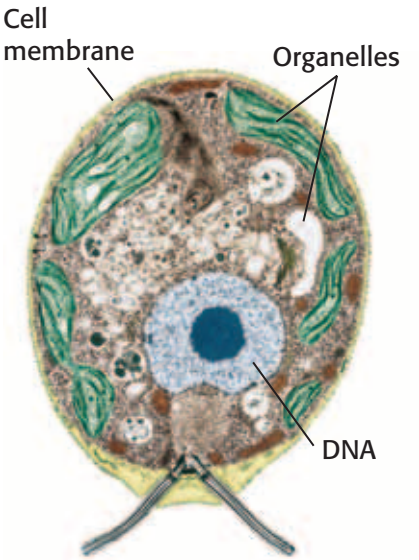


Figure 4 *The green alga in this photomicrograph has organelles. The organelles and the fluid surrounding them make up the cytoplasm.*

cell membrane (SEL MEM BRAYN) a phospholipid layer that covers a cell's surface and acts as a barrier between the inside of a cell and the cell's environment

organelle (AWR guh NEL) one of the small bodies in a cell's cytoplasm that are specialized to perform a specific function

nucleus (NOO klee uhs) in a eukaryotic cell, a membrane-bound organelle that contains the cell's DNA and that has a role in processes such as growth, metabolism, and reproduction

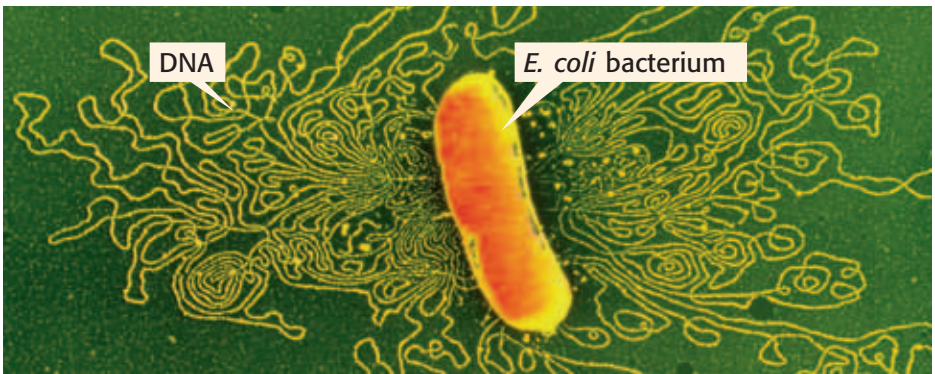


Figure 5 *This photomicrograph shows an* Escherichia coli *bacterium. The bacterium's cell membrane has been treated so that the cell's DNA is released.*

Two Kinds of Cells

All cells have cell membranes, organelles, cytoplasm, and DNA. But there are two basic types of cells. Cells without a nucleus are *prokaryotic* (proh KAR ee AHT ik) *cells*. Cells that have a nucleus are *eukaryotic* (yoo KAR ee AHT ik) *cells*. Prokaryotic cells are further classified into two groups: *bacteria* (bak TIR ee uh) and *archaea* (ahr KEE uh). **Figure 6** shows a prokaryotic cell and eukaryotic cell. Other prokaryotic and eukaryotic cells may look different from the cells in the diagrams below.

Standards Check **How do prokaryotic cells differ from eukaryotic cells?** 7.1.a

Prokaryotes

Bacteria and archaea are prokaryotes. **Prokaryotes** are single-celled organisms that do not have a nucleus. Even though prokaryotes do not have a nucleus, they do have DNA. The DNA of a prokaryote is a long, circular molecule. It is shaped like a twisted rubber band. Prokaryotes also do not have membrane-bound organelles. But they do have ribosomes. *Ribosomes* are tiny, round organelles made of protein and other material. Prokaryotic cells also have strong, weblike cell walls.

prokaryote (proh KAR ee OHT) a single-celled organism that does not have a nucleus or membrane-bound organelles; examples are archaea and bacteria

Wordwise The prefix *pro-* means "before." The root *karyon* means "nut" or "kernel."

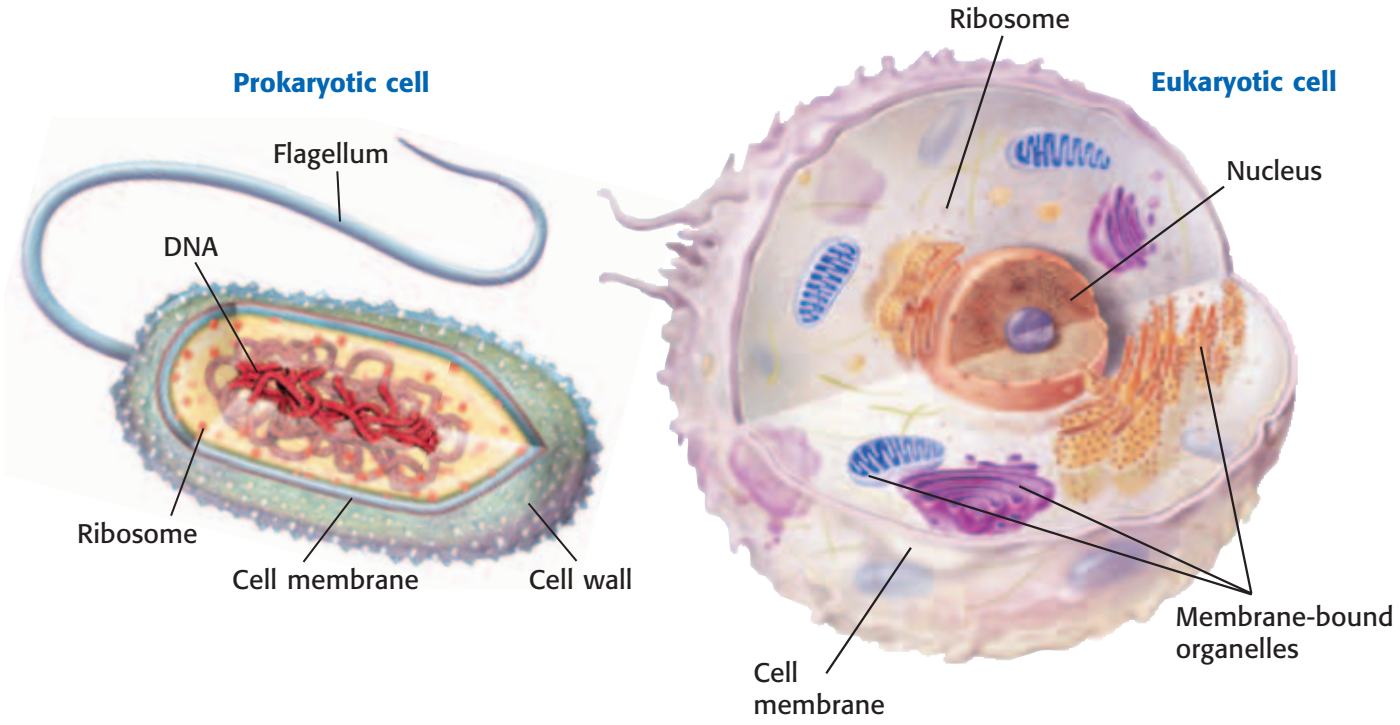
SCHOOL to HOME

Magnifying Glasses

You can make your own magnifying glasses by using items from around your home. Ask an adult to help you find clear drinking glasses. Look at a piece of newspaper through the glasses. Try holding the glasses at different heights and angles. Try putting small amounts of water in the glasses. Experiment until you find the best magnification.

ACTIVITY

Figure 6 **Two Kinds of Cells**



Eukaryotes

Eukaryotic cells are the largest cells. Most eukaryotic cells are still microscopic, but they are about 10 times as large as most prokaryotic cells.

Unlike bacteria and archaea, eukaryotic cells have a nucleus. The nucleus holds the cell's DNA. Eukaryotic cells have other membrane-bound organelles, too. Each kind of organelle has a specific job in the cell.

All living things that are not bacteria or archaea are made up of one or more eukaryotic cells. Organisms made up of eukaryotic cells are called **eukaryotes.** Yeasts and amoebas are single-celled eukaryotes. Plants and animals are eukaryotes that are made up of many cells.

eukaryote (yoo KAR ee OHT) an organism made up of cells that have a nucleus enclosed by a membrane; eukaryotes include protists, animals, plants, and fungi but not archaea or bacteria

SECTION Review

7.1.a, 7.1.c

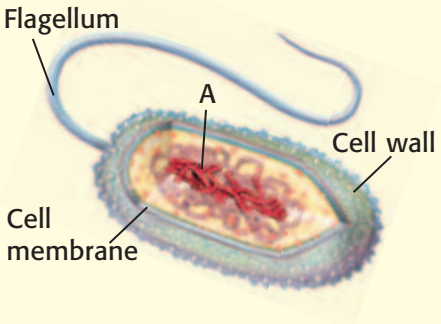
Summary

- The cell theory states that all organisms are made of cells, the cell is the basic unit of all living things, and all cells come from other cells.
- All cells have a cell membrane, cytoplasm, and DNA.
- Most cells are too small to be seen with the naked eye. The surface area–to–volume ratio of a cell limits the size of the cell.
- The two basic kinds of cells are prokaryotic cells and eukaryotic cells. Eukaryotic cells have a nucleus and membrane-bound organelles. Prokaryotic cells do not.
- Prokaryotes are single-celled.
- Eukaryotes can be single-celled or multicellular.

Understanding Concepts

1. **Summarizing** What does the cell theory tell us about cells?
2. **Listing** Name three structures that every cell has.
3. **Describing** Why are most cells small?

INTERPRETING GRAPHICS The picture below shows an organism that has one cell. Use the picture to answer the next two questions.



4. **Identifying** Is this cell a prokaryotic cell or a eukaryotic cell? How can you tell?
5. **Identifying** What part of the organism is labeled "A"?

Critical Thinking

6. **Making Comparisons** Compare the ways in which eukaryotic cells and prokaryotic cells store their DNA.
7. **Applying Concepts** You have discovered a new single-celled organism. It has ribosomes and long, circular DNA. Is it a eukaryote or a prokaryote? Explain.
8. **Identifying Relationships** You are looking at a cell under a microscope. What characteristics would this cell have if the organism is a eukaryote? What characteristics would this cell have if the organism is a prokaryote? What would you look for first?

Math Skills

9. **Analyzing Shapes** Calculate the surface area–to–volume ratio of a cube whose sides are 3 cm long.

Internet Resources

For a variety of links related to this chapter, go to www.scilinks.org

Topic: Prokaryotic Cells

SciLinks code: HY71225