

3.1 Cell Theory

VOCABULARY

cell theory
cytoplasm
organelle
prokaryotic cell
eukaryotic cell

KEY CONCEPT Cells are the basic unit of life.

MAIN IDEAS

- Early studies led to the development of the cell theory.
- Prokaryotic cells lack a nucleus and most internal structures of eukaryotic cells.

Connect to Your World

You and all other organisms are made of cells. As you saw on the previous page, a cell's structure is closely related to its function. Today we know that cells are the smallest unit of living matter that can carry out all processes required for life. But before the 1600s, people had many other ideas about the basis of life. Like many breakthroughs, the discovery of cells was aided by the development of new technology—in this case, the microscope.

MAIN IDEA

Early studies led to the development of the cell theory.



READING TOOLBOX

TAKING NOTES

As you read, make an outline using the headings as topics. Summarize details that further explain those ideas.

I. Main Idea

A. Supporting idea

1. Detail

2. Detail

B. Supporting idea

Almost all cells are too small to see without the aid of a microscope. Although glass lenses had been used to magnify images for hundreds of years, the early lenses were not powerful enough to reveal individual cells. The invention of the compound microscope in the late 1500s was an early step toward this discovery. The Dutch eyeglass maker Zacharias Janssen, who was probably assisted by his father, Hans, usually gets credit for this invention.

A compound microscope contains two or more lenses. Total magnification, the product of the magnifying power of each individual lens, is generally much more powerful with a compound microscope than with a single lens.

Discovery of Cells

In 1665, the English scientist Robert Hooke used the three-lens compound microscope shown in **FIGURE 1.1** to examine thin slices of cork. Cork is the tough outer bark of a species of oak tree. He observed that cork is made of tiny, hollow compartments. The compartments reminded Hooke of small rooms found in a monastery, so he gave them the same name: cells. The plant cells he observed, shown in **FIGURE 1.2** (top), were dead. Hooke was looking only at cell walls and empty space.

Around the same time, Anton van Leeuwenhoek, a Dutch tradesman, was studying new methods for making lenses to examine cloth. As a result of his research, his single-lens microscopes were much more powerful than Hooke's crude compound microscope. In 1674, Leeuwenhoek became one of the first people to describe living cells when he observed numerous single-celled organisms swimming in a drop of pond water. Sketches of his "animalcules" are pictured in **FIGURE 1.2** (bottom).

FIGURE 1.1 Hooke first identified cells using this microscope. Its crude lenses severely limited the amount of detail he could see.



As people continued to improve the microscope over the next century and a half, it became sturdier, easier to use, and capable of greater magnification. This combination of factors led people to examine even more organisms. They observed a wide variety of cell shapes, and they observed cells dividing. Scientists began to ask important questions: Is all living matter made of cells? Where do cells come from?

Cell Theory

The German scientist Matthias Schleiden also used compound microscopes to study plant tissue. In 1838, he proposed that plants are made of cells. Schleiden discussed the results of his work with another German scientist, Theodor Schwann, who was struck by the structural similarities between plant cells and the animal cells he had been studying. Schwann concluded that all animals are made of cells. Shortly thereafter, in 1839, he published the first statement of the cell theory, concluding that all living things are made of cells and cell products. This theory helped lay the groundwork for all biological research that followed. However, it had to be refined over the years as additional data led to new conclusions. For example, Schwann stated in his publication that cells form spontaneously by free-cell formation. As later scientists studied the process of cell division, they realized that this part of Schwann's idea was wrong. In 1855, Rudolf Virchow, another German scientist, reported that all cells come from preexisting cells. These early contributors are shown in **FIGURE 1.3**.

This accumulated research can be summarized in the cell theory, one of the first unifying concepts developed in biology. The major principles of the **cell theory** are the following:

- All organisms are made of cells.
- All existing cells are produced by other living cells.
- The cell is the most basic unit of life.

Summarize Explain the three major principles of cell theory in your own words.



FIGURE 1.2 Hooke observed the cell walls of dead plant cells (top). In contrast, Leeuwenhoek observed and drew microscopic life, which he called animalcules, in pond water (bottom).

FIGURE 1.3 Contributors to Cell Theory

HOOKE



1665 Hooke was the first to identify cells, and he named them.

LEEUVENHOEK



1674 Because he made better lenses, Leeuwenhoek observed cells in greater detail.

SCHLEIDEN



1838 Schleiden was the first to note that plants are made of cells.

SCHWANN



1839 Schwann concluded that all living things are made of cells.

VIRCHOW



1855 Virchow proposed that all cells come from other cells.

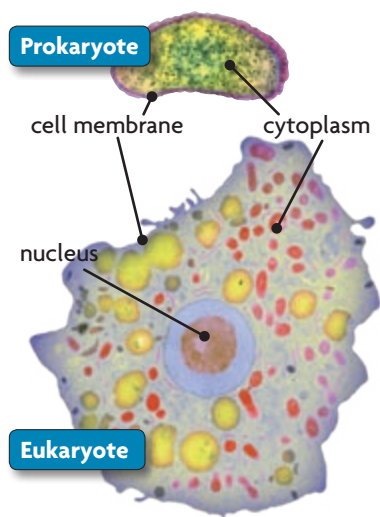


FIGURE 1.4 In prokaryotic cells, such as this bacterium (top), DNA is suspended in the cytoplasm. In eukaryotic cells, such as this protozoan (bottom), the nuclear envelope separates DNA from the cytoplasm. (colored TEMs; magnifications: protozoan 3200 \times ; bacterium 19,000 \times)

CONNECT TO PROKARYOTES

You will learn more about prokaryotes in **Viruses and Prokaryotes**, which discusses their requirements to sustain life, their role in the ecosystem, and their role in human disease.

MAIN IDEA

Prokaryotic cells lack a nucleus and most internal structures of eukaryotic cells.

The variety of cell types found in living things is staggering. Your body alone is made of trillions of cells of many different shapes, sizes, and functions. They include long, thin nerve cells that transmit sensory information, as well as short, blocky skin cells that cover and protect the body. Despite this variety, the cells in your body share many characteristics with one another and with the cells that make up every other organism. In general, cells tend to be microscopic in size and have similar building blocks. They are also enclosed by a membrane that controls the movement of materials into and out of the cell.

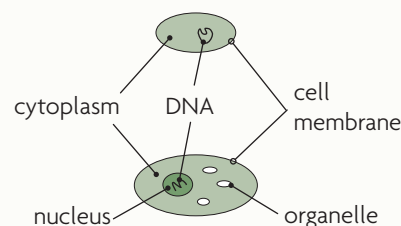
Within the membrane, a cell is filled with cytoplasm. **Cytoplasm** is a jellylike substance that contains dissolved molecular building blocks—such as proteins, nucleic acids, minerals, and ions. In some types of cells, the cytoplasm also contains **organelles**, which are structures specialized to perform distinct processes within a cell. Most organelles are surrounded by a membrane. In many cells, the largest and most visible organelle is the nucleus, which stores genetic information.

As shown in **FIGURE 1.4**, cells can be separated into two broad categories based on their internal structures: prokaryotic cells and eukaryotic cells.

- **Prokaryotic cells** (pro-KAR-ee-AHT-ihk) do not have a nucleus or other membrane-bound organelles. Instead, the cell's DNA is suspended in the cytoplasm. Most prokaryotes are microscopic single-celled organisms.
- **Eukaryotic cells** (yoo-KAR-ee-AHT-ihk) have a nucleus and other membrane-bound organelles. The nucleus, the largest organelle, encloses the genetic information. Eukaryotes may be multicellular or single-celled organisms.

VISUAL VOCAB

Prokaryotic cells do not have a nucleus or other membrane-bound organelles.



Eukaryotic cells have a nucleus and other membrane-bound organelles.

Summarize What characteristics are shared by most cells?

3.1 Formative Assessment

REVIEWING MAIN IDEAS

1. How did improvements in the microscope help scientists form the **cell theory**?
2. How do **prokaryotic** and **eukaryotic cells** differ?

CRITICAL THINKING

3. **Analyze** Today, scientists can study human cells grown in petri dishes. Explain how this technique builds on the work of early scientists.
4. **Compare** In what way are cells similar to atoms?



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PREMIUM CONTENT

CONNECT TO MEDICINE

5. Suppose a certain poison kills human cells by blocking pores in the nuclear membrane. Explain why it would or would not kill bacteria.