MS Cells and Their Structures

Jessica Harwood, (JessicaH)
Sarah Johnson, (SarahJ)
CK12 Editor

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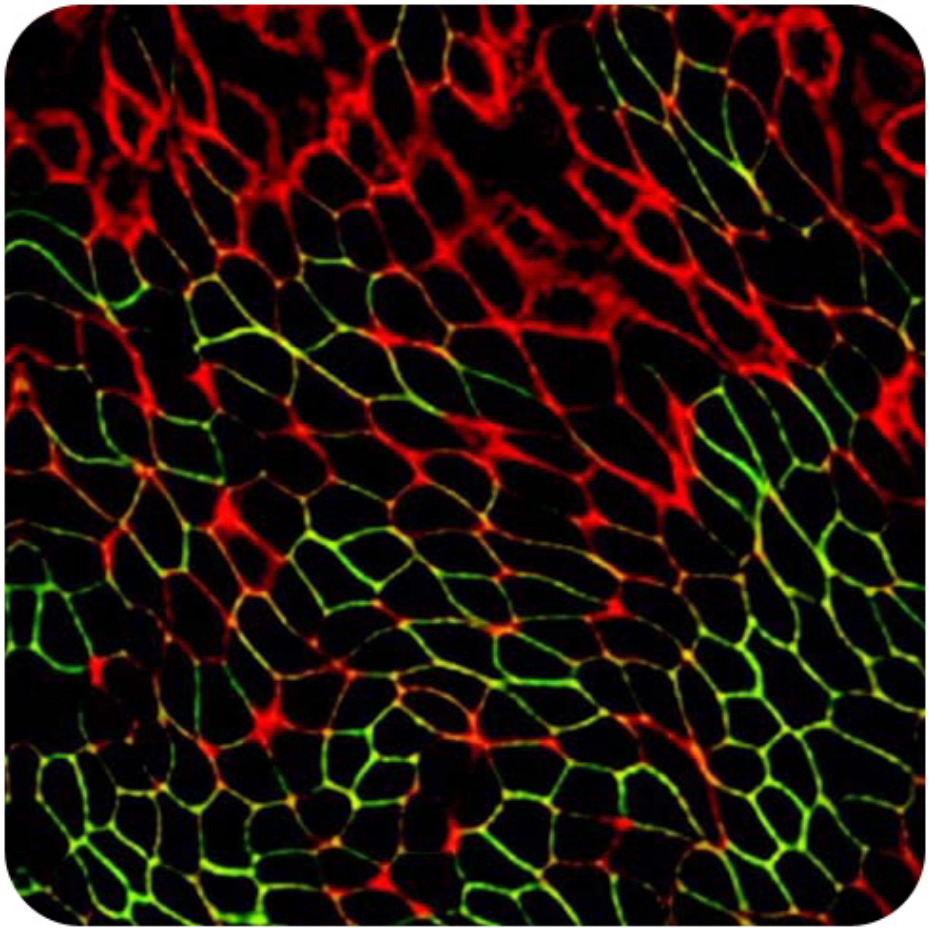
AUTHORS
Jessica Harwood, (JessicaH)
Sarah Johnson, (SarahJ)
CK12 Editor

CHAPTER 1 MS Cells and Their Structures

CHAPTER OUTLINE

1.1 Introduction to Cells
1.2 Cell Structures
1.3 References



Look carefully at the above image. What do you see? What colors? What shapes? Can you guess what it is?

These are actually cells from a dog's kidney. Cells are the smallest units of living things. You are made of cells. Plants are made of cells. So are dogs, chickens, bees and mushrooms. Our cells even look very similar to the above dog cells.

But the cells of a kidney are not actually bright green and red. Scientists remove cells from organisms, dye them with different colors, and look at them under strong microscopes. The above image is an example of what scientists see under these microscopes. Now, we will explore what different types of cells look like and what they do.

1.1 Introduction to Cells

Lesson Objectives

- Explain how cells are observed.
- Define the three main parts of the cell theory.
- Explain the levels of organization in an organism.

Check Your Understanding

- What are the five main characteristics of living things?
- Name the four main classes of organic molecules that are building blocks of life.

Vocabulary

organ A group of tissues that work together to perform a common function.

organ system A group of organs that work together to perform a common function.

tissue A group of specialized cells that function together.

What are cells?

In the chapter *What is a Living Organism?*, you learned that living things are made of big molecules called proteins, lipids, carbohydrates, and nucleic acids. When these big molecules come together, they form a cell. A **cell** is the smallest unit of an organism that is still considered living (see the onion cells in **Figure** 1.1). Some organisms, like bacteria, consist of only one cell. Big organisms, like humans, consist of trillions of cells. Compare a human to a banana. On the outside, they look very different, but if you look close enough you'll see that their cells are actually very similar.

The Inner Life of the Cell can be viewed at http://www.youtube.com/watch?v=Mszlckmc4Hw (5:28).

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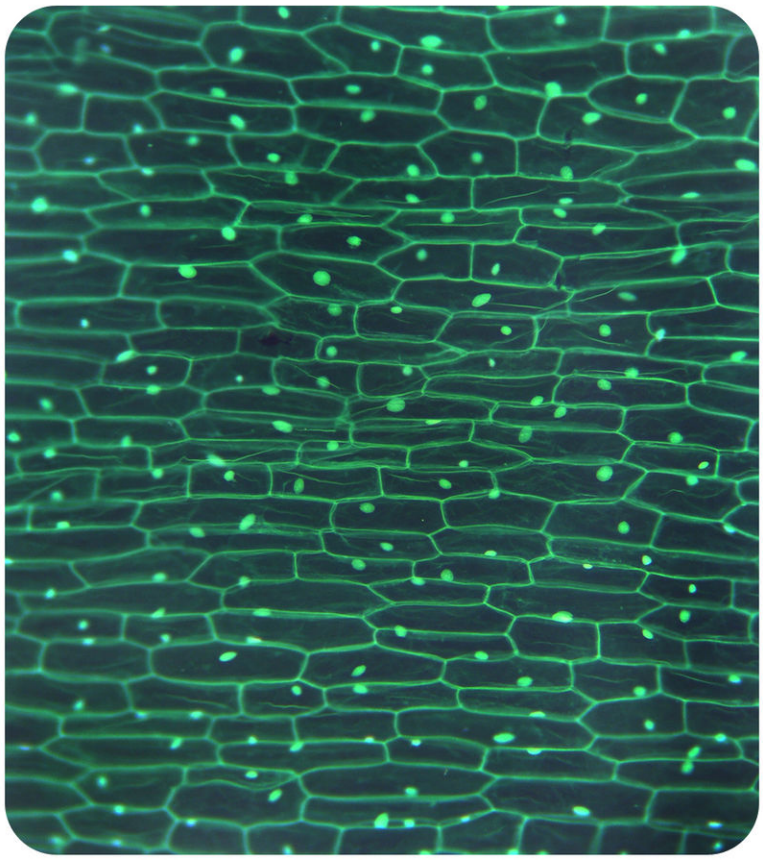

FIGURE 1.1
The outline of onion cells are visible under a light microscope.

Observing Cells

Most cells are so tiny that you cannot see them without the help of a microscope. It was not until 1665 that English scientist Robert Hooke invented a basic light microscope and observed cells for the first time. You may use light microscopes in the classroom. You can use a light microscope to see cells. But many structures in the cell are too small to see with a light microscope. So, what do you do if you want to see the tiny structures inside of cells?

In the 1950s, scientists developed more powerful microscopes. A light microscope sends a beam of light through a **specimen**, or the object you are studying. A more powerful microscope, called an **electron microscope**, passes a beam of electrons through the specimen. Sending electrons through a cell allows us to see its tiniest parts (**Figure** 1.2).

Without electron microscopes, we would not know what the inside of a cell looked like. The only problem with using an electron microscope is that it only works with dead cells. Scientists and students still use light microscopes to study living cells.

How to Correctly Use a Microscope can be viewed at http://www.youtube.com/watch?v=jP9HtcAvGDk#38;feature=related (1:43).

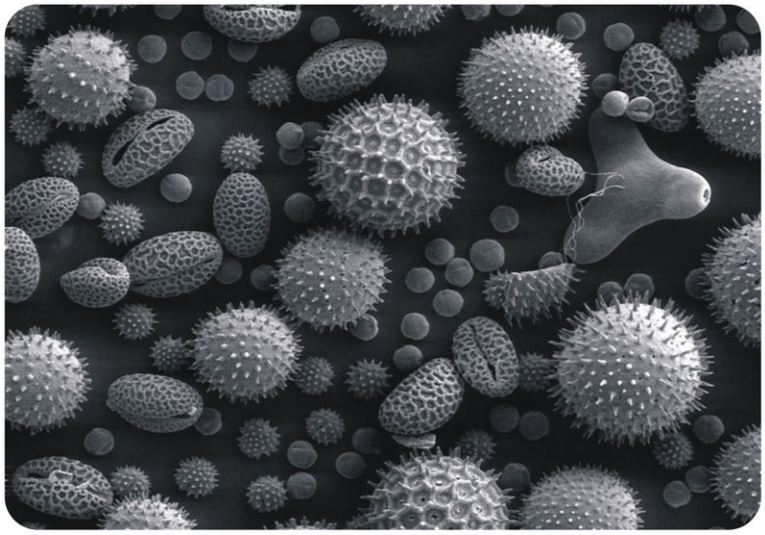

FIGURE 1.2

An electron microscope allows scientists to see much more detail than a light microscope, as with this sample of pollen. But a light microscope allows scientists to study living cells.

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Cell Theory

In 1858, after using microscopes much better than Hooke's first microscope, Rudolf Virchow developed the hypothesis that cells only come from other cells. For example, bacteria are composed of only one cell (**Figure** 1.3) and divide in half to make new bacteria. In the same way, your body makes new cells by dividing the cells you already have. In all cases, cells only come from cells that have existed before. This idea led to the development of one of the most important theories in biology, cell theory.

Cell theory states that:

a. All organisms are composed of cells.
b. Cells are alive and the basic living units of organization in all organisms.
c. All cells come from other cells.

As with other scientific theories, many hundreds, if not thousands, of experiments support the cell theory. Since Virchow created the theory, no evidence has ever contradicted it.

Levels of Organization

Although cells share many of the same features and structures, they also can be very different. Each cell in your body is designed for a specific task.

For example:

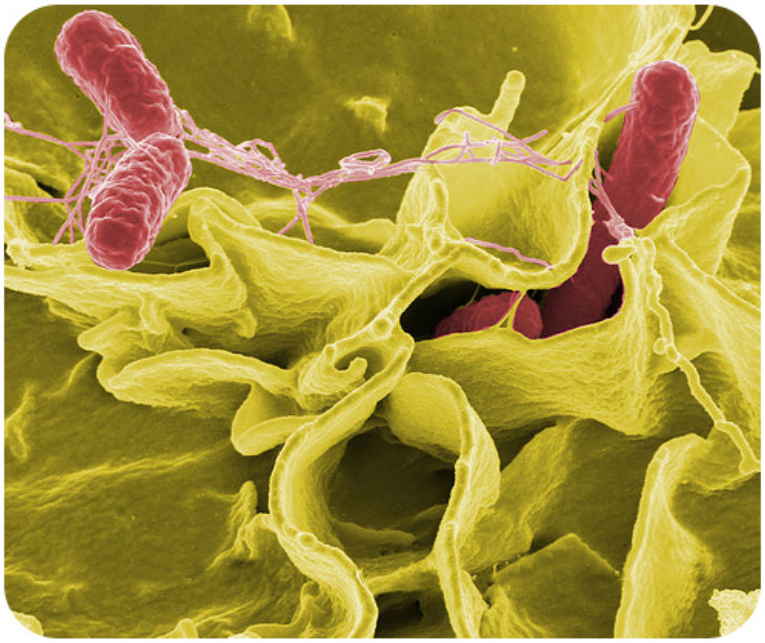

FIGURE 1.3
Bacteria (pink) are an example of an organism consisting of only one cell.

- Red blood cells (**Figure** 1.4) are shaped with a pocket that traps oxygen and brings it to other body cells.
- Nerve cells, which can quickly send the feeling of touching a hot stove to your brain, are long and stringy in order to form a line of communication with other nerve cells, like a wire (**Figure** 1.5).
- Skin cells (**Figure** 1.6) are flat and fit tightly together to protect your body.

An animation comparing the size of red blood cells and skin cells to other structures can be found at http://learn.genetics.utah.edu/content/begin/cells/scale/.

As you can see, cells are shaped in ways that help them do their jobs. Multicellular (many-celled) organisms have many types of specialized cells in their bodies.

While cells are the basic units of an organism, groups of cells can be specialized, or perform a specific job. Specialized cells can be organized into tissues. For example, your liver cells are organized into liver tissue, which is organized into an organ, your liver. Organs are formed from two or more specialized tissues working together to perform a job that helps your body work. All organs, from your heart to your liver, are made up of an organized group of tissues.

These organs are part of a larger system, the organ systems. For example, your brain works together with your spinal cord and other nerves to form the nervous system. This organ system must be organized with other organ systems, such as the circulatory system and the digestive system, for your body to work. Organ systems work together to form the entire organism. As you can see (**Figure** 1.7), there are many levels of organization in living things. See http://www.schools.utah.gov/curr/science/sciber00/7th/cells/sciber/levelorg.htm for additional information.

Lesson Summary

- Cells were first observed under a light microscope, but today's electron microscopes allow scientists to take a closer look at the inside of cells.
- Cell theory says that:
  - All organisms are composed of cells;

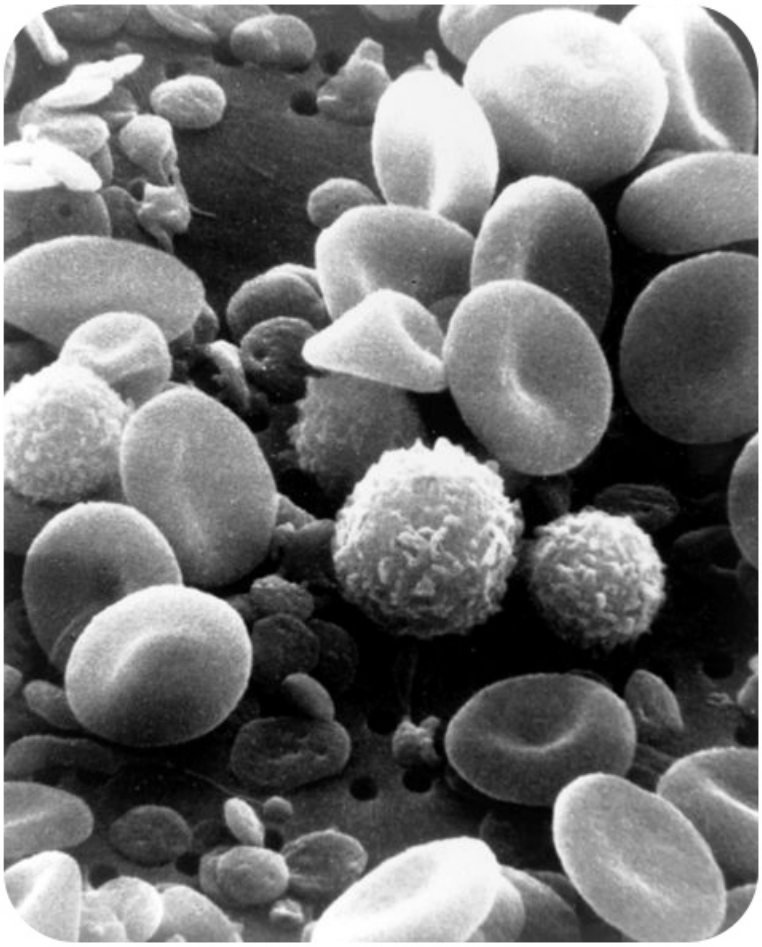

FIGURE 1.4
Red blood cells are specialized to carry oxygen in the blood.

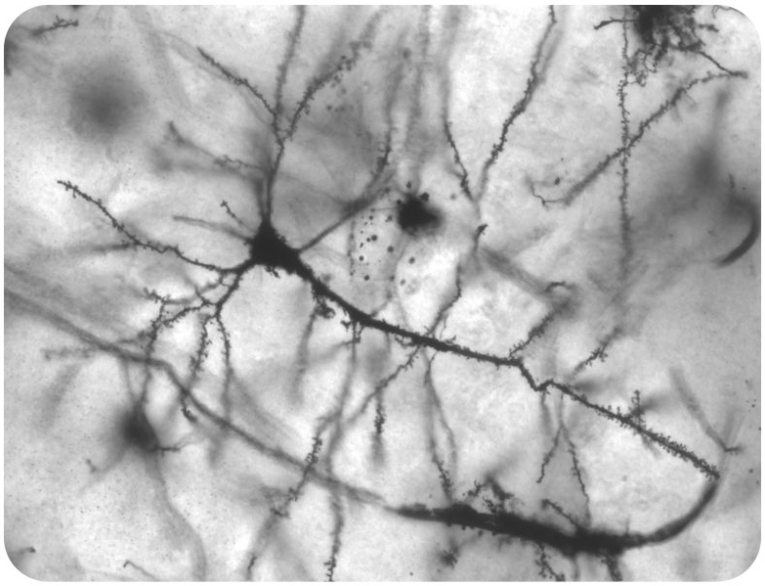

FIGURE 1.5
Neurons are shaped to conduct electrical impulses to many other nerve cells.

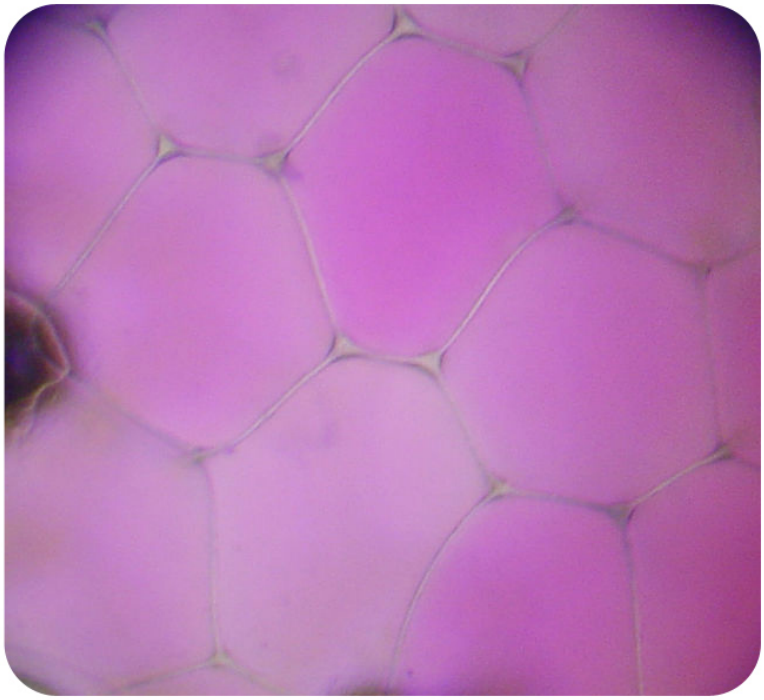

FIGURE 1.6
These epidermal cells make up the "skin" of plants. Note how the cells fit tightly together.

  - Cells are alive and the basic living units of organization in all organisms; and
  - All cells come from other cells.

- Cells are organized into tissues, which are organized into organs, which are organized into organ systems, which are organized to create the whole organism.

Review Questions

Recall

1. What scientific tool was used to first observe cells?
2. What are the three main parts of the cell theory?

Apply Concepts

3. Put the following in the correct order from simplest to most complex: organ, cell, tissue, organ system.
4. What type of microscope would be best for studying the structures found inside of cells?

Think Critically

5. According to the cell theory, can we create a new cell in laboratory by putting different molecules together? Why or why not?

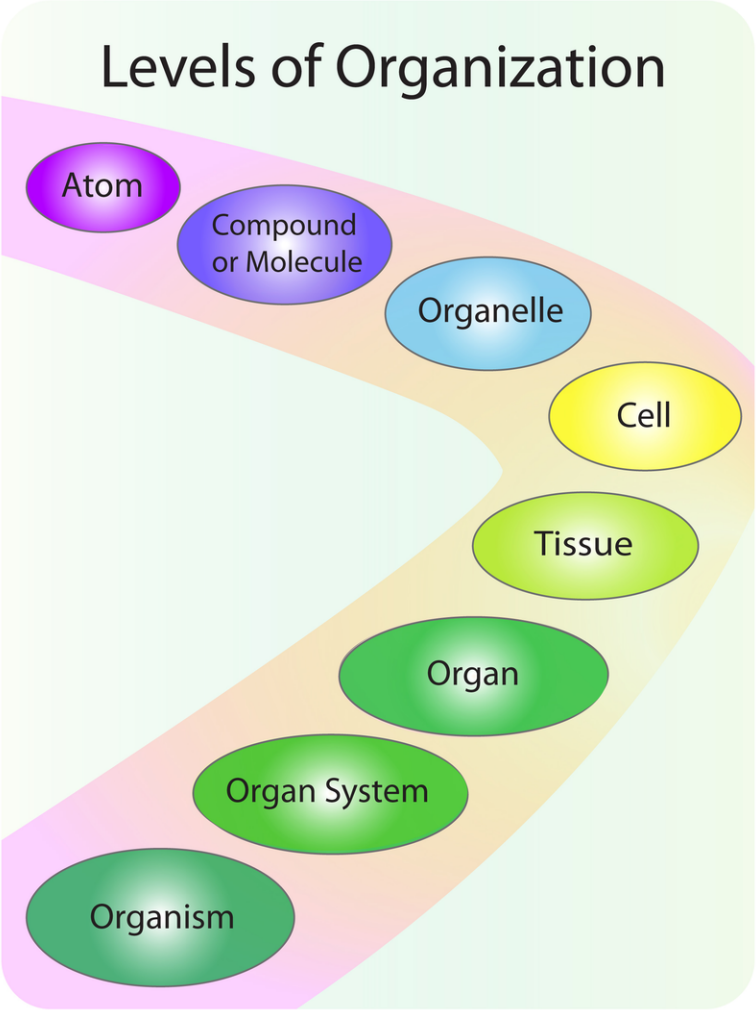

FIGURE 1.7
Levels of Organization, from the atom to the organism.

Further Reading / Supplemental Links

- Baeuerle, Patrick A. and Landa, Norbert. *The Cell Works: Microexplorers.* Barron's; 1997, Hauppauge, New York.
- Sneddon, Robert. *The World of the Cell: Life on a Small Scale.* Heinemann Library; 2003, Chicago.
- Wallace, Holly. *Cells and Systems.* Heinemann Library; 2001, Chicago.

Points to Consider

- Do you think there would be a significant difference between bacterial cells and your brain cells? What might they be?
- Do you think a bacterial cell and a brain cell have some things in common? What might they be?
- Do you think cells have organs like we do? How would that benefit cells?

1.2 Cell Structures

Lesson Objectives

- Compare prokaryotic and eukaryotic cells.
- List the organelles of the cell and their functions.
- Discuss the structure and function of the cell membrane and cytosol.
- Describe the structure and function of the nucleus.
- Distinguish between plant and animal cells.

Check Your Understanding

- What is a cell?
- How do we visualize cells?

Vocabulary

cell wall Provides strength and protection for the cell; found around plant, fungal, and bacterial cells.

central vacuole Large organelle containing water, nutrients, and wastes; can take up to 90% of a plant cell's volume.

chloroplast The organelle in which photosynthesis takes place.

chromosome DNA wound around proteins; forms during prophase of mitosis and meiosis.

cytoplasm All the contents of the cell besides the nucleus, including the cytosol and the organelles.

cytoskeleton The internal scaffolding of the cell; maintains the cell shape and aids in moving the parts of the cell.

cytosol A fluid-like substance inside the cell; organelles are embedded in the cytosol.

endoplasmic reticulum (ER) A folded membrane organelle; rough ER modifies proteins and smooth ER makes lipids.

eukaryote Cell belonging to the domain Eukarya (fungi, animals, protists, and plants); has membrane-enclosed nucleus and organelles.

Golgi apparatus The organelle where proteins are modified, labeled, packaged into vesicles, and shipped.

lysosome Organelle which contains degradative enzymes; breaks down unneeded materials.

mitochondria Organelle where cellular respiration occurs; known as the "powerhouse" of the cell because this is the organelle where the ATP that powers the cell is produced.

nuclear envelope A double membrane that surrounds the nucleus; helps regulate the passage of molecules in and out of the nucleus.

nucleus Membrane enclosed organelle in eukaryotic cells that contains the DNA; primary distinguishing feature between a eukaryotic and prokaryotic cell; the information center, containing instructions for making all the proteins in a cell, as well as how much of each one.

organelle Small structure found in cells; has specialized functions; many are membrane-bound, such as mitochondria, plastids, and vacuoles. Membrane-bound organelles are found only in eukaryotic cells.

plasma membrane Surrounds the cell; made of a double layer of specialized lipids, known as phospholipids, with embedded proteins; regulates the movement of substances into and out of the cell; also called the cell membrane.

prokaryote A microscopic single-celled organism, including bacteria and cyanobacteria; does not have a nucleus with a membrane or other specialized organelles.

ribosome The cell structure on which proteins are made; not surrounded by a membrane; found in both prokaryotic and eukaryotic cells.

rough endoplasmic reticulum The part of the ER with ribosomes attached; proteins can be modified in the rough ER before they are packed into vesicles for transport to the golgi apparatus.

semipermeable Allowing only certain materials to pass through; characteristic of the cell membrane.

smooth endoplasmic reticulum Part of the ER that does not have ribosomes attached; where lipids are synthesized.

vesicle Small membrane-enclosed sac; transports proteins around a cell or out of a cell.

Prokaryotic and Eukaryotic Cells

There are two basic types of cells, prokaryotic cells (**Figure** 1.8), found in organisms called **prokaryotes**, and eukaryotic cells (**Figure** 1.9), found in organisms called **eukaryotes**.

The main difference between eukaryotic and prokaryotic cells is that eukaryotic cells have a **nucleus**, where they store their DNA, or genetic material. The nucleus is membrane-bound, which means it is surrounded by a phospholipid membrane. Prokaryotic cells do not have a "membrane-bound" nucleus. Instead, their DNA floats around inside the cell.

Here are some other key features of eukaryotic cells:

a. They have membrane-bound structures called **organelles**. A list of the main eukaryotic organelles is located in **Table** 1.2.

b. Eukaryotic cells include the cells of fungi, animals, protists, and plants.
c. These cells are more specialized than prokaryotic cells.

Key features of prokaryotic cells include:

a. The cells are usually smaller and simpler than eukaryotic cells.
b. Prokaryotic cells do not have membrane-bound structures.
c. The DNA, or genetic material, forms a single large circle that coils up on itself.
d. Prokaryotic cells belong to the domains Bacteria or Archaea. These two domains were discussed in the *What is a Living Organism?* chapter.

From the above information, are the cells found in your body prokaryotic cells or eukaryotic cells? **Table** 1.1 compares prokaryotic and eukaryotic cells.

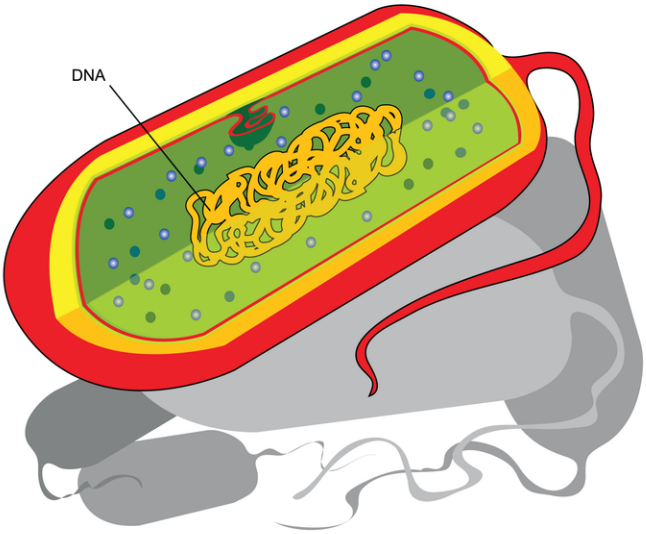

FIGURE 1.8
Prokaryotes do not have a nucleus. Instead, their genetic material is a simple loop of DNA.

TABLE 1.1: Comparison of Prokaryotic and Eukaryotic Cells

Feature	Prokaryotic cells	Eukaryotic cells
DNA	Single "naked" circle; plasmids	In membrane-enclosed nucleus
Membrane-enclosed organelles	No	Yes
Examples	Bacteria	Plants, animals, fungi

An *Introduction to Prokaryotic and Eukaryotic Cells* can be viewed at http://www.youtube.com/watch?v=nP9lZG94DO0 (2:13)

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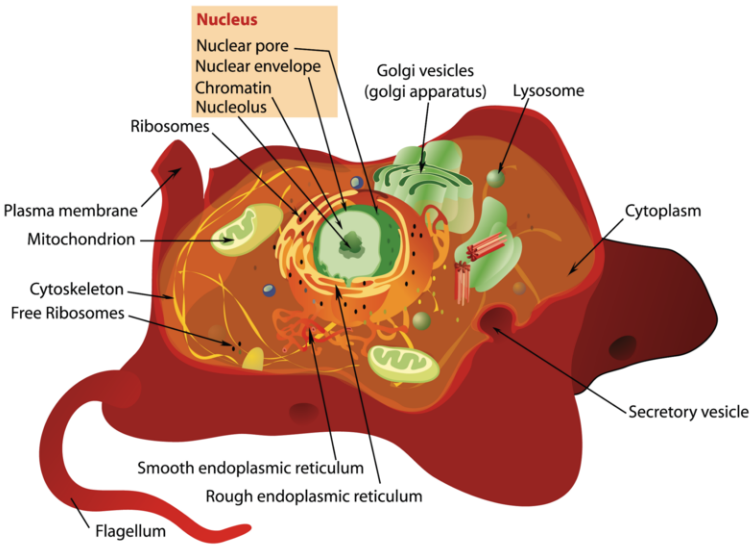

FIGURE 1.9

Eukaryotic cells contain a nucleus (where the DNA lives, and surrounded by a membrane) and various other special compartments surrounded by membranes, called organelles. For example, notice in this image the mitochondria, lysosomes, and peroxisomes.

The Plasma Membrane and Cytosol

Both eukaryotic and prokaryotic cells have walls around them that separate them from other cells and make sure the parts of the cell do not just float away. This wall is called a plasma membrane. The **plasma membrane** is made of a double layer of lipids, known as phospholipids. The function of the plasma membrane, also known as the cell membrane, is to control what goes in and out of the cell.

Some molecules can go through the cell membrane and enter and leave the cell, but some cannot. "Permeable" means that anything can cross a barrier. An open door is completely permeable to anything that wants to enter or exit through the door. The plasma membrane is **semipermeable,** meaning that some things can enter the cell and some things cannot.

The inside of eukaryotic and prokaryotic cells also both contain a jelly-like substance called **cytosol**. Cytosol is composed of water and other molecules, including enzymes that speed up the cell's chemical reactions. Everything in the cell - the nucleus and the organelles - sit in the cytosol, like fruit in a Jell-o mold. The term **cytoplasm** refers to the cytosol and all of the organelles, but not the nucleus.

TABLE 1.2: **Some Eukaryotic Organelles**

Organelle	Function
Ribosomes	Involved in making proteins
Golgi apparatus	Packages proteins and some polysaccharides
Mitochondria	Where ATP is made
Smooth Endoplasmic Reticulum	Makes lipids
Chloroplast	Makes sugar (photosynthesis)
Lysosomes	Digests macromolecules

The Nucleus

The nucleus is only found in eukaryotic cells. It is a membrane-bound structure that contains most of the genetic material of the cell (**Figure** 1.10). The nucleus contains important information that helps the cell create important molecules for life. The **nuclear envelope**, a double membrane that surrounds the nucleus, controls which molecules go in and out of the nucleus.

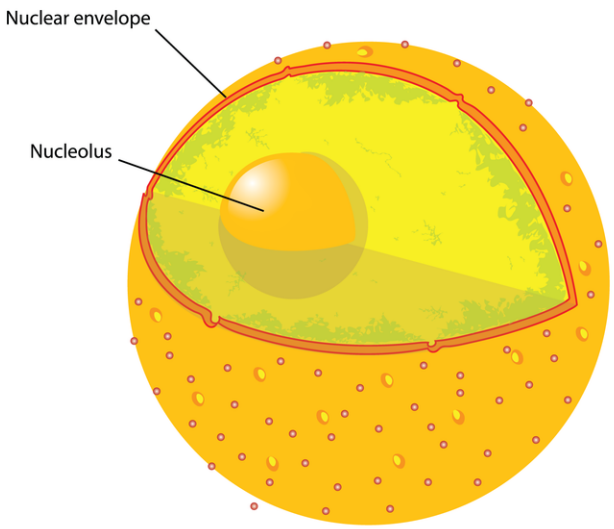

FIGURE 1.10
In eukaryotic cells, the DNA is kept in a nucleus. The nucleus is surrounded by a double plasma membrane called the nuclear envelope. Within the nucleus is the *nucleolus* (smaller yellow ball).

b. The **mitochondria** are powerhouses that create ATP (adenosine triphosphate), which provides the energy needed to power chemical reactions. Plant cells have special organelles called **chloroplasts** that capture energy from the sun and store it in the bonds of sugar molecules, using a process called photosynthesis (**Figure** 1.11). (The cells of animals and fungi do not photosynthesize and do not have chloroplasts.)
c. The **vacuoles** are like storage centers. Plant cells have larger ones than animal cells because they need to store water and other nutrients.
d. The **lysosomes** are like the recycling trucks that carry waste away from the factory. Inside lysosomes are enzymes that break down old molecules into parts that can be recycled into new ones.
e. Eukaryotic cells also contain a skeleton-like structure called the **cytoskeleton**. Like our bony skeleton, a cell's cytoskeleton gives the cell its shape and helps the cell to move. What part of a factory would act like a cytoskeleton?
f. In both eukaryotes and prokaryotes, **ribosomes** are where proteins are made. Ribosomes are like the machines in the factory that produce the factory's main product. Proteins are the main product of the cell.
g. Some ribosomes can be found on folded membranes called the endoplasmic reticulum (ER). If the ER is covered with ribosomes, it looks bumpy and is called **rough endoplasmic reticulum**. If the ER does not contain ribosomes, it is smooth and called the **smooth endoplasmic reticulum**. Proteins are made on the rough ER. Lipids are made on the smooth ER.
h. The **Golgi apparatus**, works like a mail room. The Golgi apparatus receives the proteins from the rough ER, puts "shipping addresses" on the proteins, packages them up in vesicles, and then sends them to the right place in the cell.

You can watch an interactive animation of plant and animal cells at the following link: http://www.cellsalive.com/cells/cell_model.htm.

Differences between Plant and Animal Cells

Even though plants and animals are both eukaryotes, plant cells differ in some ways from animal cells. First, plant cells have a large central vacuole that holds a mixture of water, nutrients, and wastes. A plant cell's vacuole can

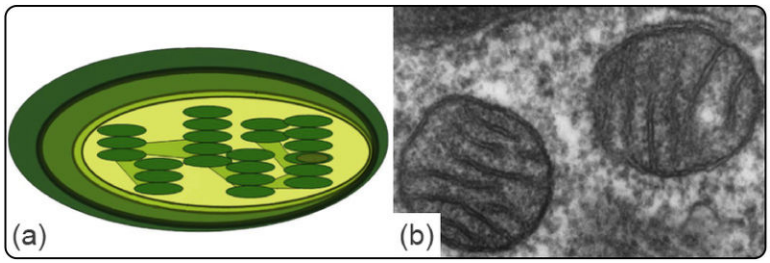

FIGURE 1.11

Diagram of chloroplast (a) and electron microscope image of two mitochondria (b). Chloroplasts and mitochondria provide energy to cells. If the bar at the bottom of the electron micrograph image is 200 nanometers, what is the diameter of one of the mitochondria?

make up 90% of the cell's volume. In animal cells, vacuoles are much smaller.

Second, plant cells have a cell wall, while animal cells do not. A **cell wall** gives the plant cell strength and protection.

A third difference between plant and animal cells is that plants have several kinds of organelles called **plastids**. There are several kinds of plastids, including chloroplasts, needed for photosynthesis; **leucoplasts**, which store starch and oil; and brightly colored **chromoplasts**, which give some flowers and fruits their yellow, orange, or red color. You will learn more about chloroplasts and photosynthesis in the chapter titled *Cell Functions*. Under a microscope one can see plant cells more clearly (**Figure** 1.12 and **Figure** 1.13).

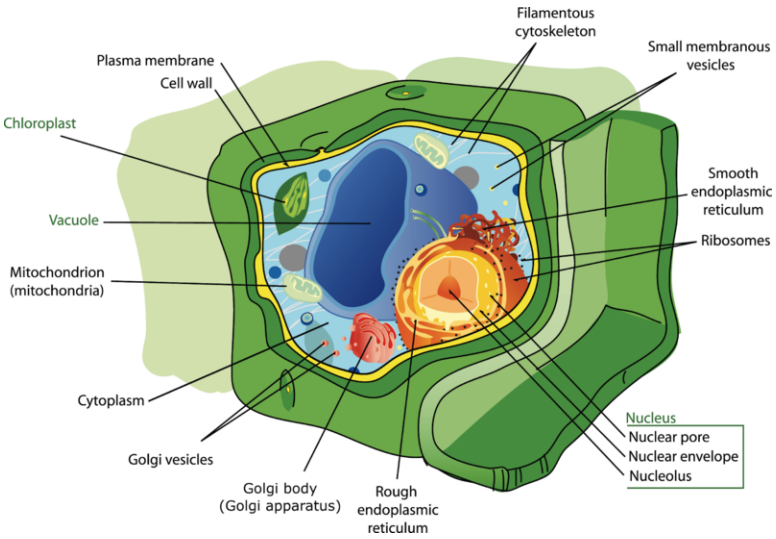

FIGURE 1.12

A plant cell has several features that make it different from an animal cell, including a cell wall, huge vacuoles, and several kinds of plastids, including chloroplasts (which photosynthesize).

Lesson Summary

- Prokaryotic cells lack a nucleus; eukaryotic cells have a nucleus.
- Each component of a cell has a specific function.
- Plant cells are different from animal cells. For example, plant cells contain plastids, cell walls, and large vacuoles.

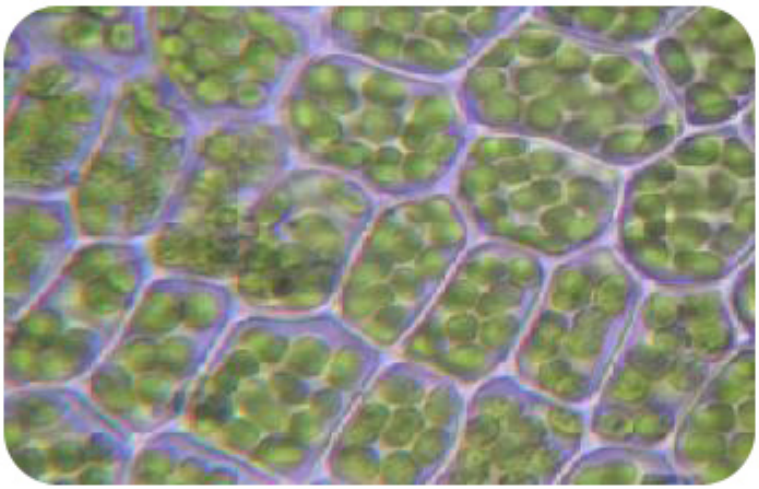

FIGURE 1.13
In this photo of plant cells taken with a light microscope, you can see a cell wall (purple) around each cell and green chloroplasts.

Review Questions

Recall

1. What are the two basic types of cells?
2. What are organelles?
3. Discuss the main differences between prokaryotic cells and eukaryotic cells.

Apply Concepts

4. What is the plasma membrane and what is its role?
5. Why is the mitochondria known as the powerhouse of the cell?

Think Critically

6. Why does photosynthesis not occur in animal cells?

Further Reading / Supplemental Links

- Baeuerle, Patrick A. and Landa, Norbert. *The Cell Works: Microexplorers.* Barron's; 1997, Hauppauge, New York.
- Sneddon, Robert. *The World of the Cell: Life on a Small Scale.* Heinemann Library; 2003, Chicago.
- Wallace, Holly. *Cells and Systems.* Heinemann Library; 2001, Chicago.

Points to Consider

- Think about what molecules would need to be transported into cells.
- Discuss why you think it would be important for some molecules to be kept out of a cell.

1.3 References

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