15.2

KEY CONCEPT

Microscopes allow us to see inside the cell.

BEFORE, you learned

- Some organisms are unicellular and some are multicellular
- A microscope is necessary to study most cells
- The cell theory describes the cell as the fundamental unit of life

NOW, you will learn

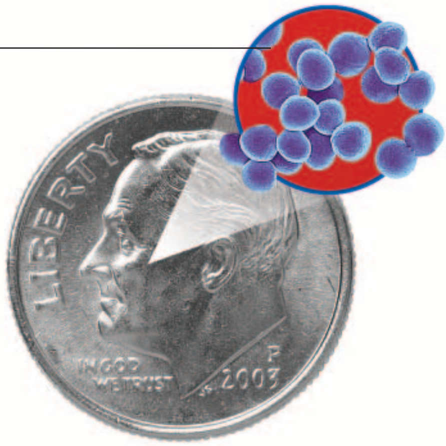
- About different types of microscopes
- About prokaryotic and eukaryotic cells
- How plant and animal cells are similar and different

VOCABULARY

cell membrane p. 512
cytoplasm p. 512
nucleus p. 512
eukaryotic cell p. 512
prokaryotic cell p. 512
organelle p. 512
cell wall p. 513
chloroplast p. 515
mitochondria p. 515

THINK ABOUT

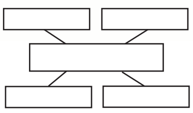
How small are cells?



Because cells are so small, describing them requires a very small unit of measure: the micrometer (μm). A micrometer is one millionth of a meter. Most cells range in size from about 1 micrometer (some bacteria) to 1000 micrometers (some plant and animal cells). To get a sense of the sizes of cells, consider that it would take about 17,000 tiny bacterial cells lined up to reach across a dime. How many of these cells might fit on your fingertip?

The microscope is an important tool.

MAIN IDEA WEB
Make a main idea web that explains the importance of the microscope.



The invention of the light microscope led to the discovery of cells and to the development of cell theory. In light microscopes, lenses are used to bend light and make objects appear bigger than they are. Modern light microscopes can magnify objects up to 1000 times.

The light microscope is still used today to study cells. Over many years scientists have found ways to make light microscopes more useful. Cell samples are treated with dyes to make structures in the cells easier to see. Scientists use video cameras and computer processing to observe the movement of cell parts and materials within cells. One important advantage of light microscopes is that scientists can observe living cells with them.

Two other types of microscopes are important in the study of cells. The scanning electron microscope (SEM) and the transmission electron microscope (TEM) can produce images of objects as small as 0.002 micrometers. The light microscope can be used only for objects that are larger than 0.2 micrometers. Therefore, although a light microscope can be used to see many of the parts of a cell, only the SEM and TEM can be used for looking at the details of those parts.

In both the SEM and the TEM, tiny particles called electrons, not light, are used to produce images. The advantage of these microscopes is that they can magnify objects up to a million times. The disadvantage is that they cannot be used to study live specimens.

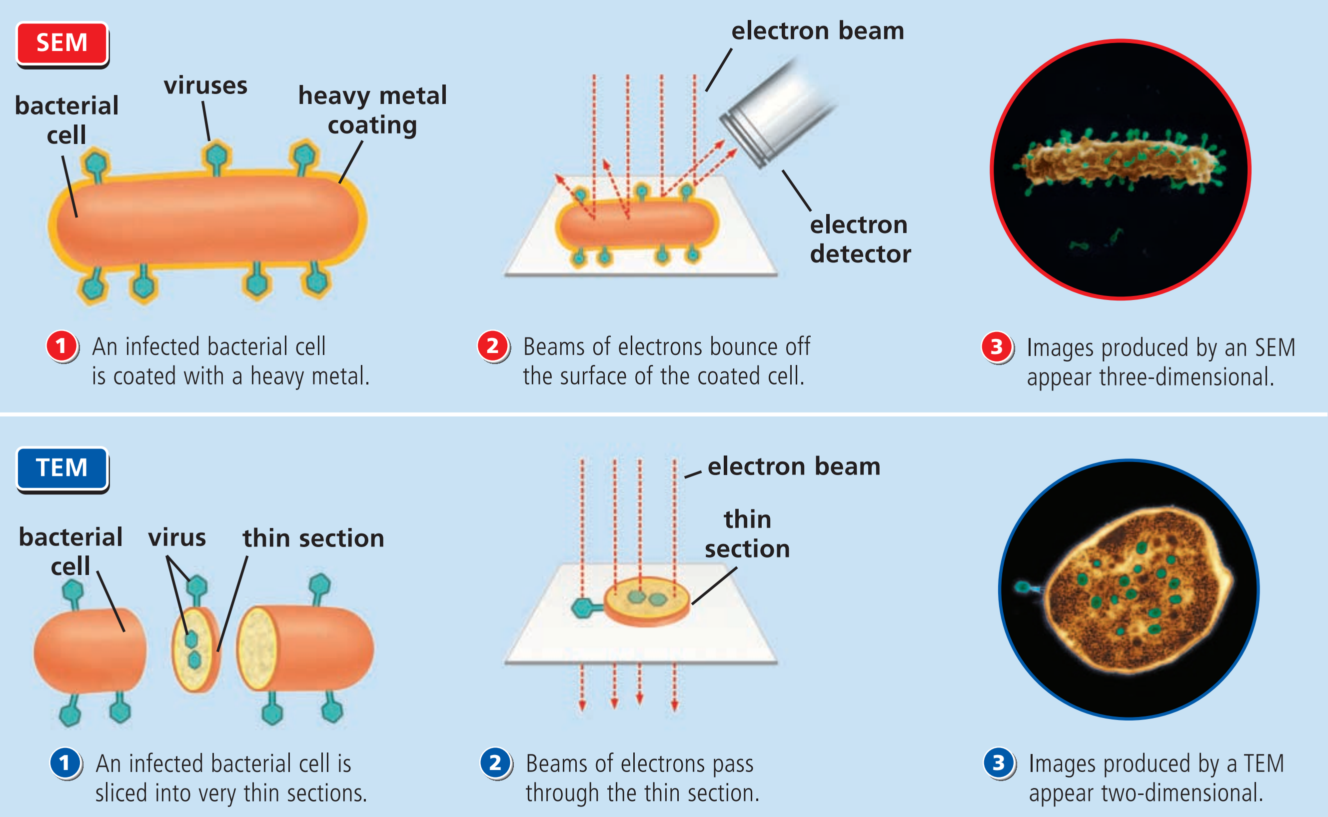
SIMULATION CLASSZONE.COM
View cells through different types of microscopes.

CHECK YOUR READING Compare light microscopes with electron microscopes. What are the advantages and disadvantages of each?

To be viewed with an SEM, a cell sample is coated in a heavy metal, such as gold. Then a beam of electrons is run back and forth over the surface of the cell. The electrons bounce off the coating and are read by a detector that produces a three-dimensional image of the surface.

A cell viewed with a TEM is sliced extremely thin. Electrons pass through a section. Images produced by a TEM appear two-dimensional.

Electron Microscopes



SEM

1 An infected bacterial cell is coated with a heavy metal.

2 Beams of electrons bounce off the surface of the coated cell.

3 Images produced by an SEM appear three-dimensional.

TEM

1 An infected bacterial cell is sliced into very thin sections.

2 Beams of electrons pass through the thin section.

3 Images produced by a TEM appear two-dimensional.

Cells are diverse.

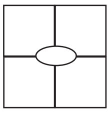
Very early on, the people studying cells knew that cells have a great diversity of sizes and shapes. As microscopes were improved, scientists could see more and more details of cells. What they saw was that the inside of one cell can be very different from that of another cell.

Every cell has a boundary that separates the inside from the outside. That boundary is the **cell membrane,** a protective covering that encloses the entire cell. Any material coming into or out of the cell must pass through the cell membrane. Contained inside the cell membrane is a gelatin-like material called **cytoplasm** (SY-tuh-PLAZ-uhm). Most of the work of the cell is carried out in the cytoplasm.

Scientists separate cells into two broad categories based on one key difference: the location of the genetic material cells need to reproduce and function. In a **eukaryotic cell** (yoo-KAR-ee-AHT-ihk) the genetic material is in a structure called the **nucleus** (NOO-klee-uhs), a structure enclosed by its own membrane. Scientists use the word **organelle** (AWR-guh-NEHL) to describe any part of a cell that is enclosed by membrane.

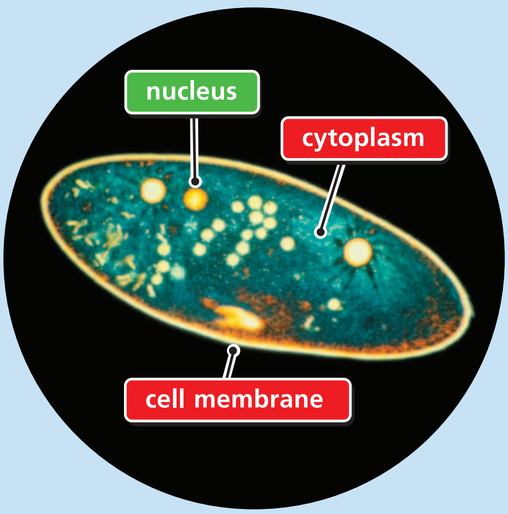
In a **prokaryotic cell** (proh-KAR-ee-AWT-ihk) there is no separate compartment for the genetic material. Instead, it is in the cytoplasm. There are no organelles. Most unicellular organisms are prokaryotic cells. Almost all multicellular organisms are eukaryotic.

VOCABULARY
Add a four square for *cell membrane* to your notebook. Try to include the word *cytoplasm* in your diagram.

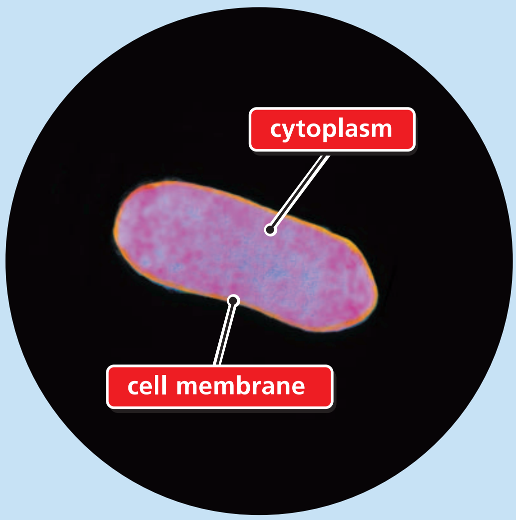


Eukaryotic and Prokaryotic Cells

Eukaryotic cells have a nucleus while prokaryotic cells do not. On average, eukaryotic cells are about 100 times larger than prokaryotic cells.



A **eukaryotic cell** has a nucleus. The paramecium shown here is magnified 133×.



A **prokaryotic cell** does not have a nucleus. The bacterium shown here is magnified 12,000×.

INVESTIGATE Plant and Animal Cells

How do plant and animal cells compare?

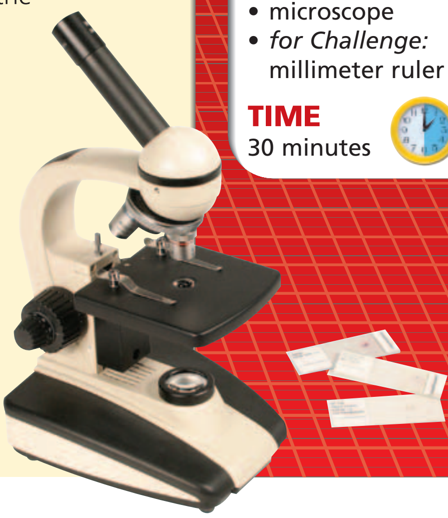
SKILL FOCUS
Observing

MATERIALS
- prepared slides
- microscope
- *for Challenge:* millimeter ruler

TIME
30 minutes

PROCEDURE

1. Choose the objective lens with the lowest magnification. Place the plant-cell slide on the stage and turn on the light source. Handle the slide carefully.
2. Observe the cells at low magnification. Make a drawing of one of the cells.
3. Observe the cells at high magnification. Fill in details. Return to the low-magnification lens before removing the slide.
4. Repeat steps 1–3 with the animal-cell slide.



WHAT DO YOU THINK?

- Compare the drawings you made. How are the plant and animal cells alike, and how are they different?
- Compare the thickness of plant cell's cell membrane and cell wall with the thickness of the animal cell's cell membrane.

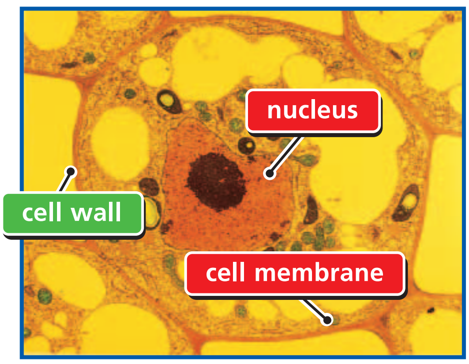
CHALLENGE Placing a ruler on top of the slides, view each slide at low power. Estimate and compare the sizes of the two cells.

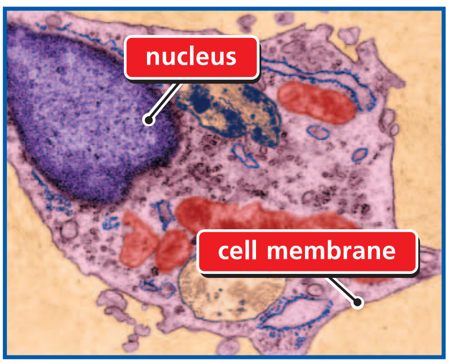
Plants and animals have eukaryotic cells.

Plant and animal cells, like all eukaryotic cells, are divided into two main compartments. The nucleus, usually the largest organelle, is the compartment that stores the instructions a cell needs to function. You will learn more about how cells use this information in grade 7.

Surrounding the nucleus is the cytoplasm. The cell membrane is the boundary between the cytoplasm and the outside of the cell. Plant cells also have cell walls. A **cell wall** is a tough outer covering that lies just outside the cell membrane. The cell wall supports and protects the cell. Having a cell wall is one important way in which plant cells differ from animal cells.

RESOURCE CENTER
CLASSZONE.COM
Find out more about cell structures.



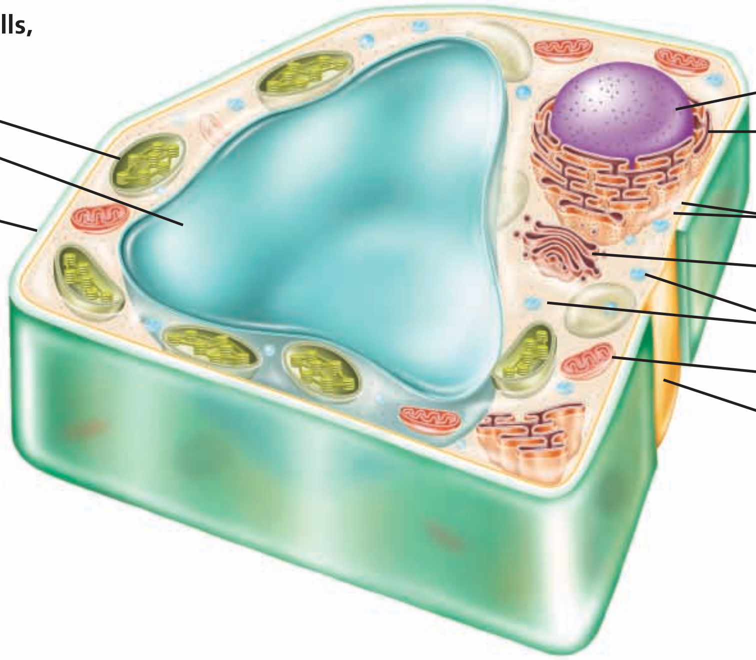


Both a plant cell (shown at left magnified 1750×) and an animal cell (shown at right magnified 12,000×) have a nucleus and a cell membrane. Plant cells also have a cell wall.

Parts of a Eukaryotic Cell

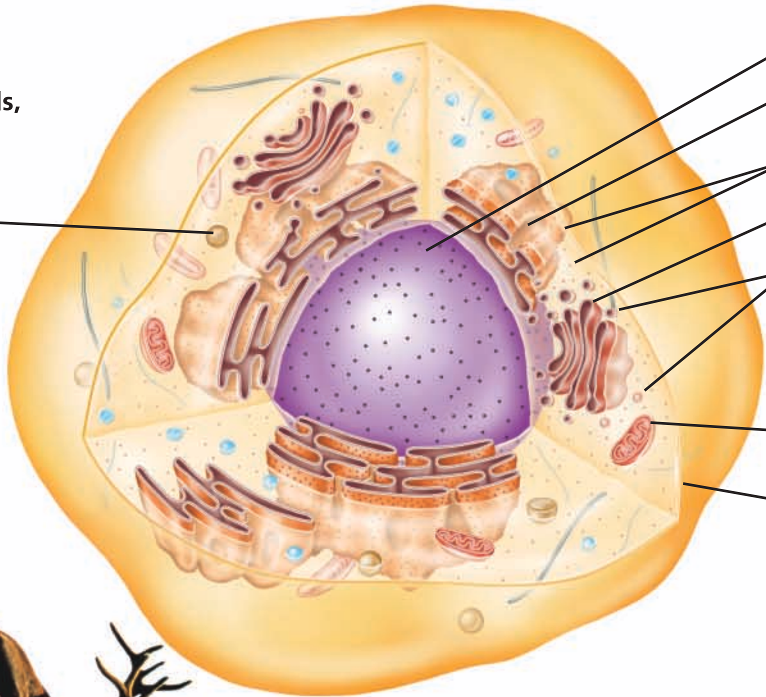
Plant Cell

Found in plant cells, not animal cells:



Animal Cell

Found in animal cells, not plant cells:

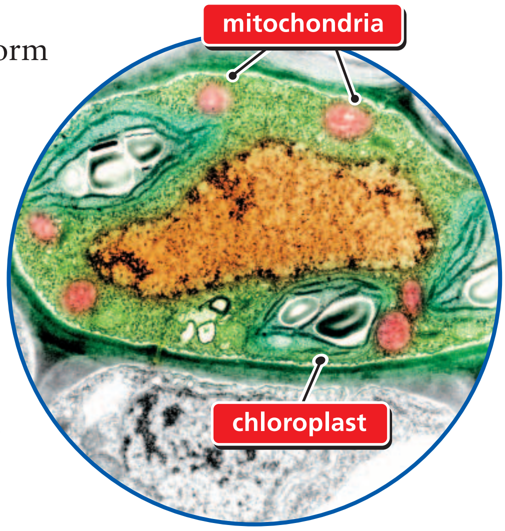


Structures That Process Information

The nucleus is often the largest organelle in a cell. It contains information a cell needs to function. Some of the information is translated by ribosomes, tiny structures located in the cytoplasm and the endoplasmic reticulum. Ribosomes use the information to build important molecules called proteins.

Organelles That Provide Energy

No cell can stay alive without energy. Cells need energy to perform all the activities of life. Plants get their energy directly from the Sun. Within plant cells are **chloroplasts** (KLAWR-uh-PLASTS), organelles in which the energy from sunlight is used to make sugar. Plants use some of the sugar immediately, to keep their cells functioning. The rest of the sugar is stored in the cells.



This plant cell is magnified 6000×.

Animal cells do not contain chloroplasts. As a result, animals are not able to use the energy of the Sun directly. Instead, animals get their energy from food. Much of the food an animal uses for energy comes from the sugar that plant cells have stored. Animals can get this energy by eating plants or by eating animals that have eaten plants.

CHECK YOUR READING How can a chloroplast, a structure found in plant cells but not in animal cells, provide energy for both plants and animals?

Both plant cells and animal cells must be able to use energy to do work. The energy is made available by organelles found in all eukaryotic cells. **Mitochondria** (MY-tuh-KAHN-dree-uh) are the organelles that use oxygen to get energy from processing food.

READING TIP
Mitochondria is plural. The singular form is *mitochondrion*.

Organelles That Process and Transport

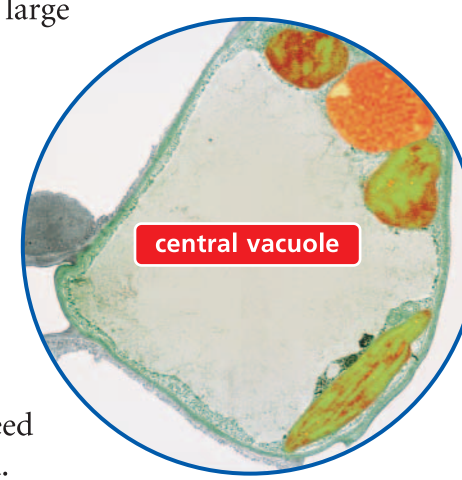
You know that plant and animal cells get their energy from the sugars that the organisms make or consume. Sugars are also an important part of the starting materials that cells use to maintain themselves and grow. The job of making cell parts from the starting materials that enter a cell is divided among a number of structures in the cytoplasm.

In the illustrations on page 514, you can see that the endoplasmic reticulum is a system of twisting and winding membranes. Some of the endoplasmic reticulum contains ribosomes, which manufacture proteins. The endoplasmic reticulum manufactures parts of the cell membrane.

The endoplasmic reticulum is also part of the cellular transport system. Portions of endoplasmic reticulum break off to form small packages called vesicles. The vesicles transport processed materials to an organelle called the Golgi apparatus. The folded membranes of the Golgi apparatus make it look something like a stack of pancakes. The Golgi apparatus takes the materials manufactured by the endoplasmic reticulum and finishes processing them.

Organelles for Storage, Recycling, and Waste

Cells store water, sugar, and other materials, which they use to function. Cells must also store waste materials until they can be removed. Inside plant and fungus cells are sacs called vacuoles. Vacuoles are enclosed by a membrane and can hold water, waste, and other materials. Vacuoles function with the cell membrane to move materials either into or out of the cell. A plant cell has a large central vacuole in which water and other materials can be stored. Water in the vacuole provides support for smaller plants.



Animal cells do not have central vacuoles. What animal cells do have are similar structures called lysosomes. Lysosomes are vesicles that contain chemicals that break down materials taken into the cell, as well as old cell parts. Remember that animals, unlike plants, take in food. Nutrients brought into the cell need to be broken down, as well as wastes contained.

CHECK YOUR READING Compare and contrast lysosomes and central vacuoles.

15.2 Review

KEY CONCEPTS

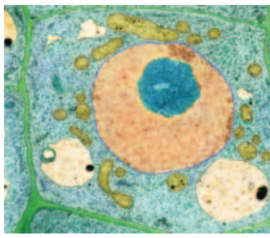
1. What advantages and disadvantages does a light microscope have in comparison with an electron microscope?
2. What is the difference between a eukaryotic cell and a prokaryotic cell?
3. List three structures found in plant cells that are not in animal cells.

CRITICAL THINKING

4. **Synthesize** What organelles can be said to act like an assembly line within a cell? Explain.
5. **Compare and Contrast** Make a Venn diagram comparing and contrasting plant and animal cells.

CHALLENGE

6. **Synthesize** Identify the type of microscope used to capture the image at the right, and indicate whether the cell is a plant cell or an animal cell. How do you know?



(magnified 27,900×)