SECTION 4

UNIQUE FEATURES OF PLANT CELLS

Plant cells have three kinds of structures that are not found in animal cells and that are extremely important to plant survival: plastids, central vacuoles, and cell walls.

OBJECTIVES

- **List** three structures that are present in plant cells but not in animal cells.
- **Compare** the plasma membrane, the primary cell wall, and the secondary cell wall.
- **Explain** the role of the central vacuole.
- **Describe** the roles of plastids in the life of a plant.
- **Identify** features that distinguish prokaryotes, eukaryotes, plant cells, and animal cells.

VOCABULARY

cell wall
central vacuole
plastid
chloroplast
thylakoid
chlorophyll

PLANT CELLS

Most of the organelles and other parts of the cell just described are common to all eukaryotic cells. However, plant cells have three additional kinds of structures that are extremely important to plant function: cell walls, large central vacuoles, and plastids.

To understand why plant cells have structures not found in animal cells, consider how a plant's lifestyle differs from an animal's. Plants make their own carbon-containing molecules directly from carbon taken in from the environment. Plant cells take carbon dioxide gas from the air, and in a process called *photosynthesis,* they convert carbon dioxide and water into sugars. The organelles and structures in plant cells are shown in Figure 4-21.

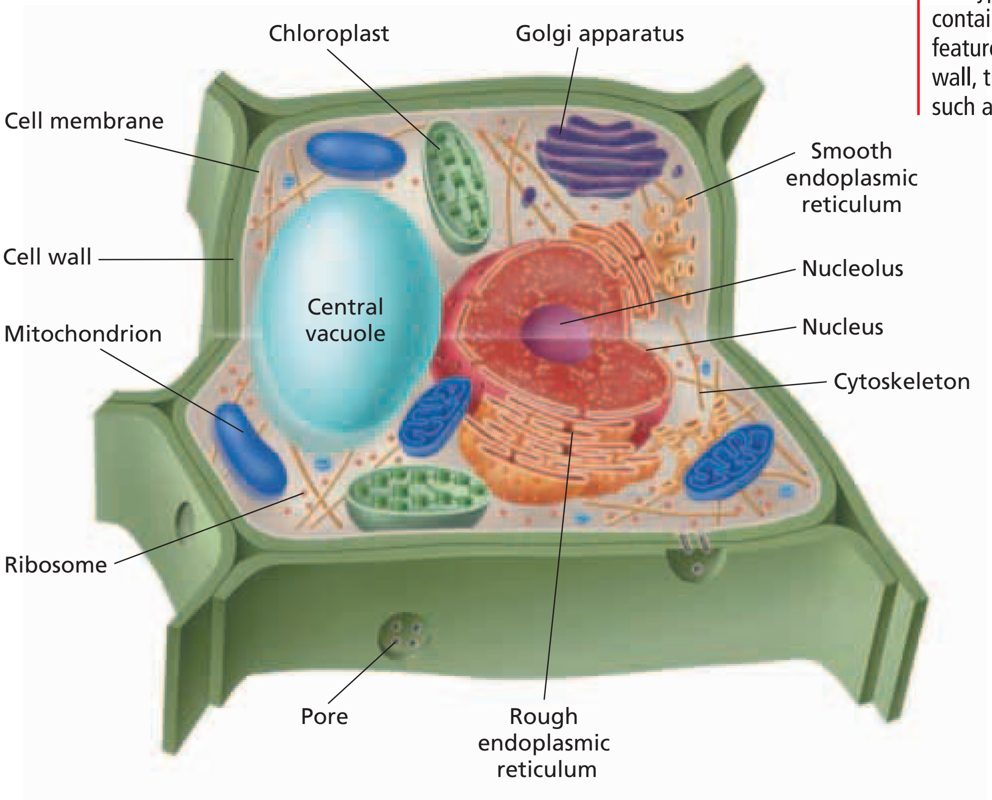


FIGURE 4-21

In addition to containing almost all of the types of organelles that animal cells contain, plant cells contain three unique features. Those features are the cell wall, the central vacuole, and plastids, such as chloroplasts.

CELL WALL

The **cell wall** is a rigid layer that lies outside the cell's plasma membrane. Plant cell walls contain a carbohydrate called *cellulose*. Cellulose is embedded in a matrix of proteins and other carbohydrates that form a stiff box around each cell. Pores in the cell wall allow water, ions, and some molecules to enter and exit the cell.

Primary and Secondary Cell Walls

The main component of the cell wall, cellulose, is made directly on the surface of the plasma membrane by enzymes that travel along the membrane. These enzymes are guided by microtubules inside the plasma membrane. Growth of the primary cell wall occurs in one direction, based on the orientation of the microtubules. Other components of the cell wall are made in the ER. These materials move in vesicles to the Golgi and then to the cell surface.

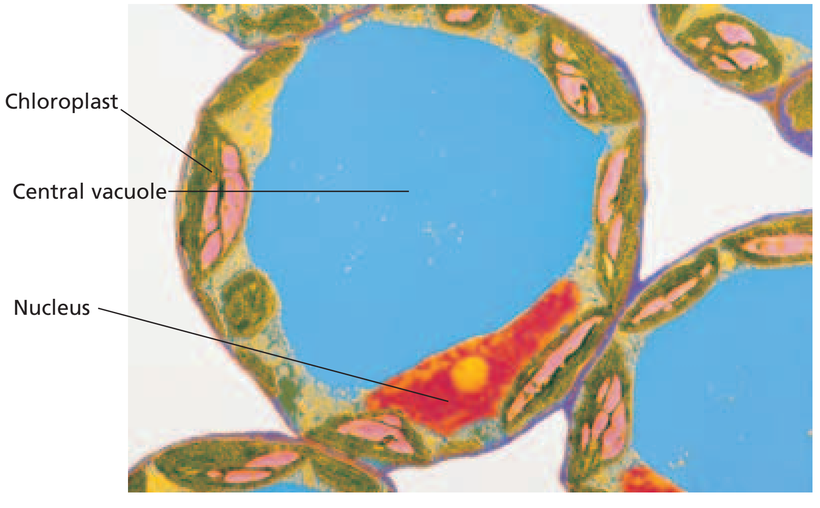
Some plants also produce a secondary cell wall. When the cell stops growing, it secretes the secondary cell wall between the plasma membrane and the primary cell wall. The secondary cell wall is very strong but can no longer expand. The wood in desks and tabletops is made of billions of secondary cell walls. The cells inside the walls have died and disintegrated.

CENTRAL VACUOLE

Plant cells may contain a reservoir that stores large amounts of water. The **central vacuole** is a large, fluid-filled organelle that stores not only water but also enzymes, metabolic wastes, and other materials. The central vacuole, shown in Figure 4-22, forms as other smaller vacuoles fuse together. Central vacuoles can make up 90 percent of the plant cell's volume and can push all of the other organelles into a thin layer against the plasma membrane. When water is plentiful, it fills a plant's vacuoles. The cells expand and the plant stands upright. In a dry period, the vacuoles lose water, the cells shrink, and the plant wilts.

FIGURE 4-22

The central vacuole occupies up to 90 percent of the volume of some plant cells. The central vacuole stores water and helps keep plant tissue firm.



Other Vacuoles

Some vacuoles store toxic materials. The vacuoles of acacia trees, for example, store poisons that provide a defense against plant-eating animals. Tobacco plant cells store the toxin nicotine in a storage vacuole. Other vacuoles store plant pigments, such as the colorful pigments found in rose petals.

PLASTIDS

Plastids are another unique feature of plant cells. **Plastids** are organelles that, like mitochondria, are surrounded by a double membrane and contain their own DNA. There are several types of plastids, including chloroplasts, chromoplasts, and leucoplasts.

Chloroplasts

Chloroplasts use light energy to make carbohydrates from carbon dioxide and water. As Figure 4-23 shows, each chloroplast contains a system of flattened, membranous sacs called **thylakoids.** Thylakoids contain the green pigment **chlorophyll,** the main molecule that absorbs light and captures light energy for the cell. Chloroplasts can be found not only in plant cells but also in a wide variety of eukaryotic algae, such as seaweed.

Chloroplast DNA is very similar to the DNA of certain photosynthetic bacteria. Plant cell chloroplasts can arise only by the division of preexisting chloroplasts. These facts may suggest that chloroplasts are descendants of ancient prokaryotic cells. Like mitochondria, chloroplasts are also thought to be the descendants of ancient prokaryotic cells that were incorporated into plant cells through a process called *endosymbiosis*.

Chromoplasts

Chromoplasts are plastids that contain colorful pigments and that may or may not take part in photosynthesis. Carrot root cells, for example, contain chromoplasts filled with the orange pigment carotene. Chromoplasts in flower petal cells contain red, purple, yellow, or white pigments.

Other Plastids

Several other types of plastids share the general features of chloroplasts but differ in content. For example, amyloplasts store starch. Chloroplasts, chromoplasts, and amyloplasts arise from a common precursor, called a *proplastid*.

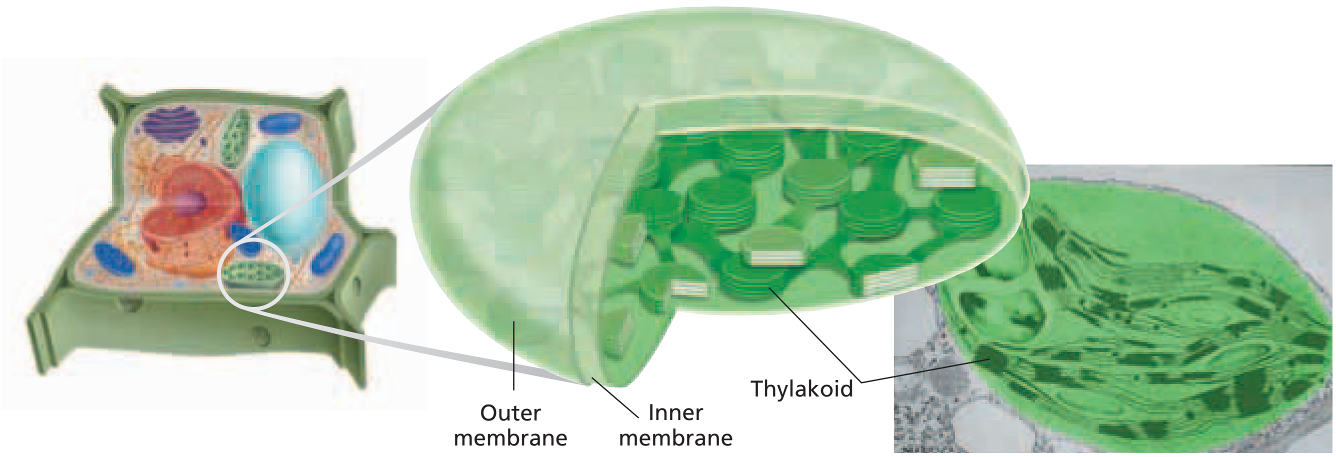
Word Roots and Origins

chloroplast

from the Greek *chloros*, meaning "pale green," and *plastos*, meaning "formed"

FIGURE 4-23

A chloroplast captures energy from sunlight and uses that energy to convert carbon dioxide and water into sugar and other carbohydrates.



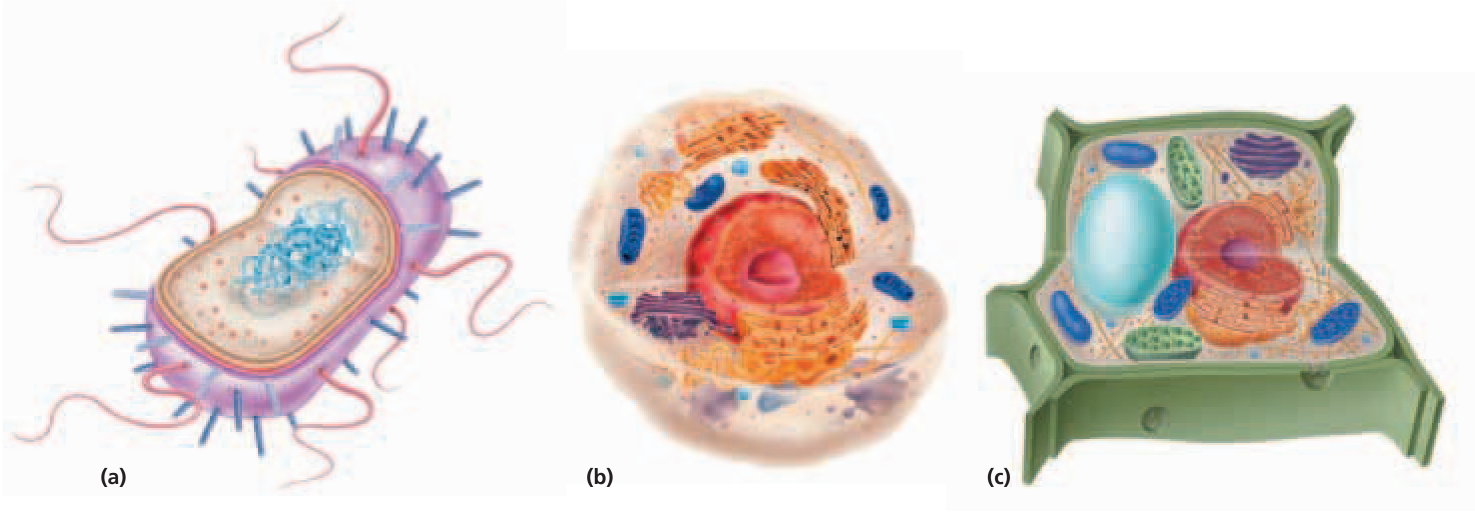


FIGURE 4-24

Prokaryotes (a) can be distinguished from eukaryotes (b and c) in that prokaryotes lack a nucleus and membrane-bound organelles. Plant cells (c) have the same organelles that animal cells do and have a cell wall, a central vacuole, and plastids.

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COMPARING CELLS

All cells share common features, such as a cell membrane, cytoplasm, ribosomes, and genetic material. But there is a high level of diversity among cells, as shown in Figure 4-24. There are significant differences between prokaryotes and eukaryotes. In addition, plant cells have features that are not found in animal cells.

Prokaryotes Versus Eukaryotes

Prokaryotes differ from eukaryotes in that prokaryotes lack a nucleus and membrane-bound organelles. Prokaryotes have a region, called a *nucleoid,* in which their genetic material is concentrated. However, prokaryotes lack an internal membrane system.

Plant Cells Versus Animal Cells

Three unique features distinguish plant cells from animal cells. One is the production of a cell wall by plant cells. Plant cells contain a large central vacuole. Third, plant cells contain a variety of plastids, which are not found in animal cells. Cell walls, central vacuoles, and plastids are unique features that are important to plant function.

SECTION 4 REVIEW

1. Identify three unique features of plant cells.
2. List the differences between the plasma membrane, the primary cell wall, and the secondary cell wall.
3. Identify three functions of plastids.
4. Name three things that may be stored in vacuoles.
5. Describe the features that distinguish prokaryotes from eukaryotes and plant cells from animal cells.

CRITICAL THINKING

6. **Evaluating Viewpoints** One student says vacuoles keep plants from wilting. Another says cell walls do this. Who is right? Explain.
7. **Making Comparisons** If you discovered a new cell, what characteristics would you use to determine which kind of cell it is? Explain.
8. **Analyzing Information** Tobacco plant cells contain a toxic chemical. Why don't tobacco plant cells poison themselves? Explain.