7–2 Eukaryotic Cell Structure

Guide for Reading

Key Concept
- What are the functions of the major cell structures?

Vocabulary
organelle
cytoplasm
nuclear envelope
chromatin
chromosome
nucleolus
ribosome
endoplasmic reticulum
Golgi apparatus
lysosome
vacuole
mitochondrion
chloroplast
cytoskeleton
centriole

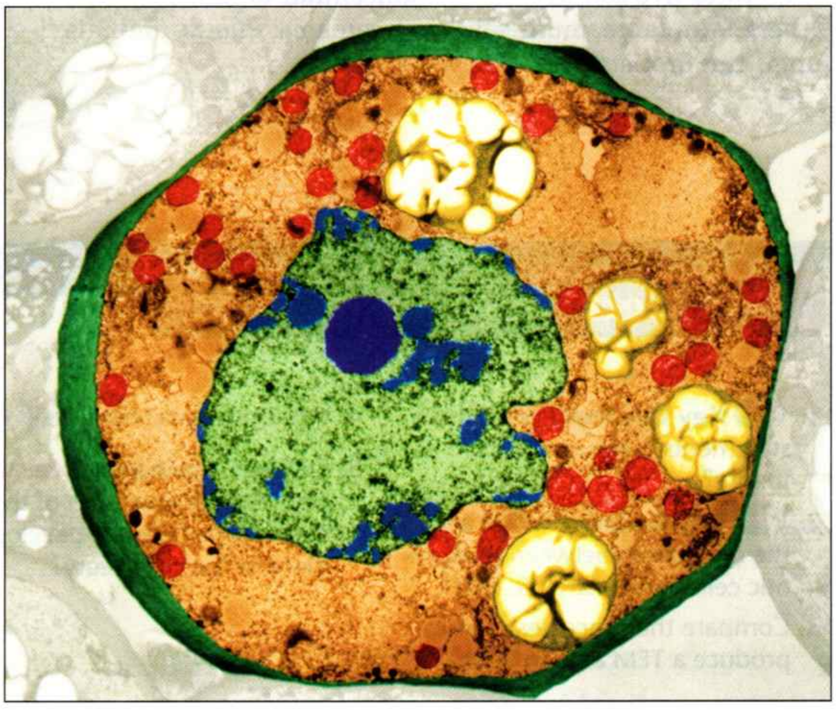
Reading Strategy: Building Vocabulary
Before you read, preview the vocabulary by skimming the section and making a list of the highlighted boldface terms. Leave space to make notes as you read.

At first glance, a factory is a puzzling place. A bewildering variety of machines buzz and clatter, people move quickly in different directions, and the sheer diversity of so much activity can be confusing. However, if you take your time and watch carefully, before long you will begin to identify patterns. What might at first have seemed like chaos suddenly begins to make sense.

Comparing the Cell to a Factory

In some respects, the eukaryotic cell is like a factory. The first time you look at a microscope image of a cell, such as the one in **Figure 7–5,** the cell seems impossibly complex. Look closely at a eukaryotic cell, however, and patterns begin to emerge. To see those patterns more clearly, we'll look at some structures that are common to eukaryotic cells, shown in **Figure 7–6.** Because many of these structures act as if they are specialized organs, these structures are known as **organelles,** literally "little organs."

Cell biologists divide the eukaryotic cell into two major parts: the nucleus and the cytoplasm. The **cytoplasm** is the portion of the cell outside the nucleus. As you will see, the nucleus and cytoplasm work together in the business of life.



(magnification: 1500×)

▶ **Figure 7–5** This electron micrograph of a plant cell shows many of the different types of structures that are found in eukaryotic cells. The cell has been artificially colored so that you can distinguish one structure from another.

Plant and Animal Cells

Figure 7–6 Both plant and animal cells contain a variety of organelles. Some structures are specific to either plant cells or animal cells only. **Interpreting Graphics** ***What structures do plant cells have that animal cells do not?***

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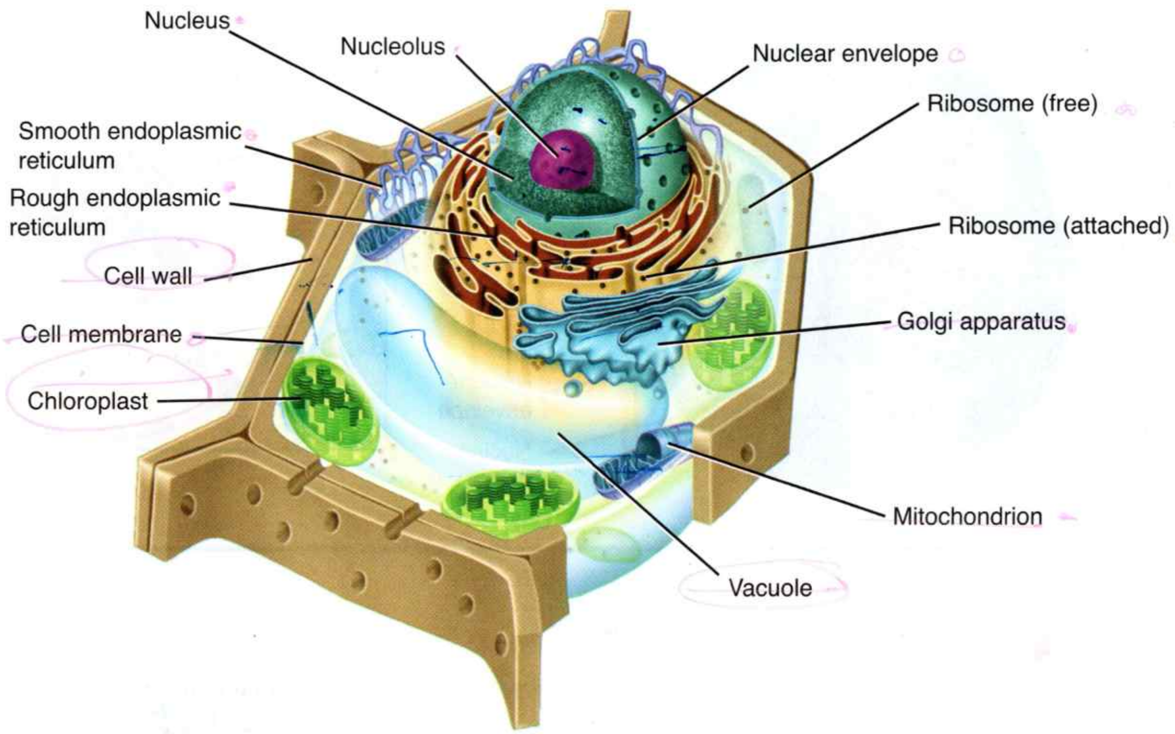
Plant Cell



Animal Cell

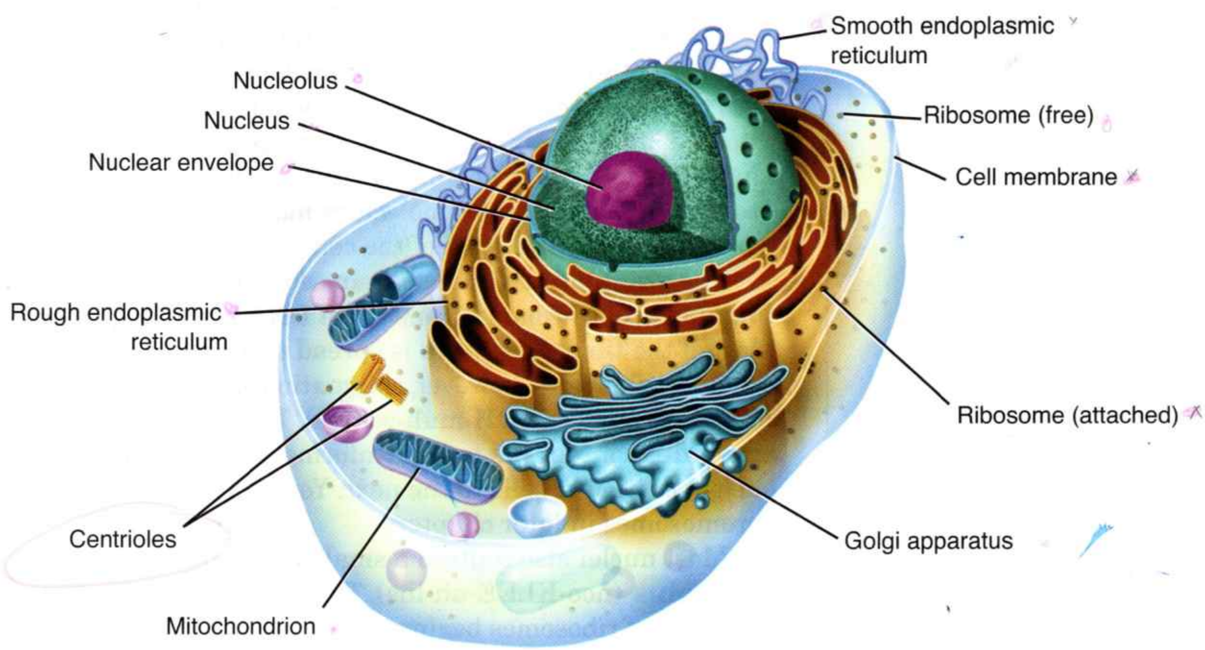
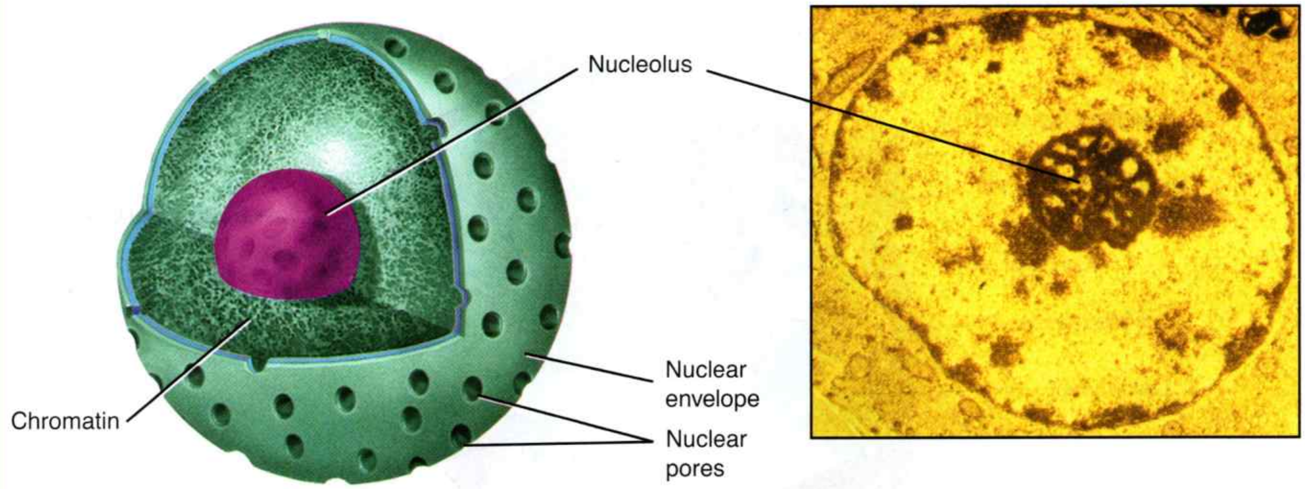


FIGURE 7–7 THE NUCLEUS

The nucleus controls most cell processes and contains the hereditary information of DNA. The DNA combines with protein to form chromatin, which is found throughout the nucleus. The small, dense region in the nucleus is the nucleolus.



Nucleus

In the same way that the main office controls a large factory, the nucleus is the control center of the cell. **The nucleus contains nearly all the cell's DNA and with it the coded instructions for making proteins and other important molecules.** The structure of the nucleus is shown in **Figure 7–7.**

The nucleus is surrounded by a **nuclear envelope** composed of two membranes. The nuclear envelope is dotted with thousands of nuclear pores, which allow material to move into and out of the nucleus. Like messages, instructions, and blueprints moving in and out of a main office, a steady stream of proteins, RNA, and other molecules move through the nuclear pores to and from the rest of the cell.

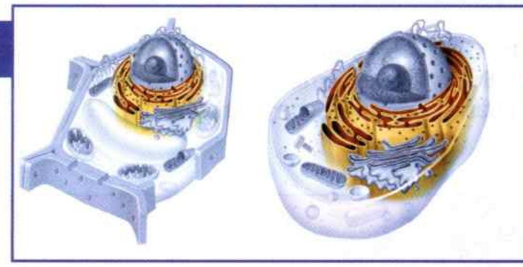
The granular material you can see in the nucleus is called **chromatin.** Chromatin consists of DNA bound to protein. Most of the time, chromatin is spread throughout the nucleus. When a cell divides, however, chromatin condenses to form **chromosomes** (KROH-muh-sohms). These distinct, threadlike structures contain the genetic information that is passed from one generation of cells to the next. You will learn more about chromosomes in later chapters.

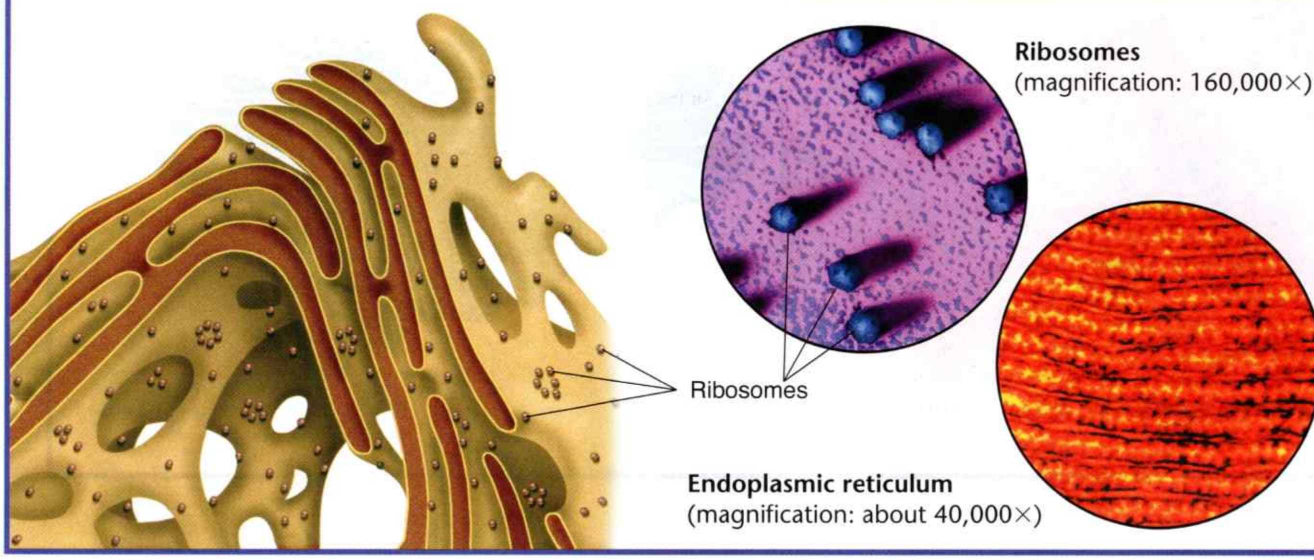
Most nuclei also contain a small, dense region known as the **nucleolus** (noo-KLEE-uh-lus). The nucleolus is where the assembly of ribosomes begins.

CHECKPOINT *What kind of information is contained in chromosomes?*

FIGURE 7–8 ENDOPLASMIC RETICULUM

The endoplasmic reticulum synthesizes proteins for export from the cell. The rough endoplasmic reticulum, shown here, gets its name from the "rough" appearance of the ribosomes on its surface.





Ribosomes

One of the most important jobs carried out in the cellular "factory" is making proteins. **Proteins are assembled on ribosomes.** **Ribosomes** are small particles of RNA and protein found throughout the cytoplasm. They produce proteins by following coded instructions that come from the nucleus. Each ribosome, in its own way, is like a small machine in a factory, turning out proteins on orders that come from its "boss"—the cell nucleus. Cells that are active in protein synthesis are often packed with ribosomes.

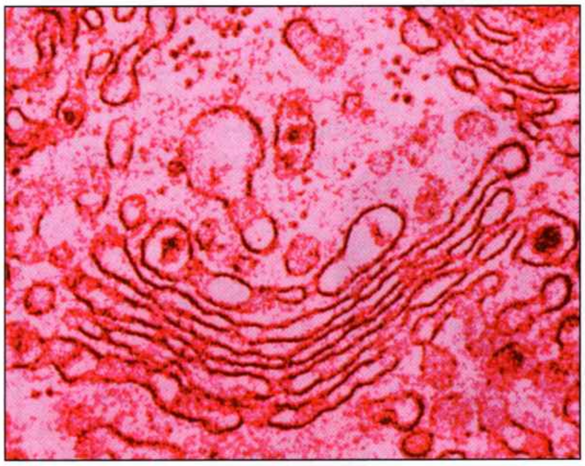
Endoplasmic Reticulum

Eukaryotic cells also contain an internal membrane system known as the **endoplasmic reticulum** (en-doh-PLAZ-mik rih-TIK-yuh-lum), or ER. **The endoplasmic reticulum is the site where lipid components of the cell membrane are assembled, along with proteins and other materials that are exported from the cell.**

The portion of the ER involved in the synthesis of proteins is called rough endoplasmic reticulum, or rough ER. It is given this name because of the ribosomes found on its surface. Newly made proteins leave these ribosomes and are inserted into the rough ER, where they may be chemically modified.

FIGURE 7–9 GOLGI APPARATUS

The Golgi apparatus modifies, sorts, and packages proteins. Notice the stacklike membranes that make up the Golgi apparatus in this transmission electron micrograph.



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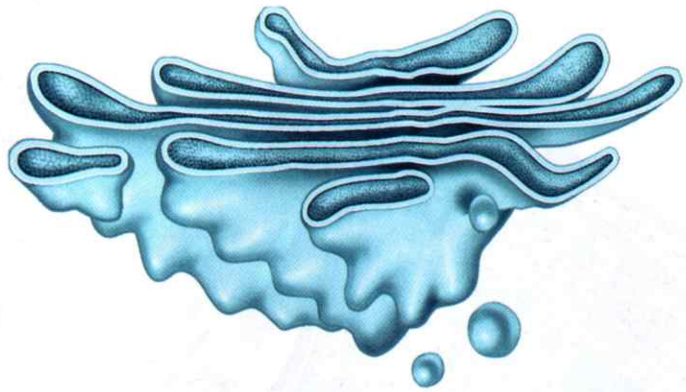


Proteins that are released, or exported, from the cell are synthesized on the rough ER, as are many membrane proteins. Rough ER is abundant in cells that produce large amounts of protein for export. Other cellular proteins are made on "free" ribosomes, which are not attached to membranes.

The other portion of the ER is known as smooth endoplasmic reticulum (smooth ER) because ribosomes are not found on its surface. In many cells, the smooth ER contains collections of enzymes that perform specialized tasks, including the synthesis of membrane lipids and the detoxification of drugs. Liver cells, which play a key role in detoxifying drugs, often contain large amounts of smooth ER.

Golgi Apparatus

Proteins produced in the rough ER move next into an organelle called the **Golgi apparatus,** discovered by the Italian scientist Camillo Golgi. As you can see in **Figure 7–9,** Golgi appears as a stack of closely apposed membranes. **The function of the Golgi apparatus is to modify, sort, and package proteins and other materials from the endoplasmic reticulum for storage in the cell or secretion outside the cell.** The Golgi apparatus is somewhat like a customization shop, where the finishing touches are put on proteins before they are ready to leave the "factory." From the Golgi apparatus, proteins are then "shipped" to their final destinations throughout the cell or outside of the cell.

Lysosomes

Even the neatest, cleanest factory needs a cleanup crew, and that's what lysosomes (LY-suh-sohmz) are. **Lysosomes** are small organelles filled with enzymes. One function of lysosomes is the digestion, or breakdown, of lipids, carbohydrates, and proteins into small molecules that can be used by the rest of the cell.

Lysosomes are also involved in breaking down organelles that have outlived their usefulness. Lysosomes perform the vital function of removing "junk" that might otherwise accumulate and clutter up the cell. A number of serious human diseases, including Tay-Sachs disease, can be traced to lysosomes that fail to function properly.

CHECKPOINT *What is the role of lysosomes?*

Vacuoles

Every factory needs a place to store things, and cells contain places for storage as well. Some kinds of cells contain saclike structures called **vacuoles** (VAK-yoo-ohlz) that store materials such as water, salts, proteins, and carbohydrates. In many plant cells there is a single, large central vacuole filled with liquid. The pressure of the central vacuole in these cells makes it possible for plants to support heavy structures such as leaves and flowers.

Vacuoles are also found in some unicellular organisms and in some animals. The paramecium in **Figure 7–10** contains a vacuole called a contractile vacuole. By contracting rhythmically, this specialized vacuole pumps excess water out of the cell. The control of water content within the cell is just one example of an important process known as homeostasis. Homeostasis is the maintenance of a controlled internal environment.

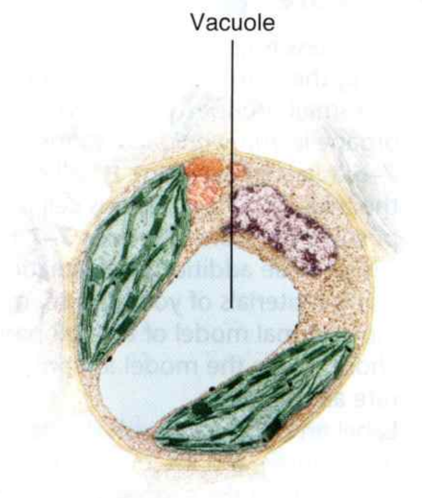
Mitochondria and Chloroplasts

All living things require a source of energy. Factories are hooked up to the local power company, but what about cells? Most cells get energy in one of two ways—from food molecules or from the sun.

Mitochondria Nearly all eukaryotic cells, including plants, contain **mitochondria** (myt-oh-KAHN-dree-uh; singular: mitochondrion). **Mitochondria are organelles that convert the chemical energy stored in food into compounds that are more convenient for the cell to use.** Mitochondria are enclosed by two membranes—an outer membrane and an inner membrane. The inner membrane is folded up inside the organelle.

One of the most interesting aspects of mitochondria is the way in which they are inherited. In humans, all or nearly all of our mitochondria come from the cytoplasm of the ovum, or egg cell. This means that when your relatives are discussing which side of the family should take credit for your best characteristics, you can tell them that you got your mitochondria from Mom!

Figure 7–10 Vacuoles have a variety of functions. In the *Coleus* plant cell (top), the large blue structure is the central vacuole that stores salts, proteins, and carbohydrates. The paramecium (bottom) contains contractile vacuoles that fill with water and then pump the water out of the cell. **Applying Concepts** ***How do vacuoles help support plant structures?***



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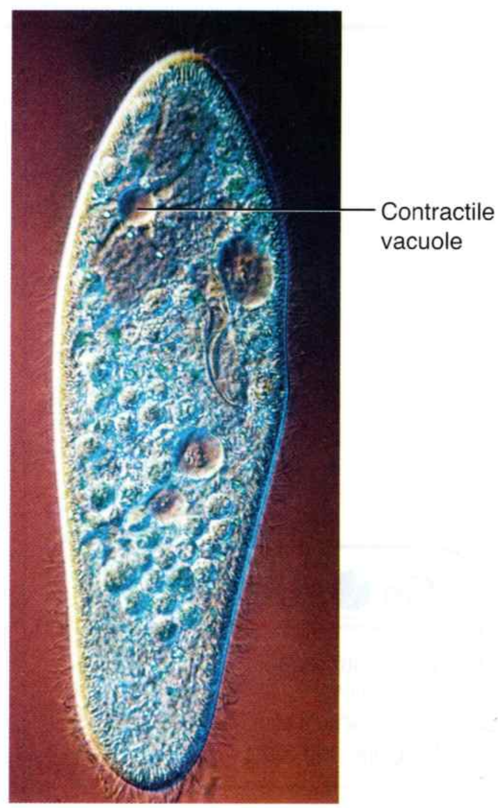

Quick Lab

How can you make a model of a cell?

Materials variety of craft supplies, index cards

Procedure

1. Your class is going to make a model of a plant cell using the whole classroom. Work with a partner or in a small group to decide what cell part or organelle you would like to model. (Use **Figure 7–6** as a starting point. It will give you an idea of the relative sizes of various cell parts and their possible positions. **Figures 7–7** through **7–10** can provide additional information.)
2. Using materials of your choice, make a three-dimensional model of the cell part or organelle you chose. Make the model as complete and as accurate as you can.
3. Label an index card with the name of your cell part or organelle and list its main features and functions. Attach the card to your model.
4. Attach your model to an appropriate place in the room. If possible, attach your model to another related cell part or organelle.

Analyze and Conclude

1. **Inferring** What are the functions of the different organelles in plant cells?
2. **Calculating** Assume that a typical plant cell is 50 micrometers wide. Calculate the scale of your classroom cell model. (*Hint:* Divide the width of the classroom by the width of a cell, making sure to use the same units.)
3. **Comparing and Contrasting** How is your model cell part or organelle similar to the real cell part or organelle? How is it different?
4. **Evaluating** Based on your work with this model, describe how you could make a better model. Specify what new information the improved model would demonstrate.

Chloroplasts Plants and some other organisms contain **chloroplasts.** **Chloroplasts are organelles that capture the energy from sunlight and convert it into chemical energy in a process called photosynthesis.** Chloroplasts are the biological equivalents of solar power plants. Like mitochondria, chloroplasts are surrounded by two membranes. Inside the organelle are large stacks of other membranes, which contain the green pigment chlorophyll. Interestingly, chloroplasts and mitochondria contain their own genetic information in the form of small DNA molecules. This has led to the idea that they may have descended from independent microorganisms. This idea, called the endosymbiotic theory, will be discussed in Chapter 17.

Cytoskeleton

A supporting structure and a transportation system complete our picture of the cell as a factory. As you know, a factory building is supported by steel or cement beams and by columns that support its walls and roof. Eukaryotic cells are given their shape and internal organization by a supporting structure known as the **cytoskeleton.**

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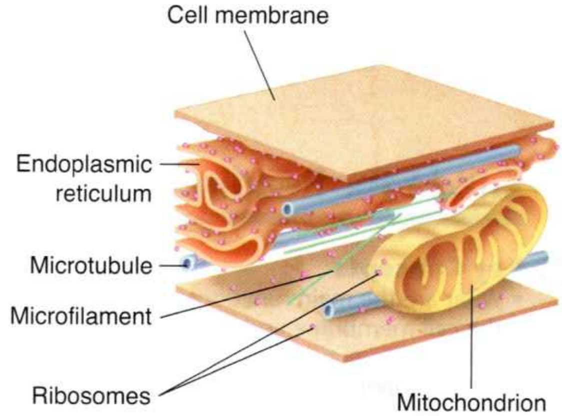
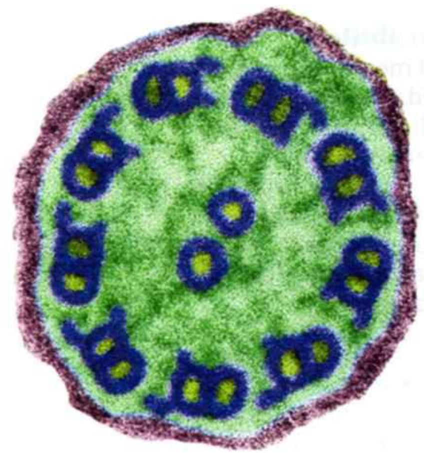
The cytoskeleton is a network of protein filaments that helps the cell to maintain its shape. The cytoskeleton is also involved in movement. Microfilaments and microtubules are two of the principal protein filaments that make up the cytoskeleton.

Microfilaments Microfilaments are threadlike structures made of a protein called actin. They form extensive networks in some cells and produce a tough, flexible framework that supports the cell. Microfilaments also help cells move. Microfilament assembly and disassembly is responsible for the cytoplasmic movements that allow cells, such as amoebas, to crawl along surfaces.

Microtubules Microtubules are hollow structures made up of proteins known as tubulins. In many cells, they play critical roles in maintaining cell shape. Microtubules are also important in cell division, where they form a structure known as the mitotic spindle, which helps to separate chromosomes. In animal cells, structures known as centrioles are also formed from tubulin. **Centrioles** are located near the nucleus and help to organize cell division. Centrioles are not found in plant cells.

Microtubules also help to build projections from the cell surface, which are known as cilia (singular: cilium) and flagella (singular: flagellum), that enable cells to swim rapidly through liquids. As you can see in **Figure 7–11**, the microtubules are arranged in a "9 + 2" pattern. Small cross-bridges between the microtubules in these organelles use chemical energy to generate force, allowing cells to produce controlled movements using the cytoskeleton.





▲ **Figure 7–11 The cytoskeleton is a network of protein filaments that helps the cell to maintain its shape and is involved in many forms of cell movement.** The micrograph shows a cross section of an epithelial cell cilia. You can see the nine pairs of microtubules surrounding the two single microtubules, hence the "9 + 2" pattern.

7–2 Section Assessment

1. **Key Concept** Describe the functions of the endoplasmic reticulum, Golgi apparatus, chloroplast, and mitochondrion.
2. Describe the role of the nucleus in the cell.
3. What are two functions of the cytoskeleton?
4. How is a cell like a factory?
5. **Critical Thinking Inferring** You examine an unknown cell under the microscope and discover that the cell contains chloroplasts. What type of organism could you infer that the cell came from?

Thinking Visually

Creating Artwork

Create a work of art—such as a painting or sculpture—depicting a cross section of a plant cell or an animal cell. Include all the different organelles described in this section that would be found in that type of cell. Label each organelle in your artwork.