SECTION 2

Eukaryotic Cells

Most eukaryotic cells are small. For a long time after cells were discovered, scientists could not see what was going on inside cells. They did not know how complex cells are.

Now, scientists know a lot about eukaryotic cells. These cells have many parts that work together and keep the cell alive.

READING WARM-UP

Objectives

- Identify the different parts of a eukaryotic cell.
- Explain the function of each part of a eukaryotic cell.

Terms to Learn

cell wall
ribosome
endoplasmic reticulum
mitochondrion
Golgi complex
vesicle
lysosome

READING STRATEGY

Reading Organizer As you read this section, make a table comparing plant cells and animal cells.

Cell Wall

Some eukaryotic cells have cell walls. A **cell wall** is a rigid structure that gives support to a cell. The cell wall is the outermost structure of a cell. Plants and algae have cell walls made of cellulose (SEL yoo LOHS) and other materials. *Cellulose* is a complex sugar that most animals can't digest.

The cell walls of plant cells allow plants to stand upright. In some plants, the cells must take in water for the cell walls to keep their shape. When such plants lack water, the cell walls collapse and the plant droops. **Figure 1** shows a cross section of a plant cell and a close-up of the cell wall.

Fungi, including yeasts and mushrooms, also have cell walls. Some fungi have cell walls made of *chitin* (KIE tin). Other fungi have cell walls made from a chemical similar to chitin. Eubacteria and archaebacteria also have cell walls, but those walls are different from plant or fungal cell walls.

Reading Check **What types of cells have cell walls?** *(See the Appendix for answers to Reading Checks.)*

cell wall a rigid structure that surrounds the cell membrane and provides support to the cell

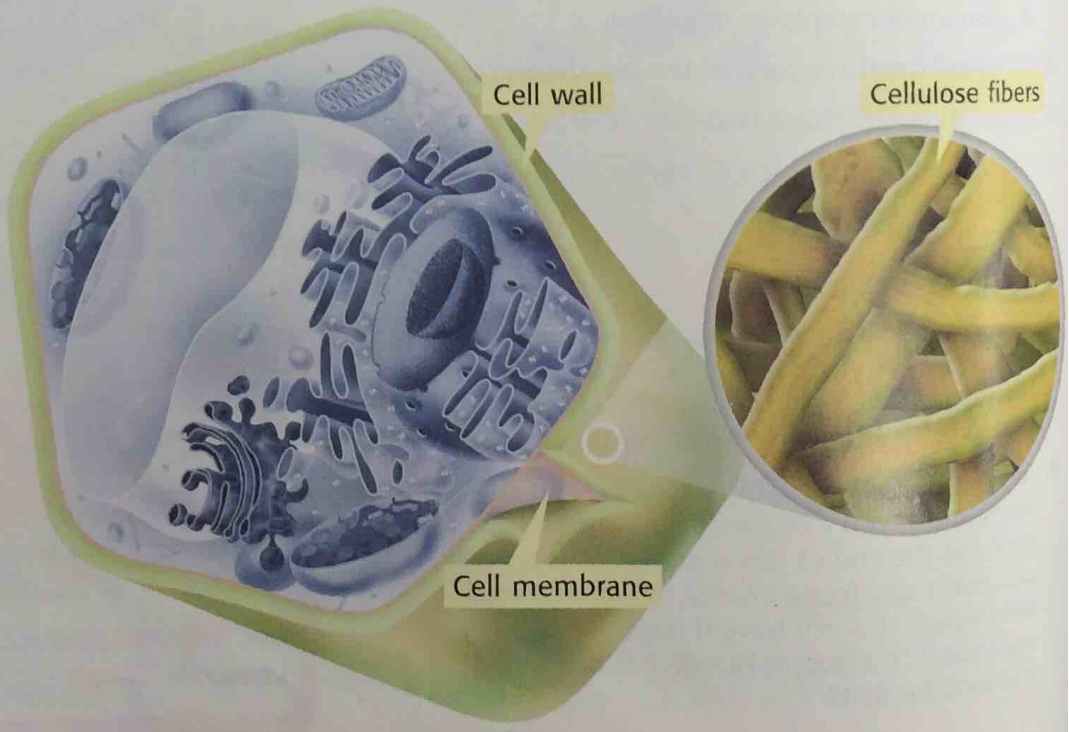


Figure 1 *The cell walls of plant cells help plants retain their shape. Plant cell walls are made of cellulose.*

Cell Membrane

All cells have a cell membrane. The *cell membrane* is a protective barrier that encloses a cell. It separates the cell's contents from the cell's environment. The cell membrane is the outermost structure in cells that lack a cell wall. In cells that have a cell wall, the cell membrane lies just inside the cell wall.

The cell membrane contains proteins, lipids, and phospholipids. *Lipids,* which include fats and cholesterol, are a group of compounds that do not dissolve in water. The cell membrane has two layers of phospholipids (FAHS foh LIP idz), shown in **Figure 2.** A *phospholipid* is a lipid that contains phosphorus. Lipids are "water fearing," or *hydrophobic*. Lipid ends of phospholipids form the inner part of the membrane. Phosphorus-containing ends of the phospholipids are "water loving," or *hydrophilic*. These ends form the outer part of the membrane.

Some of the proteins and lipids control the movement of materials into and out of the cell. Some of the proteins form passageways. Nutrients and water move into the cell, and wastes move out of the cell, through these protein passageways.

Reading Check **What are two functions of a cell membrane?**

CONNECTION TO Language Arts

WRITING SKILL **The Great Barrier**

In your **science journal,** write a science fiction story about tiny travelers inside a person's body. These little explorers need to find a way into or out of a cell to solve a problem. You may need to do research to find out more about how the cell membrane works. Illustrate your story.

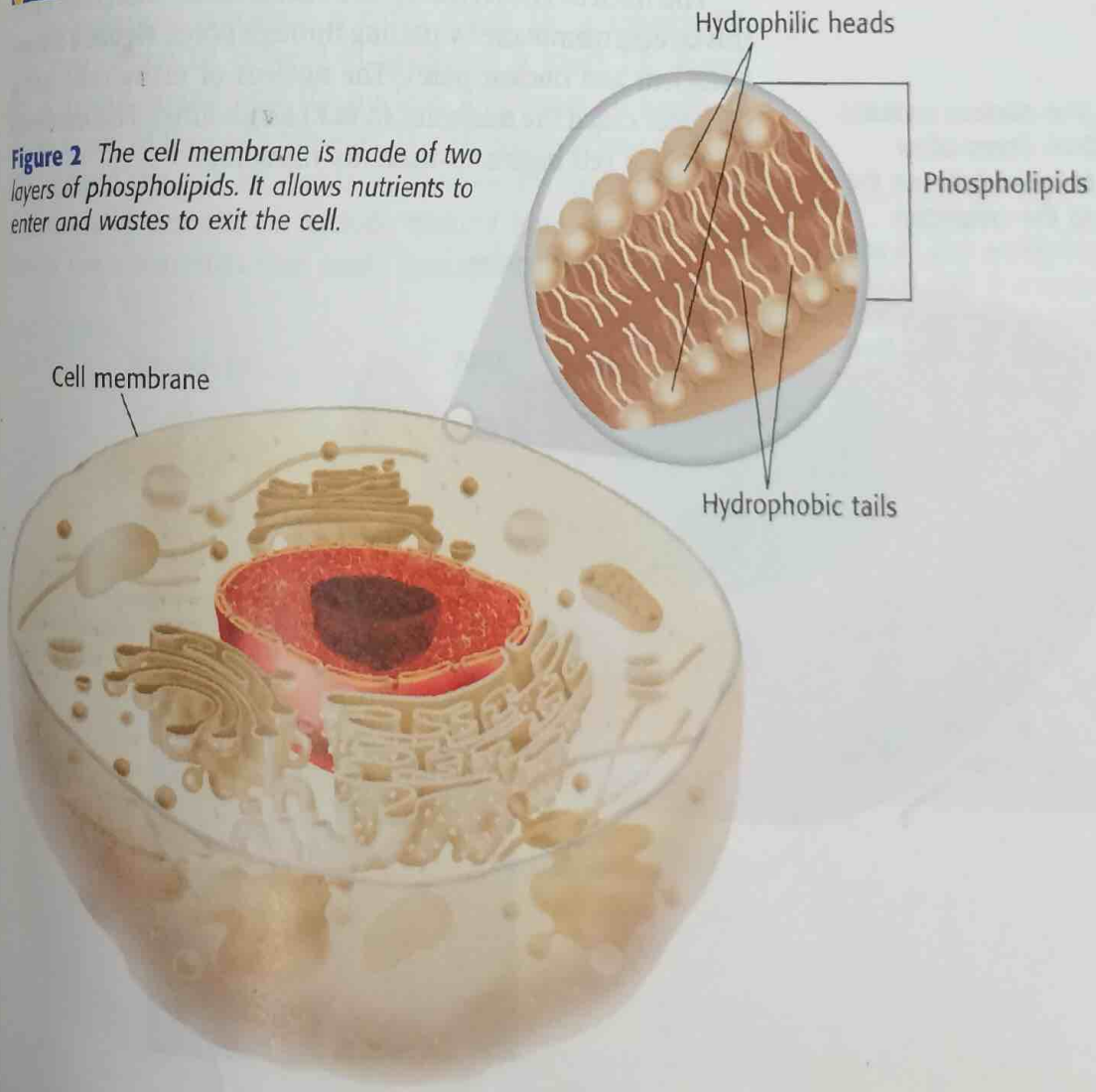


Figure 2 *The cell membrane is made of two layers of phospholipids. It allows nutrients to enter and wastes to exit the cell.*

Cytoskeleton

The *cytoskeleton* (SIET oh SKEL uh tuhn) is a web of proteins in the cytoplasm. The cytoskeleton, shown in **Figure 3,** acts as both a muscle and a skeleton. It keeps the cell's membranes from collapsing. The cytoskeleton also helps some cells move.

The cytoskeleton is made of three types of protein. One protein is a hollow tube. The other two are long, stringy fibers. One of the stringy proteins is also found in muscle cells.

Reading Check What is the cytoskeleton?

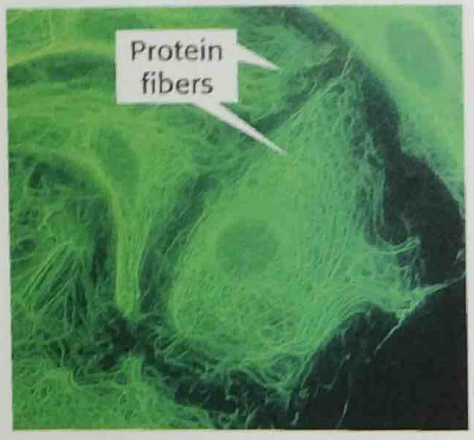


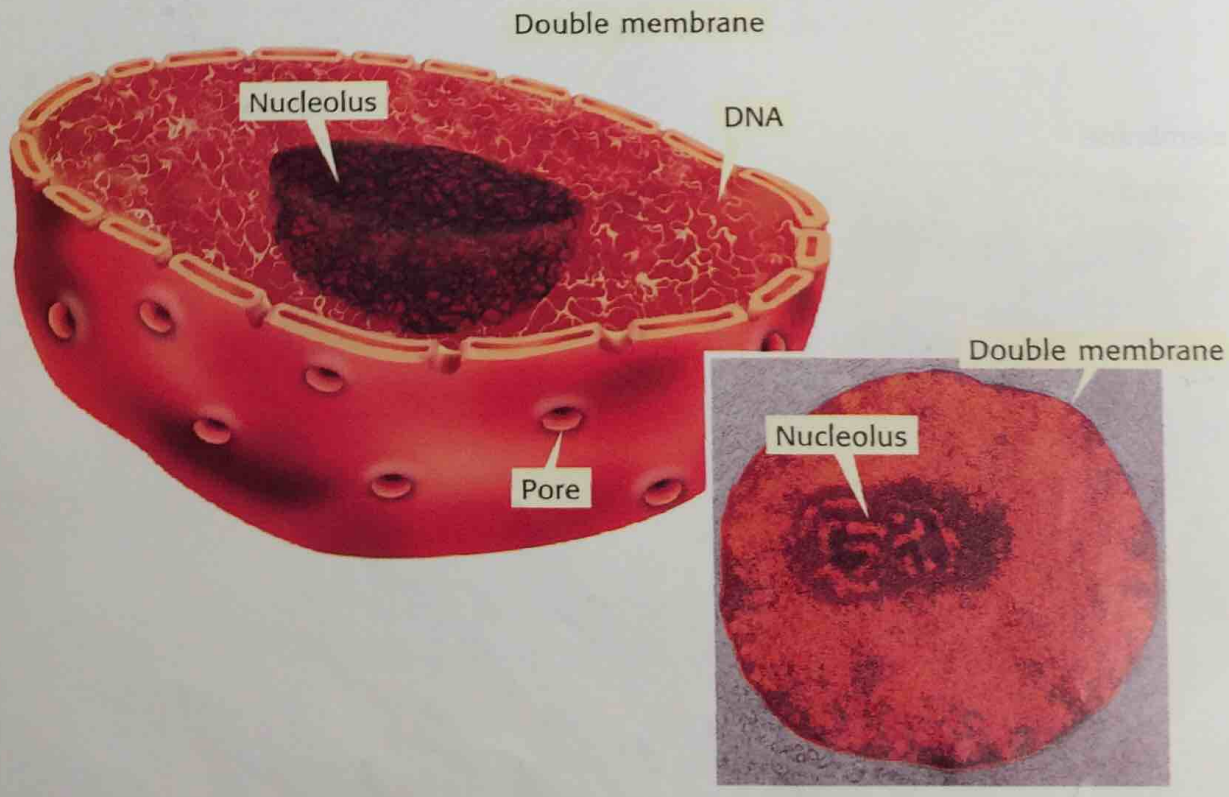
Figure 3 *The cytoskeleton, made of protein fibers, helps a cell retain its shape, move in its environment, and move its organelles.*

Nucleus

All eukaryotic cells have the same basic membrane-bound organelles, starting with the nucleus. The *nucleus* is a large organelle in a eukaryotic cell. It contains the cell's DNA, or genetic material. DNA contains the information on how to make a cell's proteins. Proteins control the chemical reactions in a cell. They also provide structural support for cells and tissues. But proteins are not made in the nucleus. Messages for how to make proteins are copied from the DNA. These messages are then sent out of the nucleus through the membranes.

The nucleus is covered by two membranes. Materials cross this double membrane by passing through pores. **Figure 4** shows a nucleus and nuclear pores. The nucleus of many cells has a dark area called the nucleolus (noo KLEE uh luhs). The *nucleolus* is where a cell begins to make its ribosomes.

Figure 4 *The nucleus contains the cell's DNA. Pores allow materials to move between the nucleus and the cytoplasm.*



Ribosomes

Organelles that make proteins are called **ribosomes.** Ribosomes are the smallest of all organelles. And there are more ribosomes in a cell than there are any other organelles. Some ribosomes float freely in the cytoplasm. Others are attached to membranes or the cytoskeleton. Unlike most organelles, ribosomes are not covered by a membrane.

Proteins are made within the ribosomes. Proteins are made of amino acids. An *amino acid* is any one of about 20 different organic molecules that are used to make proteins. All cells need proteins to live. All cells have ribosomes.

ribosome cell organelle composed of RNA and protein; the site of protein synthesis

endoplasmic reticulum a system of membranes that is found in a cell's cytoplasm and that assists in the production, processing, and transport of proteins and in the production of lipids

Endoplasmic Reticulum

Many chemical reactions take place in a cell. Many of these reactions happen on or in the endoplasmic reticulum (EN doh PLAZ mik ri TIK yuh luhm). The **endoplasmic reticulum,** or ER, is a system of folded membranes in which proteins, lipids, and other materials are made. The ER is shown in **Figure 5.**

The ER is part of the internal delivery system of the cell. Its folded membrane contains many tubes and passageways. Substances move through the ER to different places in the cell.

Endoplasmic reticulum is either rough ER or smooth ER. The part of the ER covered in ribosomes is rough ER. Rough ER is usually found near the nucleus. Ribosomes on rough ER make many of the cell's proteins. The ER delivers these proteins throughout the cell. ER that lacks ribosomes is smooth ER. The functions of smooth ER include making lipids and breaking down toxic materials that could damage the cell.

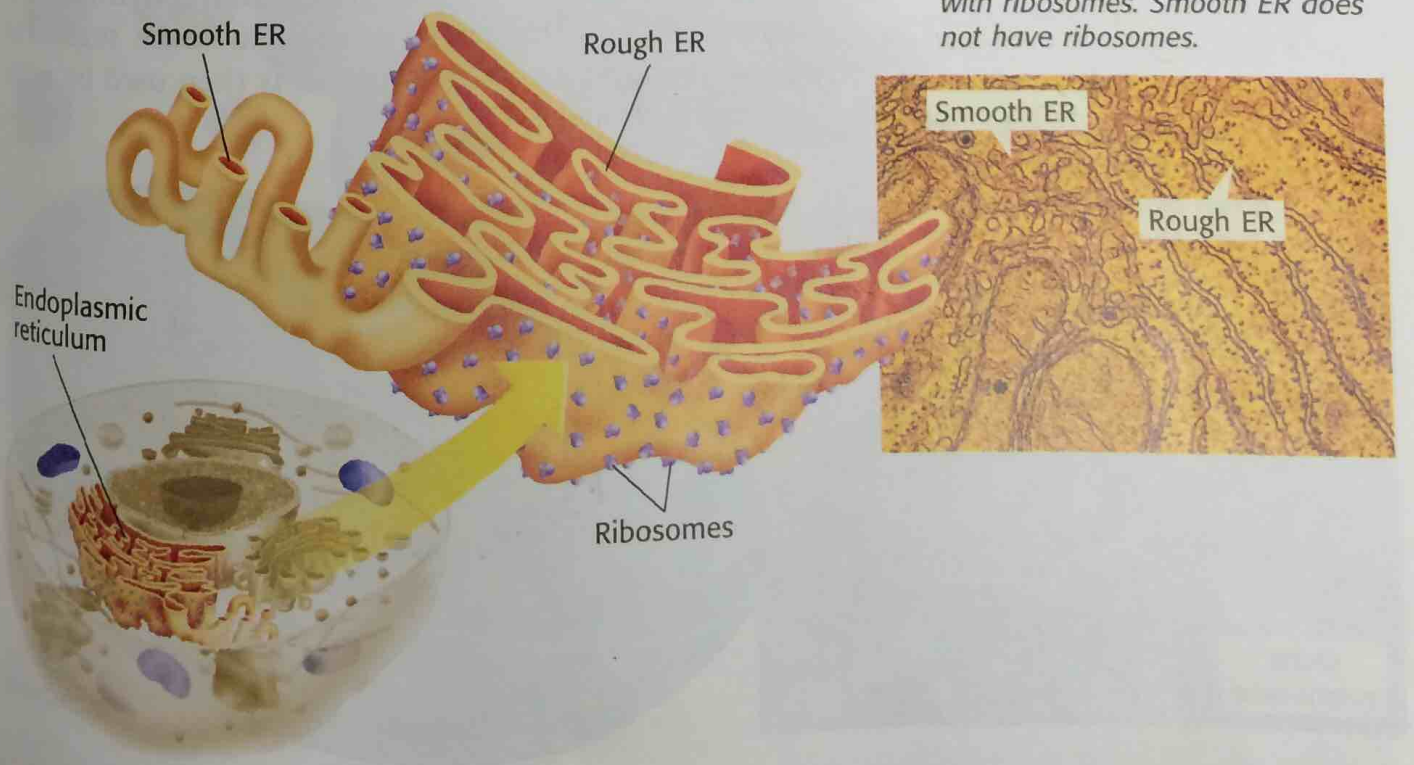


Figure 5 *The endoplasmic reticulum (ER) is a system of membranes. Rough ER is covered with ribosomes. Smooth ER does not have ribosomes.*

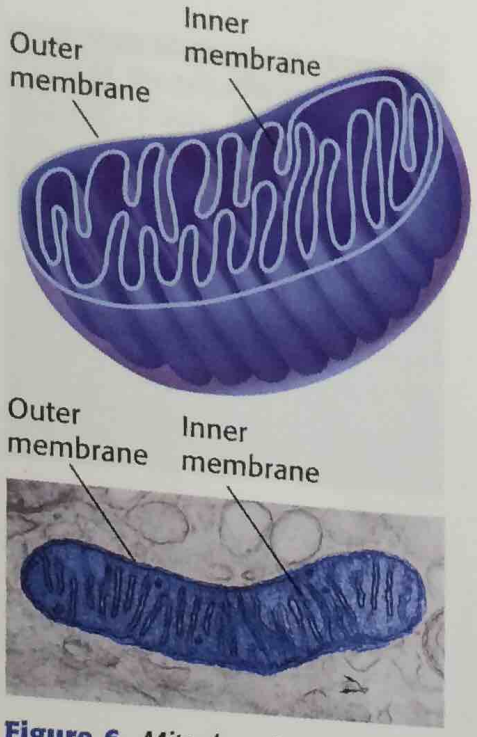


Figure 6 *Mitochondria break down sugar and make ATP. ATP is produced on the inner membrane.*

mitochondrion in eukaryotic cells, the cell organelle that is surrounded by two membranes and that is the site of cellular respiration

Mitochondria

A mitochondrion (MIET oh KAHN dree uhn) is the main power source of a cell. A **mitochondrion** is the organelle in which sugar is broken down to produce energy. Mitochondria are covered by two membranes, as shown in **Figure 6.** Energy released by mitochondria is stored in a substance called *ATP* (adenosine triphosphate). The cell then uses ATP to do work. ATP can be made at several places in a cell. But most of a cell's ATP is made in the inner membrane of the cell's mitochondria.

Most eukaryotic cells have mitochondria. Mitochondria are the size of some bacteria. Like bacteria, mitochondria have their own DNA, and mitochondria can divide within a cell.

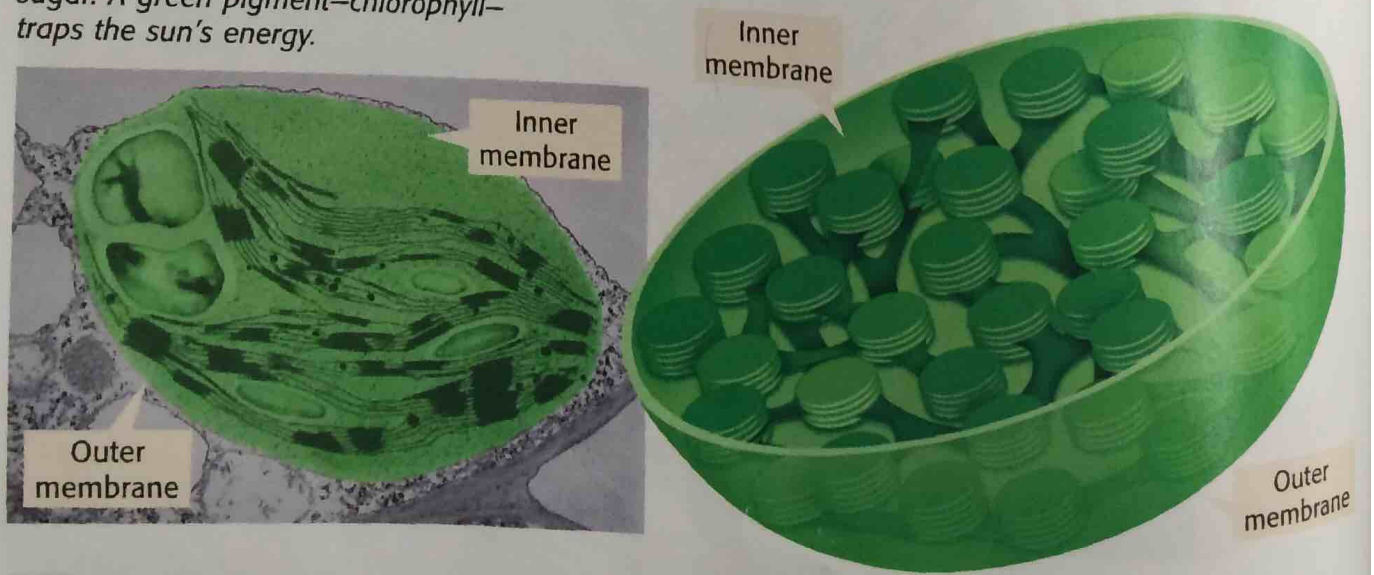
Reading Check **Where is most of a cell's ATP made?**

Chloroplasts

Animal cells cannot make their own food. Plants and algae are different. They have chloroplasts (KLAWR uh PLASTS) in some of their cells. *Chloroplasts* are organelles in plant and algae cells in which photosynthesis takes place. Like mitochondria, chloroplasts have two membranes and their own DNA. A chloroplast is shown in **Figure 7.** *Photosynthesis* is the process by which plants and algae use sunlight, carbon dioxide, and water to make sugar and oxygen.

Chloroplasts are green because they contain *chlorophyll,* a green pigment. Chlorophyll is found inside the inner membrane of a chloroplast. Chlorophyll traps the energy of sunlight, which is used to make sugar. The sugar produced by photosynthesis is then used by mitochondria to make ATP.

Figure 7 *Chloroplasts harness and use the energy of the sun to make sugar. A green pigment–chlorophyll–traps the sun's energy.*



Golgi Complex

The organelle that packages and distributes proteins is called the **Golgi complex** (GOHL jee KAHM PLEKS). It is named after Camillo Golgi, the Italian scientist who first identified the organelle.

The Golgi complex looks like smooth ER, as shown in **Figure 8.** Lipids and proteins from the ER are delivered to the Golgi complex. There, the lipids and proteins may be modified to do different jobs. The final products are enclosed in a piece of the Golgi complex's membrane. This membrane pinches off to form a small bubble. The bubble transports its contents to other parts of the cell or out of the cell.

Golgi complex cell organelle that helps make and package materials to be transported out of the cell

vesicle a small cavity or sac that contains materials in a eukaryotic cell

Cell Compartments

The bubble that forms from the Golgi complex's membrane is a vesicle. A **vesicle** (VES i kuhl) is a small sac that surrounds material to be moved into or out of a cell. All eukaryotic cells have vesicles. Vesicles also move material within a cell. For example, vesicles carry new protein from the ER to the Golgi complex. Other vesicles distribute material from the Golgi complex to other parts of the cell. Some vesicles form when part of the cell membrane surrounds an object outside the cell.

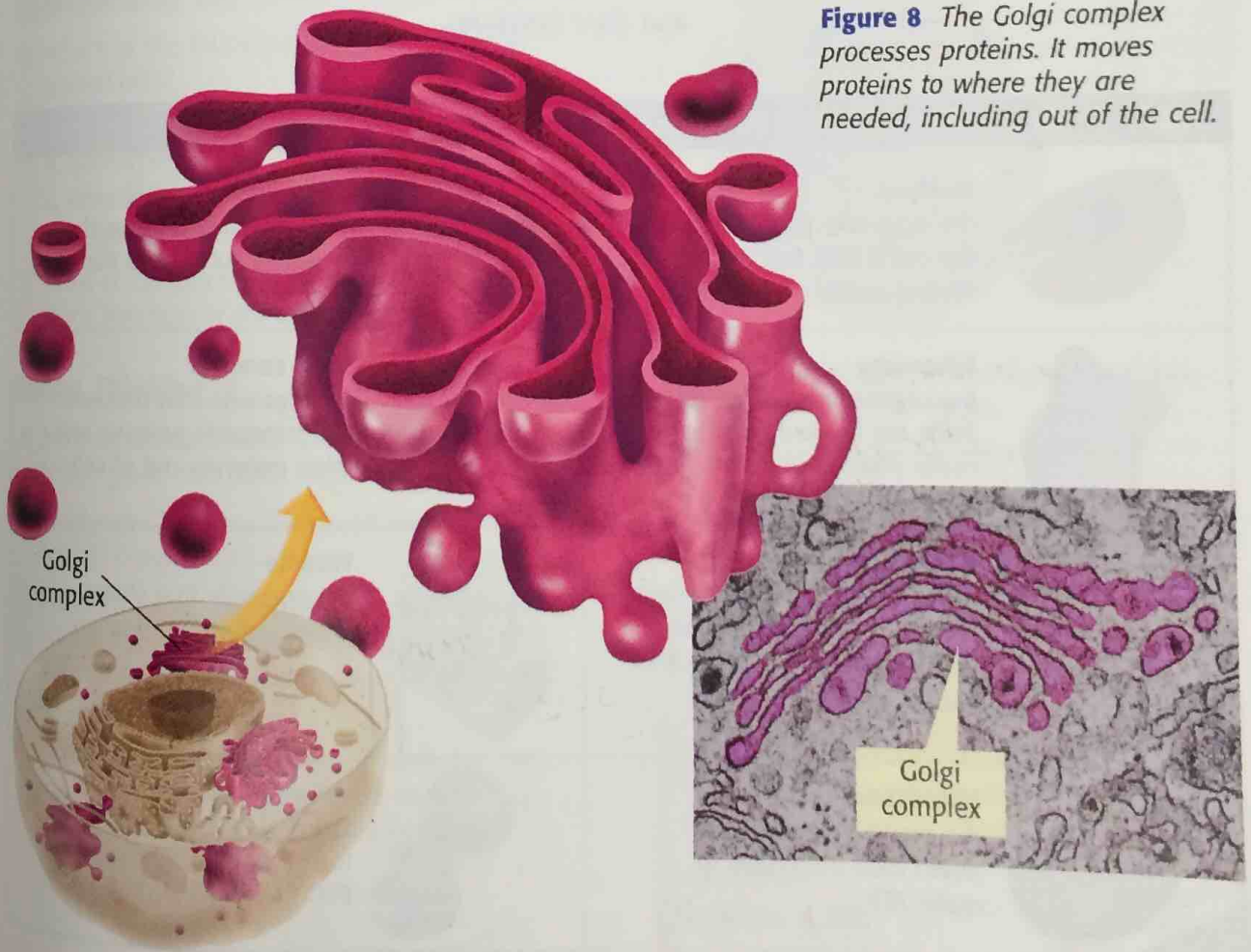
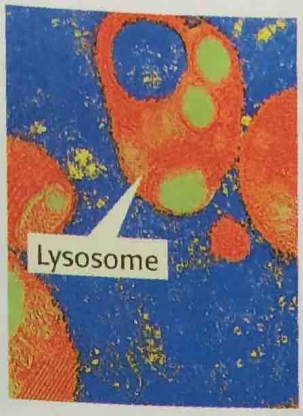


Figure 8 *The Golgi complex processes proteins. It moves proteins to where they are needed, including out of the cell.*



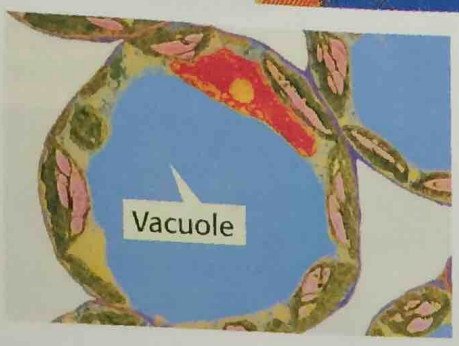


Figure 9
Lysosomes digest materials inside a cell. In plant and fungal cells, vacuoles often perform the same function.

Cellular Digestion

Lysosomes (LIE suh SOHMZ) are vesicles that are responsible for digestion inside a cell. **Lysosomes** are organelles that contain digestive enzymes. They destroy worn-out or damaged organelles, get rid of waste materials, and protect the cell from foreign invaders. Lysosomes, which come in a wide variety of sizes and shapes, are shown in **Figure 9.**

Lysosomes are found mainly in animal cells. When eukaryotic cells engulf particles, they enclose the particles in vesicles. Lysosomes bump into these vesicles and pour enzymes into them. These enzymes digest the particles in the vesicles.

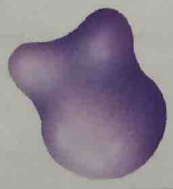
Reading Check **Why are lysosomes important?**

lysosome a cell organelle that contains digestive enzymes

Vacuoles

A *vacuole* (VAK yoo OHL) is a large vesicle. In plant and fungal cells, some vacuoles act like large lysosomes. They store digestive enzymes and aid in digestion within the cell. Other vacuoles in plant cells store water and other liquids. Vacuoles that are full of water, such as the one in **Figure 9,** help support the cell. Some plants wilt when their vacuoles lose water. **Table 1** shows some organelles and their functions.

Table 1 **Organelles and Their Functions**

 **Nucleus** the organelle that contains the cell's DNA and is the control center of the cell	 **Chloroplast** the organelle that uses the energy of sunlight to make food
 **Ribosome** the organelle in which amino acids are hooked together to make proteins	 **Golgi complex** the organelle that processes and transports proteins and other materials out of cell
 **Endoplasmic reticulum** the organelle that makes lipids, breaks down drugs and other substances, and packages proteins for Golgi complex	 **Vacuole** the organelle that stores water and other materials
 **Mitochondria** the organelle that breaks down food molecules to make ATP	 **Lysosome** the organelle that digests food particles, wastes, cell parts, and foreign invaders

SECTION
Review

Summary

- Eukaryotic cells have organelles that perform functions that help cells remain alive.
- All cells have a cell membrane. Some cells have a cell wall. Some cells have a cytoskeleton.
- The nucleus of a eukaryotic cell contains the cell's genetic material, DNA.
- Ribosomes are the organelles that make proteins. Ribosomes are not covered by a membrane.
- The endoplasmic reticulum (ER) and the Golgi complex make and process proteins before the proteins are transported to other parts of the cell or out of the cell.
- Mitochondria and chloroplasts are energy-producing organelles.
- Lysosomes are organelles responsible for digestion within a cell. In plant cells, organelles called *vacuoles* store cell materials and sometimes act like large lysosomes.

Using Key Terms

1. In your own words, write a definition for each of the following terms: *ribosome*, *lysosome*, and *cell wall*.

Understanding Key Ideas

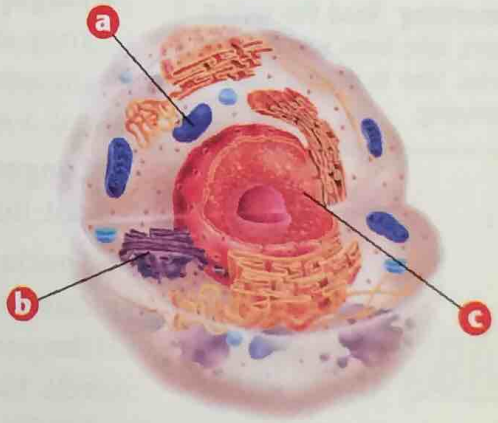
2. Which of the following are found mainly in animal cells?
   - **a.** mitochondria
   - **b.** lysosomes
   - **c.** ribosomes
   - **d.** Golgi complexes
3. What is the function of a Golgi complex? What is the function of the endoplasmic reticulum?

Critical Thinking

4. **Making Comparisons** Describe three ways in which plant cells differ from animal cells.
5. **Applying Concepts** Every cell needs ribosomes. Explain why.
6. **Predicting Consequences** A certain virus attacks the mitochondria in cells. What would happen to a cell if all of its mitochondria were destroyed?
7. **Expressing Opinions** Do you think that having chloroplasts gives plant cells an advantage over animal cells? Support your opinion.

Interpreting Graphics

Use the diagram below to answer the questions that follow.



8. Is this a diagram of a plant cell or an animal cell? Explain how you know.
9. What organelle does the letter *b* refer to?