Getting Started

Objectives

7.2.1 Describe the structure and function of the cell nucleus.
7.2.2 Describe the role of vacuoles, lysosomes, and the cytoskeleton.
7.2.3 Identify the role of ribosomes, endoplasmic reticulum, and Golgi apparatus in making proteins.
7.2.4 Describe the function of the chloroplasts and mitochondria in the cell.
7.2.5 Describe the function of the cell membrane.

Student Resources

Study Workbooks A and B, 7.2 Worksheets
Spanish Study Workbook, 7.2 Worksheets
Lab Manual A, 7.2 Quick Lab Worksheet
Lab Manual B, 7.2 Hands-On Activity Worksheet

Key Questions

- What is the role of the cell nucleus?
- What are the functions of vacuoles, lysosomes, and the cytoskeleton?
- What organelles help make and transport proteins?
- What are the functions of chloroplasts and mitochondria?
- What is the function of the cell membrane?

Vocabulary

cyttoplasm • organelle • vacuole • lysosome • cytoskeleton • centriole • ribosome • endoplasmic reticulum • Golgi apparatus • chloroplast • mitochondrion • cell wall • lipid bilayer • selectively permeable

Taking Notes

Venn Diagram: Create a Venn diagram that illustrates the similarities and differences between prokaryotes and eukaryotes.

Cell Structure

THINK ABOUT IT
At first glance, a factory is a puzzling place. Machines buzz and clatter; people move quickly in different directions. So much activity can be confusing. However, if you take the time to watch carefully, what might at first seem like chaos begins to make sense. The same is true for the living cell.

Cell Organization

What is the role of the cell nucleus?
The eukaryotic cell is a complex and busy place. But if you look closely at eukaryotic cells, patterns begin to emerge. For example, it’s easy to divide each 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. Prokaryotic cells have cytoplasm too, even though they do not have a nucleus.

In our discussion of cell structure, we consider each major component of plant and animal eukaryotic cells—some of which are also found in prokaryotic cells—one by one. Because many of these structures act like specialized organs, they are known as organelles, literally “little organs.” Understanding what each organelle does helps us understand the cell as a whole. A summary of cell structure can be found on pages 206–207.

Cell Structure

Key Questions

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- What are the functions of vacuoles, lysosomes, and the cytoskeleton?
- What organelles help make and transport proteins?
- What are the functions of chloroplasts and mitochondria?
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Comparing the Cell to a Factory  In some respects, the eukaryotic cell is much like a living version of a modern factory (Figure 7–6). The different organelles of the cell can be compared to the specialized machines and assembly lines of the factory. In addition, cells, like factories, follow instructions and produce products. As we look through the organization of the cell, we’ll find plenty of places in which the comparison works so well that it will help us understand how cells work.

The 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. Prokaryotic cells lack a nucleus, but they do have DNA that contains the same kinds of instructions.

The nucleus, shown in Figure 7–7, 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 factory’s main office, a steady stream of proteins, RNA, and other molecules move through the nuclear pores to and from the rest of the cell.

Chromosomes, which carry the cell’s genetic information, are also found in the nucleus. Most of the time, the threadlike chromosomes are spread throughout the nucleus in the form of chromatin—a complex of DNA bound to proteins. When a cell divides, its chromosomes condense and can be seen under a microscope. You will learn more about chromosomes in later chapters.

Most nuclei also contain a small dense region known as the nucleolus (nu klee uh lus). The nucleolus is where the assembly of ribosomes begins.

In Your Notebook  Describe the structure of the nucleus. Include the words nuclear envelope, nuclear pore, chromatin, chromosomes, and nucleolus in your description.

The Nucleus  The nucleus controls most cell processes and contains DNA. The small, dense region in the nucleus is known as the nucleolus.

FIGURE 7–7 The Nucleus  The nucleus controls most cell processes and contains DNA. The small, dense region in the nucleus is known as the nucleolus.

How Science Works

THE NUCLEUS AND THE CELL

During the 1930s and 1940s, the Danish biologist Joachim Hämmerling performed a series of experiments that demonstrated the link between a cell’s nucleus and the physical characteristics of the cell. Two species of Acetabularia algae were used in the experiments. This marine alga, though 5 cm long, is a single cell. Each cell consists of three areas—a cuplike cap, a stalk, and a holdfast at the bottom, where the cell’s nucleus is found. The two species have different-shaped caps. Hämmerling found that when he grafted a nucleate portion of the first species to an enucleate stalk fragment of the second species, the resulting cell regenerated a cap. Initially, the new cap resembled that of the decapitated species, but if the cap was removed or the cell was allowed to age, then eventually the cap took the form of the donor species. This suggested that the nucleus contained information that determined the type of cap formed, and also that this information was somehow stored in the cytoplasm before the cap is actually produced.

Build Study Skills

Teach

Build Study Skills

Build Study Skills

Cell Structure and Function  197
LESSON 7.2

**Teach continued**

**Use Visuals**

Call students’ attention to Figure 7–8, which shows different types of vacuoles. Explain that plant cells generally have large central vacuoles whose sizes change depending on water availability—when there is a lot of water, the central vacuoles are larger, and when there is less water, the vacuoles are smaller.

Ask What happens to vacuoles that causes a plant to wilt? *(The vacuoles lose water.)*

Explain that once the plant is watered, the vacuoles refill and the plant stands upright again.

Focus students’ attention on the image of the paramecium. Explain that a paramecium regulates water balance with its contractile vacuole. The contractile vacuole continually fills with excess water from cytoplasm, and then expels it.

You may want to point out to students that the only difference between vacuoles and vesicles is size. Vesicles are smaller.

**DIFFERENTIATED INSTRUCTION**

**L1 Special Needs** Tell students that a model often makes something easier to understand. Make a model of a plant’s central vacuole (shown in Figure 7–8) by placing a small inflated balloon inside a small plastic food container. Ask students to recall what plant cells store in their vacuoles. *(water, salts, proteins, and carbohydrates)*

**LPR Less Proficient Readers** To help students to focus on the important information in this lesson, ask them to write the Key Questions in their notebooks. Have them find the answers as they read, and write them in their notebooks.

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**Answers**

**FIGURE 7–8** The pressure of the liquid in the vacuoles makes the plant rigid, which allows it to hold up stems, leaves, and flowers.

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**Organelles That Store, Clean Up, and Support**

**What are the functions of vacuoles, lysosomes, and the cytoskeleton?**

Many of the organelles outside the nucleus of a eukaryotic cell have specific functions, or roles. Among them are structures called vacuoles, lysosomes, and cytoskeleton. These organelles represent the cellular factory’s storage space, cleanup crew, and support structures.

**Vacuoles and Vesicles**

Every factory needs a place to store things, and so does every cell. Many cells contain large, saclike, membrane-enclosed structures called vacuoles. *(Vacuoles store materials like 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 increases their rigidity, making it possible for plants to support heavy structures, such as leaves and flowers. The image on the left in Figure 7–8 shows a typical plant cell’s large central vacuole.

Vacuoles are also found in some unicellular organisms and in some animals. The paramecium on the right in Figure 7–8 contains an organelle called a contractile vacuole. By contracting rhythmically, this specialized vacuole pumps excess water out of the cell. In addition, nearly all eukaryotic cells contain smaller membrane-enclosed structures called vesicles. Vesicles store and move materials between cell organelles, as well as to and from the cell surface.

**Lysosomes**

Even the neatest, cleanest factory needs a cleanup crew, and that’s where lysosomes come in. *(Lysosomes are small organelles filled with enzymes.)* Lysosomes break down lipids, carbohydrates, and proteins into small molecules that can be used by the rest of the cell. They 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 can be traced to lysosomes that fail to function properly. Biologists once thought that lysosomes were only found in animal cells, but it is now clear that lysosomes are also found in a few specialized types of plant cells as well.

**Biology In-Depth**

**LYSOSOMES**

In functioning cells, lysosomes take in, fuse with, or engulf materials, which are then broken down by hydrolytic enzymes. The resulting products are used by the cell or carried to the cell surface and expelled. The presence of lysosomes in plant cells has been confirmed by detection of hydrolytic enzymes, even when lysosome structures are not obvious. Niemann-Pick disease and Fabry disease are examples of diseases caused by abnormal lysosomal activity in humans. Fabry disease is characterized by inadequate amounts or the absence of an enzyme in lysosomes that normally breaks down the fat, GL-3. As a result, GL-3 accumulates in blood vessel walls in major body organs. In Niemann-Pick disease, the absence of an enzyme causes a buildup of a harmful substance in the bone marrow, liver, and spleen.
The Cytoskeleton  As you know, a factory building is supported by steel or cement beams and by columns that hold up its walls and roof. Eukaryotic cells are given their shape and internal organization by a network of protein filaments known as the cytoskeleton. Certain parts of the cytoskeleton also help transport materials between different parts of the cell, much like the conveyor belts that carry materials from one part of a factory to another. Cytoskeletal components may also be involved in moving the entire cell as in cell flagella and cilia.  

**FIGURE 7–9 Cytoskeleton** The cytoskeleton supports and gives shape to the cell, and is involved in many forms of cell movement. These connective tissue fibroblast cells have been treated with fluorescent tags that bind to certain elements. Microfilaments are pale purple, microtubules are yellow, and the nuclei are green.

**Microfilaments** Microfilaments are threadlike structures made up 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 are responsible for the cytoplasmic movements that allow amoebas and other cells 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, organelles called centrioles are also formed from tubulins.  

**Centrioles** are located near the nucleus and help organize cell division. Centrioles are not found in plant cells. Microtubules also help build projections from the cell surface—known as cilia (singular: cilium) and flagella (singular: flagellum)—that enable cells to swim rapidly through liquid. The microtubules in cilia and flagella are arranged in a “9 + 2” pattern, as shown in **Figure 7–10**. Small cross-bridges between the microtubules in these organelles use chemical energy to pull on, or slide along, the microtubules, producing controlled movements.

**FIGURE 7–10 The “9 + 2” Pattern** of Microtubules. In this micrograph showing the cross section of a cilium, you can clearly see the 9 + 2 arrangement of the red microtubules.  

Apply Concepts  What is the function of cilia?

Cell Structure and Function 199

Check for Understanding

**ONE-MINUTE RESPONSE**

Give students one minute to write a summary that identifies the role of the cytoskeleton in the cell. (*The cytoskeleton helps maintain the cell’s shape and is also involved in movement.*)

**ADJUST INSTRUCTION**

If students are unable to describe the role of the cytoskeleton, have them work in pairs to review the text explanation and edit their original responses. Ask volunteers to share their revised summaries with the class.

**Answers**

**FIGURE 7–8** Cilia project from cells and enable them to move through liquids.

**DIFFERENTIATED INSTRUCTION**

**Less Proficient Readers**  Pair struggling readers with more proficient readers to construct a Concept Map of the information on this page to show the relationship between the cytoskeleton, microfilaments, and microtubules.


**Advanced Students**  Extend the content of this topic by having students independently research how the cytoskeleton was discovered and how its discovery is connected with developments in microscopy. Ask students to share what they learn with the class.

**Lead a Discussion**

Ask students if they have ever been inside a circus tent. Have them describe the structure of the tent, including the poles and extensive networks of ropes and guy wires. Ask students to suggest what those structures are used for. Draw students’ attention to **Figure 7–9**. Explain that cells have an extensive network of filaments in the cytoplasm called the cytoskeleton.

Ask students to suggest how some of the functions of their own skeleton (shape, support, and movement) might help them understand the function of a cell’s cytoskeleton.
**Smooth endoplasmic reticulum**

**Vesicle**

**Rough endoplasmic reticulum**

**Nucleus**

**Ribosome**

**Protein 1**

Proteins are assembled on ribosomes.

2. Proteins targeted for export to the cell membrane, or to specialized locations within the cell, complete their assembly on ribosomes bound to the rough endoplasmic reticulum.

3. Newly assembled proteins are carried from the rough endoplasmic reticulum to the Golgi apparatus in vesicles.

**CYTOPLASM**

**Organelles That Build Proteins**

What organelles help make and transport proteins?

Life is a dynamic process, and living things are always working, building new molecules all the time, especially proteins, which catalyze chemical reactions and make up important structures in the cell. Because proteins carry out so many of the essential functions of living things, a big part of the cell is devoted to their production and distribution. Proteins are synthesized on ribosomes, sometimes in association with the rough endoplasmic reticulum in eukaryotes. The process of making proteins is summarized in Figure 7–11.

**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 in all cells. Ribosomes produce proteins by following coded instructions that come from DNA. Each ribosome, in its own way, is like a small machine in a factory, turning out proteins on orders that come from its DNA “boss.” Cells that are especially active in protein synthesis often contain large numbers of ribosomes.

**Endoplasmic Reticulum**

Eukaryotic cells contain an internal membrane system known as the endoplasmic reticulum (endoplasmic reticulum), or ER. The endoplasmic reticulum is 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.

**Check for Understanding**

**QUESTION BOX**

Provide a box into which students can put their questions about ribosomes and the endoplasmic reticulum. Encourage students to write questions about aspects of the text that they do not understand.

**ADJUST INSTRUCTION**

If most students write essentially the same questions, discuss these topics with the class as a whole. Answer the questions, referring to specific content in the text and Figure 7–11. Then, to determine whether students now understand the concepts, ask volunteers to explain the answers to the questions in their own words. Work with students individually or in small groups to address any topics that only a few students do not comprehend.
Proteins made on the rough ER include those that will be released, or secreted, from the cell as well as many membrane proteins and proteins destined for lysosomes and other specialized locations within the cell. 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** In eukaryotic cells, proteins produced in the rough ER move next into an organelle called the **Golgi apparatus**, which appears as a stack of flattened membranes. As proteins leave the rough ER, molecular “address tags” get them to the right destinations. As these tags are “read” by the cell, the proteins are bundled into tiny vesicles that bud from the ER and carry them to the Golgi apparatus. The **Golgi apparatus** modifies, sorts, and packages proteins and other materials from the endoplasmic reticulum for storage in the cell or release 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 “shipped” to their final destination inside or outside the cell.

**In Your Notebook** Make a flowchart that shows how proteins are assembled in a cell.

1. **The Golgi apparatus** further modifies proteins before sorting and packaging them in membrane-bound vesicles.
2. Vesicles from the Golgi apparatus are shipped to their final destination in, or out of, the cell.

**Quick Facts**

**WHAT HAPPENS WITHIN THE GOLGI APPARATUS?**

In a cell, the Golgi apparatus is analogous to a person who takes a product that has been only roughly manufactured and, with hundreds of separate orders to fill, finishes off the rough edges, makes requested changes, and turns out products that meet specific individual orders. The Golgi apparatus has two general regions: the cis end and the trans end. The end closer to the endoplasmic reticulum is referred to as the cis end. It receives materials from the ER enclosed in membranous vesicles. The vesicles deliver their newly manufactured proteins by fusing with the membranes of the cis end. The materials are then passed through the layers, or cisternae, of the Golgi apparatus. They leave from the opposite, or trans, end, which is farther away from the ER. In transit, the proteins are modified and finished by enzymes before being distributed. Materials that will leave the cell are packed in vesicles that bud off from the Golgi apparatus and eventually fuse with the cell membrane.

**VISUAL SUMMARY**

**MAKING PROTEINS**

*FIGURE 7–11* Together, ribosomes, the endoplasmic reticulum, and the Golgi apparatus synthesize, modify, package, and ship proteins. Infer. What can you infer about a cell that is packed with more than the typical number of ribosomes?

**DIFFERENTIATED INSTRUCTION**

**LPR** Less Proficient Readers Explain to students that an important part of reading comprehension is taking note of art and using it to understand what is written in the text. Point out that *Figure 7–11* summarizes the process of protein assembly and export in a series of numbered steps. Tell students that they can use these steps to help them understand the section, **Organelles That Build Proteins**, and to complete the In Your Notebook.

**Answers**

**FIGURE 7–11** Ribosomes are sites of protein production. When a cell has more than the typical number of ribosomes, you might infer that it produces more proteins than other cells.

**IN YOUR NOTEBOOK** Flowcharts should summarize the steps in *Figure 7–11*. 
LESSON 7.2

Teach continued

Lead a Discussion

Make sure students understand how important energy is to living things. Discuss why chloroplasts might be referred to as “solar collectors” and mitochondria as “power plants.” Have students discuss why animals must consume food to obtain energy, whereas plants are able to produce their own food, using energy from sunlight.

DIFERENTIATED INSTRUCTION

Less Proficient Readers Ask students to preview the first three paragraphs on this page, keeping in mind the following questions:
• Which organelle captures energy from sunlight and converts it to chemical energy in cells? (chloroplast)
• Which organelle converts or releases chemical energy from food in cells? (mitochondrion)

Address Misconceptions

Mitochondria and Chloroplasts Some students may think that mitochondria are found only in animal cells and chloroplasts are found only in plant cells. Clarify that mitochondria are found in nearly all eukaryotes, including plants. Chloroplasts are found outside of the plant clade, in photosynthetic “pro-tists,” such as red and brown algae and euglenas. Try to get students to associate mitochondria and chloroplasts with their function—eukaryotes that undergo cellular respiration have mitochondria, and eukaryotes that undergo photosynthesis have chloroplasts and mitochondria. Therefore, plants, which undergo both processes, have both types of organelles, while animals have only mitochondria.

Answers

FIGURE 7–12 The cell is a plant cell, because it contains chloroplasts.

Quick Facts

MITOCHONDRIAL DISEASES

The health of an individual organism depends on the health of its organelles. For example, defects in mitochondria cause some forms of deafness, blindness, and diseases that affect muscles and nerves. Cells are dependent on energy that is normally released by chemical reactions in mitochondria. Many mitochondrial diseases affect muscles, which may have thousands of mitochondria in each cell. If mitochondria lack oxidative-phosphorylation enzymes, toxic substances accumulate, and energy cannot be released from food. The muscle weakness that appears in muscular dystrophy is related to defective mitochondria. Other conditions related to mitochondrial dysfunctions are retinitis pigmentosa, diabetes mellitus, and some forms of deafness. Mitochondrial diseases can result from mutations in nuclear DNA or mitochondrial DNA.
Mitochondria

Chloroplasts

Cell Walls

A working factory needs walls and a roof to protect it from the environment outside, and also to serve as a barrier that keeps its products safe and secure until they are ready to be shipped out. Cells have similar needs, and they meet them in a similar way. As you have learned, all cells are surrounded by a barrier known as the cell membrane. Many cells, including most prokaryotes, also produce a strong supporting layer around the membrane known as a cell wall.

Cell Walls

Many organisms have cell walls in addition to cell membranes. The main function of the cell wall is to support, shape, and protect the cell. Most prokaryotes and many eukaryotes have cell walls. Animal cells do not have cell walls. Cell walls lie outside the cell membrane. Most cell walls are porous enough to allow water, oxygen, carbon dioxide, and certain other substances to pass through easily.

Cell walls provide much of the strength needed for plants to stand against the force of gravity. In trees and other large plants, nearly all of the tissue we call wood is made up of cell walls. The cellulose fiber used for paper as well as the lumber used for building comes from these walls. So if you are reading these words off a sheet of paper from a book resting on a wooden desk, you’ve got cell walls all around you.

Analyzing and Conclude

1. Calculate
   Assume that a typical plant cell is 50 micrometers wide (50 × 10⁻⁶ m). 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.)

2. Compare and Contrast
   How is your model cell part or organelle similar to the real cell part or organelle? How is it different?

3. Evaluate
   Based on your work with this model, describe how you could make a better model. What new information would your improved model demonstrate?

Cellular Boundaries

What is the function of the cell membrane?

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Analyzing and Conclude

1. Scales will vary depending on the size of the classroom. If a room is 5 m (500,000,000 micrometers) across and a typical cell is 50 micrometers across, the scale would be 1,000,000 : 1.

2. Model organelles and cell parts should be similar in shape and structure to the real objects. The models are different in that they are much larger, are made of different materials, and do not function.

3. Students should suggest ways to make better models than the original ones.

Quick Lab

**Purpose**

Students will make models of cell parts and organelles to better understand cell structure.

**Materials**

Various craft supplies, index cards

**Planning**

Collect a variety of craft items, such as construction paper, yarn, balloons, tape, cardboard tubes, and glue. Allow students to use other items as desired.

**Building Vocabulary**

**Academic Words**

*porous* means “allowing materials to pass through.” A porous cell wall allows substances like water and oxygen to pass through it.

**Lead a Discussion**

Ask students to consider what happens when a property owner puts up a fence. What purpose does the fence serve? How do people get in and out? Are there different kinds of fences? Use the analogy to explain that a cell’s contents are also confined within a barrier. Have students use the reduced cell images on this page and the larger version in Figure 7–14 to find out which cells have cell walls and where cell walls are located in cells. Then, write this prompt on the board, and have students defend or refute it: All cells have a cell membrane, but not all cells have a cell wall.

**Differentiated Instruction**

**Special Needs**

If students do not understand the analogy comparing cell membranes/walls to fences, show a photograph or illustration of a fence. Ask students what the function of the fence is. (A fence keeps some things inside and other things outside.) Then, refer students to Figure 7–14.

**Ask**

Where are the cell membrane and cell wall found? (on the outside edge of the cell, surrounding the cell contents)

**Ask**

Do you think the mitochondria, nucleus, and other organelles can cross the cell membrane? (no)

**Advanced Students**

Have students find out what chemical compound is most commonly found in cell walls that makes certain plants useful for building materials and paper making. (cellulose) Have them describe their findings in writing.
LESSON 7.2

Cell Membranes All cells contain cell membranes, which almost always are made up of a double-layered sheet called a lipid bilayer, as shown in Figure 7–13. The lipid bilayer gives cell membranes a flexible structure that forms a strong barrier between the cell and its surroundings. The cell membrane regulates what enters and leaves the cell and also protects and supports the cell.

The Properties of Lipids The layered structure of cell membranes reflects the chemical properties of the lipids that make them up. You may recall that many lipids have oily fatty acid chains attached to chemical groups that interact strongly with water. In the language of a chemist, the fatty acid portions of this kind of lipid are hydrophobic (hy druh foh bik), or “water-hating,” while the opposite end of the molecule is hydrophilic (hy druh fil ik), or “water-loving.” When these lipids, including the phospholipids that are common in animal cell membranes, are mixed with water, their hydrophobic fatty acid “tails” cluster together while their hydrophilic “heads” are attracted to water. A lipid bilayer is the result. As you can see in Figure 7–13, the head groups of lipids in a bilayer are exposed to the outside of the cell, while the fatty acid tails form an oily layer inside the membrane that keeps water out.

DIFFERENTIATED INSTRUCTION

L3 Special Needs Make sure that students understand the relationship between the different components of Figure 7–13 and also the perspective shown by the illustration. Clarify that the illustration shows a tiny part of a cell membrane, similar to the membrane that surrounds the cell in the micrograph. Explain that the illustration is a cross section. To model a cross section, you might cut a lemon or orange in half and show how the cut reveals a cross section of the rind. Finally, show how you can tell, by looking at the “whoosh” in the illustration, that the lipid molecule is an enlargement of one tiny part of the cross section of the membrane.

L3 Advanced Students Have students work in pairs to develop an analogy related to the fluid mosaic model. Emphasize that the protein and lipid molecules in the membrane can move.

Answers

FIGURE 7–13 The hydrophobic end of the lipid molecules turns away from water molecules, but the hydrophilic end of lipid molecules is attracted to water molecules both inside and outside the cell. With water on both sides, a two-layer, or bilayer, system of lipid molecules forms, with the phobic portions within the membrane.

Check for Understanding

ONE-MINUTE RESPONSE

Give students one minute to write a response to:

• How do cell membranes regulate what enters and leaves the cell, and how do they protect the cell? (Cell membranes are selectively permeable, which means that some materials can enter them, but some are too large or too strongly charged. Keeping out or expelling some materials is a form of protection.)

ADJUST INSTRUCTION

If responses show that students are confused by the role of the cell membrane, suggest they work in pairs to discuss what might happen to a cell that did not have a selectively permeable membrane. Then, ask pairs to rewrite a response to the question.
Membranes are also called selectively permeable membranes. As you know, some things are allowed to enter and leave a factory, and some are not. The same is true for living cells. Although many substances can cross biological membranes, some are too large or too strongly charged to cross the lipid bilayer. If a substance is able to cross a membrane, the membrane is said to be permeable to it. A membrane is impermeable to substances that cannot pass across it. Most biological membranes are selectively permeable, meaning that some substances can pass across them and others cannot. Selectively permeable membranes are also called semipermeable membranes.

**The Fluid Mosaic Model** Embedded in the lipid bilayer of most cell membranes are protein molecules. Carbohydrate molecules are attached to many of these proteins. Because the proteins embedded in the lipid bilayer can move around and “float” among the lipids, and because so many different kinds of molecules make up the cell membrane, scientists describe the cell membrane as a “fluid mosaic.” A mosaic is a kind of art that involves bits and pieces of different colors or materials. What are all these different molecules doing? As you will see, some of the proteins form channels and pumps that help to move material across the cell membrane. Many of the carbohydrate molecules act like chemical identification cards, allowing individual cells to identify one another. Some proteins attach directly to the cytoskeleton, enabling cells to respond to their environment by using their membranes to help move or change shape.

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**Cell Membranes**

1. a. **Review** What are the two major parts of the cell?
   b. **Use Analogies** How is the role of the nucleus in a cell similar to the role of the captain on a sports team?
2. a. **Review** What is the function of lysosomes?
   b. **Apply Concepts** How do contractile vacuoles help maintain water balance?
3. a. **Review** What is the difference between rough and smooth ER?
   b. **Sequence** Describe the steps involved in the synthesis, packaging, and export of a protein from a cell.
4. a. **Infer** You examine an unknown cell under a microscope and discover that the cell contains chloroplasts. From what type of organism does the cell likely come?
   b. **Infer** You examine an unknown cell under a microscope and discover that the cell contains chloroplasts. From what type of organism does the cell likely come?
5. a. **Review** Why is the cell membrane sometimes referred to as a fluid mosaic? What part of the cell membrane acts like a fluid? And what makes it like a mosaic?
   b. **Explain** How do the properties of lipids help explain the structure of a cell membrane?
   c. **Infer** Why do you think it’s important that cell membranes are selectively permeable?
6. Using the cells on the next page as a guide, draw your own models of a prokaryotic cell, a plant cell, and an animal cell. Then use each of the vocabulary words from this lesson to label your cells.

**Assessment Answers**

1a. cytoplasm with organelles, nucleus
1b. The nucleus controls cell activities as a captain controls plays and players.
2a. Their enzymes break down nutrients and old organelles.
2b. by pumping out excess water
3a. Rough ER has surface ribosomes; smooth ER does not.
3b. Students should describe the steps in Figure 7–11.
4a. converting chemical energy in food into compounds the cell can use
4b. a plant or photosynthetic protist
5a. because, like a real mosaic, it is made of many parts that can float around in the membrane
5b. Hydrophilic lipid heads are attracted to water; hydrophobic fatty acid tails turn away from water. A bilayer forms when lipid heads turn toward water inside and outside the cell.

5c. Selective permeability allows needed substances to enter the cell and wastes to leave, while keeping out molecules that are not needed.

**Visual Thinking**

6. Students’ labeled illustrations should reflect characteristics of all three types of cells and include all lesson vocabulary terms.
Use Figure 7–14 to review the parts of typical cells. Divide the class into small groups, and have each group submit a question about a cell function to be answered by the class. Answers should incorporate specific vocabulary terms shown in the figure.

**DIFERENTIATED INSTRUCTION**

**Less Proficient Readers** Pair less proficient readers with proficient readers. Have students use Figure 7–14 to write questions on index cards about cell parts and then use the cards to quiz each other without looking at the table on the opposite page. (Sample question: What cell part enables a cell to release energy?) Collect the cards, and use them for a class review.

**Advanced Students** Have interested students conduct research and draw labeled models of typical fungi and protist cells. Hang their drawings on the wall for other students to see. These models will be helpful when studying protists and fungi in Unit 6.

Students can review plant and animal cell structures by checking Art Review: Plant and Animal Cells. To reinforce that plants have mitochondria, have students watch Tutor Tube.

**Biology In-Depth**

**THE ORIGIN OF EUKARYOTES**

The idea that chloroplasts and mitochondria originated in symbiotic relationships with prokaryotic cells is called the endosymbiotic hypothesis. According to this hypothesis, chloroplasts may have originated when cyanobacteria became established in larger prokaryotes, either as parasites or as prey that were not digested. Mitochondria may have been anaerobic heterotrophs that found a safe existence inside larger prokaryotes as oxygen became more abundant in the atmosphere. Over time, host and symbionts became more and more interdependent, and the organisms merged to become a single eukaryotic cell. The endosymbiotic hypothesis is covered in Chapter 19.
**Build Study Skills**

Call students’ attention to the table, which summarizes the structures and functions of cells and can help students distinguish between prokaryotes and eukaryotes. Discuss how the table is set up into columns, rows, and cells. Ask what a checkmark in the table means. (The structure is present in a cell.) Ask what an empty box indicates. (The structure is not present in a cell.) Finally, make sure students know that there are other eukaryotes (fungi and “protists”) besides animals and plants, though for simplicity, only those are listed in this table.

**DIFFERENTIATED INSTRUCTION**

**L1 Struggling Students** Write cell functions on individual index cards. Then, have students select a card and name the cell part or organelle and the kind of cell it is found in. For example, Traps sunlight: chloroplast, plant cell.

**ELL Focus on ELL: Access Content**

**ADVANCED AND ADVANCED HIGH SPEAKERS**

Have students use Figure 7–14 and Lesson 7.2 to complete a Jigsaw Review. Form groups of five. Tell students this is their “learning circle.” Assign each student a number from 1 to 5 within each group. Then, form “study groups” by having students with the same number (all the 2s, all the 5s, and so on) come together. Assign each study group a cell characteristic from the table. (See the left-most column of the table—Cellular Control Center, and so on.) Tell students they will have 10 minutes to use the information in the figure and text to create a presentation on their assigned characteristic. Finally, have students return to their learning circles. Each student in the learning circle should present his or her assigned characteristic to the rest of the group.

**Study Wkbks A/B, Appendix S7, Jigsaw Review.**

**Check for Understanding**

**INDEX CARD SUMMARY**

Provide students with an index card on which is written two structures from the cells depicted in Figure 7–14. Ask students to write a sentence that describes how the structures are related to each other.

**ADJUST INSTRUCTION**

If students have difficulty relating structures, have pairs use the table in Figure 7–14 to discuss how their different structures might be related. Then, have students exchange cards and write new sentences that show the relationship between the listed structures.