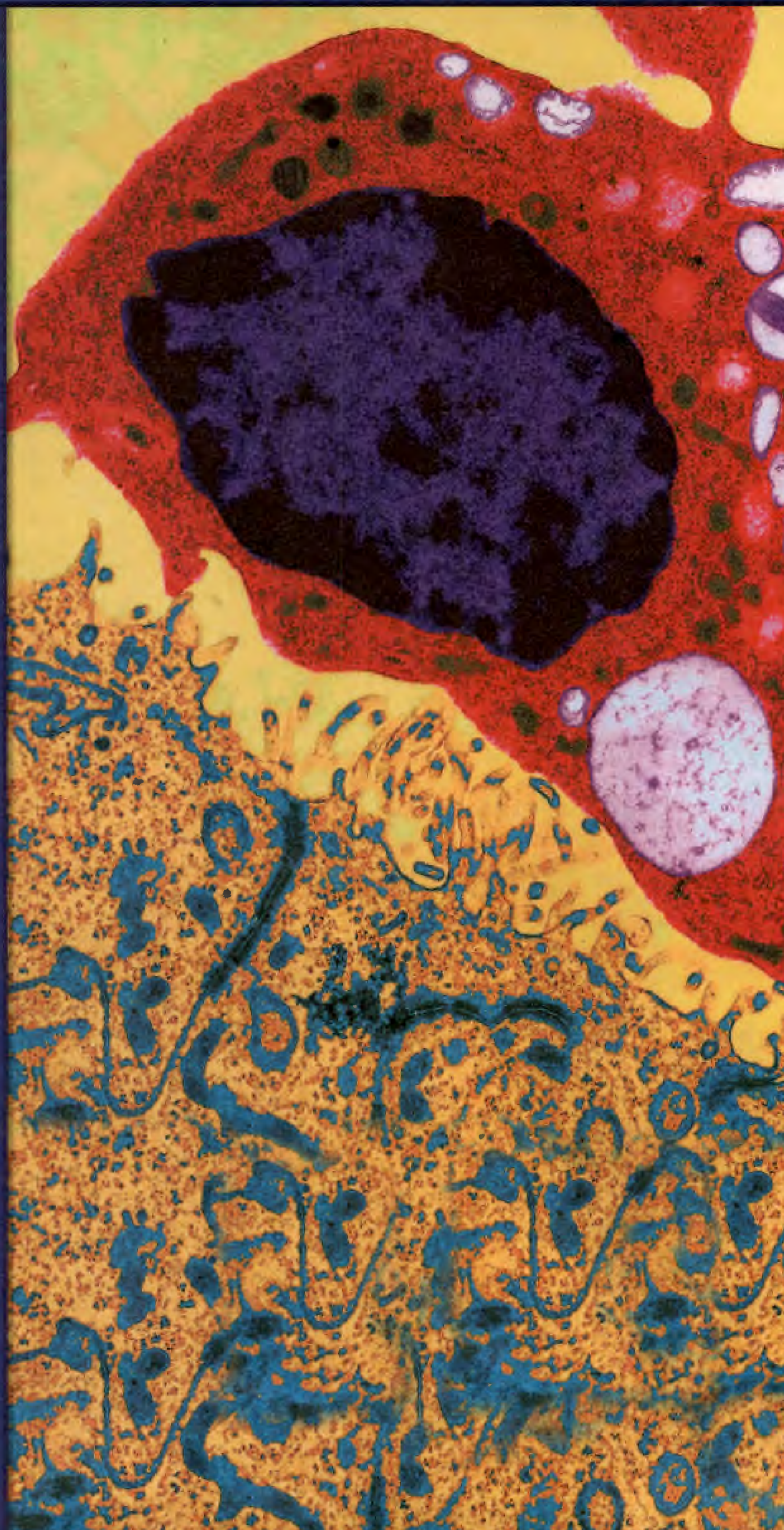
Chapter 3

Cell Structure and Function



CALIFORNIA Standards Preview

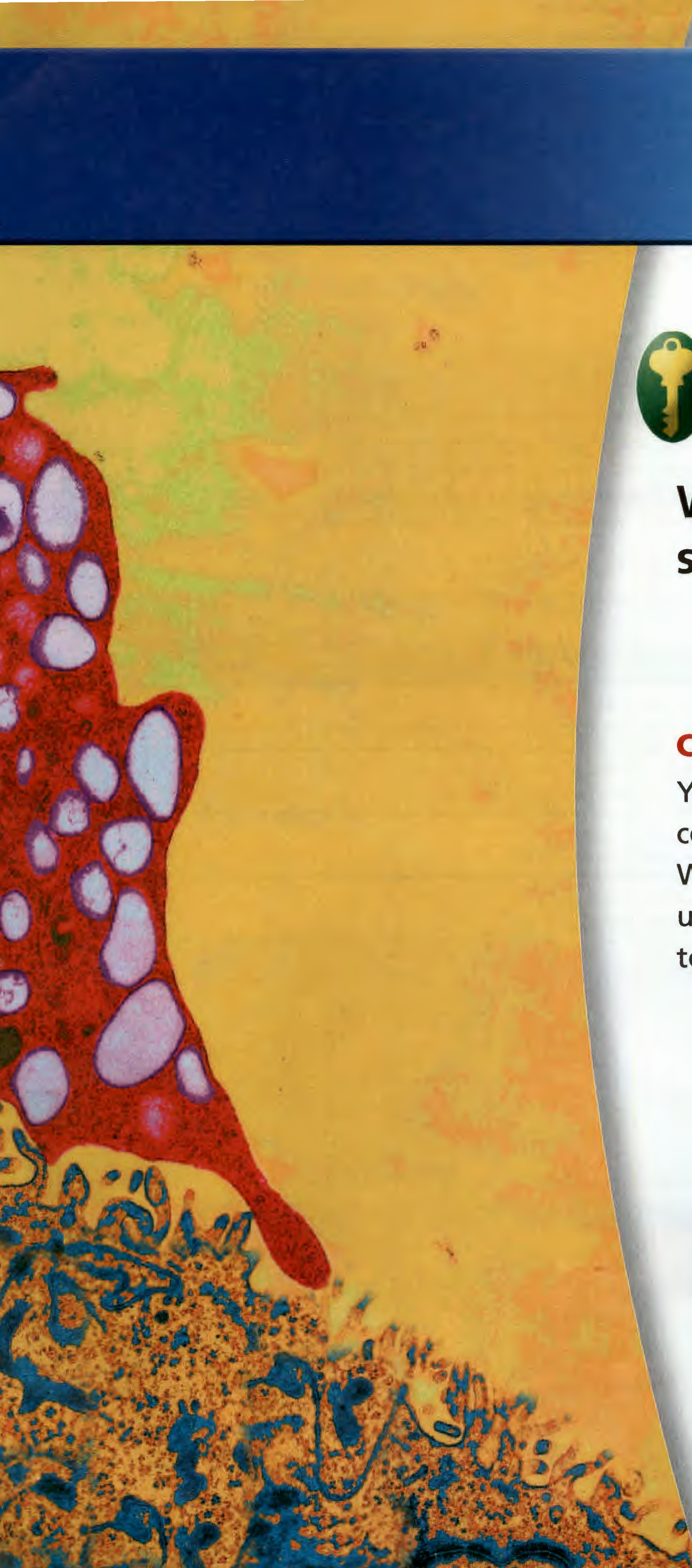
S 7.1 All living organisms are composed of cells, from just one to many trillions, whose details usually are visible only through a microscope. As a basis for understanding this concept:

- **a.** Students know cells function similarly in all living organisms.
- **b.** Students know the characteristics that distinguish plant cells from animal cells, including chloroplasts and cell walls.
- **c.** Students know that the nucleus is the repository for genetic information in plant and animal cells.

S 7.7 Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other three strands, students should develop their own questions and perform investigations. Students will:

- **a.** Select and use appropriate tools and technology (including calculators, computers, balances, spring scales, microscopes, and binoculars) to perform tests, collect data, and display data.
- **d.** Construct scale models, maps, and appropriately labeled diagrams to communicate scientific knowledge (e.g., motion of Earth's plates and cell structure).

The cell that has been colored red is found in blood. This kind of cell destroys bacteria.



Video Preview

Discovery Channel School

Cell Structure and Function

Focus on the

BIG Idea

S 7.1

What is the structure of a cell?

Check What You Know

You hear that a pinch of soil may contain millions of organisms. What optical tools would you use to see these organisms and to study their structure?

Build Science Vocabulary

The images shown here represent some of the Key Terms in this chapter. You can use this vocabulary skill to help you understand the meaning of some Key Terms in this chapter.

Vocabulary Skill

Prefixes

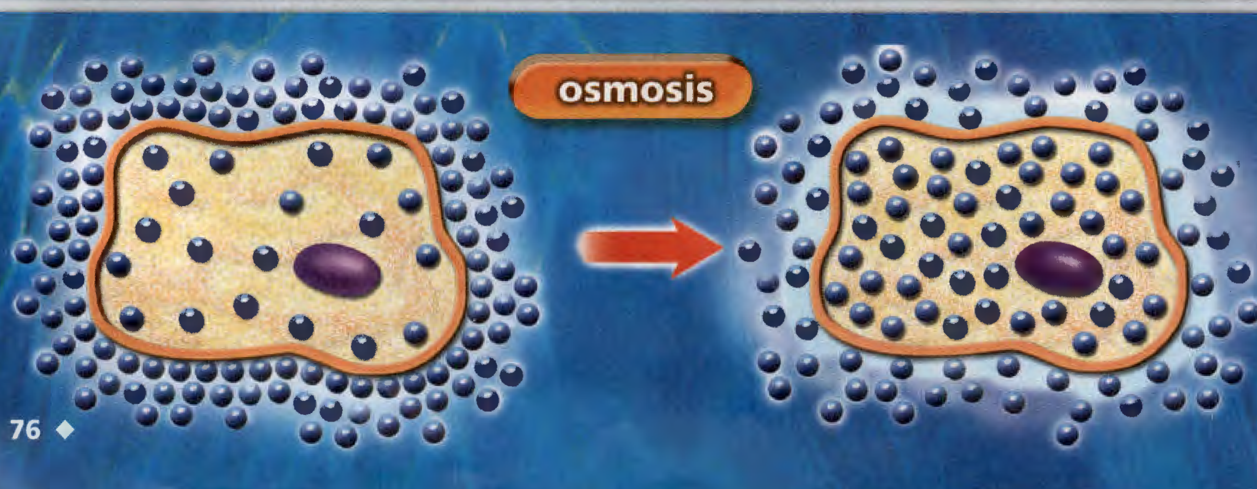
Words can sometimes be divided into parts. A root is the part of the word that carries the basic meaning. A prefix is a word part that is placed in front of the root to change the word's meaning. In the word *multicellular,* for example, *-cellular* is the root and *multi-* is the prefix. The prefix *multi-* means "many." *Multicellular* means "having many cells."

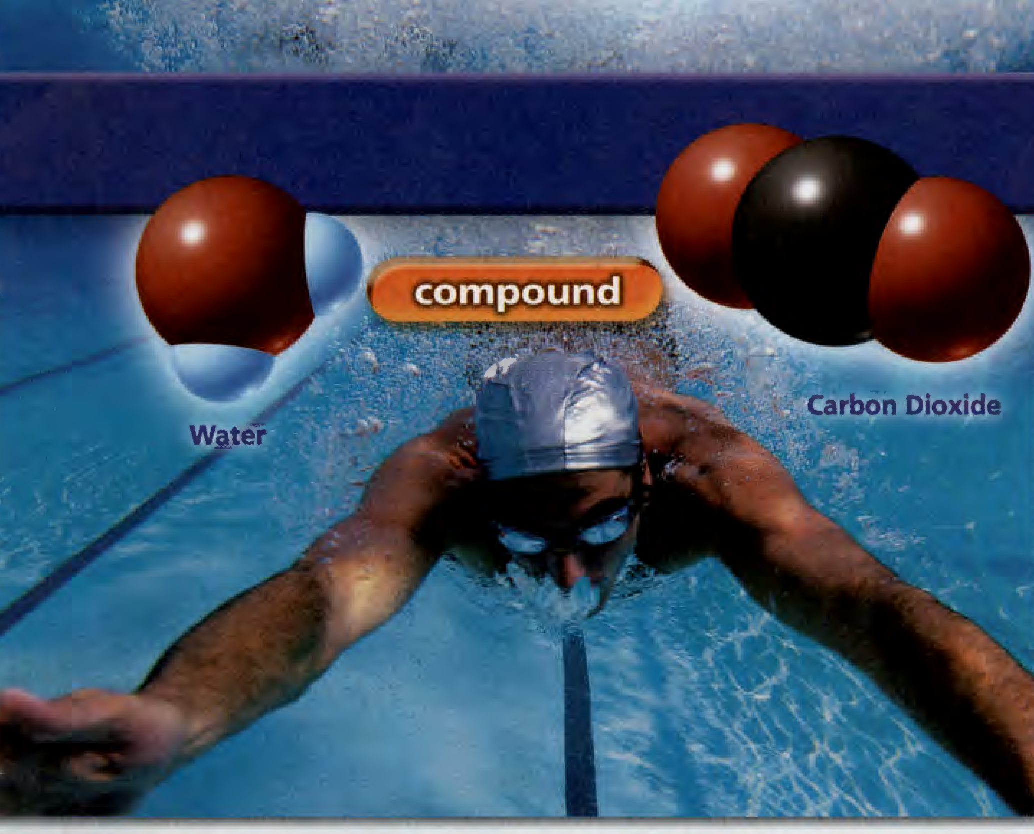
The prefixes below will help you understand some Key Terms.

Prefix	Meaning	Example Word
chlor-	green	**chloroplast** A cellular structure that captures energy from sunlight
cyto-	cell	**cytoskeleton** The framework inside a cell
multi-	many	**multicellular** Having many cells
uni-	one	**unicellular** Having one cell

Apply It!

1. A **chloroplast** is a structure in plant cells. What color do you think a chloroplast is?
2. What clue within the word **cytoplasm** lets you know that the word has something to do with cells?





Chapter 3 Vocabulary

Section 1 (page 80)

cell
cell theory
unicellular
multicellular
tissue
organ
organ system

Section 2 (page 88)

organelle
cell wall
cytoskeleton
cell membrane
nucleus
cytoplasm
mitochondria
endoplasmic reticulum
ribosome
Golgi body
chloroplast
vacuole
lysosome

Section 3 (page 97)

element
compound
carbohydrate
protein
amino acid
enzyme
lipid
nucleic acid
DNA
RNA

Section 4 (page 102)

selectively permeable
diffusion
osmosis
passive transport
active transport

Interactive Textbook

Build Science Vocabulary *Online*
Visit: PHSchool.com
Web Code: cvj-1030

How to Read Science

Reading Skill

Identify Main Ideas

The main idea in a section or paragraph is the most important—or biggest—idea. Sometimes the main idea is stated directly. Other times you have to figure it out on your own. Be sure to look at any headings. Headings can help you identify main ideas.

The details in a paragraph or section support the main idea. Details are often specific facts and examples.

Look for the main idea and details in the paragraph below.

What Are Cells? Cells are the basic units of structure and function in living things. Cells form the parts of an organism. The structure of a living thing is determined by the variety of ways in which its cells are put together. Cells carry out all the basic functions or processess of life in an organism, such as getting oxygen and food and getting rid of wastes.

Apply It!

Copy the graphic organizer below in your notebook. Complete it by writing the main idea of the paragraph in the box at the top. Then add two important details.

Main Idea

Detail: Cells form the parts of an organism.

Detail

Detail

Lab zone

Standards Investigation

S 7.1.a

Egg-speriment With a Cell

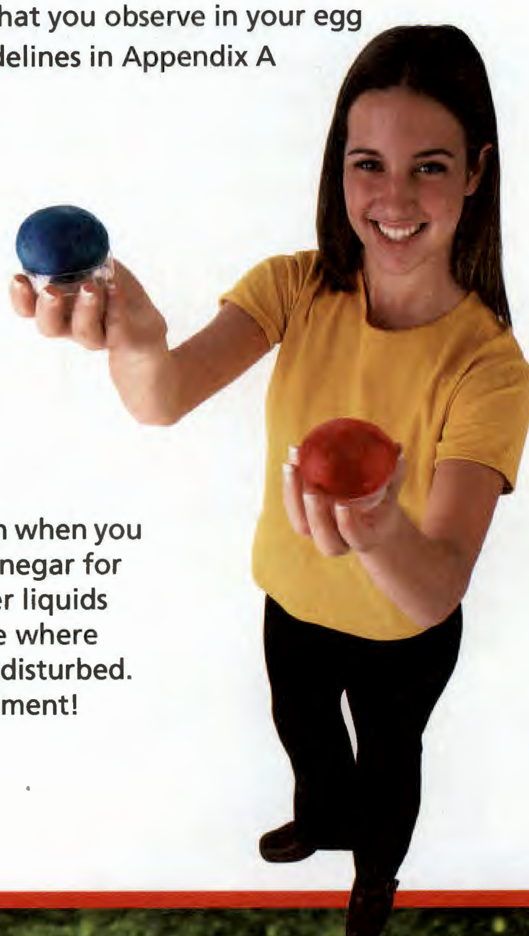
In this chapter, you'll learn that all living things are made of cells—sometimes just one cell, sometimes trillions! You can study an everyday object that can serve as a model of a cell: an uncooked egg.

Your Goal

To observe how various materials enter or leave the cells of organisms, using an egg as a model of a typical cell

To complete this investigation, you will

- observe what happens when you soak an uncooked egg in vinegar, then in water, food coloring, salt water, and finally in a liquid of your choice
- measure the circumference of the egg every day, and graph your results
- explain the changes that you observe in your egg
- follow the safety guidelines in Appendix A



Plan It!

Predict what might happen when you put an uncooked egg in vinegar for two days. How might other liquids affect an egg? Find a place where you can leave your egg undisturbed. Then begin your egg-speriment!

Section 1

Discovering Cells

CALIFORNIA Standards Focus

S 7.1 All living organisms are composed of cells, from just one to many trillions, whose details usually are visible only through a microscope.

- What are cells?
- How did the invention of the microscope contribute to knowledge about living things?
- What is the cell theory?
- How are the cells of multicellular organisms organized?

Key Terms

- cell
- cell theory
- unicellular
- multicellular
- tissue
- organ
- organ system

Lab zone Standards Warm-Up

Is Seeing Believing?

1. Cut a black-and-white photograph out of a page in a newspaper. With only your eyes, closely examine the photo. Record your observations.
2. Examine the same photo with a hand lens. Again, record your observations.
3. Place the photo on the stage of a microscope. Use the clips to hold the photo in place. Shine a light down on the photo. Focus the microscope on part of the photo. (See Appendix B for instructions on using the microscope.) Record your observations.

Think It Over

Observing What did you see in the photo with the hand lens and microscope that you could not see with only your eyes? Which tool is a better choice for studying a tiny object?

A forest is filled with an amazing variety of living things. Some are easy to see, but you have to look closely to find others. If you look carefully at the floor of a forest, you can often find spots of bright color. A beautiful pink coral fungus grows beneath tall trees. Beside the pink fungus, a tiny red newt perches on a fallen leaf.

What do you think a fungus, a tree, and a red newt have in common? They are all living things, or organisms. And, like all organisms, they are made of cells.

FIGURE 1
Newt and Coral Fungus
All living things are made of cells, including this pink fungus and the red newt that perches next to it.

An Overview of Cells

Cells are the basic units of structure and function in living things. This means that cells form the parts of an organism and carry out all of an organism's processes, or functions.

Cells and Structure When you describe the structure of an object, you describe what it is made of and how its parts are put together. The structures of many buildings, for example, are determined by the way in which bricks, steel beams, and other materials are arranged. The structures of living things are determined by the amazing variety of ways in which cells are put together. A red newt's cells, for example, form a body with a head and four legs.

Cells and Function The functions of an organism include obtaining oxygen, getting rid of wastes, obtaining food, and growing. Cells are involved in all these functions. For example, cells in your digestive system absorb food. The food provides your body with energy and materials needed for growth.

Cells function similarly in all organisms. Regardless of the organism they are a part of, cells carry out the basic processes of life in similar ways.

Size of Cells Cells are so small that they are measured in units call micrometers (μm). One micrometer is one millionth of a meter. Each one of your red blood cells is about 7 micrometers across. Figure 2 shows human skin cells. To give you an idea of their size, one square centimeter of your skin's surface contains more than 100,000 cells. No matter how closely you look with your eyes alone, you won't be able to see the individual cells in your skin. Cells are usually visible only through a microscope.

Reading Checkpoint What are some functions that cells perform in living things?

FIGURE 2
Skin Cells
Your skin is made of cells such as these. **Applying Concepts** *What are cells?*

First Observations of Cells

Until the late 1600s, no one knew cells existed because there was no way to see them. Around 1590, the invention of the microscope enabled people to look at very small objects. **The invention of the microscope made it possible for people to discover and learn about cells.** As people built more advanced microscopes, it was possible to discover more about cells. Two early contributors to the understanding of cells were Robert Hooke and Anton van Leeuwenhoek (LAY vun hook). Both built their own microscopes.

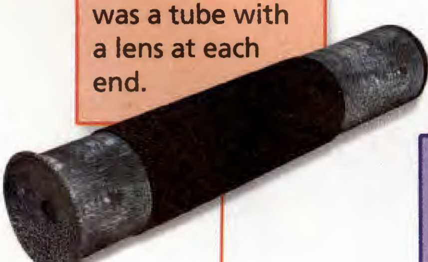
Robert Hooke One of the first people to observe cells was the English scientist and inventor Robert Hooke. Hooke built his own compound microscope, which was one of the best microscopes of his time. In 1663, Hooke used his microscope to observe the structure of a thin slice of cork. Cork, the bark of the cork oak tree, is made up of cells that are no longer alive. To Hooke, the empty spaces in the cork looked like tiny rectangular rooms. Therefore, Hooke called the empty spaces *cells,* which is a word meaning "small rooms."

Hooke described his observations this way: "These pores, or cells, were not very deep, but consisted of a great many little boxes. . . ." What most amazed Hooke was how many cells the cork contained. He calculated that in a cubic inch there were about twelve hundred million cells—a number he described as "almost incredible."

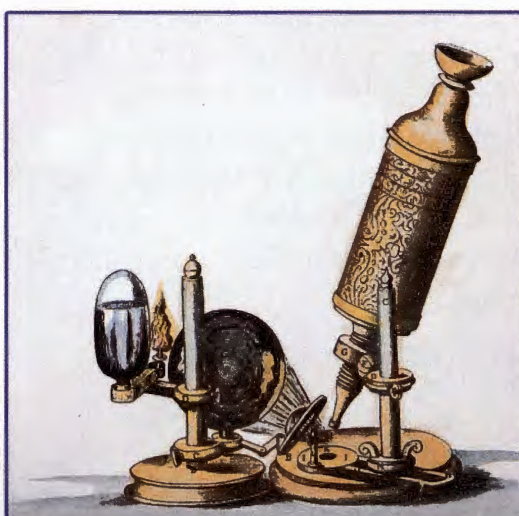
• Tech & Design in History •

The Microscope: Improvements Over Time

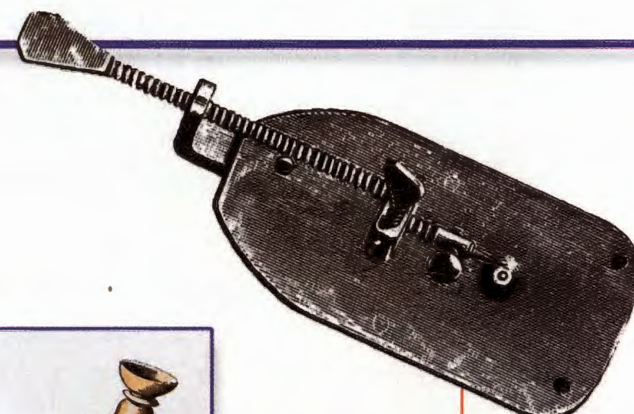
The microscope made the discovery of cells possible. Microscopes have improved in many ways over the last 400 years.



1590 First Compound Microscope
Dutch eyeglass makers Zacharias and Hans Janssen made one of the first compound microscopes. It was a tube with a lens at each end.



1660 Hooke's Compound Microscope
Robert Hooke's compound microscope included an oil lamp for lighting. A lens focuses light from the flame onto the specimen.



1674 Leeuwenhoek's Simple Microscope
Although Anton van Leeuwenhoek's simple microscope used only one tiny lens, it could magnify a specimen up to 266 times.

1500 1600 1700

Anton van Leeuwenhoek At about the same time that Robert Hooke made his discovery, Anton van Leeuwenhoek also began to observe tiny objects with microscopes. Leeuwenhoek was a Dutch businessman who sold cloth. In his spare time, he built simple microscopes.

Leeuwenhoek looked at drops of lake water, scrapings from teeth and gums, and water from rain gutters. In many materials, Leeuwenhoek was surprised to find a variety of tiny organisms. Leeuwenhoek noted that many of these tiny organisms moved. Some whirled, some hopped, and some shot through water like fast fish. He called these moving organisms *animalcules* (an ih MAL kyoolz), meaning "little animals."

Reading Checkpoint **Which type of microscope—simple or compound—did Leeuwenhoek make and use?**

Writing in Science

Research and Write Find out more about one of the microscopes. Then write an advertisement for it that might appear in a popular science magazine. Be creative. Emphasize the microscope's usefulness or describe the wonders that can be seen with it.

1886 Modern Compound Light Microscope

German scientists Ernst Abbé and Carl Zeiss made a compound light microscope with complex lenses that greatly improved the image. A mirror focuses light up through the specimen. Modern compound microscopes can effectively magnify a specimen up to 1,000 times.

1933 Transmission Electron Microscope (TEM)

German physicist Ernst Ruska created the first electron microscope. TEMs send electrons through a very thinly sliced specimen. TEMs can magnify a specimen up to 500,000 times.

1965 Scanning Electron Microscope (SEM)

An SEM sends electrons over the surface of a specimen, rather than through it. The result is a three-dimensional image of the specimen's surface. SEMs can magnify a specimen up to 150,000 times.

1981 Scanning Tunneling Microscope (STM)

An STM measures electrons that leak, or "tunnel," from the surface of a specimen. STMs can magnify a specimen up to 1,000,000 times.

1800 1900 2000

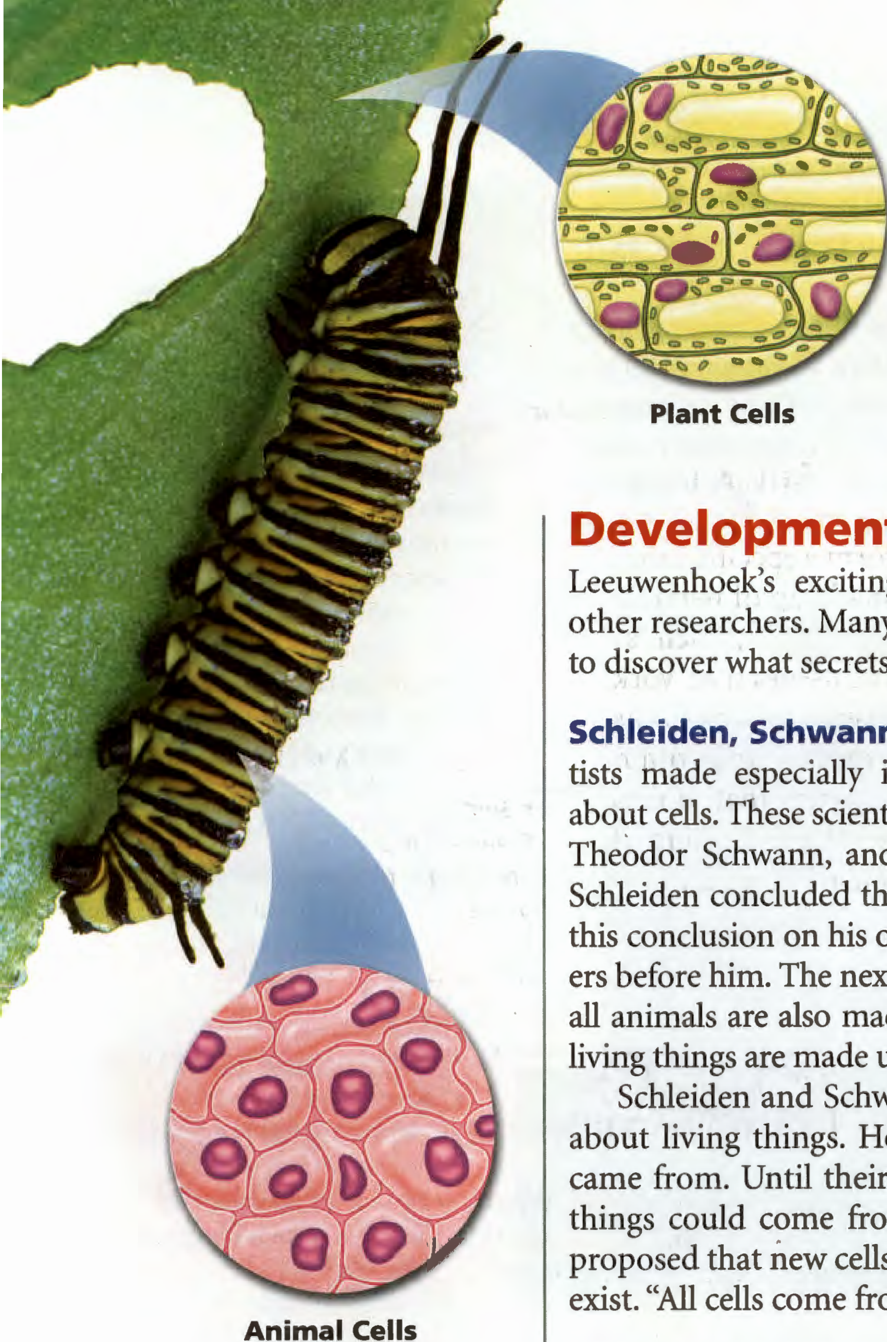


FIGURE 3
Monarch and Milkweed
The monarch butterfly caterpillar and the milkweed leaf that the caterpillar nibbles on are both made of cells.
Applying Concepts *Where do the cells of the caterpillar and leaf come from?*

Development of the Cell Theory

Leeuwenhoek's exciting discoveries caught the attention of other researchers. Many other people began to use microscopes to discover what secrets they could learn about cells.

Schleiden, Schwann, and Virchow Three German scientists made especially important contributions to knowledge about cells. These scientists were Matthias Schleiden (SHLY dun), Theodor Schwann, and Rudolf Virchow (FUR koh). In 1838, Schleiden concluded that all plants are made of cells. He based this conclusion on his own research and on the research of others before him. The next year, Theodor Schwann concluded that all animals are also made up of cells. Thus, stated Schwann, all living things are made up of cells.

Schleiden and Schwann had made an important discovery about living things. However, they didn't explain where cells came from. Until their time, most people thought that living things could come from nonliving matter. In 1855, Virchow proposed that new cells are formed only from cells that already exist. "All cells come from cells," wrote Virchow.

What the Cell Theory Says Schleiden, Schwann, Virchow, and others helped develop the cell theory. The **cell theory** is a widely accepted explanation of the relationship between cells and living things. **The cell theory states the following:**

- **All living things are composed of cells.**
- **Cells are the basic units of structure and function in living things.**
- **All cells are produced from other cells.**

The cell theory holds true for all living things, no matter how big or how small. Since cells are common to all living things, they can provide information about the functions that living things perform. Because all cells come from other cells, scientists can study cells to learn about growth and reproduction.

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For: Links on cell theory
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Unicellular and Multicellular

Organisms may be composed of only one cell or many trillions of cells. **Unicellular**, or single-celled, organisms include bacteria (bak TIHR ee uh), the most numerous organisms on Earth. **Multicellular** organisms are composed of many cells.

In multicellular organisms, cells are often organized into tissues, organs, and organ systems. A **tissue** is a group of similar cells that work together to perform a specific function. For example, your brain is mostly made up of nervous tissue, which consists of nerve cells. An **organ**, such as your brain, is made up of different kinds of tissues that work together. In addition to nervous tissue, your brain contains other kinds of tissue that support and protect it. Your brain is part of your nervous system, an organ system that directs body activities and processes. An **organ system** is a group of organs that work together to perform a major function.

Reading Checkpoint What is an organ?

FIGURE 4
Cellular Organization
This dog is multicellular. The bacteria that live naturally on its teeth are unicellular. Each green sphere is a bacterial cell.

Section 1 Assessment

S 7.1 E-LA: Reading 7.1.2, Writing 7.2.4

Vocabulary Skill **Prefixes** Complete the following sentences with Key Terms.
Because bacteria each have only one cell, they are ________ organisms.
Animals have many cells. Therefore, animals are ___________ organisms.

Reviewing Key Concepts

1. a. **Defining** Define *structure* and *function*.
   b. **Explaining** Explain this statement: Cells are the basic units of structure and function in organisms.
   c. **Applying Concepts** In what important function are the cells in your eyes involved?
2. a. **Reviewing** What does a microscope enable people to do?
   b. **Summarizing** Summarize Hooke's observations of cork under a microscope.
   c. **Relating Cause and Effect** Why would Hooke's discovery have been impossible without a microscope?
3. a. **Listing** What does the cell theory state?
   b. **Explaining** What did Virchow contribute to the cell theory?
   c. **Applying Concepts** Use Virchow's ideas to explain why plastic plants are not alive.
4. a. **Reviewing** How do multicellular organisms differ from unicellular organisms?
   b. **Explaining** What is the relationship among cells, tissues, and organs?
   c. **Inferring** Would a tissue or an organ have more kinds of specialized cells? Explain.

Writing in Science

Writing an Award Speech Suppose you are a member of a scientific society that is giving an award to one of the early cell scientists. Choose the scientist, and write a speech that you might give at the award ceremony. Be sure to describe the scientist's accomplishments.

Lab zone **Technology Lab**

• Tech & Design •

Design and Build a Microscope

S 7.6.d, 7.7.a

Problem

How can you design and build a compound microscope?

Design Skills

building a prototype, evaluating design constraints

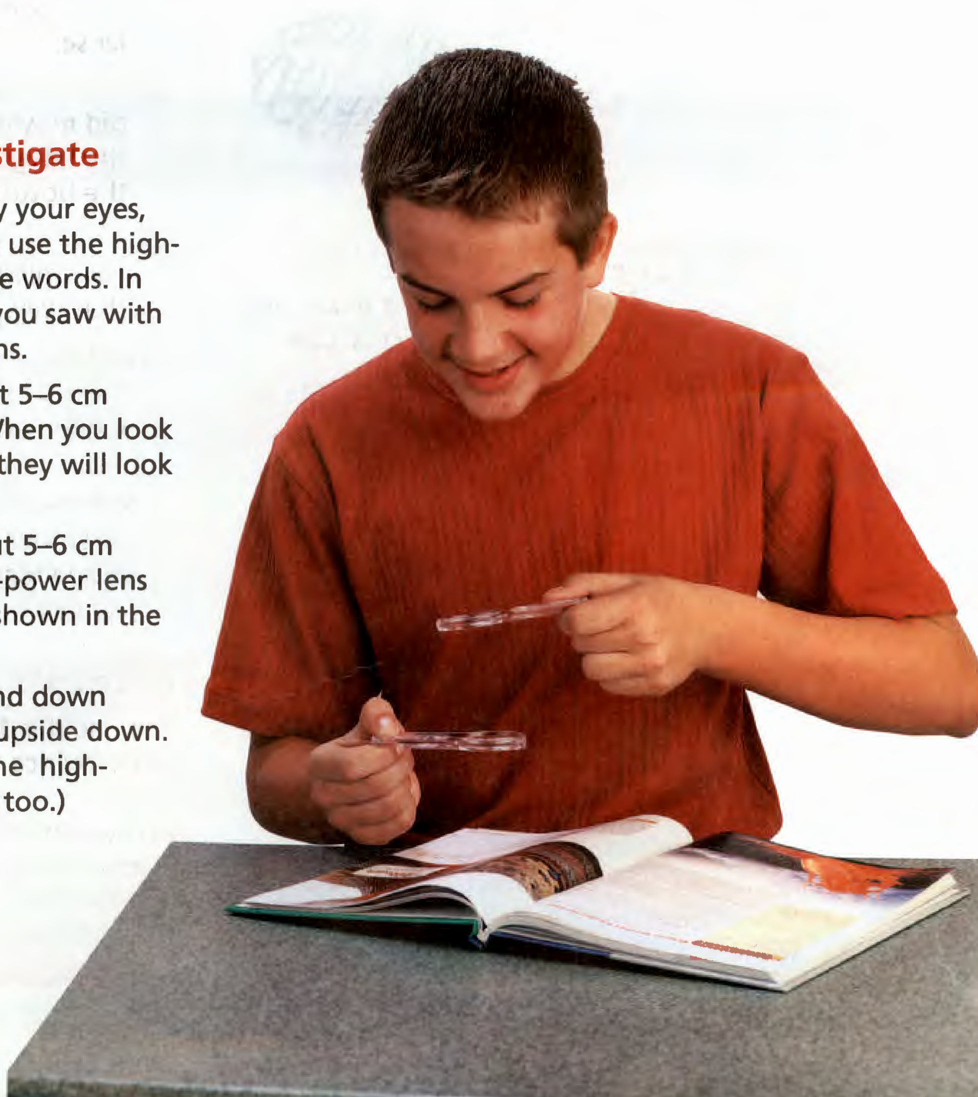
Materials

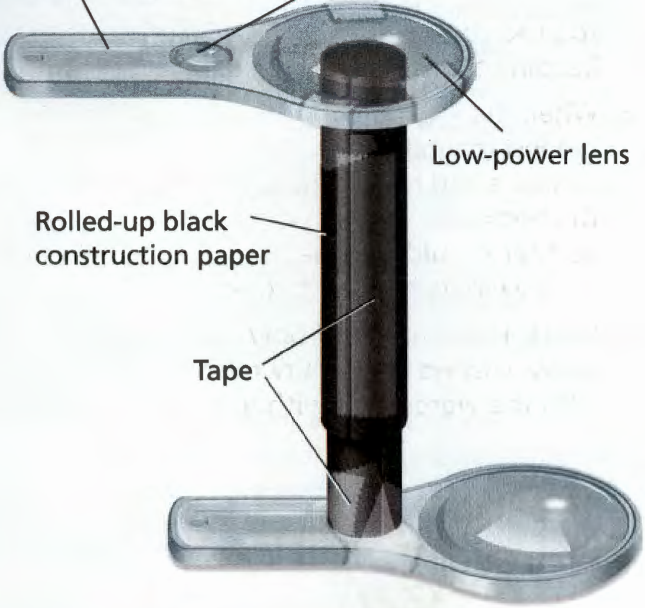
- book
- 2 dual magnifying glasses, each with one high-power and one low-power lens
- metric ruler
- 2 cardboard tubes from paper towels, or black construction paper
- tape

Procedure

PART 1 Research and Investigate

1. Work with a partner. Using only your eyes, examine words in a book. Then use the high-power lens to examine the same words. In your notebook, contrast what you saw with and without the magnifying lens.
2. Hold the high-power lens about 5–6 cm above the words in the book. When you look at the words through the lens, they will look blurry.
3. Keep the high-power lens about 5–6 cm above the words. Hold the low-power lens above the high-power lens, as shown in the photograph on the right.
4. Move the low-power lens up and down until the image is in focus and upside down. (*Hint:* You may have to move the high-power lens up or down slightly too.)
5. Once the image is in focus, experiment with raising and lowering both lenses. Your goal is to produce the highest magnification while keeping the image in clear focus.
6. When the image is in focus at the position of highest magnification, have your lab partner measure and record the distance between the book and the high-power lens. Your lab partner should also measure and record the distance between the two lenses.
7. Write a description of how the magnified words viewed through two lenses compares with the words seen without magnification.





PART 2 Design and Build

8. Based on what you learned in Part 1, work with a partner to design your own two-lens (compound) microscope. Your microscope should
   - consist of one high-power lens and one low-power lens, each attached to a tube of paper or rolled-up cardboard
   - allow one tube to fit snugly inside the other tube so the distance between the two lenses can be easily adjusted
   - focus to produce a clear, enlarged, upside-down image of the object
   - be made from dual magnifying glasses, cardboard tubes, and tape
9. Sketch your design on a sheet of paper. Obtain your teacher's approval for your design. Then construct your microscope.

PART 3 Evaluate and Redesign

10. Test your microscope by examining printed words or a printed photograph. Then, examine other objects such as a leaf or your skin. Record your observations. Did your microscope meet the criteria listed in Step 8?
11. Examine microscopes made by other students. Based on your tests and your examination of other microscopes, list ways you could improve your microscope.

Analyze and Conclude

1. **Observing** Compare the images you observed using one lens with the image from two lenses.
2. **Evaluating** When you used two lenses, how did moving the top lens up and down affect the image? What was the effect of moving the bottom lens up and down?
3. **Building a Prototype** Describe how you built your microscope and explain why you built it that way.
4. **Evaluating the Impact on Society** Describe some of the ways that microscopes have aided scientists in their work.
5. **Making Judgments** Suppose you had to observe the movement of an ant's legs as the ant moved across the ground. You can use a single magnifying glass or the tool you just constructed. Which would you select? Why?

Communicate

Imagine it is 1675. Write an explanation that will convince scientists to use your new microscope rather than the single-lens variety used by Leeuwenhoek. Describe how your microscope makes the details of organisms more visible.

Section 2

Looking Inside Cells

CALIFORNIA Standards Focus

S 7.1.b Students know the characteristics that distinguish plant cells from animal cells, including chloroplasts and cell walls.

S 7.1.c Students know that the nucleus is the repository for genetic information in plant and animal cells.

- What role do the cell wall and cell membrane play in the cell?
- What is the role of the nucleus in the cell?
- What organelles are found in the cytoplasm and what are their functions?
- How do cells differ?

Key Terms

- organelle
- cell wall
- cytoskeleton
- cell membrane
- nucleus
- cytoplasm
- mitochondria
- endoplasmic reticulum
- ribosome
- Golgi body
- chloroplast
- vacuole
- lysosome

Lab zone Standards Warm-Up

How Large Are Cells?

1. Look at the organism in the photo. The organism is an amoeba (uh MEE buh), a large single-celled organism. This type of amoeba is about 1 mm long.
2. Multiply your height in meters by 1,000 to get your height in millimeters. How many amoebas would you have to stack end-to-end to equal your height?
3. Many of the cells in your body are about 0.01 mm long—one hundredth the size of an amoeba. How many body cells would you have to stack end-to-end to equal your height?

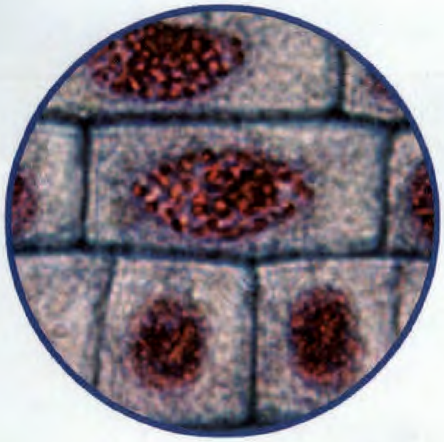
Think It Over

Inferring Look at a metric ruler to see how small 1 mm is. Now imagine a distance one one-hundredth as long, or 0.01 mm. Why can't you see your body's cells without a microscope?

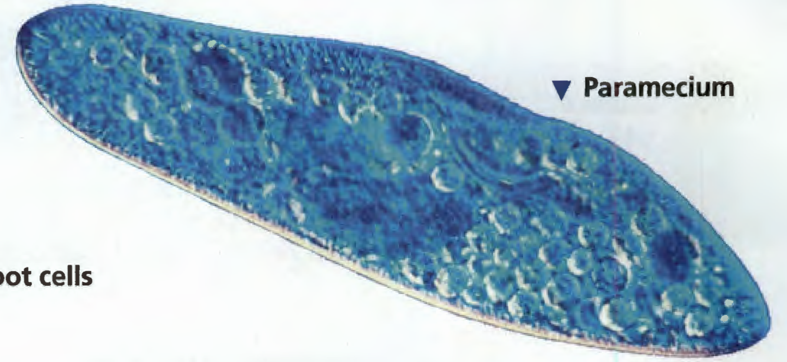
Nasturtiums brighten up many gardens with green leaves and colorful flowers. How do nasturtiums carry out all the functions necessary to stay alive? To answer this question, you will take an imaginary journey into the cell of a nasturtium leaf. You will observe some of the structures found in plant cells. You will also learn some differences between plant and animal cells.

As you will discover on your journey, there are even smaller structures inside a cell, called organelles. **Organelles** carry out specific functions within the cell. Just as your stomach, lungs, and heart have different functions in your body, each organelle has a different function within the cell. Now, hop aboard your imaginary ship and sail into a typical plant cell. As you travel through the plant cell, refer to Figure 6. And be sure to note the differences between plant and animal cells.

Nasturtiums ▶



◀ Onion root cells



▼ Paramecium

FIGURE 5
Cell Wall and Cell Membrane
The onion root cells have both a cell wall and a cell membrane. The single-celled paramecium has only a cell membrane, but it is dense and tough.
Interpreting Photographs *What shape do the cell walls give to the onion root cells?*

Enter the Cell

Your ship doesn't have an easy time getting inside the plant cell. It has to pass through the cell wall and the cell membrane.

Cell Wall The **cell wall** is a rigid layer of nonliving material that surrounds the cells of plants and some other organisms. **A cell wall helps to protect and support the cell.** In plants, the cell wall is made mostly of a strong material called cellulose. Although the cell wall is tough, many materials, including water and oxygen, can pass through easily.

Unlike plant cells, the cells of animals and many single-celled organisms do not have cell walls. Instead, a protein "framework" inside the cell called a **cytoskeleton** gives the cells their shape.

Cell Membrane After passing through the cell wall, the next barrier you must cross is the **cell membrane.** All cells have cell membranes. The cell membrane forms the outside boundary that separates the cell from its environment. In cells with cell walls, the cell membrane is located just inside the cell wall. In other cells, the cell membrane forms the outside boundary that separates the cell from its environment.

The cell membrane controls what substances come into and out of a cell. Everything the cell needs, from food to oxygen, enters the cell through the cell membrane. For a cell to survive, the cell membrane must allow these materials to pass in and out. Harmful waste products leave the cell through the cell membrane. The cell membrane also prevents harmful materials from entering the cell. In a sense, the cell membrane is like a window screen. The screen allows air to enter and leave a room, but it keeps insects out. Fortunately, on this trip, your ship can slip through.

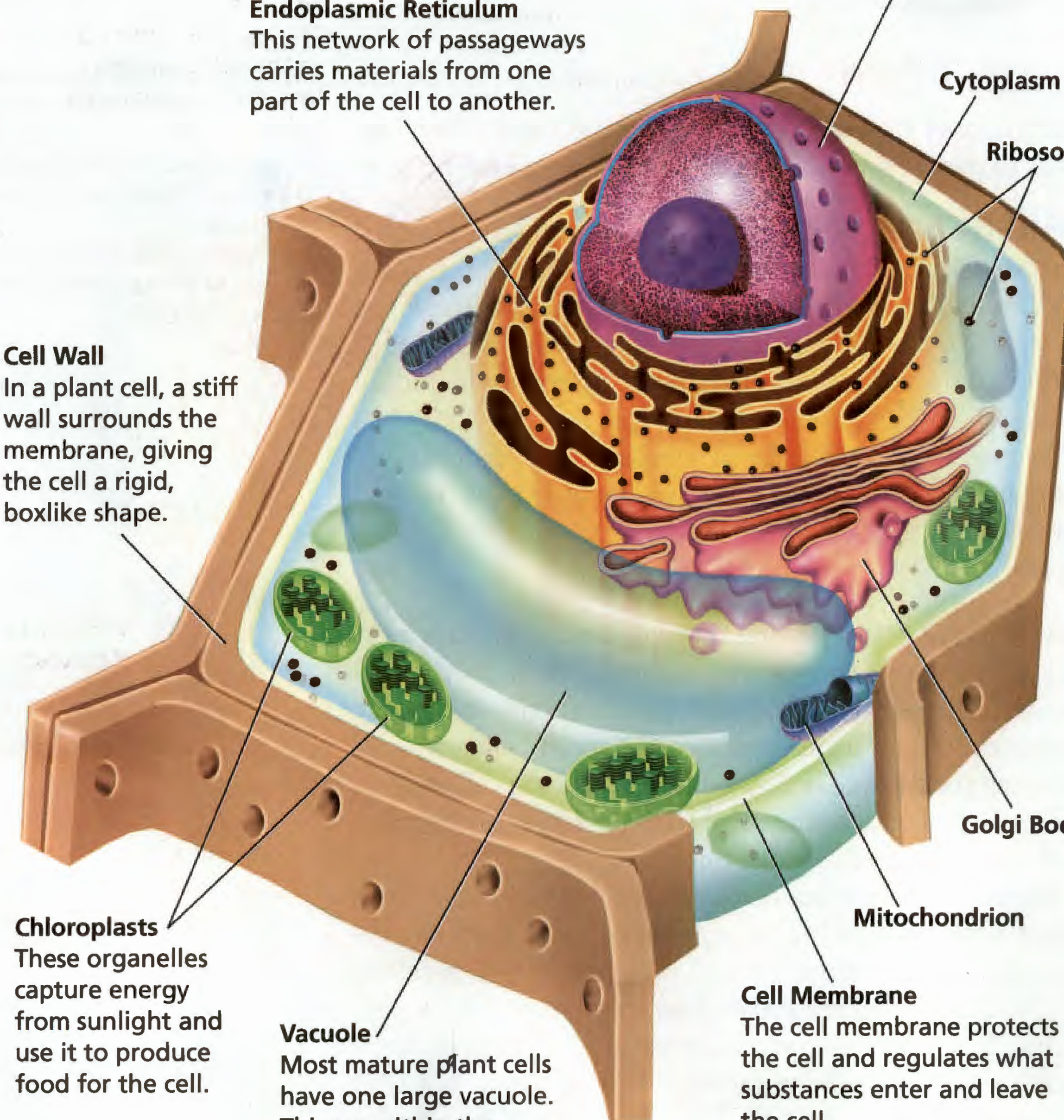
Reading Checkpoint Do animal cells contain cell walls?

Video Field Trip
Discovery Channel School
Cell Structure and Function

FIGURE 6

Plant and Animal Cells

These illustrations show typical structures found in plant and animal cells. **Comparing and Contrasting** *Identify one structure found in plant cells but not animal cells.*



Plant Cell

Go Online *active art*

For: Plant and Animal Cells activity
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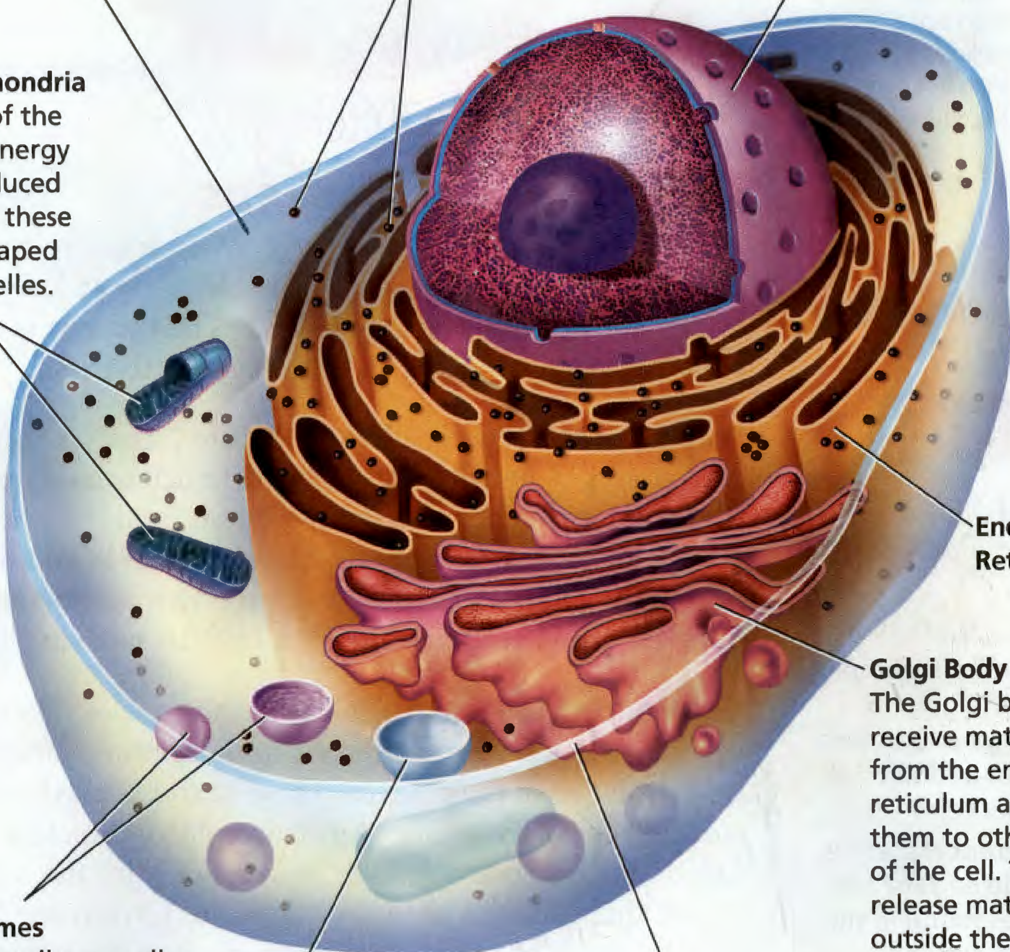


Animal Cell

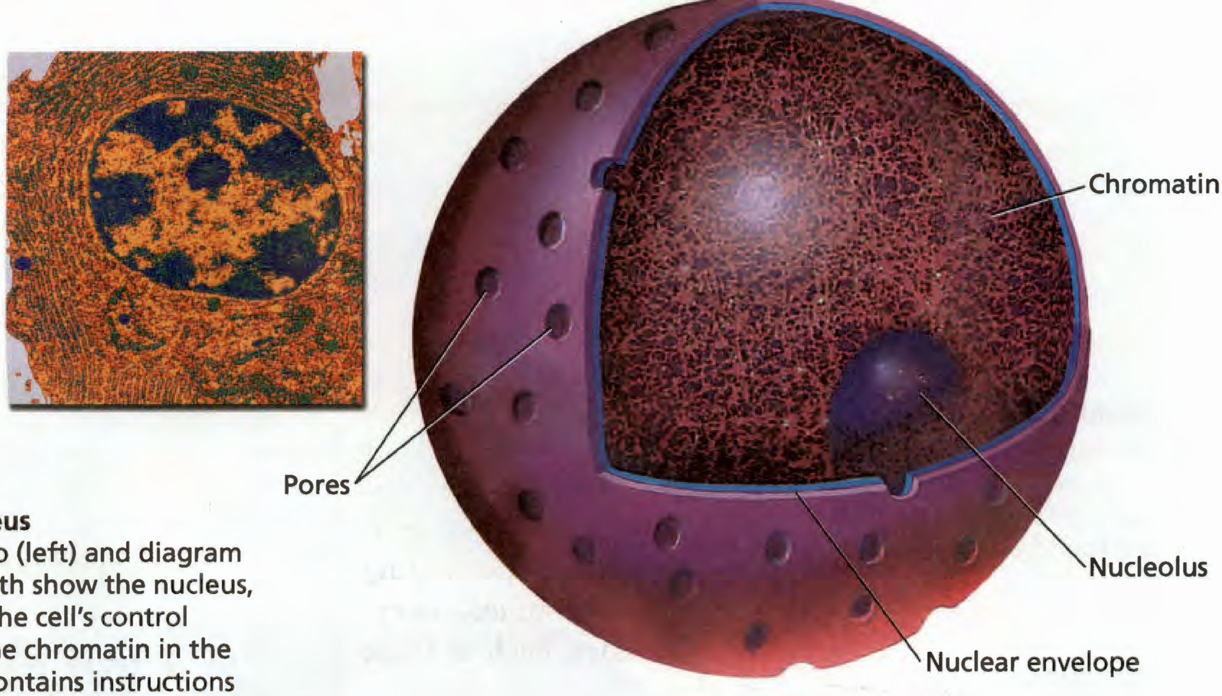


FIGURE 7
The Nucleus
The photo (left) and diagram (right) both show the nucleus, which is the cell's control center. The chromatin in the nucleus contains instructions for carrying out the cell's activities.

Sail on to the Nucleus

As you sail inside the cell, a large, oval structure comes into view. This structure, called the **nucleus** (NOO klee us), acts as the control center of the cell. **The nucleus is the cell's control center, directing all of the cell's activities.**

Nuclear Envelope Notice in Figure 7 that the nucleus is surrounded by a membrane called the nuclear envelope. Just as a mailing envelope protects the letter inside it, the nuclear envelope protects the nucleus. Materials pass in and out of the nucleus through pores in the nuclear envelope. So aim for that pore just ahead and carefully glide into the nucleus.

Chromatin You might wonder how the nucleus "knows" how to direct the cell. The answer lies in those thin strands floating directly ahead in the nucleus. These strands, called chromatin, contain genetic material, the instructions for directing the cell's functions. For example, the instructions in the chromatin ensure that leaf cells grow and divide to form more leaf cells. You can think of the nucleus as a repository for genetic information in cells. A repository is a storage area.

Nucleolus As you prepare to leave the nucleus, you spot a small object floating by. This structure, a nucleolus, is where ribosomes are made. Ribosomes are the organelles where proteins are produced. Proteins are important chemicals in cells.

Reading Checkpoint **Where in the nucleus is genetic material found?**

Lab zone Try This Activity

Gelatin Cell

Make your own model of a cell.

1. Dissolve a packet of colorless gelatin in warm water. Pour the gelatin into a rectangular pan (for a plant cell) or a round pan (for an animal cell).
2. Choose different materials that resemble each of the cell structures found in the cell you are modeling. Insert these materials into the gelatin before it begins to solidify.

Making Models On a sheet of paper, develop a key that identifies each cell structure in your model. Describe the function of each structure.

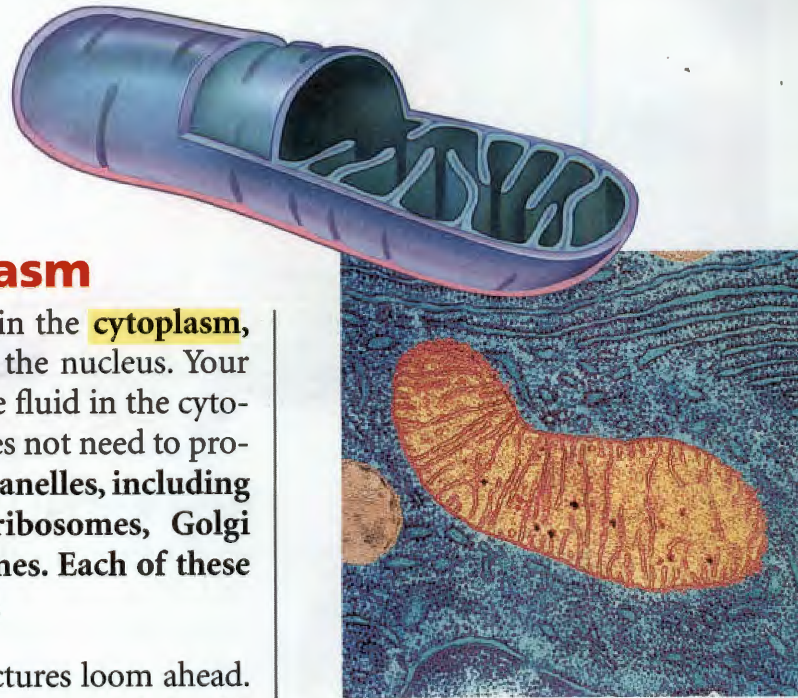


FIGURE 8
Mitochondrion
The mitochondria release most of the cell's energy. **Inferring** *In what types of cells would you expect to find a lot of mitochondria?*

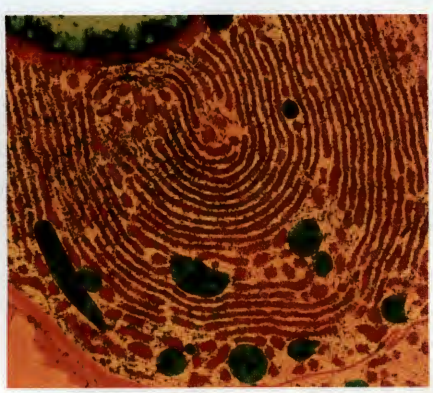
Organelles in the Cytoplasm

As you leave the nucleus, you find yourself in the **cytoplasm**, the region between the cell membrane and the nucleus. Your ship floats in a clear, thick, gel-like fluid. The fluid in the cytoplasm is constantly moving, so your ship does not need to propel itself. **In the cytoplasm are many organelles, including mitochondria, endoplasmic reticulum, ribosomes, Golgi bodies, chloroplasts, vacuoles, and lysosomes. Each of these organelles has specific functions in the cell.**

Mitochondria Suddenly, rod-shaped structures loom ahead. These organelles are **mitochondria** (my tuh KAHN dree uh) (singular *mitochondrion*). Mitochondria are known as the "powerhouses" of the cell because they convert energy in food molecules to energy the cell can use to carry out its functions. Figure 8 shows a mitochondrion up close.

Endoplasmic Reticulum As you sail farther into the cytoplasm, you find yourself in a maze of passageways called the **endoplasmic reticulum** (en duh PLAZ mik rih TIK yuh lum). The endoplasmic reticulum's passageways help form proteins and other materials. They also carry material throughout the cell.

Ribosomes Attached to some surfaces of the endoplasmic reticulum are small, grainlike bodies called **ribosomes.** Other ribosomes float in the cytoplasm. Ribosomes function as factories to produce proteins. Some newly made proteins are released through the wall of the endoplasmic reticulum. From the interior of the endoplasmic reticulum, the proteins will be transported to the Golgi bodies.



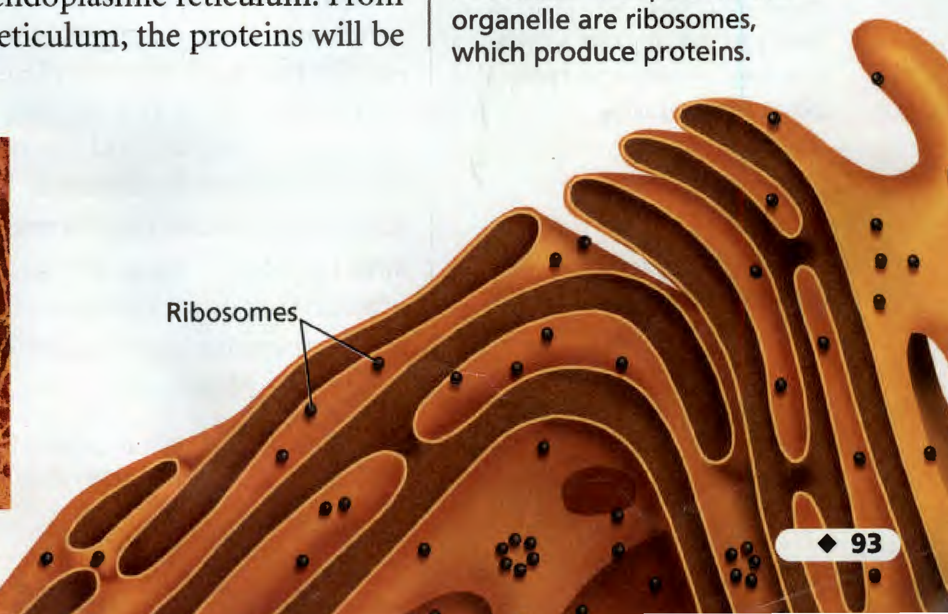


FIGURE 9
Endoplasmic Reticulum
The endoplasmic reticulum is similar to the system of hallways in a building. Proteins and other materials move throughout the cell by way of the endoplasmic reticulum. The spots on this organelle are ribosomes, which produce proteins.

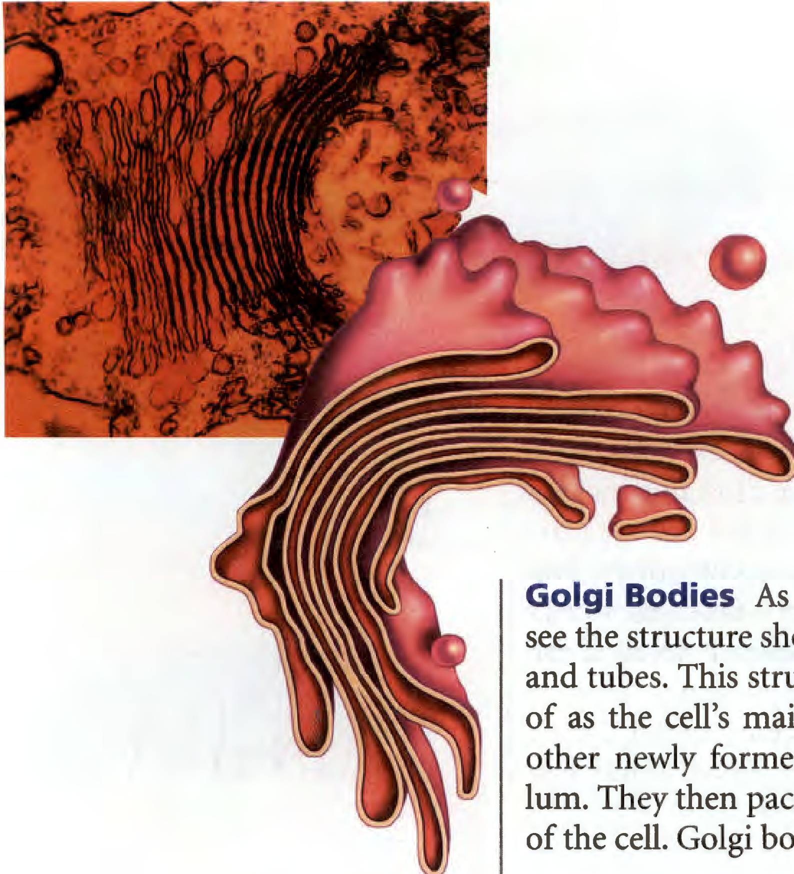


FIGURE 10
A Golgi Body
Golgi bodies are organelles that transport materials.

Golgi Bodies As you leave the endoplasmic reticulum, you see the structure shown in Figure 10. It looks like flattened sacs and tubes. This structure, called a **Golgi body,** can be thought of as the cell's mail room. Golgi bodies receive proteins and other newly formed materials from the endoplasmic reticulum. They then package and distribute materials to other parts of the cell. Golgi bodies also release materials outside the cell.

Chloroplasts Have you noticed the many large green structures floating in the cytoplasm? Only the cells of plants and some other organisms have these green organelles called **chloroplasts** (KLAWR uh plasts). Chloroplasts capture energy from sunlight and use it to produce food. Chloroplasts make leaves green.

Vacuoles Steer past the chloroplasts and head for that large, water-filled sac, called a **vacuole** (VAK yoo ohl), floating in the cytoplasm. Vacuoles are the storage areas of cells. Most plant cells have one large, central vacuole. Vacuoles store food and other materials needed by the cell. Vacuoles can also store waste products. Animal cells do not have central vacuoles. However, some animal cells have smaller storage organelles.

Lysosomes Your journey through the cell is almost over. Before you leave, take another look around you. If you carefully swing your ship around the vacuole, you may be lucky enough to see a lysosome. **Lysosomes** (LY suh sohms) are small, round structures containing chemicals that break down certain materials in the cell. Some chemicals break down large food particles into smaller ones. Lysosomes also break down old cell parts and release the substances so they can be used again. In this sense, you can think of lysosomes as the cell's cleanup crew.

Reading Checkpoint **What organelle captures the energy of sunlight and uses it to make food for the cell?**

Lab zone Try This Activity

Comparing Cells

Observe the characteristics of plant and animal cells.

1. Obtain a prepared slide of plant cells from your teacher. Examine these cells under the low-power and high-power lenses of a microscope.
2. Draw a picture of what you see.
3. Repeat Steps 1 and 2 with a prepared slide of animal cells.

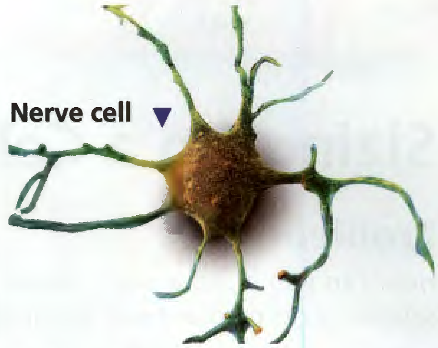
Observing How are plant and animal cells alike? How are they different?

Cell Diversity

You just had a tour of a typical leaf cell. But actually, there's a lot of variety in cells—both within individual organisms and across different organisms. **The variety of structure in cells reflects differences in cell function.**

Cells come in many shapes. Look at the nerve cell and red blood cells in Figure 11. Notice the long, fingerlike extensions of the nerve cell. These extensions help transmit information from one part of your body to another. Red blood cells carry oxygen throughout your body. Their flattened shape enables them to fit through tiny blood vessels.

Some cells contain certain organelles but not others. For example, not all plant cells have chloroplasts. Since root cells grow underground away from sunlight, they have no need for chloroplasts. Cells may also have more of a particular kind of organelle. For example, cells that actively produce proteins, such as liver cells, contain many ribosomes. Each human liver cell has millions of ribosomes.



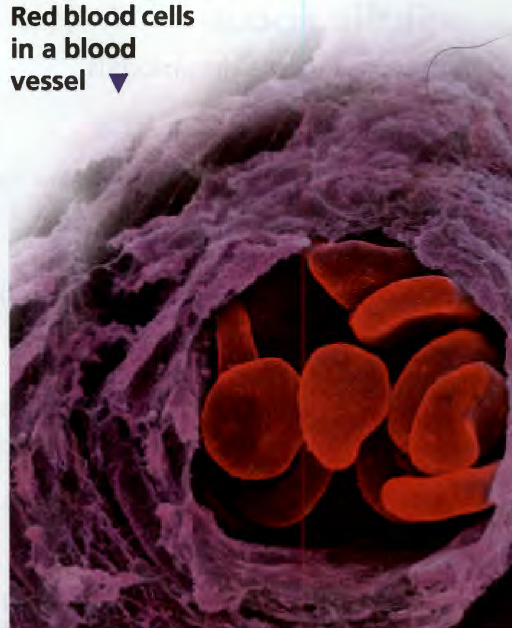


FIGURE 11 Specialized Cells
Nerve cells carry information throughout the human body. Red blood cells carry oxygen.
Developing Hypotheses *How do the shapes of these cells help them function?*

Section 2 Assessment

S 7.1.b, 7.7.c, E-LA: Reading 7.1.2, Writing 7.2.0

Vocabulary Skill **Prefixes** The Key Term *endoplasmic reticulum* begins with the prefix *endo-*, which means "in" or "within." Within what part of a cell is the endoplasmic reticulum located?

Reviewing Key Concepts

1. a. **Comparing and Contrasting** Compare the functions of the cell wall and the cell membrane in plant and animal cells.
   b. **Inferring** How does cellulose help with the function of the cell wall?
2. a. **Identifying** What is the key function of the nucleus?
   b. **Describing** Which structure inside the nucleus is involved in this function?
   c. **Predicting** Suppose a dye for staining cells stains the region where ribosomes are made. What would you expect to see inside the stained cell's nucleus?
3. a. **Identifying** Identify the functions of ribosomes and Golgi bodies.
   b. **Describing** Describe the characteristics of the endoplasmic reticulum.
   c. **Applying Concepts** How are the functions of ribosomes, Golgi bodies, and the endoplasmic reticulum related?
4. a. **Listing** What are two ways cells can differ?
   b. **Applying Concepts** Which organelles might you expect to see in large quantities in cells that actively release proteins outside the cell?

Writing in Science

Writing a Description Write a paragraph describing a typical animal cell. Your paragraph should include all the structures generally found in animal cells and a brief explanation of the functions of those structures.

Lab zone **Skills Lab**

Sizing Up a Cell

S 7.1.b, 7.7.d

Problem

How can you build a scale model showing the relative sizes of plant cell organelles?

Skills Focus

calculating, making models

Materials

- various materials provided by your teacher

Procedure

1. The table below gives the approximate sizes of structures in a typical plant cell. Copy the table into your notebook.
2. Convert the size of each structure using the scale one centimeter to one micrometer (1 cm : 1 μm). For example, at this scale, a model of a plant cell that is 150 μm long would be 150 cm long.

$$\text{Length of model} = 150\,\mu\text{m} \times \frac{1\text{ cm}}{1\,\mu\text{m}} = 150\text{ cm}$$

Record your calculations in the third column.

3. Then, calculate the size of each structure at a scale of 10 cm : 1 μm. Fill in your calculations in the correct column.
4. Now select a scale you would like to use for your model. Calculate the sizes of structures for a cell model built according to the scale you selected. Record your calculations.
5. With your lab partner, choose four cell structures that would be practical to model. Discuss the possible materials you can use.
6. Sketch your design on a sheet of paper. Obtain your teacher's approval for your design. Then construct your model.

Analyze and Conclude

1. **Calculating** A plant cell model has been built using the scale one meter to one micrometer. How large would a ribosome with a diameter of 0.02 micrometer be in this model?
2. **Making Models** What scale did you choose to use for your model? Why? What problems did you encounter in building your model?
3. **Drawing Conclusions** Based on your calculations in this lab, why would it be difficult to include all the structures of a cell in a scale model the size of a shoebox?
4. **Communicating** You are designing a giant scale model of a cell for a museum exhibit. The museum is able to provide unlimited space and construction materials for your project. Write a memo to your construction team explaining what factors to keep in mind while building a giant cell to scale.

Cell Structure	Actual Size	1 cm : 1 µm	10 cm : 1 µm	Your Scale (__:__)
Plant cell	150 µm (length); 100 µm (width)	150 cm; 100 cm	1,500 cm; 1,000 cm	
Nucleus	6.5–10 µm (diameter)			
Vacuole	130 µm (length); 80 µm (width)			
Chloroplast	5–10 µm (length); 2–3 µm (width)			
Mitochondrion	3–5 µm (length); 0.5–1 µm (width)			
Ribosome	0.017–0.023 µm (diameter)			

Section 3

Integrating Chemistry

Chemical Compounds in Cells

CALIFORNIA Standards Focus

S 7.1.a Students know cells function similarly in all living organisms.

- What are elements and compounds?
- How is water important to the function of cells?
- What are the functions of carbohydrates, lipids, proteins, and nucleic acids?

Key Terms

- element
- compound
- carbohydrate
- lipid
- protein
- amino acid
- enzyme
- nucleic acid
- DNA
- RNA

Lab zone **Standards Warm-Up**

What Is a Compound?

1. Your teacher will provide you with containers filled with various substances. All of the substances are chemical compounds.
2. Examine each substance. Read the label on each container to learn what each substance is made of.

Think It Over

Forming Operational Definitions Chemical compounds are important to the structure and function of all cells. Write a definition of what you think a chemical compound is.

Cells and organelles are very small, but you are surrounded by particles even smaller than cells! Air is made up of trillions of these tiny particles. They bump into your skin, hide in the folds of your clothes, and whoosh into your nose every time your take a breath. In fact, you and the world around you, including the cells in your body and all other organisms, are composed of tiny particles. Some of these particles are elements, and others are compounds. One reason why cells function similarly in all organisms is that cells consists of, use, and produce many identical compounds.

Elements and Compounds

You may not realize it, but air is a mixture of gases. These gases include both elements and compounds. Three gases in the air are oxygen, nitrogen, and carbon dioxide.

Elements Oxygen and nitrogen are examples of **elements.** **An element is any substance that cannot be broken down into simpler substances.** The smallest unit of an element is called an atom. An element is made up of only one kind of atom. The elements found in living things include carbon, hydrogen, oxygen, nitrogen, phosphorus, and sulfur.

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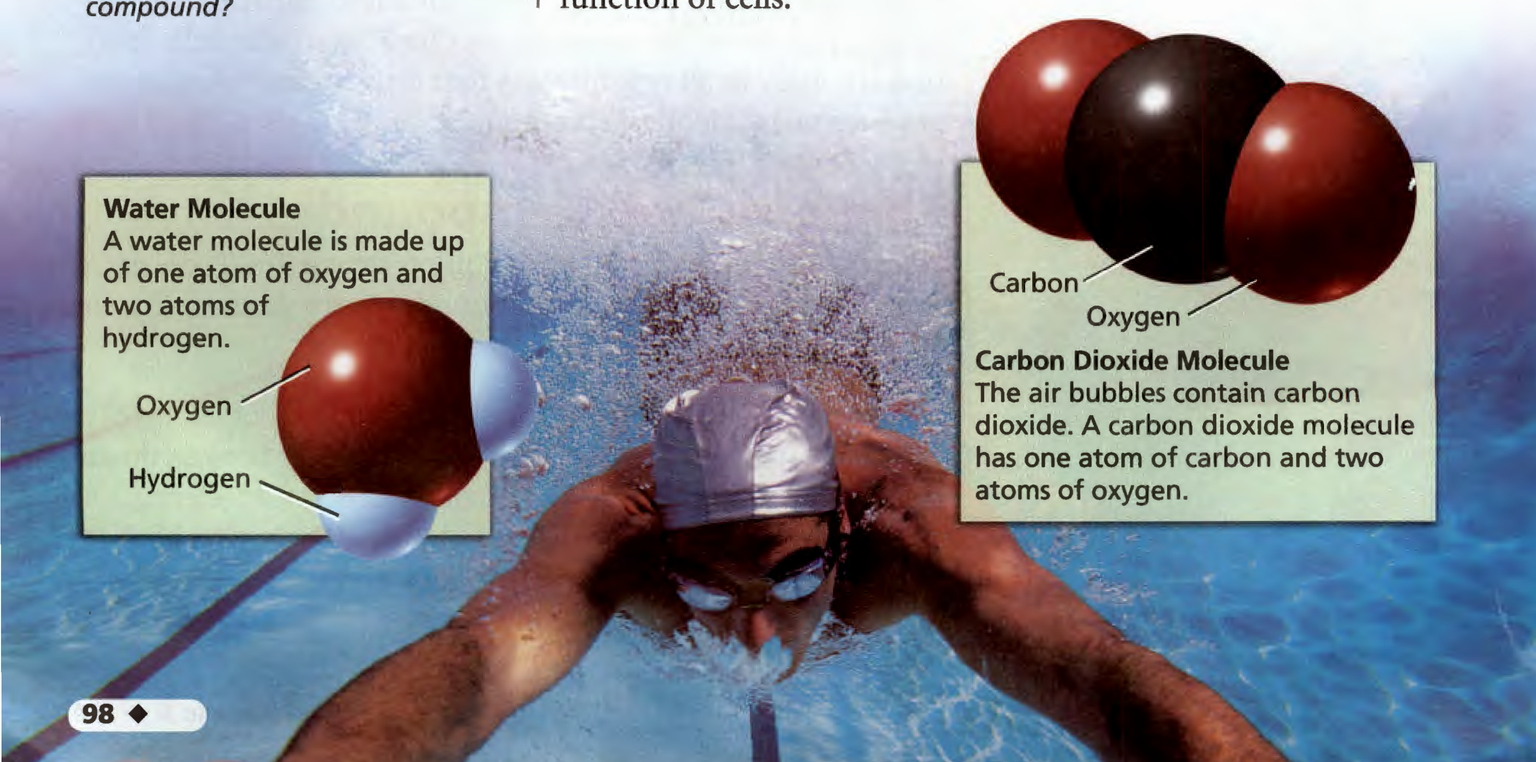
Compounds Carbon dioxide is a **compound** made up of the elements carbon and oxygen. **When two or more elements combine chemically, they form a compound.** Most elements in living things occur in the form of compounds. The smallest unit of many compounds is a molecule. A molecule of carbon dioxide consists of one carbon atom and two oxygen atoms.

The Compound Called Water Like carbon dioxide, water is a compound. Each water molecule is made up of two hydrogen atoms and one oxygen atom. Water makes up about two thirds of your body. Water plays many important roles in cells. Water dissolves chemicals that cells need. **Most chemical reactions within cells could not take place without water.** For example, without water, plants would not be able to convert the energy captured by chloroplasts into food. Water also helps cells keep their size and shape. In fact, a cell without water would be like a balloon without air. In addition, because water changes temperature so slowly, it helps keep the temperature of cells from changing rapidly.

Inorganic and Organic Compounds Water is an example of an inorganic compound. An inorganic compound does not contain the element carbon. Sodium chloride, or table salt, is another inorganic compound.

Many compounds in living things contain the element carbon. Most compounds that contain carbon are called organic compounds. **Carbohydrates, lipids, proteins, and nucleic acids are important groups of organic compounds in living things.** These organic compounds play important roles in the function of cells.

FIGURE 12
Molecules and Compounds
Water is a chemical compound. So is carbon dioxide, which is found in the gas bubbles.
Applying Concepts *What is a compound?*



Water Molecule
A water molecule is made up of one atom of oxygen and two atoms of hydrogen.

Carbon Dioxide Molecule
The air bubbles contain carbon dioxide. A carbon dioxide molecule has one atom of carbon and two atoms of oxygen.

Carbohydrates

A **carbohydrate** is an energy-rich organic compound made of the elements carbon, hydrogen, and oxygen. Sugars and starches are examples of carbohydrates.

Sugars are produced during the food-making process that takes place in plants. Foods such as fruits and some vegetables have a high sugar content. Sugar molecules can combine, forming large molecules called starches, or complex carbohydrates. Plant cells store excess energy in molecules of starch. Many foods that come from plants contain starch. These foods include potatoes, pasta, rice, and bread. When you eat these foods, your body breaks down the starch into glucose, a sugar that your cells can use for energy.

In addition to providing energy for the cell, carbohydrates are important components of some cell parts. For example, the cellulose found in the cell walls of plants is a type of carbohydrate. Carbohydrates are also found in cell membranes.

FIGURE 13
Starch
These potatoes contain a large amount of starch. Starch is a carbohydrate. The blue grains in the close-up are starch granules in a potato. The grains have been colored blue to make them easier to see.

Lipids

Have you ever seen a cook trim the fat from a piece of meat before cooking it? The cook is trimming away a lipid. Fats, oils, and waxes are all lipids. Like carbohydrates, **lipids** are energy-rich organic compounds made of carbon, hydrogen, and oxygen. Lipids contain even more energy than carbohydrates. Cells store energy in lipids for later use. For example, during winter, a dormant bear lives on the energy stored in fat within its cells. **In addition to their function as an energy source, lipids also make up most of the cell membrane.**

Reading Checkpoint **What are the kinds of lipids?**

FIGURE 14
Lipids
Olive oil, which comes from olives such as those shown here, is made mostly of lipids.
Making Generalizations
What elements are lipids composed of?

Reviewing Math: Statistics, Data Analysis, and Probability 7.1.1

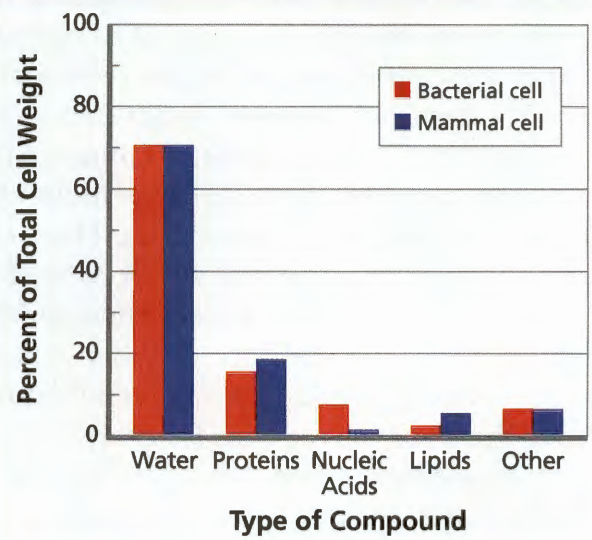
Math Analyzing Data

Compounds in Bacteria and Mammals

Do all cells contain the same amounts of carbohydrates, lipids, proteins, and nucleic acids? The graph compares the percentages of different compounds in a bacterial cell and a mammal cell.

1. **Reading Graphs** What do the red bars represent? What do the blue bars represent?
2. **Interpreting Data** Which kind of compound—proteins or nucleic acids—makes up the larger percentage of a mammal cell?
3. **Drawing Conclusions** In general, how do a bacterial cell and a mammal cell compare in their chemical composition?

Comparing Compounds in Cells



Proteins

What do a bird's feathers, a spider's web, and your fingernails have in common? All of these substances are made mainly of proteins. **Proteins** are large organic molecules made of carbon, hydrogen, oxygen, nitrogen, and, in some cases, sulfur. Foods that are high in protein include meat, eggs, fish, nuts, and beans.

Structure of Proteins Protein molecules are made up of smaller molecules called **amino acids.** Although there are only 20 common amino acids, cells can combine them in different ways to form thousands of different proteins. The kinds of amino acids and the order in which they link together determine the type of protein that forms. You can think of the 20 amino acids as being like the 26 letters of the alphabet. Those 26 letters can form thousands of words. The letters you use and their order determine the words you form.

Functions of Proteins Much of the structure of cells is made up of proteins. Proteins form parts of cell membranes. Proteins also make up many of the organelles within the cell.

The proteins known as enzymes perform important functions in the chemical reactions that take place in cells. An **enzyme** is a type of protein that speeds up a chemical reaction in a living thing. Without enzymes, many chemical reactions that are necessary for life would either take too long or not occur at all. For example, enzymes in your saliva speed up the digestion of food by breaking down starches into sugars in your mouth.

Nucleic Acids

Nucleic acids are very long organic molecules made of carbon, oxygen, hydrogen, nitrogen, and phosphorus. **Nucleic acids contain the instructions that cells need to carry out all the functions of life.**

There are two kinds of nucleic acids. Deoxyribonucleic acid (dee ahk see ry boh noo KLEE ik), or **DNA,** is the genetic material that carries information about an organism and is passed from parent to offspring. The information in DNA is also used to direct all of the cell's functions. Most of the DNA in a cell is found in the chromatin in the nucleus.

Ribonucleic acid (ry boh noo KLEE ik), or **RNA,** plays an important role in the production of proteins. RNA is found in the cytoplasm as well as in the nucleus.

Reading Checkpoint **What are the two kinds of nucleic acids? What are their functions?**

FIGURE 15
DNA in the Nucleus
A cell's nucleus (colored purple) contains most of the cell's DNA in its chromatin (colored red and yellow).

Section 3 Assessment

S 7.1.a, E-LA: Reading 7.2.0

Target Reading Skill **Identify Main Ideas** Reread the text following the heading Structure of Proteins. What sentence expresses the main idea of this paragraph?

Reviewing Key Concepts

1. a. **Defining** What is a compound?
   b. **Classifying** What is one inorganic compound vital for chemical reactions in cells? What are four groups of organic compounds important to living things?
2. a. **Reviewing** What three important functions does water perform in cells?
   b. **Relating Cause and Effect** Suppose a cell is seriously deprived of water. How might this lack of water affect the cell's enzymes? Explain.
3. a. **Reviewing** Which of the four types of organic compounds serve as an energy source for cells?
   b. **Classifying** Which of the four types of organic molecules contain the element nitrogen?
   c. **Inferring** An organic compound contains only the elements carbon, hydrogen, and oxygen. Could this compound be a carbohydrate? Could it be a protein? Explain.

Lab zone At-Home Activity

Compounds in Food With family members, look at the "Nutrition Facts" labels on a variety of food products. Identify foods that contain large amounts of the following organic compounds: carbohydrates, proteins, and fats. Discuss with your family what elements make up each of these compounds and what roles they play in cells and in your body.

Section 4

The Cell in Its Environment

CALIFORNIA **Standards Focus**

S 7.1.a Students know cells function similarly in all living organisms.

- How do most small molecules cross the cell membrane?
- Why is osmosis important to cells?
- What is the difference between passive transport and active transport?

Key Terms

- selectively permeable
- diffusion
- osmosis
- passive transport
- active transport

Lab zone Standards Warm-Up

How Do Molecules Move?

1. Stand with your classmates in locations that are evenly spaced throughout the classroom.
2. Your teacher will spray an air freshener into the room. When you first smell the air freshener, raise your hand.
3. Note how long it takes for other students to smell the scent.

Think It Over

Developing Hypotheses How was each student's distance from the teacher related to when he or she smelled the air freshener? Develop a hypothesis about why this pattern occurred.

As darkness fell, the knight urged his horse toward the castle. The weary knight longed for the safety of the castle, with its thick walls of stone and strong metal gates. The castle's gatekeeper opened the gates and slowly lowered the drawbridge. The horse clopped across the bridge, and the knight sighed with relief. Home at last!

Like ancient castles, cells have structures that protect their contents from the world outside. All cells are surrounded by a cell membrane that separates the cell from the outside environment. The cell membrane is **selectively permeable**, which means that some substances can pass through the membrane while others cannot.

Cells, like castles, must let things enter and leave. All cells must let in needed materials, such as oxygen and food molecules. In contrast, waste materials must move out of cells. Oxygen, food molecules, waste products, and many useful cell products must pass through the cell membrane.

Diffusion

Substances that can move into and out of a cell do so by one of three methods: diffusion, osmosis, or active transport. **Diffusion is the main method by which small molecules move across the cell membrane.** **Diffusion** (dih FYOO zhun) is the process by which molecules move from an area of higher concentration to an area of lower concentration. The concentration of a substance is the amount of the substance in a given volume. For example, suppose you dissolve 1 gram of sugar in 1 liter of water. The concentration of the sugar solution is 1 gram per liter.

If you did the Standards Warm-Up activity, you observed diffusion in action. The area where the air freshener was sprayed had many molecules of freshener. The molecules gradually moved from this area of higher concentration to the other parts of the classroom, where there were fewer molecules of freshener—and thus a lower concentration.

What Causes Diffusion? Molecules are always moving. As they move, the molecules bump into one another. The more molecules there are in an area, the more collisions there will be. Collisions cause molecules to push away from one another. Over time, the molecules of a substance will continue to spread out. Eventually, they will be spread evenly throughout the area.

Math Skills

Ratios

The concentration of a solution can be expressed as a ratio. A ratio compares two numbers. It tells you how much you have of one item in comparison to another. For example, suppose you dissolve 5 g of sugar in 1 L of water. You can express the concentration of the solution in ratio form as

5 g : 1 L

This can also be written

5 g/L

Practice Problem Suppose you dissolve 7 g of salt in 1 L of water. Express the concentration of the solution as a ratio.

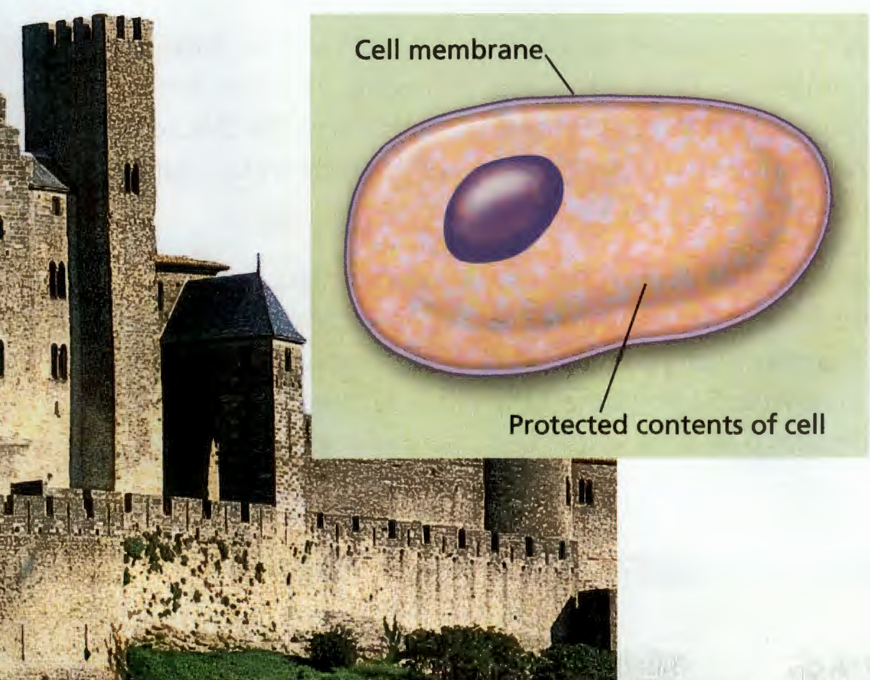
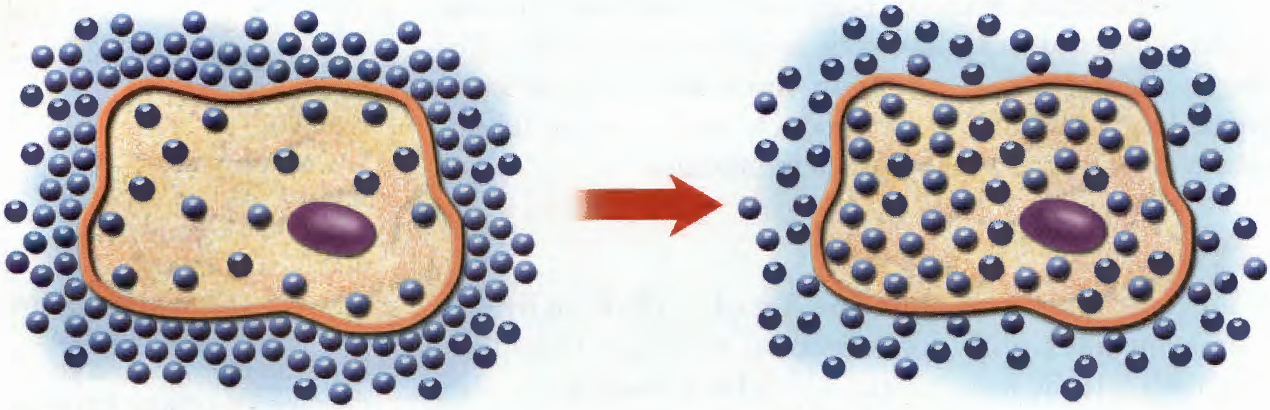


FIGURE 16
A Selective Barrier
The walls of a castle protected the inhabitants within, and the castle gatekeeper allowed only certain people to pass through. Similarly, the cell membrane protects the contents of the cell and helps control the materials that enter and leave.



Before Diffusion
There is a higher concentration of oxygen molecules outside the cell than inside the cell.

After Diffusion
The concentration of oxygen molecules is the same outside and inside the cell.

FIGURE 17
Diffusion in Action
Molecules move by diffusion from an area of higher concentration to an area of lower concentration.
Predicting *What would happen if the concentration of oxygen molecules outside the cell was lower than inside the cell?*

Diffusion of Oxygen Have you ever used a microscope to observe one-celled organisms in pond water? These organisms obtain the oxygen they need to survive from the water around them. Luckily for them, there are many more molecules of oxygen in the water outside the cell than there are inside the cell. In other words, there is a higher concentration of oxygen molecules in the water than inside the cell. Remember that the cell membrane is permeable to oxygen molecules. The oxygen molecules diffuse from the area of higher concentration—the pond water—through the cell membrane to the area of lower concentration—the inside of the cell.

Reading Checkpoint **By what process do small molecules move into cells?**

Osmosis
Like oxygen, water passes easily into and out of cells through the cell membrane. **Osmosis** is the diffusion of water molecules through a selectively permeable membrane. **Because cells cannot function properly without adequate water, many cellular processes depend on osmosis.**

Osmosis and Diffusion Remember that molecules tend to move from an area of higher concentration to an area of lower concentration. In osmosis, water molecules move by diffusion from an area where they are highly concentrated through the cell membrane to an area where they are less concentrated.

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Effects of Osmosis Osmosis can have important consequences for the cell. Look at Figure 18 to see the effect of osmosis on cells. In Figure 18A, a red blood cell is bathed in a solution in which the concentration of water is the same as it is inside the cell. This is the normal shape of a red blood cell.

Contrast this shape to the cell in Figure 18B. The red blood cell is floating in water that contains a lot of salt. The concentration of water molecules outside the cell is lower than the concentration of water molecules inside the cell. This difference in concentration occurs because the salt takes up space in the salt water. Therefore, there are fewer water molecules in the salt water outside the cell compared to the water inside the cell. As a result, water moves out of the cell by osmosis. When water moves out, the cell shrinks.

In Figure 18C, the red blood cell is floating in water that contains a very small amount of salt. The water inside the cell contains more salt than the solution outside the cell. Thus, the concentration of water outside the cell is greater than it is inside the cell. The water moves into the cell, causing it to swell.

Reading Checkpoint **How is osmosis related to diffusion?**

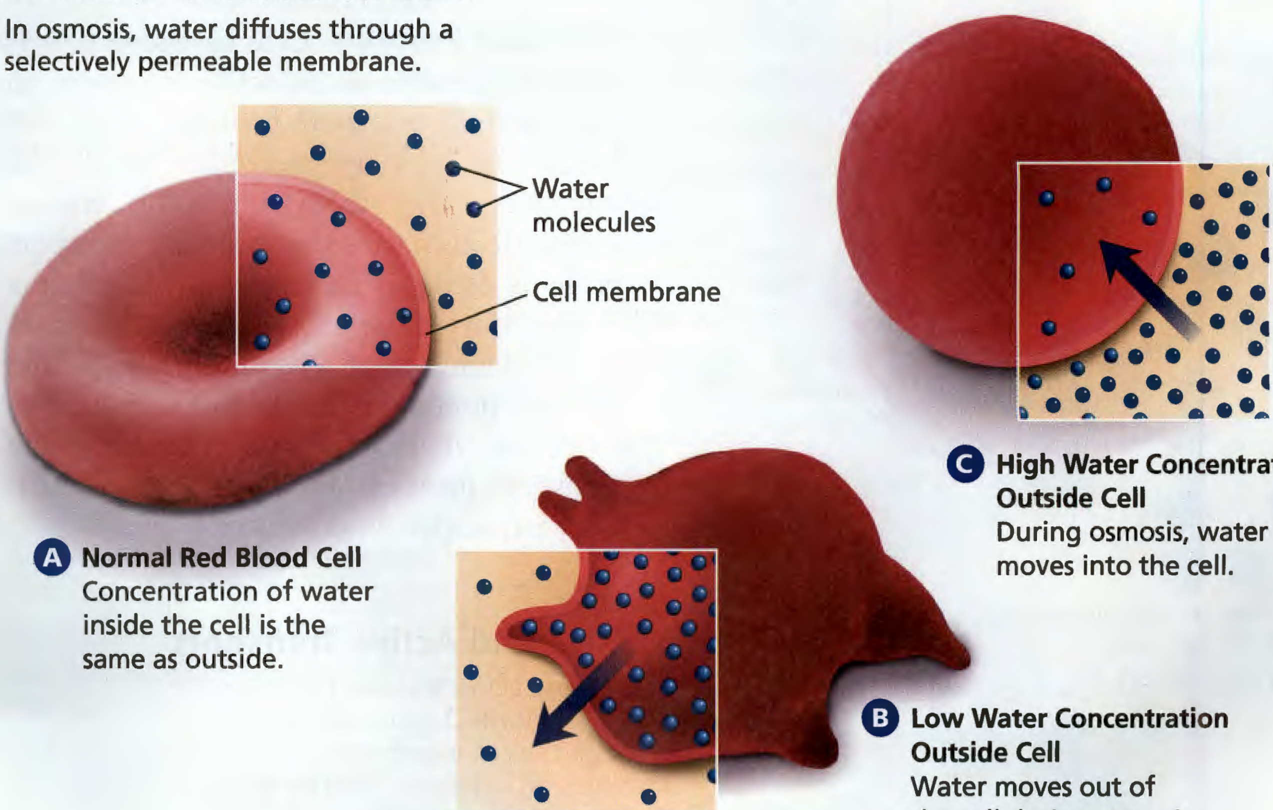
Lab zone Try This Activity

Osmosis in Action

1. Use water to prepare a wet-mount slide of *Elodea* (a freshwater plant).
2. Observe the leaf cells at low magnification and record your observations.
3. Increase the magnification and record what you see.
4. Place a drop of 10% salt solution on one edge of the coverslip.
5. Place a small piece of paper towel on the opposite edge of the coverslip to draw the salt solution under the coverslip.
6. Repeat steps 2 and 3.

Inferring What role did osmosis play in the changes you observed?

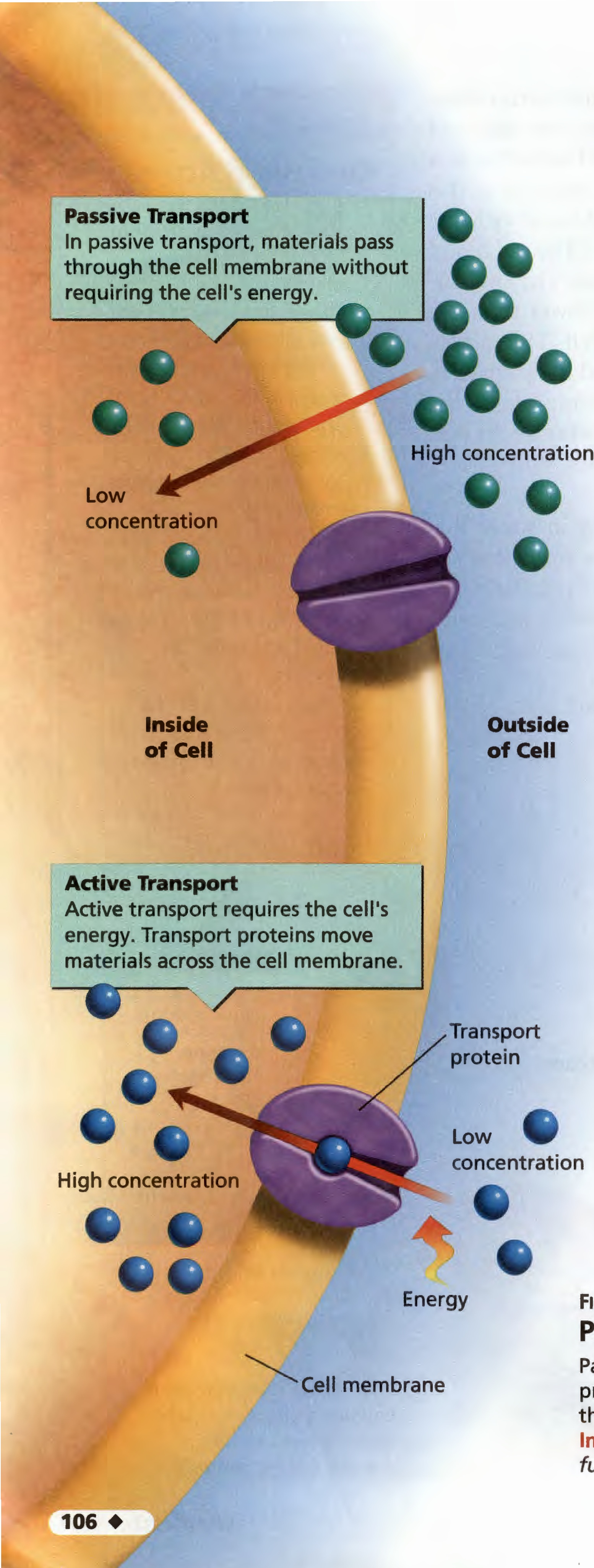
FIGURE 18
Effects of Osmosis on Cells
In osmosis, water diffuses through a selectively permeable membrane.



A Normal Red Blood Cell
Concentration of water inside the cell is the same as outside.

B Low Water Concentration Outside Cell
Water moves out of the cell during osmosis.

C High Water Concentration Outside Cell
During osmosis, water moves into the cell.



Active Transport

If you have ever ridden a bicycle down a long hill, you know that it doesn't take any of your energy to go fast. But you do have to use some of your energy to pedal back up the hill. For a cell, moving materials through the cell membrane by diffusion and osmosis is like cycling downhill. These processes do not require the cell to use its own energy. The movement of dissolved materials through a cell membrane without using cellular energy is called **passive transport.**

What if a cell needs to take in a substance that is present in a higher concentration inside the cell than outside? The cell would have to move the molecules in the opposite direction than they naturally move by diffusion. Cells can do this, but they have to use energy—just as you would use energy to pedal back up the hill. **Active transport** is the movement of materials through a cell membrane using cellular energy. **Active transport requires the cell to use its own energy, while passive transport does not.**

Transport Proteins Cells have several ways of moving materials by active transport. In one method, transport proteins in the cell membrane "pick up" molecules outside the cell and carry them in, using energy. Figure 19 illustrates this process. Transport proteins also carry molecules out of cells in a similar way. Some substances that are carried into and out of cells in this way include calcium, potassium, and sodium.

A cell membrane may contain many transport proteins. Each transport protein can carry a specific substance.

FIGURE 19
Passive and Active Transport
Passive and active transport are two processes by which materials pass through the cell membrane.
Interpreting Diagrams *What is the function of a transport protein?*

Transport by Engulfing Figure 20 shows another method of active transport. First, the cell membrane surrounds and engulfs, or encloses, a particle. Once the particle is engulfed, the cell membrane wraps around the particle and forms a vacuole within the cell. The cell must use energy in this process.

FIGURE 20
Amoeba Engulfing Food
This single-celled amoeba is surrounding a smaller organism. The amoeba will engulf the organism and use it for food. Engulfing is a form of active transport.

Why Cells Are Small As you know, most cells are so small that you cannot see them without a microscope. Have you ever wondered why cells are so small? One reason is related to how materials move into and out of cells.

As a cell's size increases, more of its cytoplasm is located farther from the cell membrane. Once a molecule enters a cell, it is carried to its destination by a stream of moving cytoplasm, somewhat like the way currents in the ocean move a raft. But in a very large cell, the streams of cytoplasm must travel farther to bring materials to all parts of the cell. It would take much longer for a molecule to reach the center of a very large cell than it would in a small cell. Likewise, it would take a long time for wastes to be removed. If a cell grew too large, it could not function well enough to survive.

Reading Checkpoint **What prevents cells from growing very large?**

Section 4 Assessment

S 7.1.a, E-LA: Reading 7.2.0

Target Reading Skill **Identify Main Ideas** Reread the text following the heading Osmosis. What is the main idea of the text under this heading?

Reviewing Key Concepts

1. a. **Defining** What is diffusion?
   b. **Relating Cause and Effect** Use diffusion to explain what happens when you drop a sugar cube into a mug of hot tea.
2. a. **Defining** What is osmosis?
   b. **Describing** Describe how water molecules move through the cell membrane during osmosis.
   c. **Applying Concepts** A selectively permeable membrane separates solutions A and B. The concentration of water molecules in Solution B is higher than that in Solution A. Describe how the water molecules will move.
3. a. **Comparing and Contrasting** How is active transport different from passive transport?
   b. **Reviewing** What are transport proteins?
   c. **Explaining** Explain why transport proteins require energy to function in active transport.

Math Practice

A scientist dissolves 60 g of sugar in 3 L of water.

4. **Calculating a Concentration** Calculate the concentration of the solution in grams per liter.
5. **Ratios** Express the concentration as a ratio.

Chapter 3

Study Guide

The BIG Idea **Cells are the basic building blocks of all living things. All cells have similar structures and carry out similar functions.**

1 Discovering Cells

Key Concepts S 7.1

- Cells are the basic units of structure and function in living things.
- The invention of the microscope enabled people to discover and learn about cells.
- The cell theory states the following: All living things are composed of cells. Cells are the basic units of structure and function in living things. All cells are produced from other cells.
- In multicellular organisms, cells are often organized into tissues, organs, and organ systems.

Key Terms

cell
cell theory
unicellular
multicellular
tissue
organ
organ system

2 Looking Inside Cells

Key Concepts S 7.1.b, 7.1.c

- A cell wall helps to protect and support a plant cell.
- The cell membrane controls what substances come into and out of a cell.
- The nucleus directs the cell's activities.
- In the cytoplasm are many organelles, including mitochondria, endoplasmic reticulum, ribosomes, Golgi bodies, chloroplasts, vacuoles, and lysosomes. Each of these organelles has specific functions in the cell.
- The variety among cells reflects differences in structure and function.

Key Terms

organelle
cell wall
cytoskeleton
cell membrane
nucleus
cytoplasm
mitochondria
endoplasmic reticulum
ribosome
Golgi body
chloroplast
vacuole
lysosome

3 Chemical Compounds in Cells

Key Concepts S 7.1.a

- An element is any substance that cannot be broken down into simpler substances. When two or more elements combine chemically, they form a compound.
- Most chemical reactions within cells could not take place without water.
- Carbohydrates, lipids, proteins, and nucleic acids are important groups of organic compounds in living things. Carbohydrates provide energy for the cell and are important components of some cell parts.
- Lipids function as an energy source and make up most of the cell membrane.
- The proteins known as enzymes perform important functions in the chemical reactions that take place in cells.
- Nucleic acids contain the instructions that cells need to carry out all the functions of life.

Key Terms

element
compound
carbohydrate
protein
amino acid
enzyme
lipid
nucleic acid
DNA
RNA

4 The Cell in Its Environment

Key Concepts S 7.1.a

- Diffusion is the main method by which small molecules move across the cell membrane.
- Osmosis is important because cells cannot function properly without adequate water.
- Active transport requires the cell to use energy, while passive transport does not.

Key Terms

selectively permeable
diffusion
osmosis
passive transport
active transport

Review and Assessment

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Target Reading Skill

Identifying Main Ideas To review part of Section 3, reread the text following the heading The Compound Called Water. Copy the graphic organizer at right. Complete the graphic organizer by supplying details that support the main idea.

Main Idea

Most chemical reactions within cells could not take place without water.

Detail	Detail	Detail
a. ___?___	b. ___?___	c. ___?___

Reviewing Key Terms

Choose the letter of the best answer.

1. All living things are composed of
   a. blood.
   b. chloroplasts.
   c. vacuoles.
   d. cells.
2. In plant and animal cells, the control center of the cell is the
   a. chloroplast.
   b. cytoplasm.
   c. nucleus.
   d. Golgi body.
3. A storage compartment of the cell is the
   a. cell wall.
   b. lysosome.
   c. endoplasmic reticulum.
   d. vacuole.
4. Starch is an example of a
   a. nucleic acid.
   b. protein.
   c. lipid.
   d. carbohydrate.
5. The process by which water moves across a cell membrane is called
   a. osmosis.
   b. active transport.
   c. organelle.
   d. resolution.

Complete the following sentences so that your answers clearly explain the Key Terms.

6. The **nucleus** can direct the cell's activities because it contains __________ .
7. **Mitochondria** are "powerhouses" of the cell because __________ .
8. Water is an example of a **compound,** which is __________ .
9. Saliva in your mouth is an example of an **enzyme** because __________ .
10. Oxygen molecules enter a cell by **diffusion,** which is __________ .

Writing in Science

Dialogue A dialogue is a conversation. Write a dialogue that might have taken place between Schleiden and Schwann. The scientists should discuss their observations and conclusions.

Video Assessment
Discovery Channel School
Cell Structure and Function

Review and Assessment

Checking Concepts

11. What role did the microscope play in the development of the cell theory?

12. Describe the function of the cell wall.

13. Explain the difference between elements and compounds.

14. How are enzymes important to living things?

15. What are the functions of DNA and RNA?

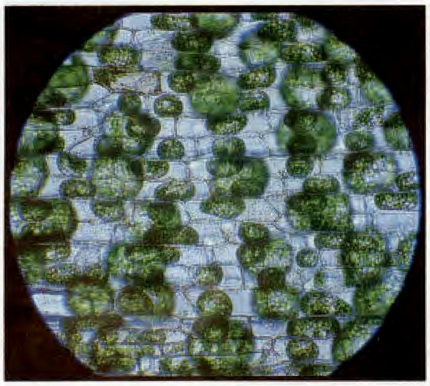
16. Why is water important in the cell?

17. What is diffusion? What function does diffusion have in the cell?

18. Explain the relationship between cell size and the movement of materials into and out of cells.

Thinking Critically

19. **Applying Concepts** Do the cells below come from a plant or an animal? Explain your answer.



20. **Problem Solving** A cell is actively producing a protein to be released outside the cell. Sequence the following organelles in the order that the protein will travel: Golgi bodies, ribosomes, endoplasmic reticulum.

21. **Predicting** Suppose a cell did not have a supply of amino acids and could not produce them. What effect might this have on the cell?

22. **Comparing and Contrasting** Explain how active transport is different from osmosis.

Math Practice

23. **Ratios** A solution consists of 24 g of table salt dissolved in 2 L of water. Express the concentration of salt in the form of a ratio.

24. **Ratios** What is the concentration of a sugar solution that contains 8 g sugar dissolved in 500 mL of water? Express your answer in the form of a ratio.

Applying Skills

Use the diagrams to answer Questions 25–27.

A scientist watered the plant in Figure A with salt water. After 30 minutes, the plant looked as you see it in Figure B.

25. **Observing** How did the plant cells change after the plant was watered?

26. **Inferring** Describe a process that would lead to the changes in the plant cells.

27. **Developing Hypotheses** Suppose the scientist were to water the plant in B with fresh (unsalted) water. Develop a hypothesis about what would happen to the plant. Explain your hypothesis.

Lab zone Standards Investigation

Performance Assessment Bring in your egg, graph, and any diagrams you made. As a class, discuss your results and conclusions. Then, as a group, try to answer these questions: What happened to the eggshell? What process took place at each stage of the experiment?

CALIFORNIA Standards Practice

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Choose the letter of the best answer.

1. A reasonable estimate for the size of a cell's nucleus is
A 0.006 mm.
B 6 mm.
C 0.006 m.
D 6 m. **S 7.1.a**

2. Which of the following statements is not true according to the cell theory?
A All plants and animals are made of cells.
B Cells are the basic unit of structure in organisms.
C Only some cells come from other cells.
D All cells come from other cells. **S 7.1**

Use the table below and your knowledge of science to answer Question 3.

Comparing the Cells of Three Organisms

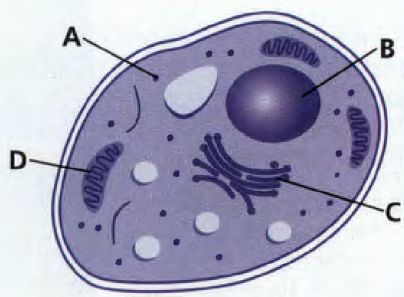
Organism	Cell Wall	Cell Membrane	Chloroplasts
1	No	Yes	Yes
2	Yes	Yes	No
3	No	Yes	No

3. Which organism is most likely an animal?
A Organism 1
B Organism 2
C Organism 3
D None of the organisms is an animal. **S 7.1.b**

4. Which of the following statements about a cell's membrane is true?
A Only small molecules can pass through the membrane.
B Only water molecules can pass through the membrane.
C Only food molecules can pass through the membrane.
D Some substances can pass through the membrane while others cannot. **S 7.5**

5. A tissue in an animal produces and releases chemicals that are used by cells throughout the animal's body. Cells in that tissue probably have a larger than normal number of
A lysosomes.
B mitochondria.
C Golgi bodies.
D nuclei. **S 7.1.b**

Use the diagram below and your knowledge of science to answer Questions 6 and 7.



6. Which organelle contains instructions for directing the cell's functions?
A A
B B
C C
D D **S 7.1.c**

7. In which organelle is food energy converted to energy that the cell can use?
A A
B B
C C
D D **S 7.1.d**

Apply the BIG Idea

8. How are plant and animal cells similar? How are they different? Make a list of the different organelles in each cell. Explain how each organelle is vital to the life and function of a plant or animal. **S 7.5**