Section 3

• Tech & Design •

Discovering Cells

Reading Preview

Key Concepts

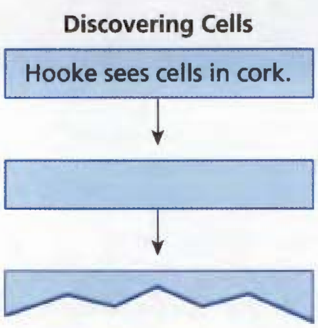
- What are cells?
- How did the invention of the microscope contribute to knowledge about living things?
- What is the cell theory?
- How do microscopes produce magnified images?

Key Terms

- cell
- microscope
- cell theory

Target Reading Skill

Sequencing A sequence is the order in which a series of events occurs. As you read, construct a flowchart showing how the work of Hooke, Leeuwenhoek, Schleiden, Schwann, and Virchow contributed to scientific understanding of cells.



Lab zone Discover Activity

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 that you could not see with only your eyes? What additional details could you see with the microscope?

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 13
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

You are made 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.

FIGURE 14
Skin Cells
Your skin is made of cells such as these. **Applying Concepts** *What are cells?*

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 tall tree, for example, consists of cells arranged to form a high trunk and leafy branches. A red newt's cells form a body with a head and four legs.

Cells and Function An organism's functions are the processes that enable it to stay alive and reproduce. Some functions in organisms 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.

Many and Small Figure 14 shows human skin cells. One square centimeter of your skin's surface contains more than 100,000 cells. But no matter how closely you look with your eyes alone, you won't be able to see individual skin cells. That is because, like most cells, those of your skin are very small. Until the late 1600s, no one knew cells existed because there was no way to see them.

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

First Observations of Cells

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.** A microscope is an instrument that makes small objects look larger. Some microscopes do this by using lenses to focus light. The lenses used in light microscopes are similar to the clear, curved pieces of glass or plastic used in eyeglasses. A simple microscope contains only one lens. A light microscope that has more than one lens is called a compound microscope.

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."

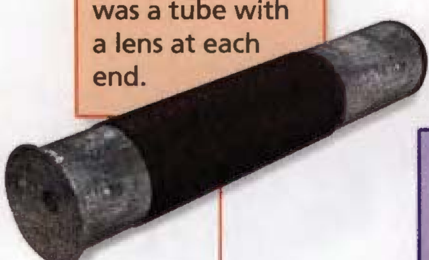
• Tech & Design in History •

The Microscope: Improvements Over Time

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

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.

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.

1500 1600 1700

Anton van Leeuwenhoek At about the same time that Robert Hooke made his discovery, Anton van Leeuwenhoek (LAY vun hook) 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 one-celled 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

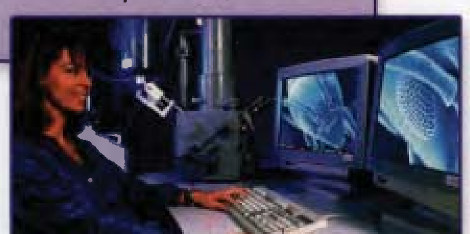
German scientists Ernst Abbé and Carl Zeiss made a compound light microscope with complex lenses that greatly improved the image. A mirror focuses light up through the specimen. Modern compound microscopes can effectively magnify a specimen up to 1,000 times.

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.

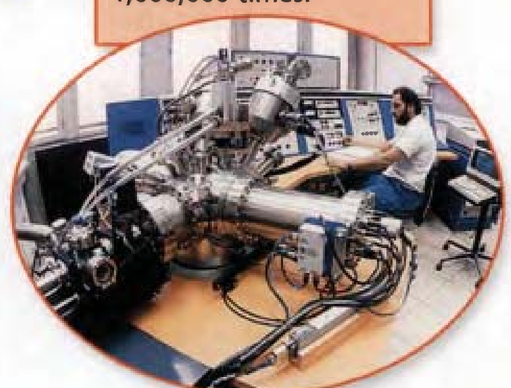
1965 Scanning Electron Microscope (SEM)

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 15
Monarch and Milkweed
The monarch butterfly caterpillar and the milkweed leaf that the caterpillar nibbles on are both made of cells.

Development of the Cell Theory

Leeuwenhoek's exciting discoveries caught the attention of other researchers. Like Hooke, Leeuwenhoek, and all good scientists, these other researchers were curious about the world around them, including things they couldn't normally see. 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 people's 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.**

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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.

Reading Checkpoint **What did Schleiden and Schwann conclude about cells?**

Light and Electron Microscopes

The cell theory could not have been developed without microscopes. For a microscope to be useful, it must combine two important properties—magnification and resolution. Scientists today use two kinds of microscopes: light microscopes and electron microscopes.

Magnification and Lenses The first property, magnification, is the ability to make things look larger than they are. **The lenses in light microscopes magnify an object by bending the light that passes through them.** If you examine a hand lens, such as the one in Figure 16, you will see that the lens is curved, not flat. The center of the lens is thicker than the edge. A lens with this curved shape is called a convex lens. The light passing through the sides of the lens bends inward. When this light hits the eye, the eye sees the object as larger than it really is.

Lab zone Skills Activity

Observing

1. Read about using the microscope (Appendix B) before beginning this activity.
2. Place a prepared slide of a thin slice of cork on the stage of a microscope.
3. Observe the slide under low power. Draw what you see.
4. Place a few drops of pond water on another slide and cover it with a coverslip.
5. Observe the slide under low power. Draw what you see. Wash your hands after handling pond water.

How does your drawing in Step 3 compare to Hooke's description of cells on page 52? Based on your observations in Step 5, why did Leeuwenhoek call the organisms he saw "little animals"?

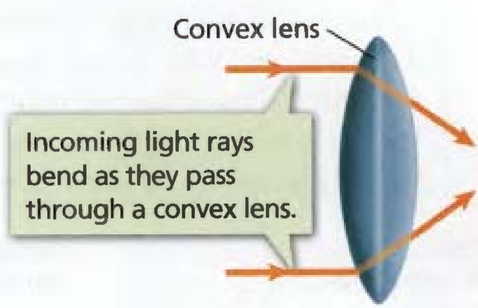


FIGURE 16
A Convex Lens
A magnifying glass is a convex lens. The lines in the diagram represent rays of light, and the arrows show the direction in which the light travels.
Interpreting Diagrams *Describe what happens to light rays as they pass through a convex lens.*

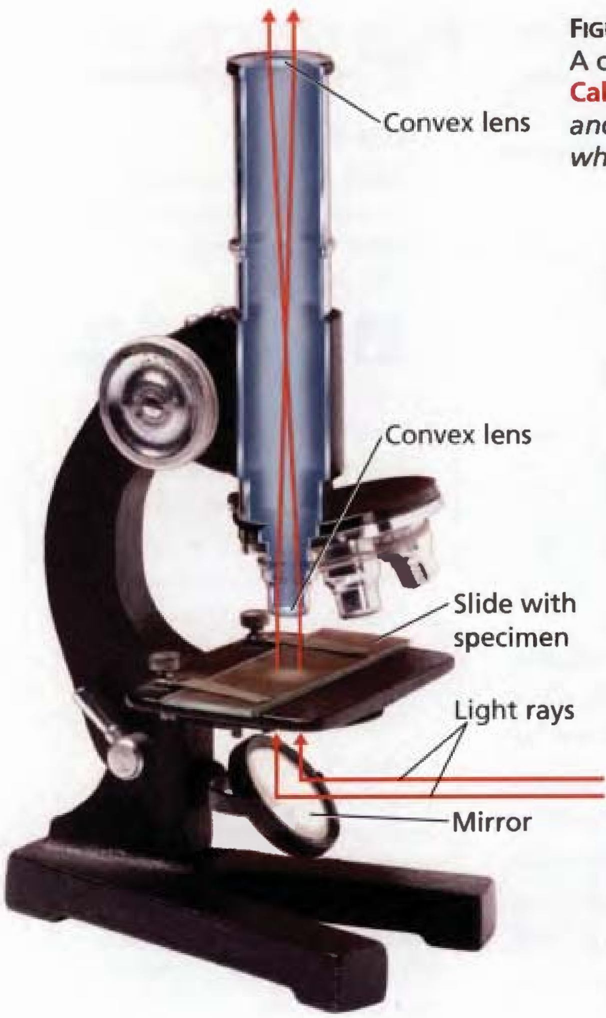


FIGURE 17 A Compound Microscope
A compound microscope has two convex lenses.
Calculating *If one lens has a magnification of 10, and the other lens has a magnification of 50, what is the total magnification?*

Compound Microscope Magnification

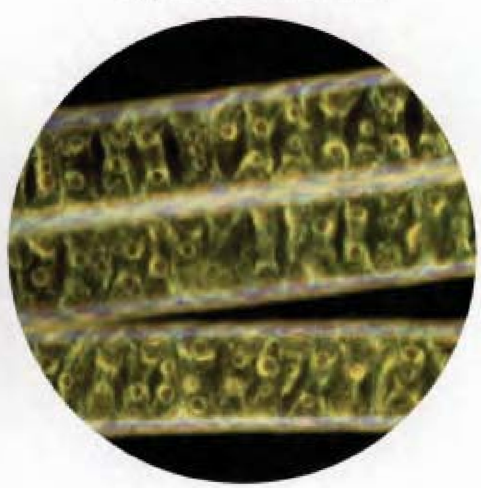
A compound microscope uses more than one lens. As a result, it can magnify an object more than one lens by itself. Light passes through a specimen and then through two lenses, as shown in Figure 17. The first lens, near the specimen, magnifies the object. Then a second lens, near the eye, further magnifies the enlarged image. The total magnification of the microscope is equal to the magnifications of the two lenses multiplied together. For example, suppose the first lens makes an object look 10 times bigger than it actually is, and the second lens makes the object look 40 times bigger than it actually is. The total magnification of the microscope is 10×40, or 400.

Resolution To create a useful image, a microscope must also help you see individual parts clearly. The ability to clearly distinguish the individual parts of an object is called resolution. Resolution is another term for the sharpness of an image. For example, a photograph in a newspaper is really made up of a collection of small dots. If you put the photo under a microscope, you can see the dots. You see the dots not only because they are magnified but also because the microscope improves resolution. Good resolution is needed when you study cells.

FIGURE 18
Light Microscope Photos
The pictures of the water flea and the threadlike *Spirogyra* were both taken with a light microscope.

Water flea
40 times actual size

Spirogyra
300 times actual size



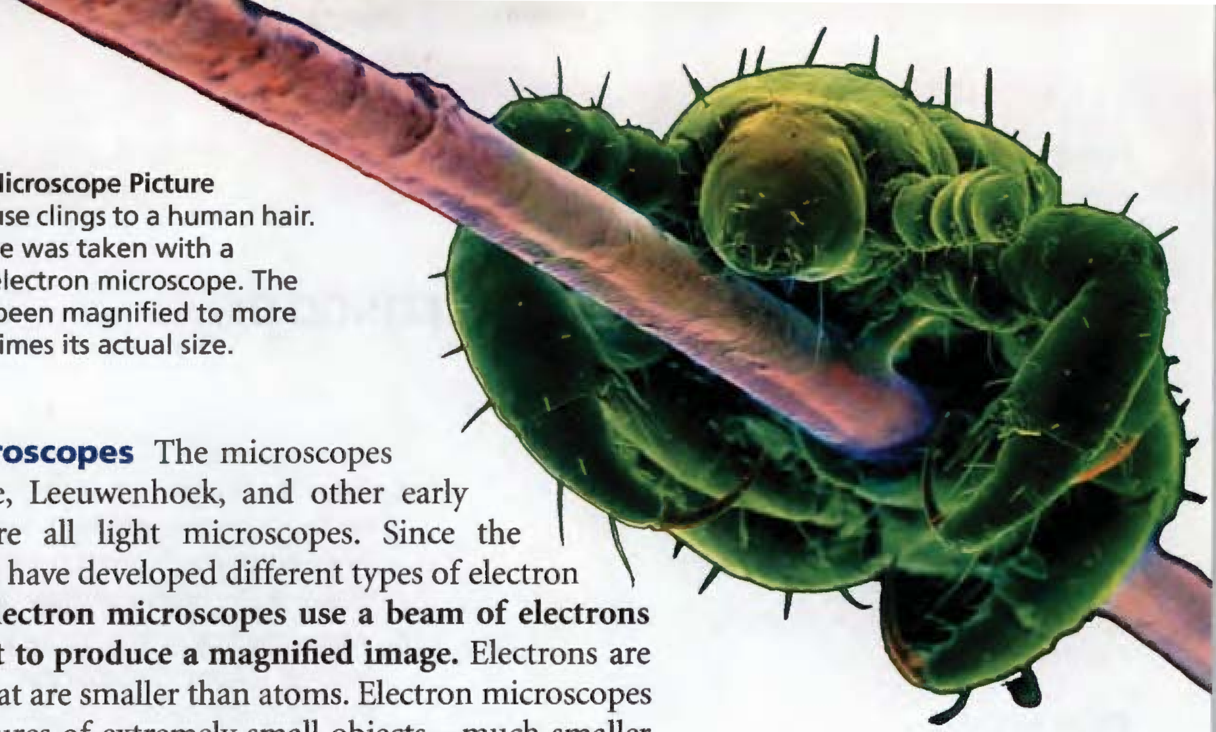


FIGURE 19
Electron Microscope Picture
A head louse clings to a human hair. This picture was taken with a scanning electron microscope. The louse has been magnified to more than 100 times its actual size.

Electron Microscopes The microscopes used by Hooke, Leeuwenhoek, and other early researchers were all light microscopes. Since the 1930s, scientists have developed different types of electron microscopes. **Electron microscopes use a beam of electrons instead of light to produce a magnified image.** Electrons are tiny particles that are smaller than atoms. Electron microscopes can obtain pictures of extremely small objects—much smaller than those that can be seen with light microscopes. The resolution of electron microscopes is much better than the resolution of light microscopes.

Reading Checkpoint **What do electron microscopes use to produce magnified images?**

Section 3 Assessment

Target Reading Skill **Sequencing** Review your flowchart and use it to answer Questions 2 and 3 below.

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. **Reviewing** What are the main ideas of the cell theory?
   b. **Explaining** What did Virchow contribute to the cell theory?
   c. **Applying Concepts** Use the ideas of Virchow to explain why plastic plants and stuffed animals are not alive.
4. a. **Defining** What is magnification?
   b. **Comparing and Contrasting** Contrast the way light microscopes and electron microscopes magnify objects.

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. Your speech should describe the scientist's accomplishments.

Lab zone **Technology Lab**

Design and Build a Microscope

Problem

How can you design and build a compound microscope?

Design Skills

building a prototype, evaluating design constraints

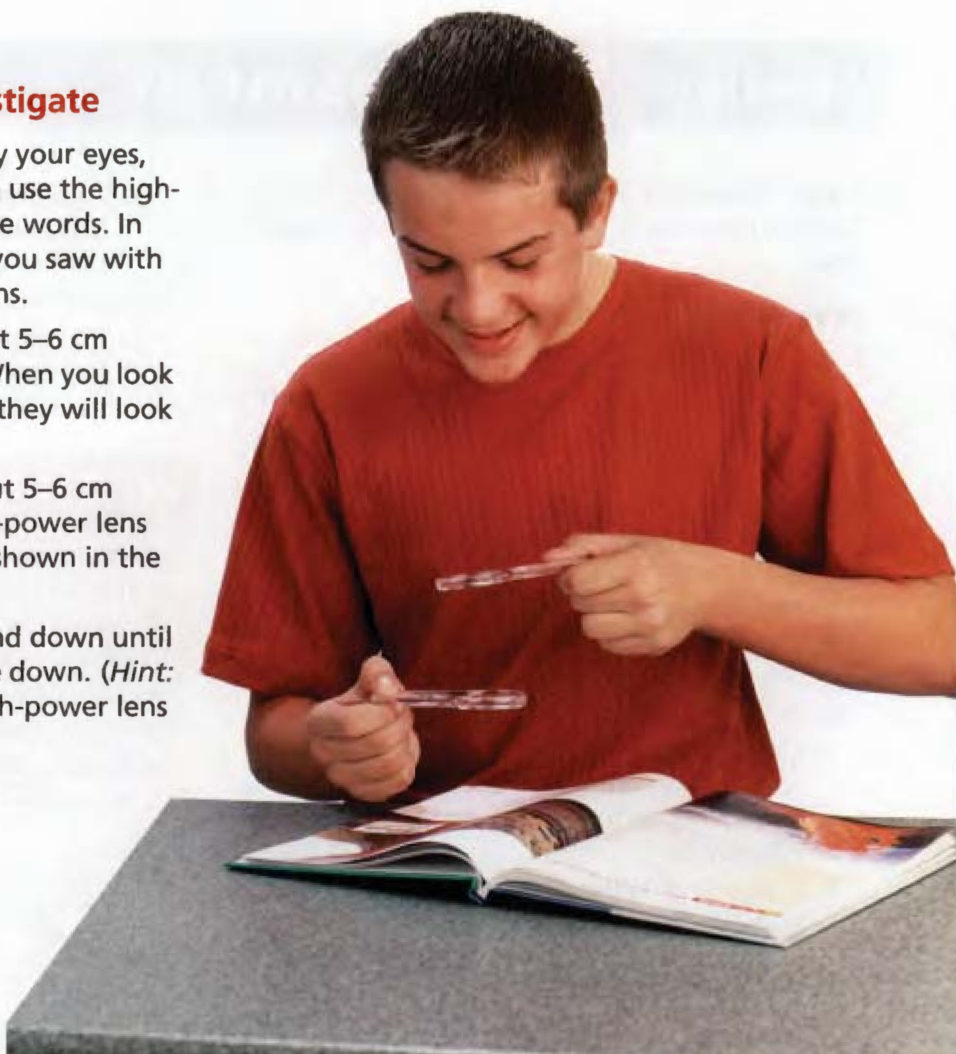
Materials

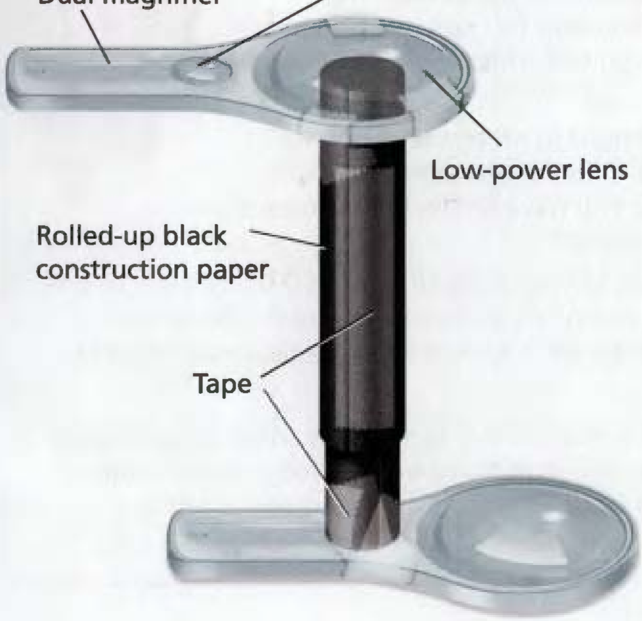
- book
- 2 dual magnifying glasses, each with one high-power and one low-power lens
- metric ruler
- 2 cardboard tubes from paper towels, or black construction paper
- tape

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.

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.

Section 4 Looking Inside Cells

Reading Preview

Key Concepts

- What role do the cell wall and cell membrane play in the cell?
- What are the functions of cell organelles?
- How are cells organized in many-celled organisms?

Key Terms

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

Target Reading Skill

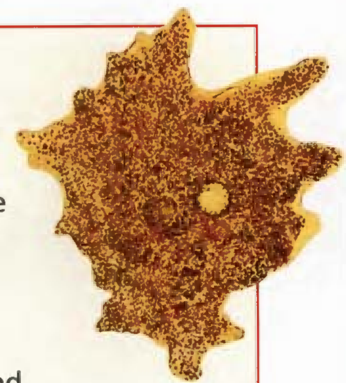
Previewing Visuals Before you read, preview Figure 24. Then write two questions that you have about the illustrations in a graphic organizer like the one below. As you read, answer your questions.

Plant and Animal Cells

Q.	How are animal cells different from plant cells?
A.	
Q.	

Lab zone Discover Activity

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?

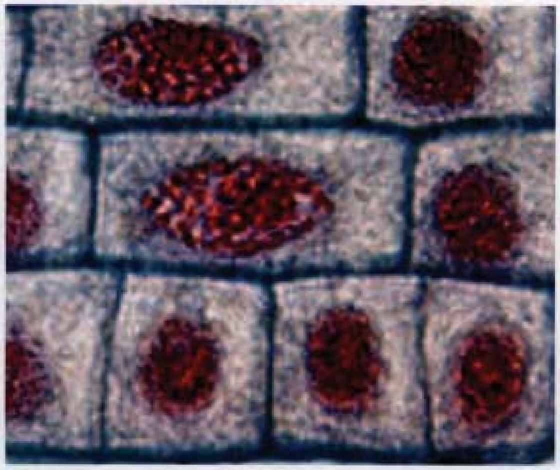
Think It Over

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 the aid of a microscope?

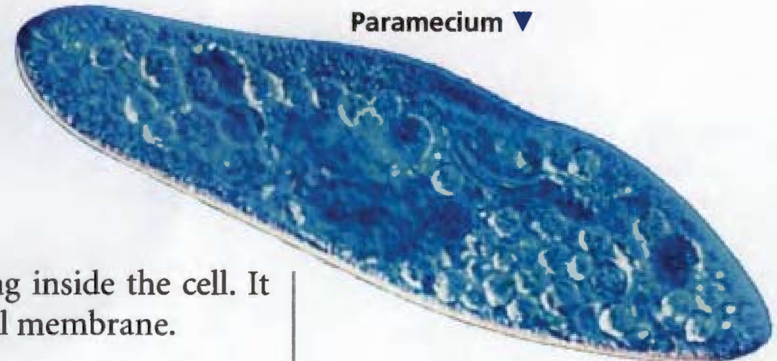
Nasturtiums brighten up many gardens with green leaves and colorful flowers. How do nasturtiums carry out all the functions necessary to stay alive? To answer this question, you are about to take an imaginary journey. You will travel inside a nasturtium leaf, visiting its tiny cells. You will observe 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. These tiny cell structures, called **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 it's time to hop aboard your imaginary ship and sail into a typical plant cell.

Nasturtiums ►



◀ Onion root cells



Paramecium ▼

Enter the Cell

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

Cell Wall As you travel through the plant cell, refer to Figure 24 in this section. First, you must slip through the cell wall. The **cell wall** is a rigid layer of nonliving material that surrounds the cells of plants and some other organisms. The cells of animals, in contrast, do not have cell walls. **A plant's cell wall helps to protect and support the cell.** 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.

Cell Membrane After you sail through the cell wall, the next barrier you must cross is the **cell membrane.** All cells have cell membranes. 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. Fortunately, your ship can slip through, too. Harmful waste products leave the cell through the cell membrane. For a cell to survive, the cell membrane must allow these materials to pass in and out. In addition, the cell membrane 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.

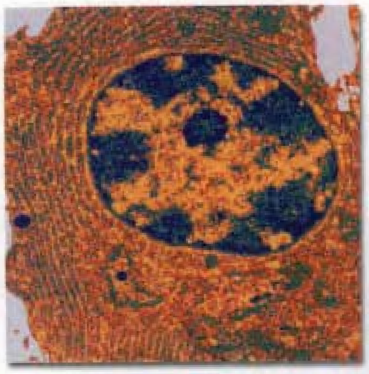
Reading Checkpoint What is the function of the cell wall?

FIGURE 20
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.
Interpreting Photographs *What shape do the cell walls give to the onion root cells?*

Discovery Channel School

Cell Structure and Function

Video Preview
▶ Video Field Trip
Video Assessment



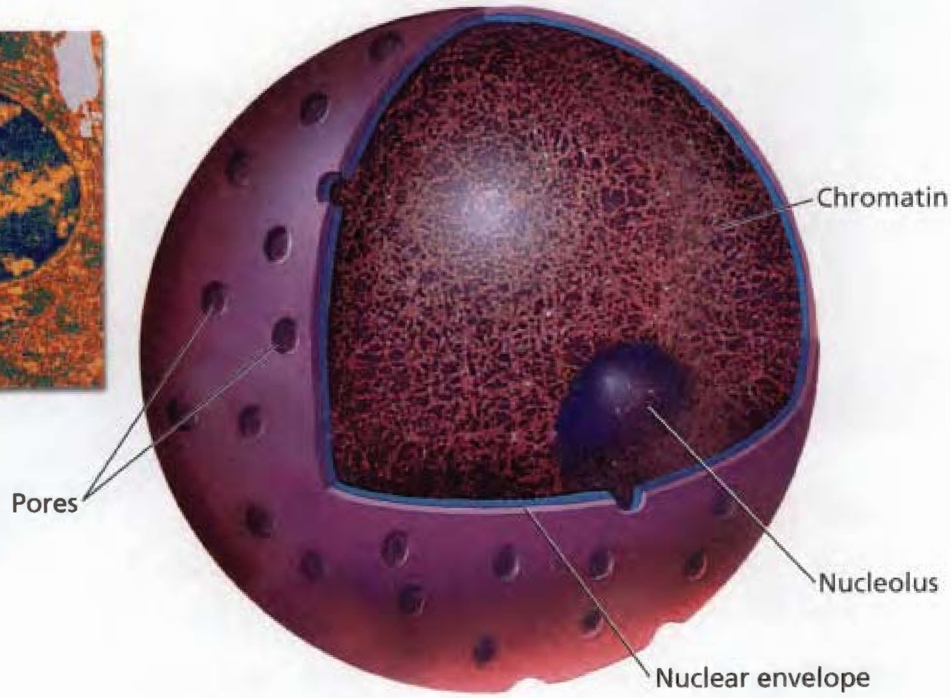


FIGURE 21
The Nucleus
The photo (left) and diagram (right) both show the nucleus, which is the cell's control center. The chromatin in the nucleus contains instructions for carrying out the cell's activities.

Sail On to the Nucleus

As you sail inside the cell, a large, oval structure comes into view. This structure, the nucleus, acts as the "brain" of the cell. **You can think of the nucleus as the cell's control center, directing all of the cell's activities.**

Nuclear Envelope Notice in Figure 21 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.

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.

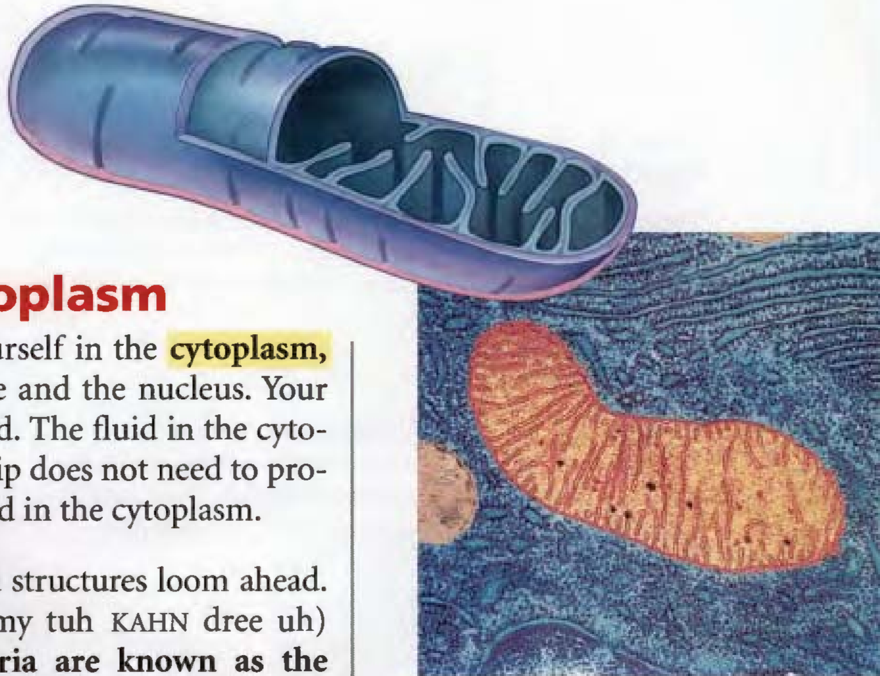


FIGURE 22 Mitochondrion
The mitochondria produce most of the cell's energy. **Inferring** *In what types of cells would you expect to find a lot of mitochondria?*

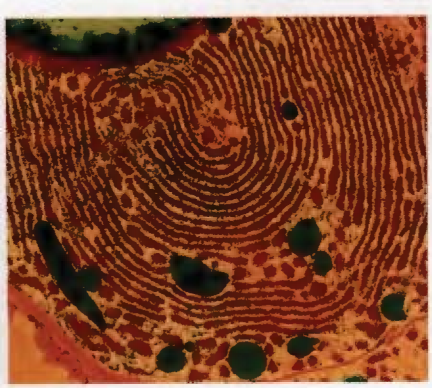
Organelles in the Cytoplasm

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. Many cell organelles are found in the cytoplasm.

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 22 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 carry proteins and other materials from one part of the cell to another.**

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.



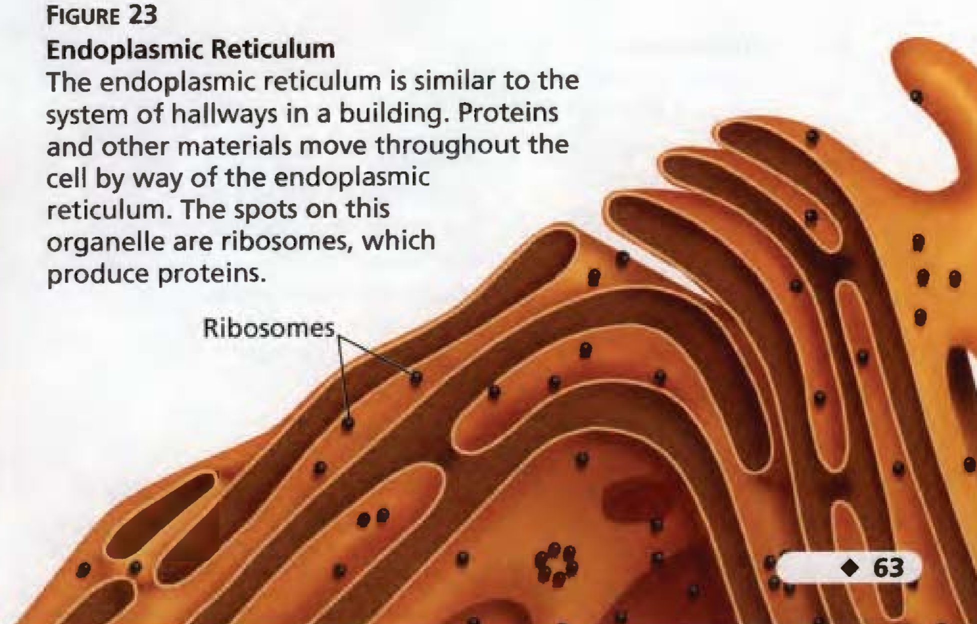
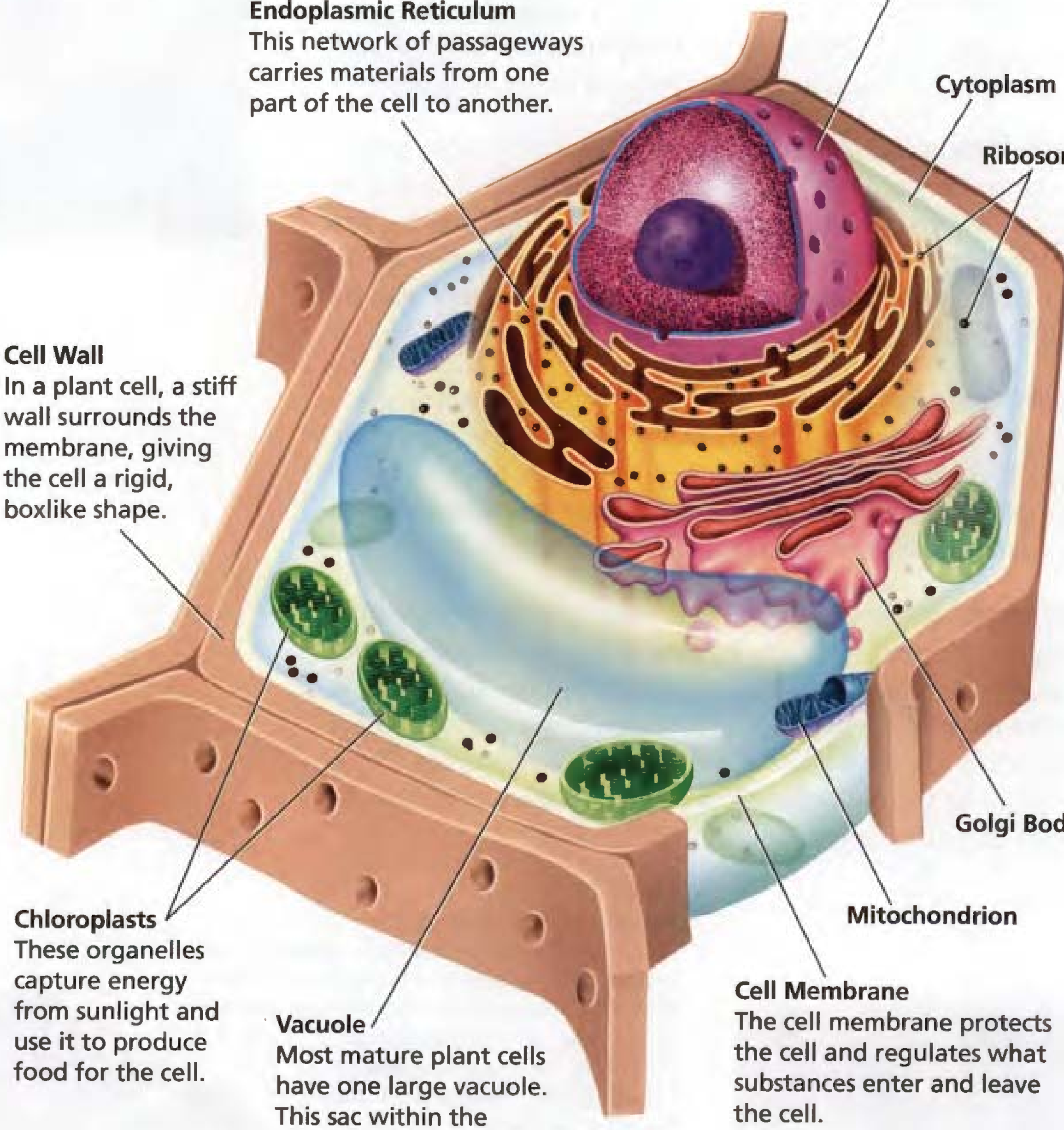


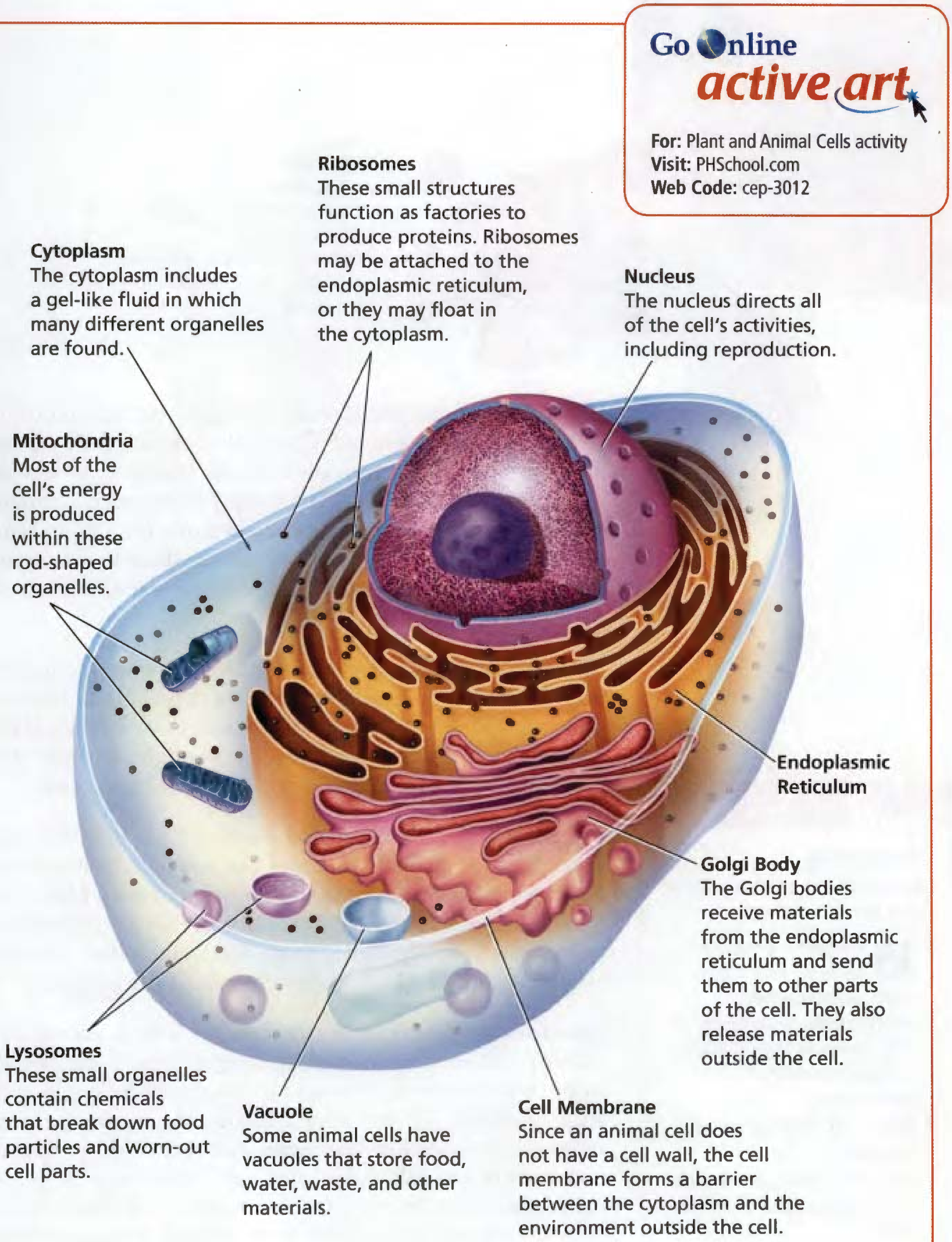
FIGURE 23
Endoplasmic Reticulum
The endoplasmic reticulum is similar to the system of hallways in a building. Proteins and other materials move throughout the cell by way of the endoplasmic reticulum. The spots on this organelle are ribosomes, which produce proteins.

FIGURE 24
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 in animal cells.*



Plant Cell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Ribosomes
These small structures function as factories to produce proteins. Ribosomes may be attached to the endoplasmic reticulum, or they may float in the cytoplasm.
Cytoplasm
The cytoplasm includes a gel-like fluid in which many different organelles are found.
Nucleus
The nucleus directs all of the cell's activities, including reproduction.
Mitochondria
Most of the cell's energy is produced within these rod-shaped organelles.
Endoplasmic Reticulum
Golgi Body
The Golgi bodies receive materials from the endoplasmic reticulum and send them to other parts of the cell. They also release materials outside the cell.
Lysosomes
These small organelles contain chemicals that break down food particles and worn-out cell parts.
Vacuole
Some animal cells have vacuoles that store food, water, waste, and other materials.
Cell Membrane
Since an animal cell does not have a cell wall, the cell membrane forms a barrier between the cytoplasm and the environment outside the cell.

Animal Cell

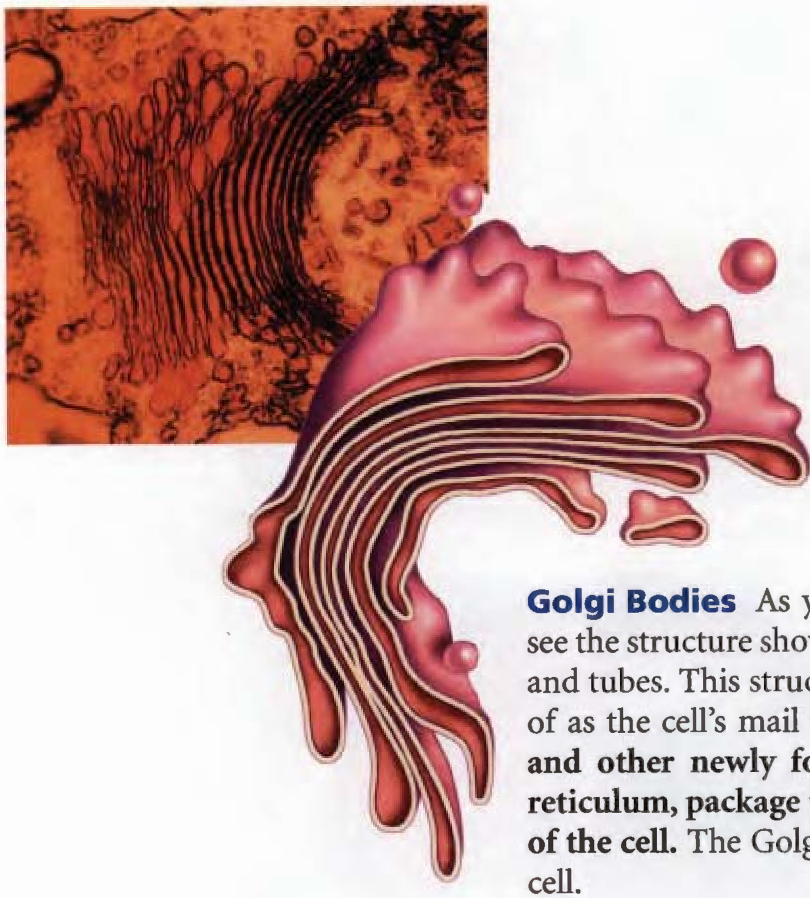


FIGURE 25
A Golgi Body
Golgi bodies are organelles that transport materials.
Applying Concepts *Why can a Golgi body be described as a cell's mail room?*

Golgi Bodies As you leave the endoplasmic reticulum, you see the structure shown in Figure 25. It looks like flattened sacs and tubes. This structure, called a **Golgi body,** can be thought of as the cell's mail room. **The Golgi bodies receive proteins and other newly formed materials from the endoplasmic reticulum, package them, and distribute them to other parts of the cell.** The 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. Chloroplasts capture energy from sunlight and use it to produce food for the cell.** 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 vacuole. Some animal cells do not have vacuoles; others do. Vacuoles store food and other materials needed by the cell. Vacuoles can also store waste products.

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** (LY suh sohm). **Lysosomes 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 Skills Activity

Observing

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.

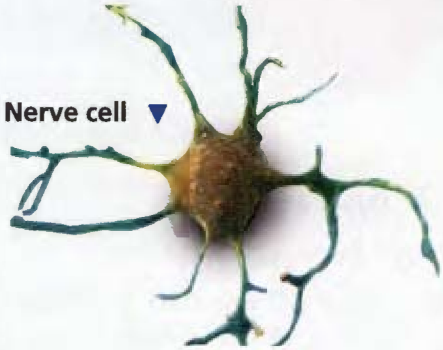
How are plant and animal cells alike? How are they different?

Specialized Cells

Plants and animals (including yourself) contain many cells. In a many-celled organism, the cells are often quite different from each other and are specialized to perform specific functions. Contrast, for example, the nerve cell and red blood cells in Figure 26. Nerve cells are specialized to transmit information from one part of your body to another, and red blood cells carry oxygen throughout your body.

In many-celled 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 made mostly of nervous tissue, which consists of nerve cells. An organ, such as your brain, is made of different kinds of tissues that function together. In addition to nervous tissue, the brain contains other kinds of tissue that support and protect it. Your brain is part of your nervous system, which is 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.

Nerve cell ▼



Red blood cells in a blood vessel ▼

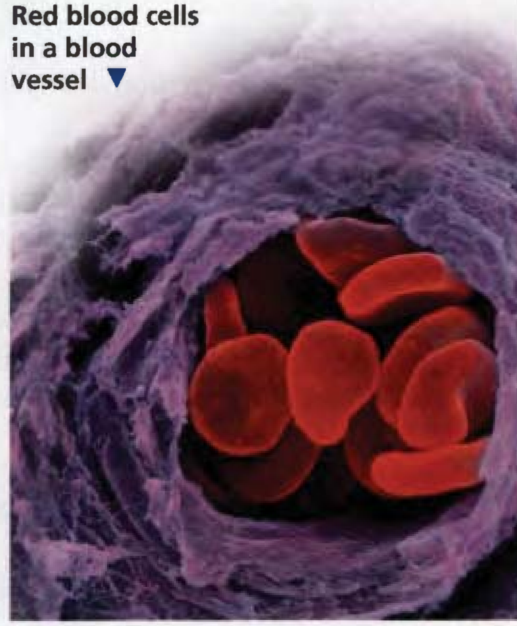


FIGURE 26 Specialized Cells
Nerve cells carry information throughout the human body. Red blood cells carry oxygen.

Section 4 Assessment

Target Reading Skill Previewing Visuals
Refer to your questions and answers about Figure 24 to help you answer the questions below.

Reviewing Key Concepts

1. a. **Comparing and Contrasting** Compare the functions of the cell wall and the cell membrane.
   b. **Inferring** How does cellulose help with one function of the cell wall?
2. 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 to one another?
3. a. **Reviewing** What is a tissue? What is an organ?
   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 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.