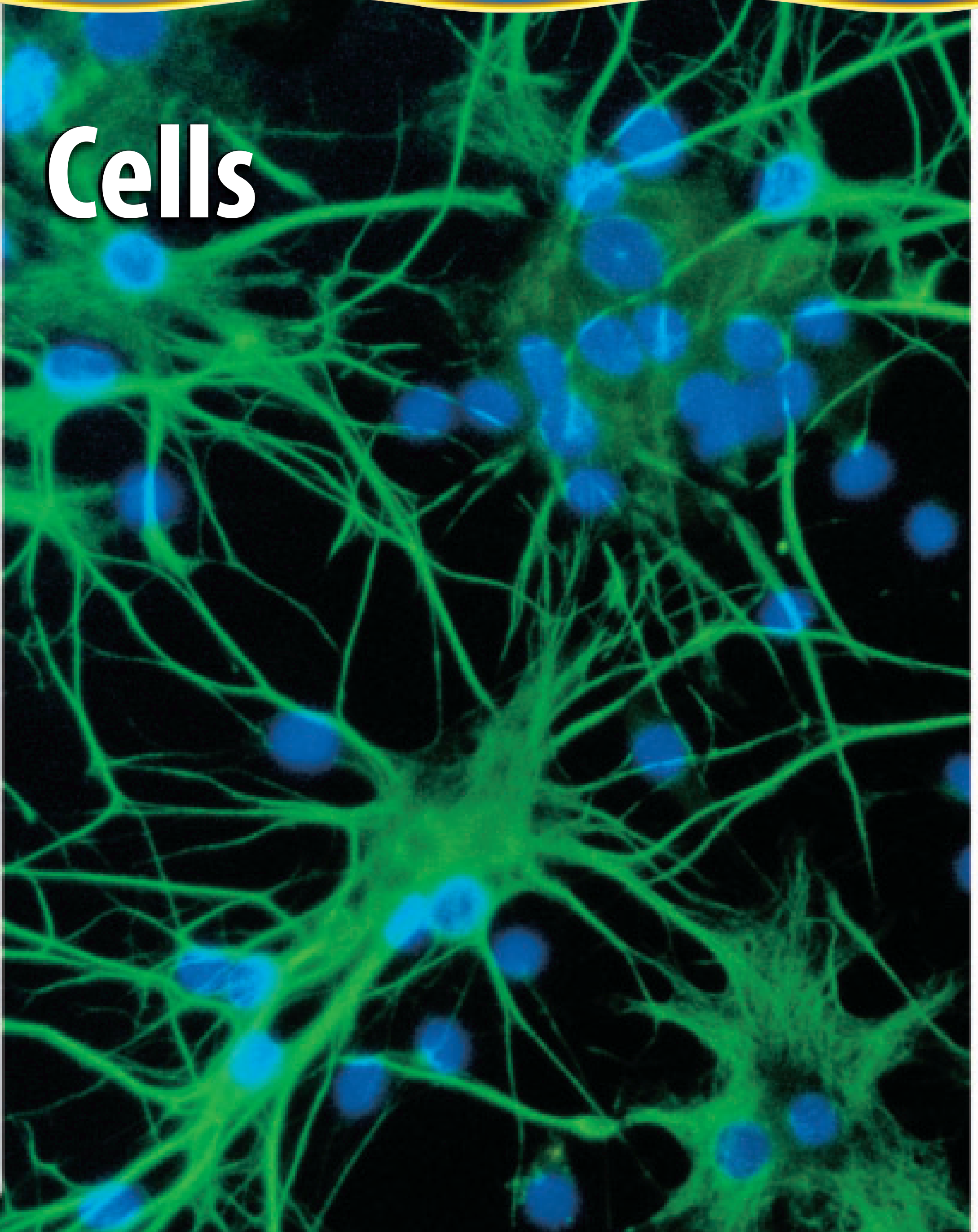
chapter 2

Cells



The BIG Idea

The different structures in a cell work together to ensure the cell's survival.

SECTION 1
Cell Structure

Main Idea Different cell types can have different structures, but some cell structures are common to all cells.

SECTION 2
Viewing Cells

Main Idea Scientists can study living things too small to be seen with only the human eye by using microscopes.

SECTION 3
Viruses

Main Idea Although viruses are not considered living things, they can affect all living things.

Too Small To Be Seen

The world around you is filled with organisms that you could overlook, or even be unable to see. Some of these organisms are one-celled and some are many-celled. You can study these organisms and the cells of other organisms by using microscopes.

Science Journal Write three questions that you would ask a scientist researching cancer cells.

Nancy Kedersha/Science Photo Library/Photo Researchers

Start-Up Activities

Launch LAB

Magnifying Cells

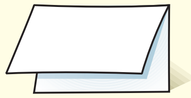
If you look around your classroom, you can see many things of all sizes. Using a magnifying lens, you can see more details. You might examine a speck of dust and discover that it is a living or dead insect. In the following lab, use a magnifying lens to search for the smallest thing you can find in the classroom.

1. Obtain a magnifying lens from your teacher. Note its power (the number followed by ×, shown somewhere on the lens frame or handle).
2. Using the magnifying lens, look around the room for the smallest object that you can find.
3. Measure the size of the image as you see it with the magnifying lens. To estimate the real size of the object, divide that number by the power. For example, if it looks 2 cm long and the power is 10×, the real length is about 0.2 cm.
4. **Think Critically** Write a paragraph that describes what you observed. Did the details become clearer? Explain.

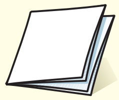
FOLDABLES™ Study Organizer

Cells Make the following Foldable to help you illustrate the main parts of cells.

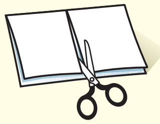
STEP 1 **Fold** a vertical sheet of paper in half from top to bottom.



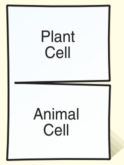
STEP 2 **Fold** in half from side to side with the fold at the top.



STEP 3 **Unfold** the paper once. **Cut** only the fold of the top flap to make two tabs.

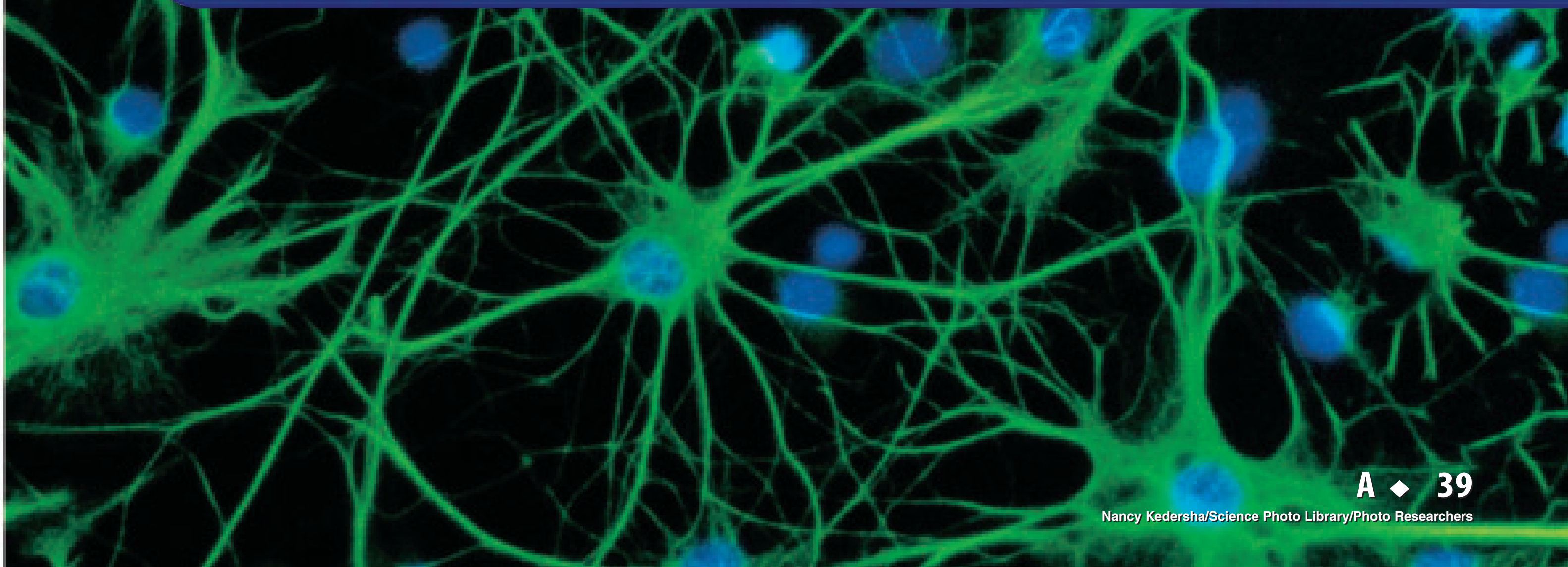


STEP 4 **Turn** the paper vertically and **write** on the front tabs as shown.



Illustrate and Label As you read the chapter, draw and identify the parts of plant and animal cells under the appropriate tab.

Science Online — Preview this chapter's content and activities at booka.msscience.com



Nancy Kedersha/Science Photo Library/Photo Researchers

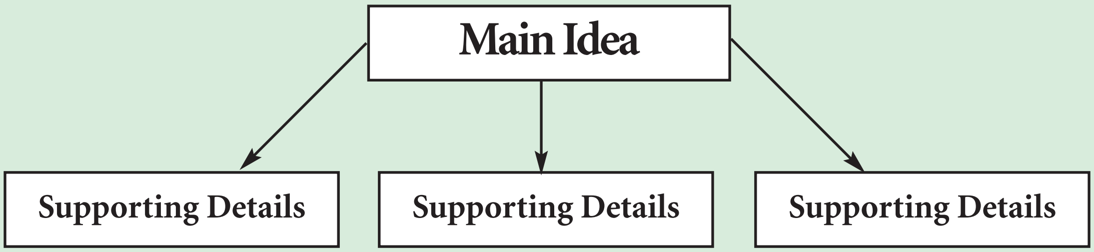
Get Ready to Read

Identify the Main Idea

1 Learn It! Main ideas are the most important ideas in a paragraph, lesson, or chapter. Supporting details are facts or examples that explain the main idea. Understanding the main idea allows you to grasp the whole picture.

2 Picture It! Read the following paragraph. Draw a graphic organizer like the one below to show the main idea and supporting details.

> Things that are too small to be seen with other microscopes can be viewed with an electron microscope. Instead of using lenses to direct beams of light, an electron microscope uses a magnetic field in a vacuum to direct beams of electrons. Some electron microscopes can magnify images up to one million times. To see electron microscope images, they must be photographed or electronically produced.
>
> —*from page 52*



3 Apply It! Pick a paragraph from another section of this chapter and diagram the main ideas as you did above.

Target Your Reading

Use this to focus on the main ideas as you read the chapter.

1. **Before you read** the chapter, respond to the statements below on your worksheet or on a numbered sheet of paper.
   - Write an **A** if you **agree** with the statement.
   - Write a **D** if you **disagree** with the statement.

2. **After you read** the chapter, look back to this page to see if you've changed your mind about any of the statements.
   - If any of your answers changed, explain why.
   - Change any false statements into true statements.
   - Use your revised statements as a study guide.

Reading Tip

The main idea is often the first sentence in a paragraph but not always.

Before You Read A or D	Statement	After You Read A or D
	1 All new cells come from preexisting cells.	
	2 You must use a microscope to see most cells.	
	3 A flexible cell membrane surrounds every cell.	
	4 Chromosomes are in the nucleus of every cell.	
	5 A bacterium is larger than an animal cell.	
	6 A cell wall and cytoplasm control the shape of each cell.	
	7 Tissues are groups of similar types of cells that work together to perform a function.	
	8 The most powerful microscopes create images by focusing light through two or more lenses.	
	9 A cell's mitochondria transform light energy into chemical energy.	
	10 Viruses are harmful and never beneficial.	

Science Online
Print out a worksheet of this page at booka.msscience.com

section 1

Cell Structure

as you read

What You'll Learn

- **Identify** names and functions of each part of a cell.
- **Explain** how important a nucleus is in a cell.
- **Compare** tissues, organs, and organ systems.

Why It's Important

If you know how organelles function, it's easier to understand how cells survive.

Review Vocabulary
photosynthesis: process by which most plants, some protists, and many types of bacteria make their own food

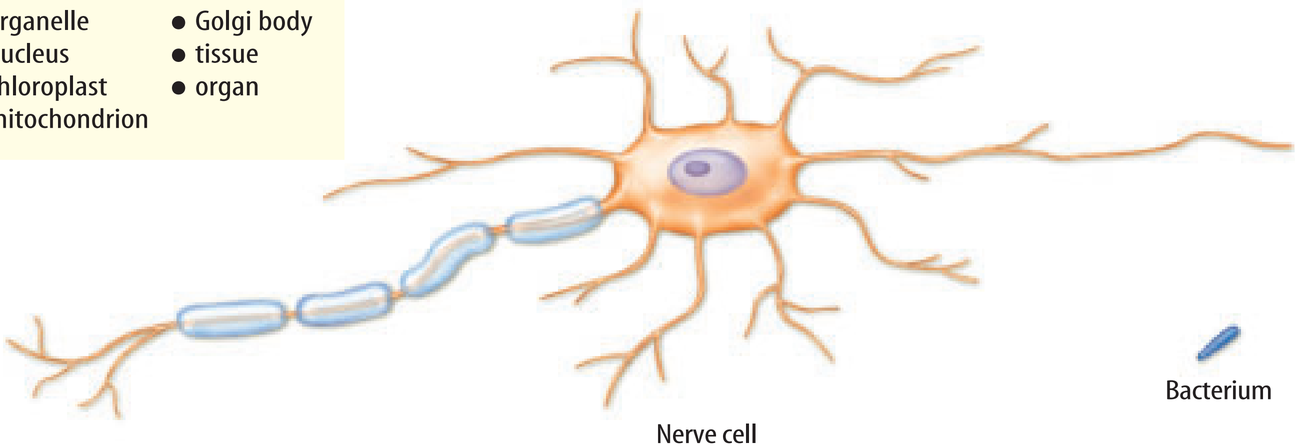
New Vocabulary
- cell membrane
- cytoplasm
- cell wall
- organelle
- nucleus
- chloroplast
- mitochondrion
- ribosome
- endoplasmic reticulum
- Golgi body
- tissue
- organ

Common Cell Traits

Living cells are dynamic and have several things in common. A cell is the smallest unit that is capable of performing life functions. All cells have an outer covering called a **cell membrane.** A living membrane is made of one or more layers of linked molecules. Inside every cell is a gelatinlike material called **cytoplasm** (SI tuh pla zum). In the cytoplasm of every cell is hereditary material that controls the life of the cell.

Comparing Cells Cells come in many sizes. A nerve cell in your leg could be a meter long. A human egg cell is no bigger than the dot on this *i*. A human red blood cell is about one-tenth the size of a human egg cell. A bacterium is even smaller—8,000 of the smallest bacteria can fit inside one of your red blood cells.

A cell's shape might tell you something about its function. The nerve cell in **Figure 1** has extensions that send impulses to or receive impulses from other cells. A nerve cell cannot change shape but muscle cells and some blood cells can. Some plant stems have long, hollow cells with openings at their ends. These cells carry food and water throughout the plant.



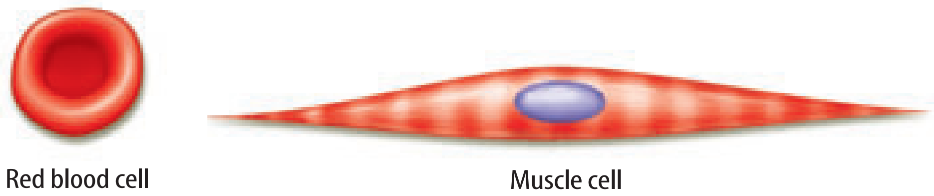


Figure 1 The shape of the cell can tell you something about its function. These cells are drawn 700 times their actual size.

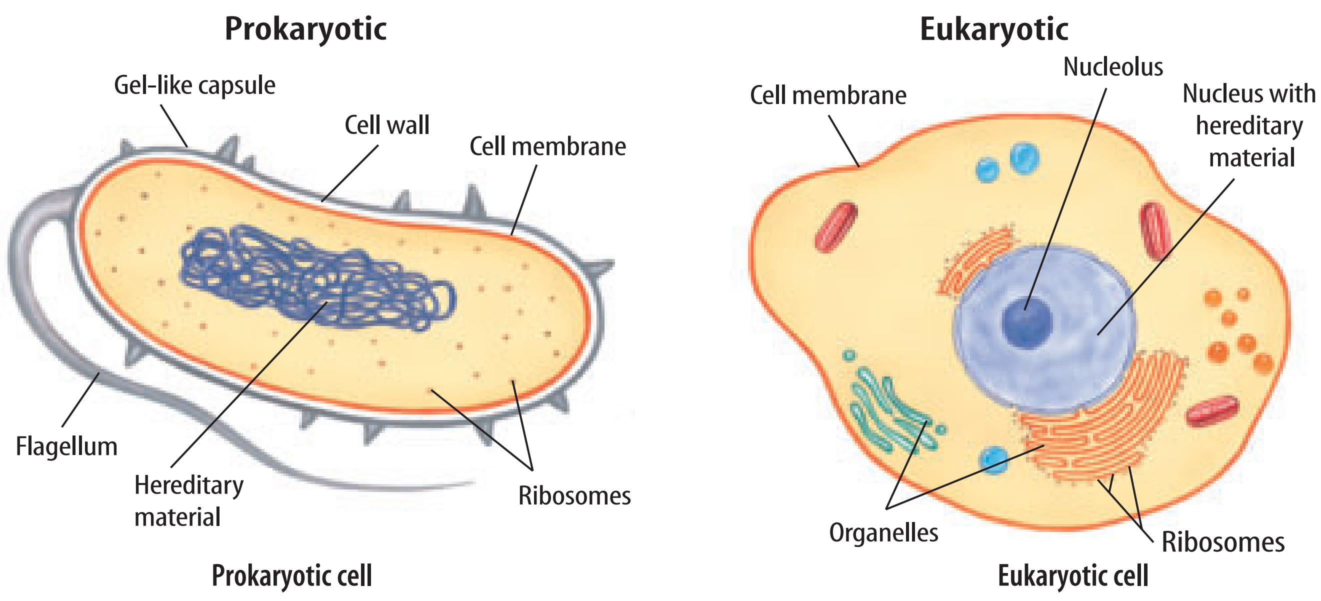


Figure 2 Examine these drawings of cells. Prokaryotic cells are only found in one-celled organisms, such as bacteria. Protists, fungi, plants, and animals are made of eukaryotic cells.
Describe *differences you see between them.*

Cell Types Scientists have found that cells can be separated into two groups. One group has no membrane-bound structures inside the cell and the other group does, as shown in **Figure 2.** Cells without membrane-bound structures are called prokaryotic (proh KAYR ee yah tihk) cells. Cells with membrane-bound structures are called eukaryotic (yew KAYR ee yah tihk) cells.

Reading Check *Into what two groups can cells be separated?*

Cell Organization

Each cell in your body has a specific function. You might compare a cell to a busy delicatessen that is open 24 hours every day. Raw materials for the sandwiches are brought in often. Some food is eaten in the store, and some customers take their food with them. Sometimes food is prepared ahead of time for quick sale. Wastes are put into trash bags for removal or recycling. Similarly, your cells are taking in nutrients, secreting and storing chemicals, and breaking down substances 24 hours every day.

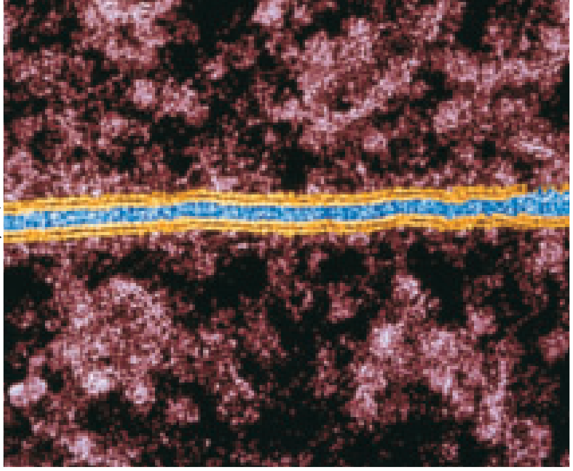
Cell Wall Just like a deli that is located inside the walls of a building, some cells are enclosed in a cell wall. The cells of plants, algae, fungi, and most bacteria are enclosed in a cell wall. **Cell walls** are tough, rigid outer coverings that protect the cell and give it shape.

A plant cell wall, as shown in **Figure 3,** mostly is made up of a substance called cellulose. The long, threadlike fibers of cellulose form a thick mesh that allows water and dissolved materials to pass through it. Cell walls also can contain pectin, which is used in jam and jelly, and lignin, which is a compound that makes cell walls rigid. Plant cells responsible for support have a lot of lignin in their walls.

Figure 3 The protective cell wall of a plant cell is outside the cell membrane.

Color-enhanced TEM Magnification: 9000×

David M. Phillips/Visuals Unlimited



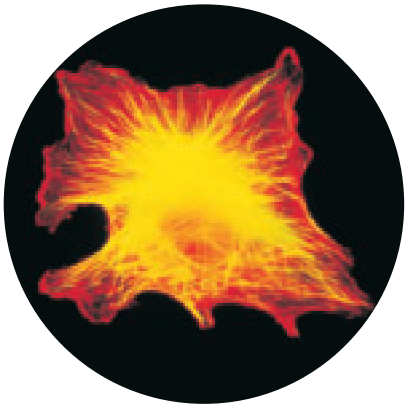
Cell membranes

Color-enhanced TEM Magnification: 125000×

Figure 4 A cell membrane is made up of a double layer of fatlike molecules.

Cell Membrane

The protective layer around all cells is the cell membrane, as shown in **Figure 4.** If cells have cell walls, the cell membrane is inside of it. The cell membrane regulates interactions between the cell and the environment. Water is able to move freely into and out of the cell through the cell membrane. Food particles and some molecules enter and waste products leave through the cell membrane.



Stained LM Magnification: 700×

Figure 5 Cytoskeleton, a network of fibers in the cytoplasm, gives cells structure and helps them maintain shape.

Cytoplasm

Cells are filled with a gelatinlike substance called cytoplasm that constantly flows inside the cell membrane. Many important chemical reactions occur within the cytoplasm.

Throughout the cytoplasm is a framework called the cytoskeleton, which helps the cell maintain or change its shape. Cytoskeletons enable some cells to move. An amoeba, a one-celled eukaryotic organism, moves by stretching and contracting its cytoskeleton. A cytoskeleton is made up of thin, hollow tubes of protein and thin, solid protein fibers, as shown in **Figure 5.** Proteins are organic molecules made up of amino acids.

Reading Check *What is the function of the cytoskeleton?*

Most of a cell's life processes occur in the cytoplasm. Within the cytoplasm of eukaryotic cells are structures called **organelles.** Some organelles process energy and others manufacture substances needed by the cell or other cells. Certain organelles move materials, while others act as storage sites. Most organelles are surrounded by membranes. The nucleus is usually the largest organelle in a cell.

Nucleus

The nucleus is like the deli manager who directs the store's daily operations and passes on information to employees. The **nucleus,** shown in **Figure 6,** directs all cell activities and is separated from the cytoplasm by a membrane. Materials enter and leave the nucleus through openings in this membrane.

The nucleus contains the instructions for everything the cell does. These instructions are found on long, threadlike, hereditary material made of DNA. DNA is the chemical that contains the code for the cell's structure and activities. During cell division, the hereditary material coils tightly around proteins to form structures called chromosomes. A structure called a nucleolus also is found in the nucleus.

Mini LAB

Modeling Cytoplasm

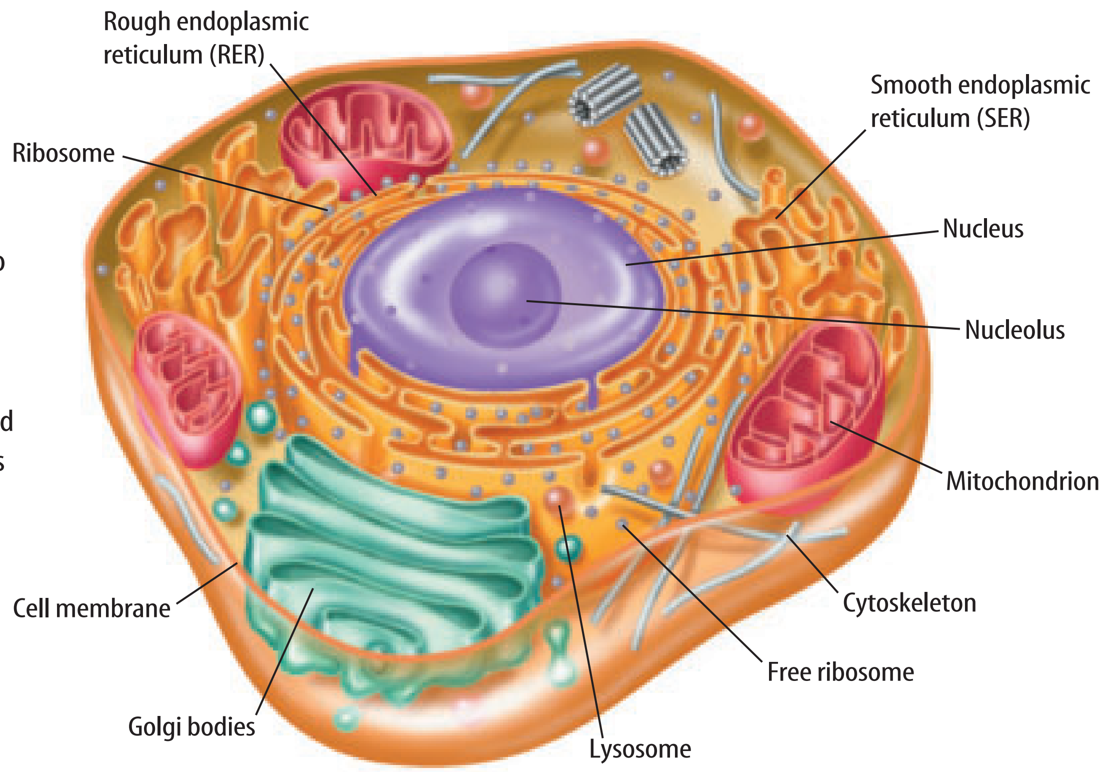
Procedure

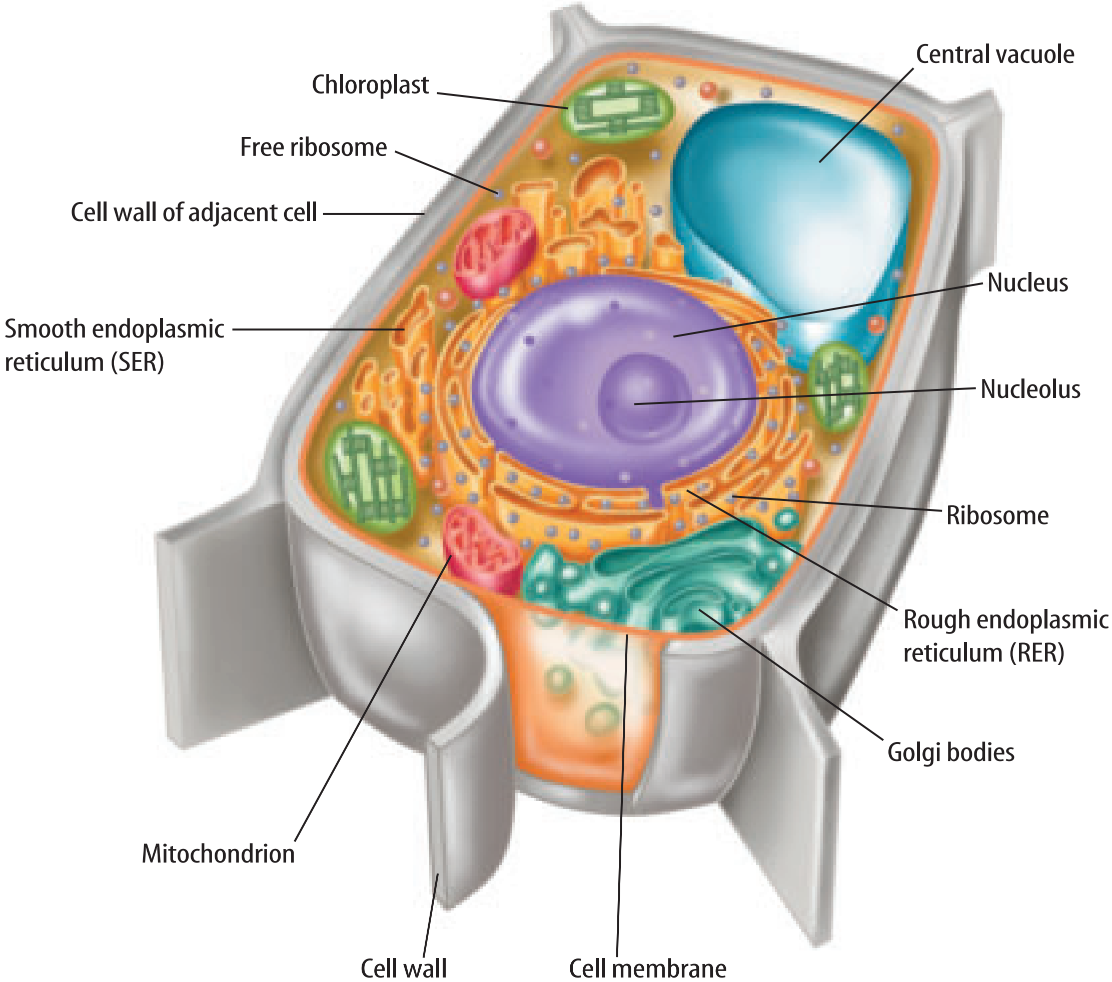
1. Add 100 mL of **water** to a **clear container.**
2. Add **unflavored gelatin** and stir.
3. Shine a **flashlight** through the solution.

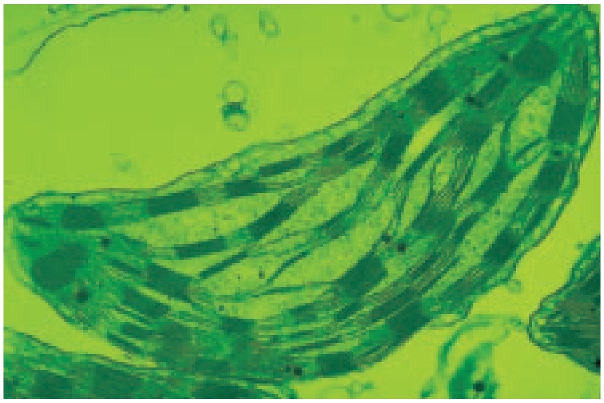
Analysis

1. Describe what you see.
2. How does a model help you understand what cytoplasm might be like?

Figure 6 Refer to these diagrams of a typical animal cell (top) and plant cell (bottom) as you read about cell structures and their functions. **Determine** *which structures a plant cell has that are not found in animal cells.*







Color-enhanced TEM Magnification: 37000×

Figure 7 Chloroplasts are organelles that use light energy and make sugar from carbon dioxide and water.

INTEGRATE Physics

Energy-Processing Organelles

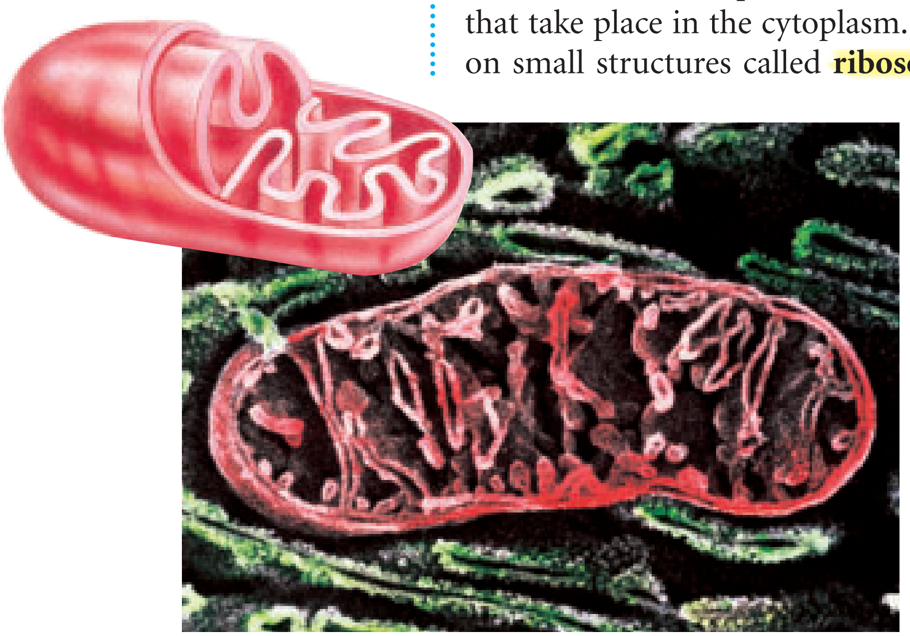
Cells require a continuous supply of energy to process food, make new substances, eliminate wastes, and communicate with each other. In some plant cells, food is made in green organelles in the cytoplasm called **chloroplasts** (KLOR uh plasts), as shown in **Figure 7.** Chloroplasts contain the green pigment chlorophyll, which gives many leaves and stems their green color. Chlorophyll captures light energy that is used to make a sugar called glucose. Glucose molecules store the captured light energy as chemical energy. Many cells, including animal cells, do not have chloroplasts for making food. They must get food from their environment.

The energy in food is stored until it is released by the mitochondria. **Mitochondria** (mi tuh KAHN dree uh) (singular, *mitochondrion*), such as the one shown in **Figure 8,** are organelles where energy is released from the breakdown of food into carbon dioxide and water. Just as the gas or electric company supplies fuel for the deli, a mitochondrion releases energy for use by the cell. Some types of cells, such as muscle cells, are more active than other cells. These cells have large numbers of mitochondria. Why would active cells have more or larger mitochondria?

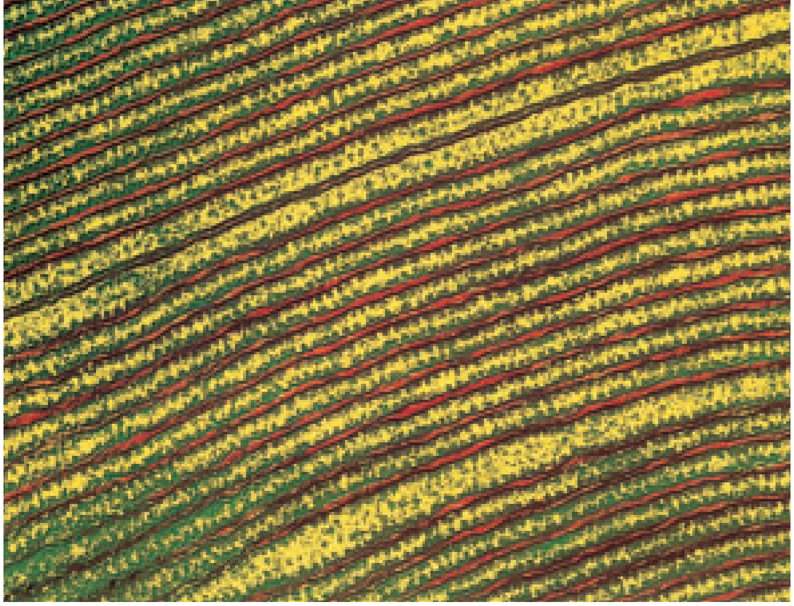
Figure 8 Mitochondria are known as the powerhouses of the cell because they release energy that is needed by the cell from food.
Name *the cell types that might contain many mitochondria.*

Manufacturing Organelles

One substance that takes part in nearly every cell activity is protein. Proteins are part of cell membranes. Other proteins are needed for chemical reactions that take place in the cytoplasm. Cells make their own proteins on small structures called **ribosomes.** Even though ribosomes are considered organelles, they are not membrane bound. Some ribosomes float freely in the cytoplasm; others are attached to the endoplasmic reticulum. Ribosomes are made in the nucleolus and move out into the cytoplasm. Ribosomes receive directions from the hereditary material in the nucleus on how, when, and in what order to make specific proteins.



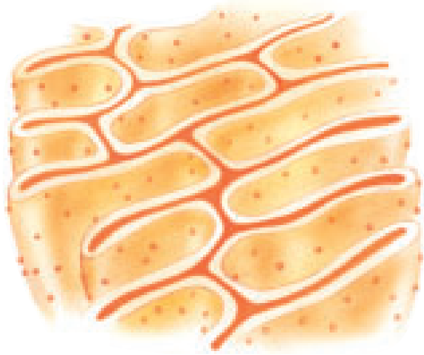
Color-enhanced SEM Magnification: 48000×



Color-enhanced TEM Magnification: 65000×

(t)Don Fawcett/Photo Researchers, (b)Biophoto Associates/Photo Researchers

Figure 9 Endoplasmic reticulum (ER) is a complex series of membranes in the cytoplasm of the cell.
Infer *what smooth ER would look like.*



Processing, Transporting, and Storing Organelles

The **endoplasmic reticulum** (en duh PLAZ mihk • rih TIHK yuh lum) or ER, as shown in **Figure 9,** extends from the nucleus to the cell membrane. It is a series of folded membranes in which materials can be processed and moved around inside of the cell. The ER takes up a lot of space in some cells.

The endoplasmic reticulum may be "rough" or "smooth." ER that has no attached ribosomes is called smooth endoplasmic reticulum. This type of ER processes other cellular substances such as lipids that store energy. Ribsomes are attached to areas on the rough ER. There they carry out their job of making proteins that are moved out of the cell or used within the cell.

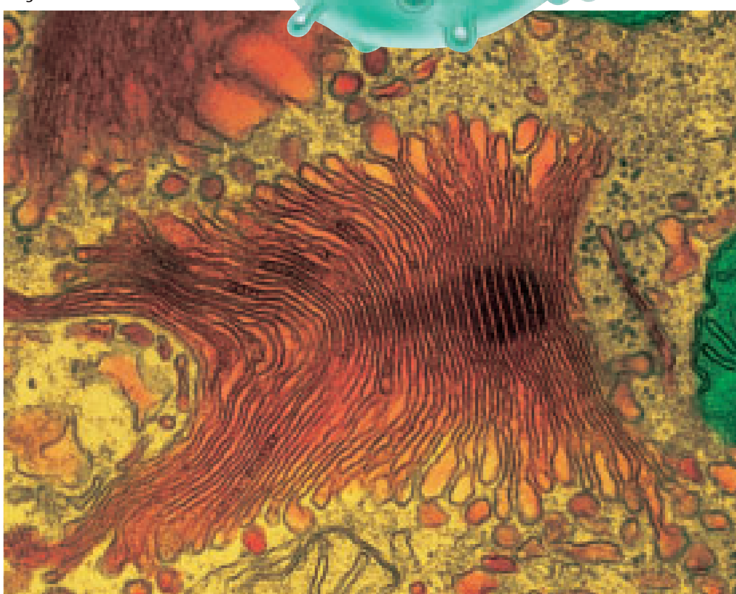
Reading Check ***What is the difference between rough ER and smooth ER?***

After proteins are made in a cell, they are transferred to another type of cell organelle called the Golgi (GAWL jee) bodies. The **Golgi bodies,** as shown ion **Figure 10,** are stacked, flattened membranes. The Golgi bodies sort proteins and other cellular substances and package them into membrane-bound structures called vesicles. The vesicles deliver cellular substances to areas inside the cell. They also carry cellular substances to the cell membrane where they are released to the outside of the cell.

Just as a deli has refrigerators for temporary storage of some of its foods and ingredients, cells have membrane-bound spaces called vacuoles for the temporary storage of materials. A vacuole can store water, waste products, food, and other cellular materials. In plant cells, the vacuole may make up most of the cell's volume.

Figure 10 The Golgi body packages materials and moves them to the outside of the cell.
Explain *why materials are removed from the cell.*

Color-enhanced TEM Magnification: 28000×



INTEGRATE Environment

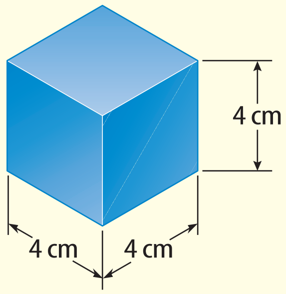
Recycling Just like a cell, you can recycle materials. Paper, plastics, aluminum, and glass are materials that can be recycled into usable items. Make a promotional poster to encourage others to recycle.

Recycling Organelles Active cells break down and recycle substances. Organelles called lysosomes (LI suh sohmz) contain digestive chemicals that help break down food molecules, cell wastes, and worn-out cell parts. In a healthy cell, chemicals are released into vacuoles only when needed. The lysosome's membrane prevents the digestive chemicals inside from leaking into the cytoplasm and destroying the cell. When a cell dies, a lysosome's membrane disintegrates. This releases digestive chemicals that allow the quick breakdown of the cell's contents.

Reading Check ***What is the function of the lysosome's membrane?***

Applying Math — Calculate a Ratio

CELL RATIO Assume that a cell is like a cube with six equal sides. Find the ratio of surface area to volume for a cube that is 4 cm high.



Solution

1 *This is what you know:* A cube has 6 equal sides of 4 cm × 4 cm.

2 *This is what you need to find out:* What is the ratio (R) of surface area to volume for the cube?

3 *These are the equations you use:*

- surface area (A) = width × length × 6
- volume (V) = length × width × height
- $R = A/V$

4 *This is the procedure you need to use:*

- Substitute in known values and solve the equations

$A = 4\text{ cm} \times 4\text{ cm} \times 6 = 96\text{ cm}^2$

$V = 4\text{ cm} \times 4\text{ cm} \times 4\text{ cm} = 64\text{ cm}^3$

$R = 96\text{ cm}^2/64\text{ cm}^3 = 1.5\text{ cm}^2/\text{cm}^3$

5 *Check your answer:* Multiply the ratio by the volume. Did you calculate the surface area?

Practice Problems

1. Calculate the ratio of surface area to volume for a cube that is 2 cm high. What happens to this ratio as the size of the cube decreases?
2. If a 4-cm cube doubled just one of its dimensions, what would happen to the ratio of surface area to volume?

Science Online — For more practice, visit **booka.msscience.com/math_practice**

From Cell to Organism

Many one-celled organisms perform all their life functions by themselves. Cells in a many-celled organism, however, do not work alone. Each cell carries on its own life functions while depending in some way on other cells in the organism.

In **Figure 11,** you can see cardiac muscle cells grouped together to form a tissue. A **tissue** is a group of similar cells that work together to do one job. Each cell in a tissue does its part to keep the tissue alive.

Tissues are organized into organs. An **organ** is a structure made up of two or more different types of tissues that work together. Your heart is an organ made up of cardiac muscle tissue, nerve tissue, and blood tissues. The cardiac muscle tissue contracts, making the heart pump. The nerve tissue brings messages from the brain that tell the heart how fast to beat. The blood tissue is carried from the heart to other organs of the body.

Reading Check *What types of tissues make up your heart?*

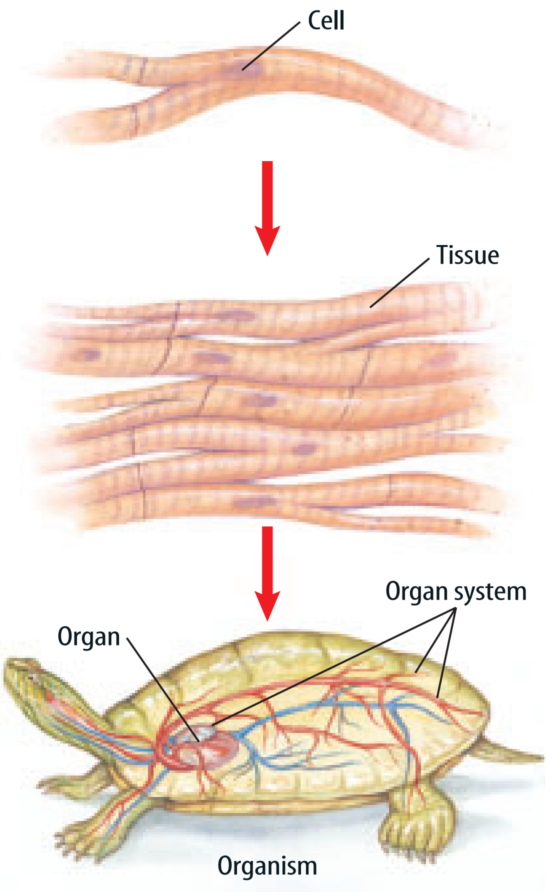


Figure 11 In a many-celled organism, cells are organized into tissues, tissues into organs, organs into systems, and systems into an organism.

A group of organs working together to perform a certain function is an organ system. Your heart, arteries, veins, and capillaries make up your cardiovascular system. In a many-celled organism, several systems work together in order to perform life functions efficiently. Your nervous, circulatory, respiratory, muscular, and other systems work together to keep you alive.

section 1 review

Summary

Common Cell Traits

- All cells have an outer covering called a cell membrane.
- Cells can be classified as prokaryotic or eukaryotic.

Cell Organization

- Each cell in your body has a specific function.
- Most of a cell's life processes occur in the cytoplasm.

From Cell to Organism

- In a many-celled organism, several systems work together to perform life functions.

Self Check

1. **Explain** why the nucleus is important in the life of a cell.
2. **Determine** why digestive enzymes in a cell are enclosed in a membrane-bound organelle.
3. **Discuss** how cells, tissues, organs, and organ systems are related.
4. **Think Critically** How is the cell of a one-celled organism different from the cells in many-celled organisms?

Applying Skills

5. **Interpret Scientific Illustrations** Examine **Figure 6.** Make a list of differences and similarities between the animal cell and the plant cell.

LAB

Comparing Cells

If you compared a goldfish to a rose, you would find them unlike each other. Are their individual cells different also?

Real-World Question

How do human cheek cells and plant cells compare?

Goals

- **Compare and contrast** an animal cell and a plant cell.

Materials

microscope
microscope slide
coverslip
forceps
tap water
dropper
Elodea plant
prepared slide of human cheek cells

Safety Precautions

Procedure

1. Copy the data table in your Science Journal. Check off the cell parts as you observe them.

Cell Observations		
Cell Part	Cheek	*Elodea*
Cytoplasm		
Nucleus		
Chloroplasts	Do not write in this book.	
Cell wall		
Cell membrane		

2. Using forceps, make a wet-mount slide of a young leaf from the tip of an *Elodea* plant.
3. **Observe** the leaf on low power. Focus on the top layer of cells.
4. Switch to high power and focus on one cell. In the center of the cell is a membrane-bound organelle called the central vacuole. Observe the chloroplasts—the green, disk-shaped objects moving around the central vacuole. Try to find the cell nucleus. It looks like a clear ball.
5. **Draw** the *Elodea* cell. Label the cell wall, cytoplasm, chloroplasts, central vacuole, and nucleus. Return to low power and remove the slide. Properly dispose of the slide.
6. **Observe** the prepared slide of cheek cells under low power.
7. Switch to high power and observe the cell nucleus. Draw and label the cell membrane, cytoplasm, and nucleus. Return to low power and remove the slide.

Conclude and Apply

1. **Compare and contrast** the shapes of the cheek cell and the *Elodea* cell.
2. **Draw conclusions** about the differences between plant and animal cells.

Communicating Your Data

Draw the two kinds of cells on one sheet of paper. Use a green pencil to label the organelles found only in plants, a red pencil to label the organelles found only in animals, and a blue pencil to label the organelles found in both. **For more help, refer to the Science Skill Handbook.**

section 2

Viewing Cells

Magnifying Cells

The number of living things in your environment that you can't see is much greater than the number that you can see. Many of the things that you cannot see are only one cell in size. To see most cells, you need to use a microscope.

Trying to see separate cells in a leaf, like the ones in **Figure 12,** is like trying to see individual photos in a photo mosaic picture that is on the wall across the room. As you walk toward the wall, it becomes easier to see the individual photos. When you get right up to the wall, you can see details of each small photo. A microscope has one or more lenses that enlarge the image of an object as though you are walking closer to it. Seen through these lenses, the leaf appears much closer to you, and you can see the individual cells that carry on life processes.

Early Microscopes In the late 1500s, the first microscope was made by a Dutch maker of reading glasses. He put two magnifying glasses together in a tube and could see an image that was larger than that made by either lens alone.

In the mid 1600s, Antonie van Leeuwenhoek, a Dutch fabric merchant, made a simple microscope with a tiny glass bead for a lens, as shown in **Figure 13.** With it, he reported seeing things in pond water that no one had ever imagined. His microscope could magnify up to 270 times. Another way to say this is that his microscope could make the object appear 270 times larger than its actual size. Today you would say his lens had a power of 270×. Early compound microscopes were crude by today's standards. The lenses would make a larger image, but it wasn't always sharp or clear.

as you read

What You'll Learn

- **Compare** the differences between the compound light microscope and the electron microscope.
- **Summarize** the discoveries that led to the development of the cell theory.

Why It's Important

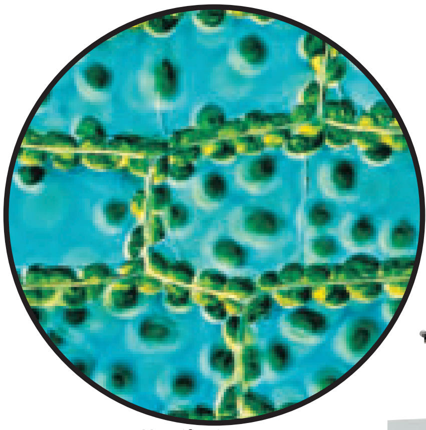
Humans are like other living things because they are made of cells.

Review Vocabulary

magnify: to increase the size of something

New Vocabulary

- cell theory



Magnification: 250×

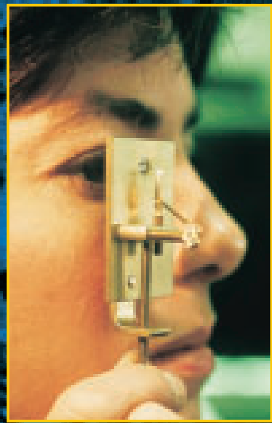
Figure 12 Individual cells become visible when a plant leaf is viewed using a microscope with enough magnifying power.

NATIONAL GEOGRAPHIC **VISUALIZING MICROSCOPES**

Figure 13

Microscopes give us a glimpse into a previously invisible world. Improvements have vastly increased their range of visibility, allowing researchers to study life at the molecular level. A selection of these powerful tools—and their magnification power—is shown here.

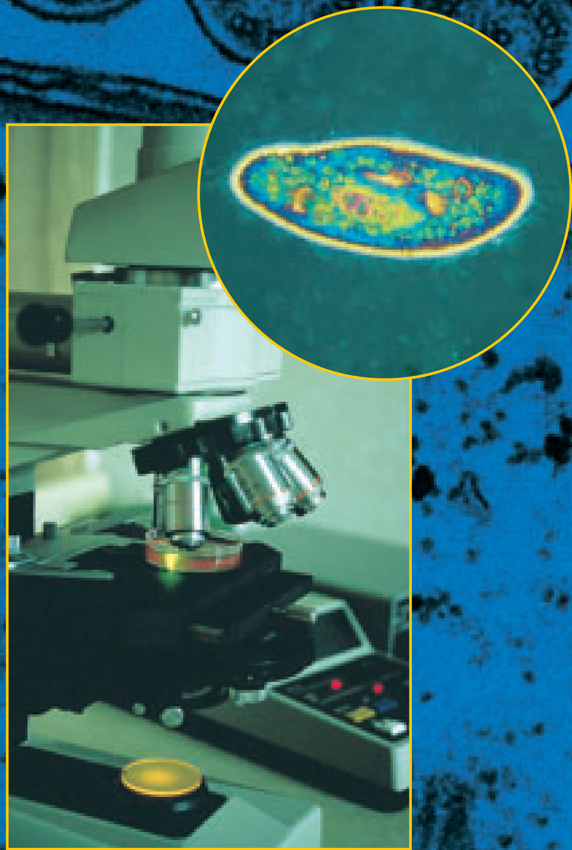
▶ **Up to 250×** **LEEUWENHOEK MICROSCOPE** Held by a modern researcher, this historic microscope allowed Leeuwenhoek to see clear images of tiny freshwater organisms that he called "beasties."



▼ **Up to 2,000×** **BRIGHTFIELD / DARKFIELD MICROSCOPE** The light microscope is often called the brightfield microscope because the image is viewed against a bright background. A brightfield microscope is the tool most often used in laboratories to study cells. Placing a thin metal disc beneath the stage, between the light source and the objective lenses, converts a brightfield microscope to a darkfield microscope. The image seen using a darkfield microscope is bright against a dark background. This makes details more visible than with a brightfield microscope. Below are images of a *Paramecium* as seen using both processes.

Darkfield

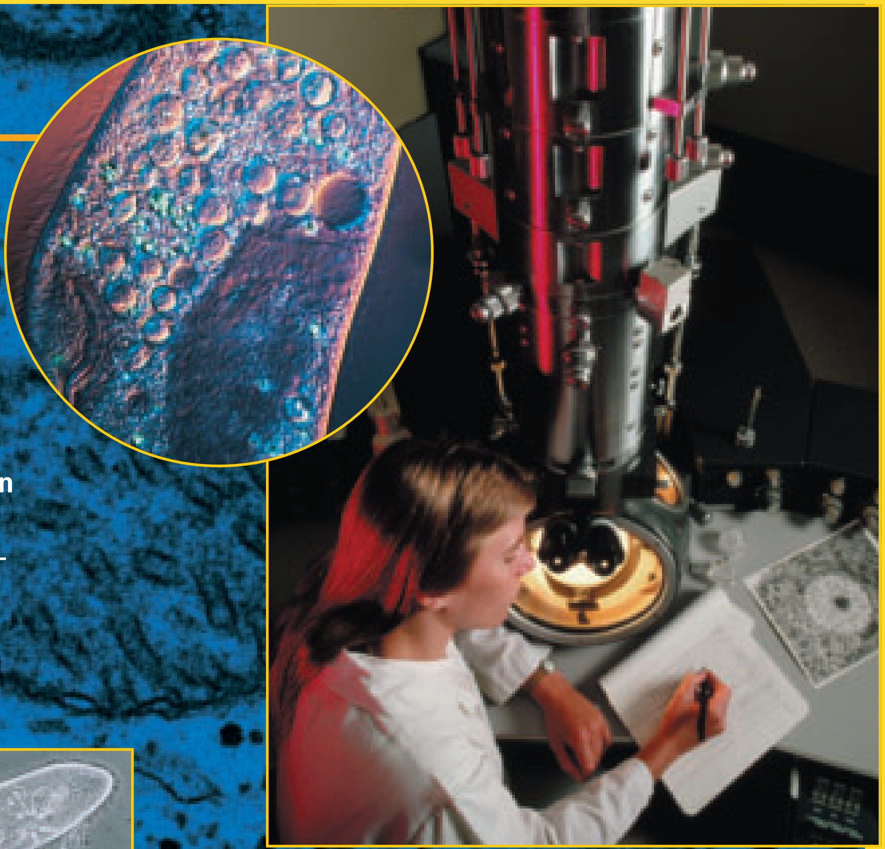
Brightfield



▲ **Up to 1,500×** **FLUORESCENCE MICROSCOPE** This type of microscope requires that the specimen be treated with special fluorescent stains. When viewed through this microscope, certain cell structures or types of substances glow, as seen in the image of a *Paramecium* above.

(cw from top)courtesy Olympus Corporation, James W. Evarts, Michael Abbey/Visuals Unlimited, Bob Krist/CORBIS, Lawrence Migdale/Stock Boston/PictureQuest, Karl Aufderheide/Visuals Unlimited

Up to 1,000,000× **TRANSMISSION ELECTRON MICROSCOPE** A TEM aims a beam of electrons through a specimen. Denser portions of the specimen allow fewer electrons to pass through and appear darker in the image. Organisms, such as the *Paramecium* at right, can only be seen when the image is photographed or shown on a monitor. A TEM can magnify hundreds of thousands of times.



Up to 1,500× **PHASE-CONTRAST MICROSCOPE** A phase-contrast microscope emphasizes slight differences in a specimen's capacity to bend light waves, thereby enhancing light and dark regions without the use of stains. This type of microscope is especially good for viewing living cells, like the *Paramecium* above left. The images from a phase-contrast microscope can only be seen when the specimen is photographed or shown on a monitor.

Up to 200,000× **SCANNING ELECTRON MICROSCOPE** An SEM sweeps a beam of electrons over a specimen's surface, causing other electrons to be emitted from the specimen. SEMs produce realistic, three-dimensional images, which can only be viewed as photographs or on a monitor, as in the image of the *Paramecium* at right. Here a researcher compares an SEM picture to a computer monitor showing an enhanced image.

Mini LAB

Observing Magnified Objects

Procedure

1. Look at a **newspaper** through the curved side and through the flat bottom of an **empty, clear glass.**
2. Look at the newspaper through a **clear glass bowl filled with water** and then with a **magnifying lens.**

Analysis

In your Science Journal, compare how well you can see the newspaper through each of the objects.

Try at Home

INTEGRATE Career

Cell Biologist Microscopes are important tools for cell biologists as they research diseases. In your Science Journal, make a list of diseases for which you think cell biologists are trying to find effective drugs.

Modern Microscopes Scientists use different microscopes to study organisms, cells, and cell parts that are too small to be seen with just the human eye. Depending on how many lenses a microscope contains, it is called simple or compound. A simple microscope is similar to a magnifying lens. It has only one lens. A microscope's lens makes an enlarged image of an object and directs light toward your eye. The change in apparent size produced by a microscope is called magnification. Microscopes vary in powers of magnification. Some microscopes can make images of individual atoms.

The microscope you probably will use to study life science is a compound light microscope, similar to the one in the Reference Handbook at the back of this book. The compound light microscope has two sets of lenses—eyepiece lenses and objective lenses. The eyepiece lenses are mounted in one or two tubelike structures. Images of objects viewed through two eyepieces, or stereomicroscopes, are three-dimensional. Images of objects viewed through one eyepiece are not. Compound light microscopes usually have two to four movable objective lenses.

Magnification The powers of the eyepiece and objective lenses determine the total magnifications of a microscope. If the eyepiece lens has a power of 10× and the objective lens has a power of 43×, then the total magnification is 430× (10× times 43×). Some compound microscopes, like those in **Figure 13,** have more powerful lenses that can magnify an object up to 2,000 times its original size.

Electron Microscopes Things that are too small to be seen with other microscopes can be viewed with an electron microscope. Instead of using lenses to direct beams of light, an electron microscope uses a magnetic field in a vacuum to direct beams of electrons. Some electron microscopes can magnify images up to one million times. To see electron microscope images, they must be photographed or electronically produced.

Several kinds of electron microscopes have been invented, as shown in **Figure 13.** Scanning electron microscopes (SEM) produce a realistic, three-dimensional image. Only the surface of the specimen can be observed using an SEM. Transmission electron microscopes (TEM) produce a two-dimensional image of a thinly-sliced specimen. Details of cell parts can be examined using a TEM. Scanning tunneling microscopes (STM) are able to show the arrangement of atoms on the surface of a molecule. A metal probe is placed near the surface of the specimen and electrons flow from the tip. The hills and valleys of the specimen's surface are mapped.

Cell Theory

During the seventeenth century, scientists used their new invention, the microscope, to explore the newly discovered microscopic world. They examined drops of blood, scrapings from their own teeth, and other small things. Cells weren't discovered until the microscope was improved. In 1665, Robert Hooke cut a thin slice of cork and looked at it under his microscope. To Hooke, the cork seemed to be made up of empty little boxes, which he named cells.

In the 1830s, Matthias Schleiden used a microscope to study plants and concluded that all plants are made of cells. Theodor Schwann, after observing different animal cells, concluded that all animals are made up of cells. Eventually, they combined their ideas and became convinced that all living things are made of cells.

Several years later, Rudolf Virchow hypothesized that cells divide to form new cells. Virchow proposed that every cell came from a cell that already existed. His observations and conclusions and those of others are summarized in the **cell theory**, as described in **Table 1.**

Table 1 The Cell Theory

All organisms are made up of one or more cells.	An organism can be one cell or many cells like most plants and animals.
The cell is the basic unit of organization in organisms.	Even in complex organisms, the cell is the basic unit of structure and function.
All cells come from cells.	Most cells can divide to form two new, identical cells.

Reading Check *Who first concluded that all animals are made of cells?*

section 2 review

Summary

Magnifying Cells

- The powers of the eyepiece and objective lenses determine the total magnification of a microscope.
- An electron microscope uses a magnetic field in a vacuum to direct beams of electrons.

Development of the Cell Theory

- In 1665, Robert Hooke looked at a piece of cork under his microscope and called what he saw cells.
- The conclusions of Rudolf Virchow and those of others are summarized in the cell theory.

Self Check

1. **Determine** why the invention of the microscope was important in the study of cells.
2. **State** the cell theory.
3. **Compare** a simple and a compound light microscope.
4. **Explain** Virchow's contribution to the cell theory.
5. **Think Critically** Why would it be better to look at living cells than at dead cells?

Applying Math

6. **Solve One-Step Equations** Calculate the magnifications of a microscope that has an 8× eyepiece and 10× and 40× objectives.

section 3

Viruses

as you read

What You'll Learn

- **Explain** how a virus makes copies of itself.
- **Identify** the benefits of vaccines.
- **Investigate** some uses of viruses.

Why It's Important

Viruses infect nearly all organisms, usually affecting them negatively yet sometimes affecting them positively.

Review Vocabulary

disease: a condition that results from the disruption in function of one or more of an organism's normal processes

New Vocabulary

- virus
- host cell

What are viruses?

Cold sores, measles, chicken pox, colds, the flu, and AIDS are diseases caused by nonliving particles called viruses. A **virus** is a strand of hereditary material surrounded by a protein coating. Viruses don't have a nucleus or other organelles. They also lack a cell membrane. Viruses, as shown in **Figure 14,** have a variety of shapes. Because they are too small to be seen with a light microscope, they were discovered only after the electron microscope was invented. Before that time, scientists only hypothesized about viruses.

How do viruses multiply?

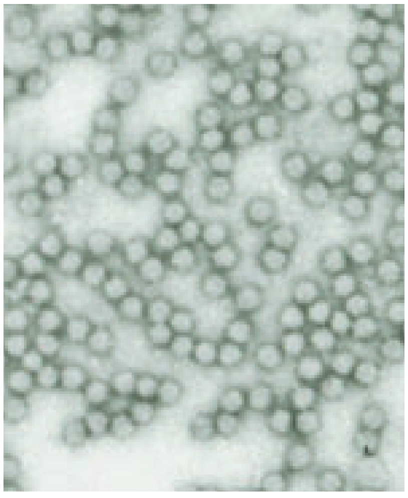
All viruses can do is make copies of themselves. However, they can't do that without the help of a living cell called a **host cell**. Crystalized forms of some viruses can be stored for years. Then, if they enter an organism, they can multiply quickly.

Once a virus is inside of a host cell, the virus can act in two ways. It can either be active or it can become latent, which is an inactive stage.

Figure 14 Viruses come in a variety of shapes.

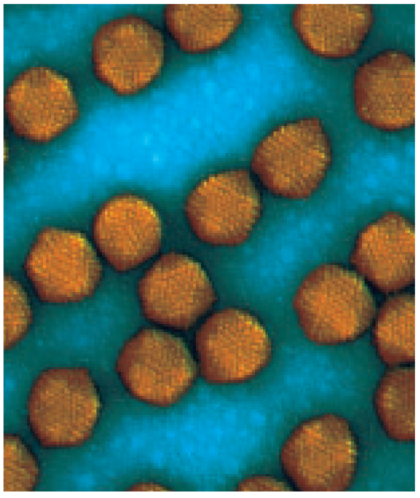
Color-enhanced TEM Magnification: 160000×

Filoviruses do not have uniform shapes. Some of these *Ebola* viruses have a loop at one end.



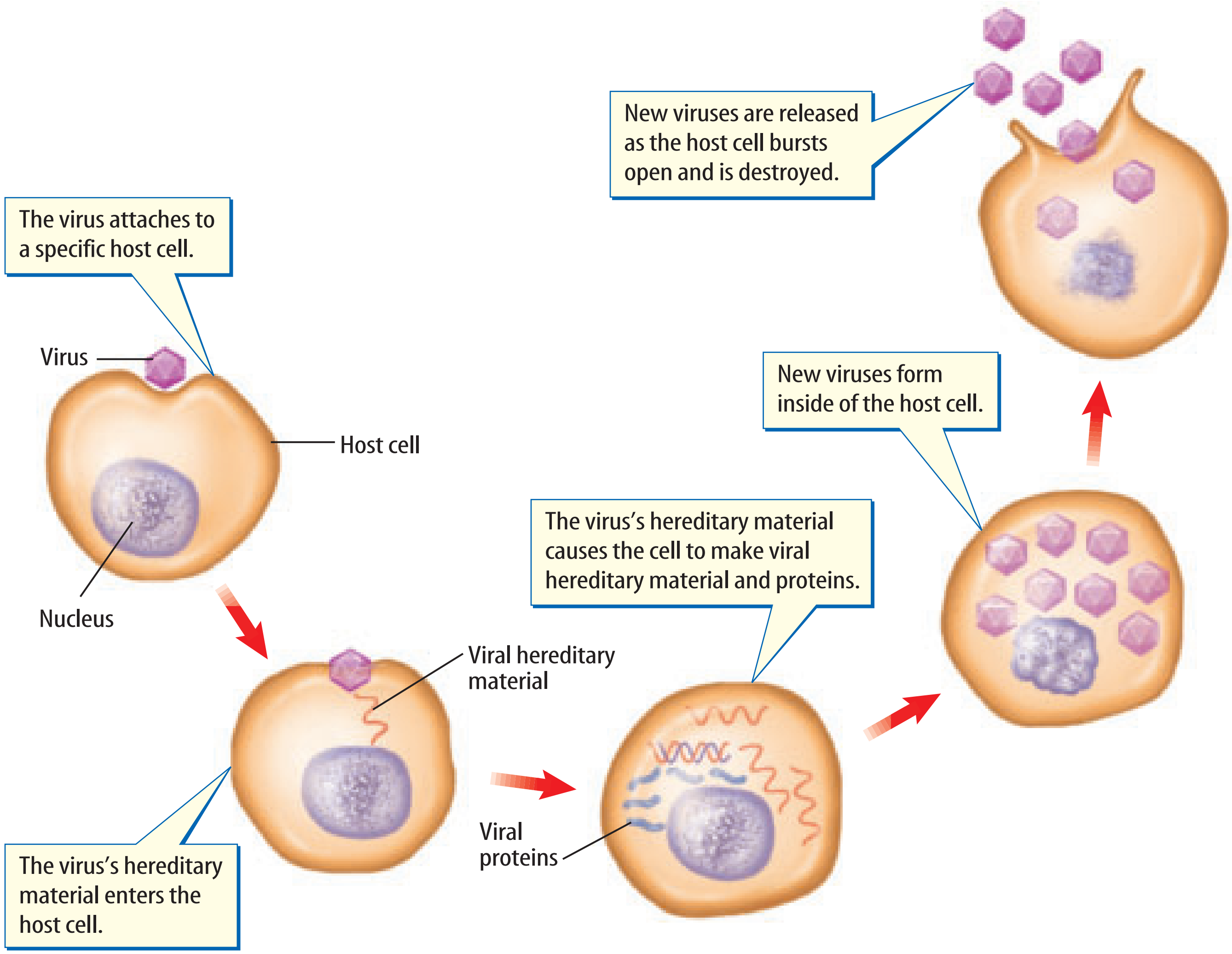
The potato leafroll virus, *Polervirus,* damages potato crops worldwide.

Color-enhanced SEM Magnification: 140000×



This is just one of the many adenoviruses that can cause the common cold.

Figure 15 An active virus multiplies and destroys the host cell.



Active Viruses When a virus enters a cell and is active, it causes the host cell to make new viruses. This process destroys the host cell. Follow the steps in **Figure 15** to see one way that an active virus functions inside a cell.

Latent Viruses Some viruses can be latent. That means that after the virus enters a cell, its hereditary material can become part of the cell's hereditary material. It does not immediately make new viruses or destroy the cell. As the host cell reproduces, the viral DNA is copied. A virus can be latent for many years. Then, certain conditions, either inside or outside your body, cause the latent virus to become an active virus.

If you have had a cold sore on your lip, a latent virus in your body has become active. The cold sore is a sign that the virus is active and destroying cells in your lip. When the cold sore disappears, the virus has become latent again. The virus is still in your body's cells, but it is hiding and doing no apparent harm.

Science Online

Topic: Virus Reactivation
Visit booka.msscience.com for Web links to information about viruses.

Activity In your Science Journal, list five stimuli that might activate a latent virus.

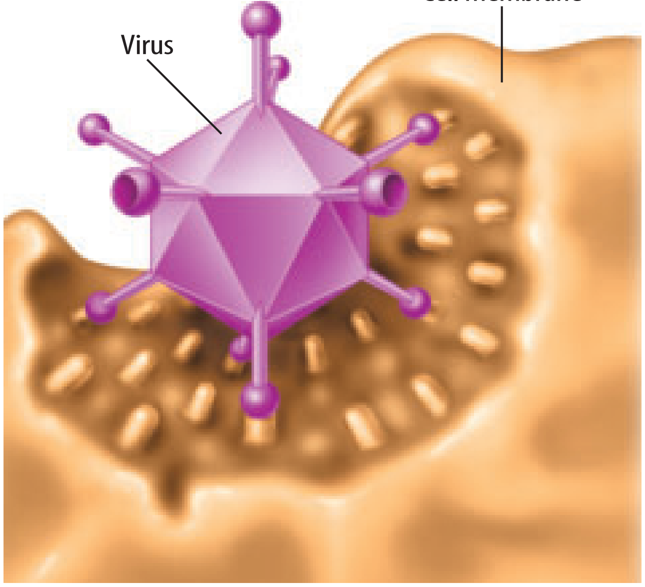


Figure 16 Viruses and the attachment sites of the host cell must match exactly. That's why most viruses infect only one kind of host cell.
Identify *diseases caused by viruses.*

How do viruses affect organisms?

Viruses attack animals, plants, fungi, protists, and bacteria. Some viruses can infect only specific kinds of cells. For instance, many viruses, such as the potato leafroll virus, are limited to one host species or to one type of tissue within that species. A few viruses affect a broad range of hosts. An example of this is the rabies virus. Rabies can infect humans and many other animal hosts.

A virus cannot move by itself, but it can reach a host's body in several ways. For example, it can be carried onto a plant's surface by the wind or it can be inhaled by an animal. In a viral infection, the virus first attaches to the surface of the host cell. The virus and the place where it attaches must fit together exactly, as shown in **Figure 16.** Because of this, most viruses attack only one kind of host cell.

Viruses that infect bacteria are called bacteriophages (bak TIHR ee uh fay jihz). They differ from other kinds of viruses in the way that they enter bacteria and release their hereditary material. Bacteriophages attach to a bacterium and inject their hereditary material. The entire cycle takes about 20 min, and each virus-infected cell releases an average of 100 viruses.

Fighting Viruses

Vaccines are used to prevent disease. A vaccine is made from weakened virus particles that can't cause disease anymore. Vaccines have been made to prevent many diseases, including measles, mumps, smallpox, chicken pox, polio, and rabies.

Reading Check *What is a vaccine?*

The First Vaccine Edward Jenner is credited with developing the first vaccine in 1796. He developed a vaccine for smallpox, a disease that was still feared in the early twentieth century. Jenner noticed that people who got a disease called cowpox didn't get smallpox. He prepared a vaccine from the sores of people who had cowpox. When injected into healthy people, the cowpox vaccine protected them from smallpox. Jenner didn't know he was fighting a virus. At that time, no one understood what caused disease or how the body fought disease.

Science Online
Topic: Filoviruses
Visit booka.msscience.com for Web links to information about the virus family *Filoviridae.*

Activity Make a table that displays the virus name, location, and year of the initial outbreaks associated with the *Filoviridae* family.

Treating Viral Diseases Antibiotics treat bacterial infections but are not effective against viral diseases. One way your body can stop viral infections is by making interferons. Interferons are proteins that are produced rapidly by virus-infected cells and move to noninfected cells in the host. They cause the noninfected cells to produce protective substances.

Antiviral drugs can be given to infected patients to help fight a virus. A few drugs show some effectiveness against viruses but some have limited use because of their adverse side effects.

Preventing Viral Diseases Public health measures for preventing viral diseases include vaccinating people, improving sanitary conditions, quarantining patients, and controlling animals that spread disease. For example, annual rabies vaccinations of pets and farm animals protect them and humans from infection. To control the spread of rabies in wild animals such as coyotes and wolves, wildlife workers place bait containing an oral rabies vaccine, as shown in **Figure 17,** where wild animals will find it.

Figure 17 This oral rabies bait is being prepared for an aerial drop by the Texas Department of Health as part of their Oral Rabies Vaccination Program. This five-year program has prevented the expansion of rabies into Texas.

Research with Viruses

You might think viruses are always harmful. However, through research, scientists are discovering helpful uses for some viruses. One use, called gene transfer, substitutes normal hereditary material for a cell's defective hereditary material. The normal material is enclosed in viruses that "infect" targeted cells. The new hereditary material enters the cells and replaces the defective hereditary material. Using gene therapy, scientists hope to help people with genetic disorders and find a cure for cancer.

section 3 review

Summary

What are viruses?

- A virus is a strand of hereditary material surrounded by a protein coating.

How do viruses multiply?

- An active virus immediately destroys the host cell but a latent virus does not.

Fighting Viruses and Research with Viruses

- Antiviral drugs can be given to infected patients to help fight a virus.
- Scientists are discovering helpful uses for some viruses.

Self Check

1. **Describe** how viruses multiply.
2. **Explain** how vaccines are beneficial.
3. **Determine** how some viruses might be helpful.
4. **Discuss** how viral diseases might be prevented.
5. **Think Critically** Explain why a doctor might not give you any medication if you have a viral disease.

Applying Skills

6. **Concept Map** Make an events-chain concept map to show what happens when a latent virus becomes active.

Science Online booka.msscience.com/self_check_quiz

Pam Wilson/Texas Dept. of Health

LAB Design Your Own

Comparing Light Microscopes

Goals

- **Learn** how to correctly use a stereomicroscope and a compound light microscope.
- **Compare** the uses of the stereomicroscope and compound light microscope.

Possible Materials

compound light microscope
stereomicroscope
items from the classroom—include some living or once-living items (8)
microscope slides and coverslips
plastic petri dishes
distilled water
dropper

Safety Precautions

Real-World Question

You're a technician in a police forensic laboratory. You use a stereomicroscope and a compound light microscope in the laboratory. A detective just returned from a crime scene with bags of evidence. You must examine each piece of evidence under a microscope. How do you decide which microscope is the best tool to use? Will all of the evidence that you've collected be viewable through both microscopes?

Form a Hypothesis

Compare the items to be examined under the microscopes. Form a hypothesis to predict which microscope will be used for each item and explain why.

Matt Meadows

Test Your Hypothesis

Make a Plan

1. As a group, decide how you will test your hypothesis.
2. **Describe** how you will carry out this experiment using a series of specific steps. Make sure the steps are in a logical order. Remember that you must place an item in the bottom of a plastic petri dish to examine it under the stereomicroscope and you must make a wet mount of any item to be examined under the compound light microscope. For more help, see the Reference Handbook.
3. If you need a data table or an observation table, design one in your Science Journal.

Follow Your Plan

1. Make sure your teacher approves the objects you'll examine, your plan, and your data table before you start.
2. Carry out the experiment.
3. While doing the experiment, record your observations and complete the data table.

Analyze Your Data

1. **Compare** the items you examined with those of your classmates.
2. **Classify** the eight items you observed based on this experiment.

Conclude and Apply

1. **Infer** which microscope a scientist might use to examine a blood sample, fibers, and live snails.
2. **List** five careers that require people to use a stereomicroscope. List five careers that require people to use a compound light microscope. Enter the lists in your Science Journal.
3. **Infer** how the images would differ if you examined an item under a compound light microscope and a stereomicroscope.
4. **Determine** which microscope is better for looking at large, or possibly live, items.

Communicating Your Data

In your Science Journal, **write** a short description of an imaginary crime scene and the evidence found there. Sort the evidence into two lists—items to be examined under a stereomicroscope and items to be examined under a compound light microscope. **For more help, refer to the Science Skill Handbook.**

Matt Meadows

Cobb Against Cancer

This colored scanning electron micrograph (SEM) shows two breast cancer cells in the final stage of cell division.

Jewel Plummer Cobb is a cell biologist who did important background research on the use of drugs against cancer in the 1950s. She removed cells from cancerous tumors and cultured them in the lab. Then, in a controlled study, she tried a series of different drugs against batches of the same cells. Her goal was to find the right drug to cure each patient's particular cancer. Cobb never met that goal, but her research laid the groundwork for modern chemotherapy—the use of chemicals to treat cancer.

Jewel Cobb also influenced science in another way. She was a role model, especially in her role as dean or president of several universities. Cobb promoted equal opportunity for students of all backgrounds, especially in the sciences.

Light Up a Cure

Vancouver, British Columbia 2000. While Cobb herself was only able to infer what was going on inside a cell from its reactions to various drugs, her work has helped others go further. Building on Cobb's work, Professor Julia Levy and her research team at the University of British Columbia actually go inside cells, and even organelles, to work against cancer. One technique they are pioneering is the use of light to guide cancer drugs to the right cells. First, the patient is given a chemotherapy drug that reacts to light. Then, a fiber optic tube is inserted into the tumor. Finally, laser light is passed through the tube, which activates the light-sensitive drug—but only in the tumor itself. This will hopefully provide a technique to keep healthy cells healthy while killing sick cells.

Write Report on Cobb's experiments on cancer cells. What were her dependent and independent variables? What would she have used as a control? What sources of error did she have to guard against? Answer the same questions about Levy's work.

Science Online
For more information, visit booka.msscience.com/time

(t)Quest/Science Photo Library/Photo Researchers, (b)courtesy California University

chapter 2 Study Guide

Reviewing Main Ideas

Section 1 Cell Structure

1. Prokaryotic and eukaryotic are the two cell types.
2. The DNA in the nucleus controls cell functions.
3. Organelles such as mitochondria and chloroplasts process energy.
4. Most many-celled organisms are organized into tissues, organs, and organ systems.

Section 2 Viewing Cells

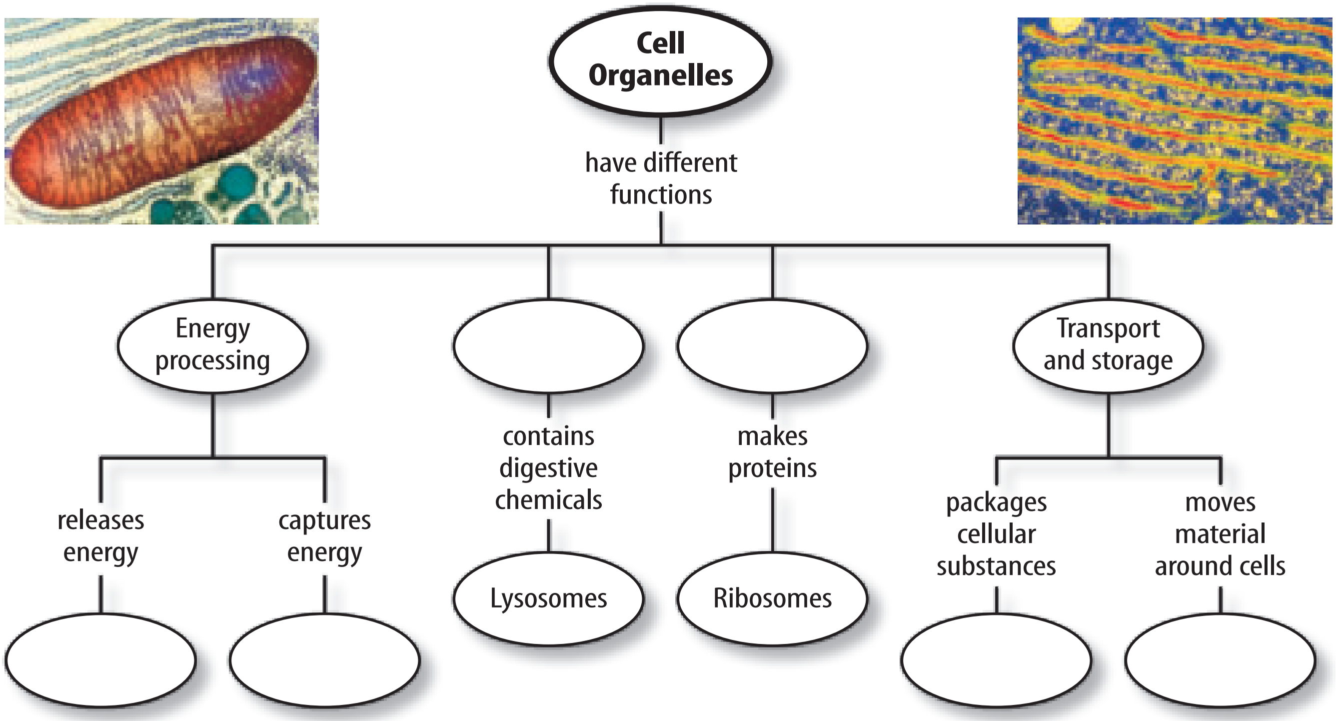
1. A simple microscope has just one lens. A compound light microscope has an eyepiece and objective lenses.
2. To calculate the magnification of a microscope, multiply the power of the eyepiece by the power of the objective lens.
3. According to the cell theory, the cell is the basic unit of life. Organisms are made of one or more cells, and all cells come from other cells.

Section 3 Viruses

1. A virus is a structure containing hereditary material surrounded by a protein coating.
2. A virus can make copies of itself only when it is inside a living host cell.

Visualizing Main Ideas

Copy and complete the following concept map of the basic units of life.



(l)Keith Porter/Photo Researchers, (r)NIBSC/Science Photo Library/Photo Researchers

chapter 2 Review

Using Vocabulary

cell membrane p. 40	host cell p. 54
cell theory p. 53	mitochondrion p. 44
cell wall p. 41	nucleus p. 42
chloroplast p. 44	organ p. 47
cytoplasm p. 40	organelle p. 42
endoplasmic reticulum p. 45	ribosome p. 44
Golgi body p. 45	tissue p. 47
	virus p. 54

Using the vocabulary words, give an example of each of the following.

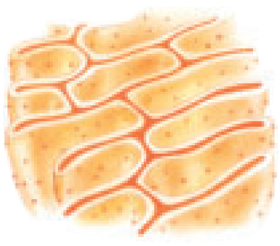
1. found in every organ
2. smaller than one cell
3. a plant-cell organelle
4. part of every cell
5. powerhouse of a cell
6. used by biologists
7. contains hereditary material
8. a structure that surrounds the cell
9. can be damaged by a virus
10. made up of cells

Checking Concepts

Choose the word or phrase that best answers the question.

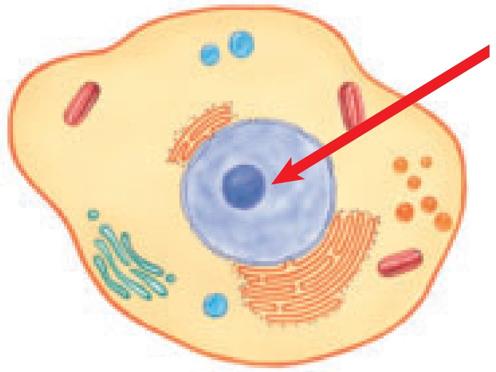
11. What structure allows only certain things to pass in and out of the cell?
    A) cytoplasm
    B) cell membrane
    C) ribosomes
    D) Golgi body

12. What is the organelle to the right?



    A) nucleus
    B) cytoplasm
    C) Golgi body
    D) endoplasmic reticulum

Use the illustration below to answer question 13.



13. In the figure above, what is the function of the structure that the arrow is pointing to?
    A) recycles old cell parts
    B) controls cell activities
    C) protection
    D) releases energy

14. Which scientist gave the name *cells* to structures he viewed?
    A) Hooke
    B) Schwann
    C) Schleiden
    D) Virchow

15. Which of the following is a viral disease?
    A) tuberculosis
    B) anthrax
    C) smallpox
    D) tetanus

16. Which microscope can magnify up to a million times?
    A) compound light microscope
    B) stereomicroscope
    C) transmission electron microscope
    D) atomic force microscope

17. Which of the following is part of a bacterial cell?
    A) a cell wall
    B) lysosomes
    C) mitochondria
    D) a nucleus

18. Which of the following do groups of different tissues form?
    A) organ
    B) organelle
    C) organ system
    D) organism

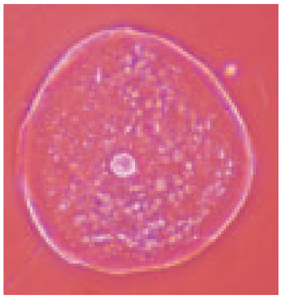
Thinking Critically

19. Infer why it is difficult to treat a viral disease.

20. Explain which type of microscope would be best to view a piece of moldy bread.

21. Predict what would happen to a plant cell that suddenly lost its chloroplasts.

22. Predict what would happen if the animal cell shown to the right didn't have ribosomes.



23. Determine how you would decide whether an unknown cell was an animal cell, a plant cell, or a bacterial cell.

24. Concept Map Make an events-chain concept map of the following from simple to complex: *small intestine, circular muscle cell, human,* and *digestive system.*

25. Interpret Scientific Illustrations Use the illustrations in **Figure 1** to describe how the shape of a cell is related to its function.

Use the table below to answer question 26.

Cell Structures

Structure	Prokaryotic Cell	Eukaryotic Cell
Cell membrane		Yes
Cytoplasm	Yes	
Nucleus		Yes
Endoplasmic reticulum		
Golgi bodies		

26. Compare and Contrast Copy and complete the table above.

27. Make a Model Make and illustrate a time line about the development of the cell theory. Begin with the development of the microscope and end with Virchow. Include the contributions of Leeuwenhoek, Hooke, Schleiden, and Schwann.

Performance Activities

28. Model Use materials that resemble cell parts or represent their functions to make a model of a plant cell or an animal cell. Include a cell-parts key.

29. Poster Make a poster about the history of vaccinations. Contact your local Health Department for current information.

Applying Math

Use the illustration below to answer question 30.

30. Cell Width If the pointer shown above with the cell is 10 micrometers (μm) in length, then about how wide is this cell?

A) 20 μm
B) 10 μm
C) 5 μm
D) 0.1 μm

31. Magnification Calculate the magnification of a microscope with a 20× eyepiece and a 40× objective.

chapter 2 Standardized Test Practice

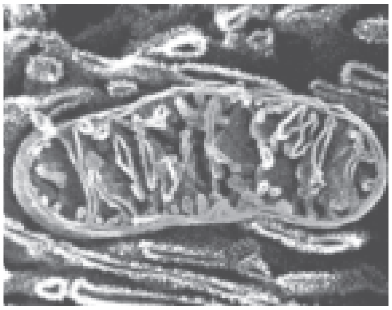
Part 1 Multiple Choice

Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

1. What do a bacterial cell, a plant cell, and a nerve cell have in common?
   A. cell wall and nucleus
   B. cytoplasm and cell membrane
   C. endoplasmic reticulum
   D. flagella

2. Which is not a function of an organelle?
   A. cell shape and movement
   B. energy release
   C. chemical transfer
   D. chemical storage

Use the images below to answer question 3.

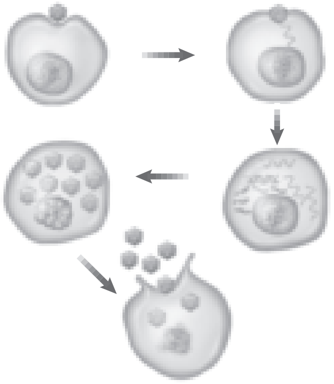


3. What is the primary function of this organelle?
   A. capturing light energy
   B. directing cell processes
   C. releasing energy stored in food
   D. making proteins

4. Which organelles receive the directions from the DNA in the nucleus about which proteins to make?
   A. ribosomes
   B. endoplasmic reticulum
   C. Golgi bodies
   D. cell wall

5. Why is a virus not considered a living cell?
   A. It has a cell wall.
   B. It has hereditary material.
   C. It has no organelles.
   D. It cannot multiply.

Use the illustration below to answer questions 6 and 7.



6. What does the diagram above represent?
   A. cell reproduction
   B. bacterial reproduction
   C. active virus multiplication
   D. vaccination

7. What does the largest circular structure represent?
   A. a host cell **C.** a vacuole
   B. a ribosome **D.** the nucleus

8. Where do most of a cell's life processes occur?
   A. nucleus **C.** organ
   B. cell wall **D.** cytoplasm

9. What is a group of similar cells that work together?
   A. tissue **C.** organ system
   B. organ **D.** organism

Test-Taking Tip

Read Carefully Read each question carefully for full understanding.

Part 2 Short Response/Grid In

Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

10. Compare and contrast the cell wall and the cell membrane.

11. How would a cell destroy or breakdown a harmful chemical which entered the cytoplasm?

12. How does your body stop viral infections? What are other ways of protection against viral infections?

13. Where is cellulose found in a cell and what is its function?

Use the following table to answer question 14.

Organelle	Function
	Directs all cellular activities
Mitochondria	
	Captures light energy to make glucose
Ribosomes	

14. Copy and complete the table above with the appropriate information.

15. How are Golgi bodies similar to a packaging plant?

16. Why does a virus need a host cell?

17. Give an example of an organ system and list the organs in it.

18. Compare and contrast the energy processing organelles.

19. Describe the structure of viruses.

20. How do ribosomes differ from other cell structures found in the cytoplasm?

21. What kind of microscope uses a series of lenses to magnify?

Part 3 Open Ended

Record your answers on a sheet of paper.

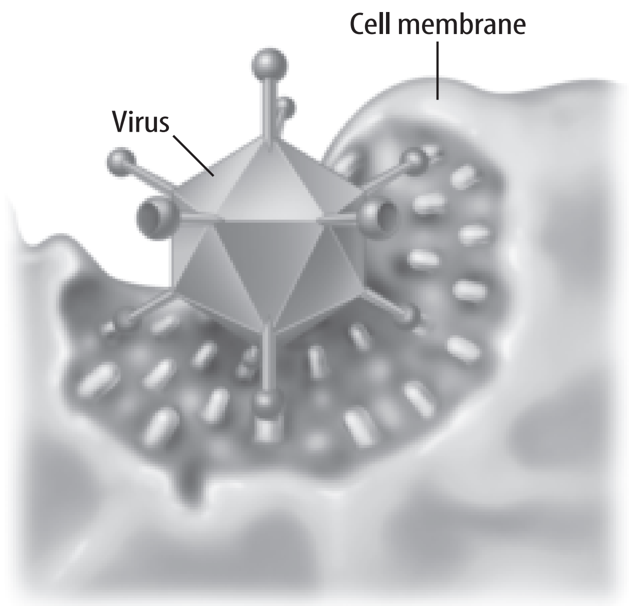
22. Name three different types of microscopes and give uses for each.

23. Some viruses, like the common cold, only make the host organism sick, but other viruses, like *Ebola,* are deadly to the host organism. Which of these strategies is more effective for replication and transmission of the virus to new host organisms? Which type of virus would be easier to study and develop a vaccine against?

24. Discuss the importance of the cytoplasm.

25. Explain how Hooke, Schleiden, and Schwann contributed to the cell theory.

Use the illustration below to answer question 26.



26. What interaction is taking place in the illustration above? What are two possible outcomes of this interaction?

27. Describe how the first vaccine was developed.