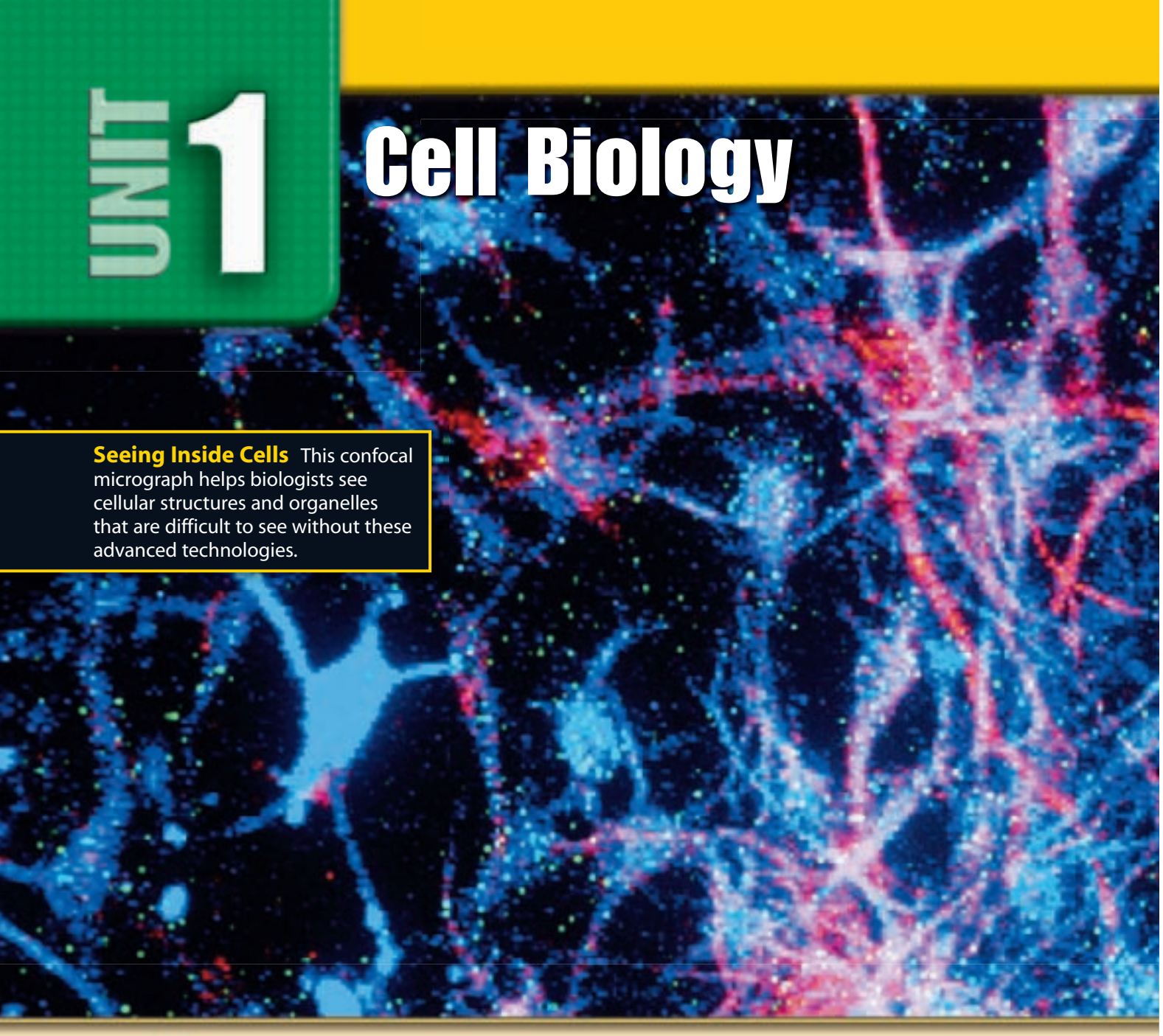
UNIT 1

Cell Biology

Seeing Inside Cells This confocal micrograph helps biologists see cellular structures and organelles that are difficult to see without these advanced technologies.



10,000–9,000 Years Ago
Early people settle in what is now Mexico and southward; hunters-gatherers live in what is now California.

1769
Spanish build (1769) first of 21 missions in California at San Diego.

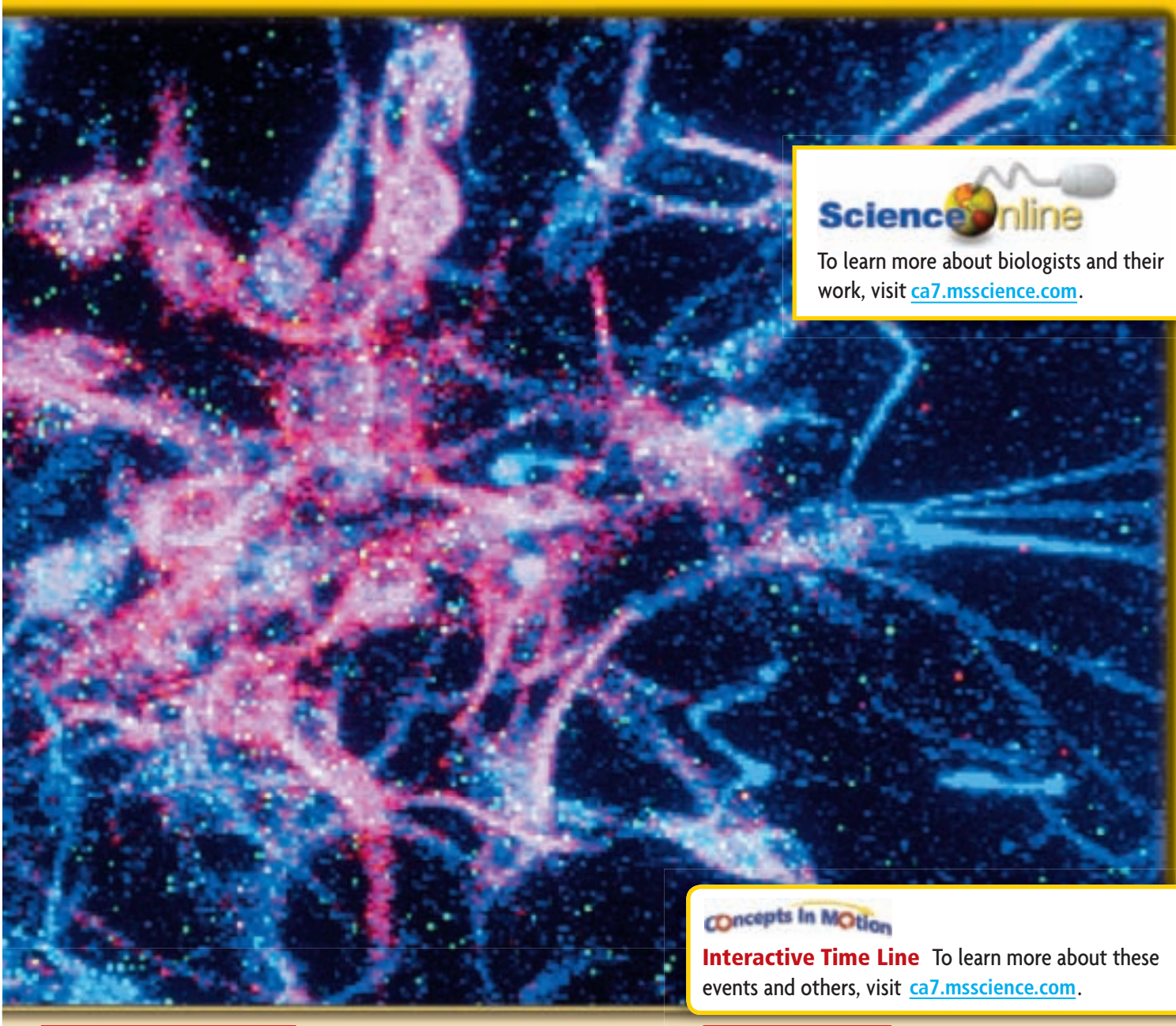
1848–1850
Mexico loses California to the U.S. as a result of the Mexican War; California becomes a U.S. state (1850).

A.D. 1500 | 1600 | 1700 | 1800 | 1900

c. 1600
Compound microscope using two lenses is developed.

1665
Robert Hooke observes cells.

1838–1839
M. J. Schleiden declares that all plants are made of cells. Thomas Schwann says all animals are made of cells. They propose the cell theory.



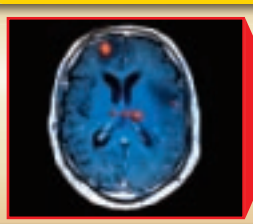
Science Online

To learn more about biologists and their work, visit ca7.msscience.com.

Concepts in Motion

Interactive Time Line To learn more about these events and others, visit ca7.msscience.com.

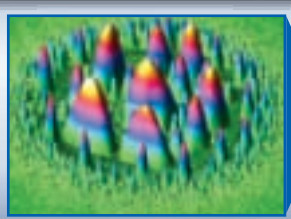
1950s
Jewell Plummer Cobb works to find the right drug to cure cancerous tumors; later she serves as president of Cal State Fullerton.



July 2004
Surgeons test heat imaging instruments built by scientists at the Jet Propulsion Laboratory (JPL) in Pasadena, California, to map brain tumors.

1920 1940 1960 1980 2000 2020

c. 1930
Ernst Ruska and Max Knoll of Germany develop the transmission electron microscope (TEM); magnifies sample hundreds of thousands of times.

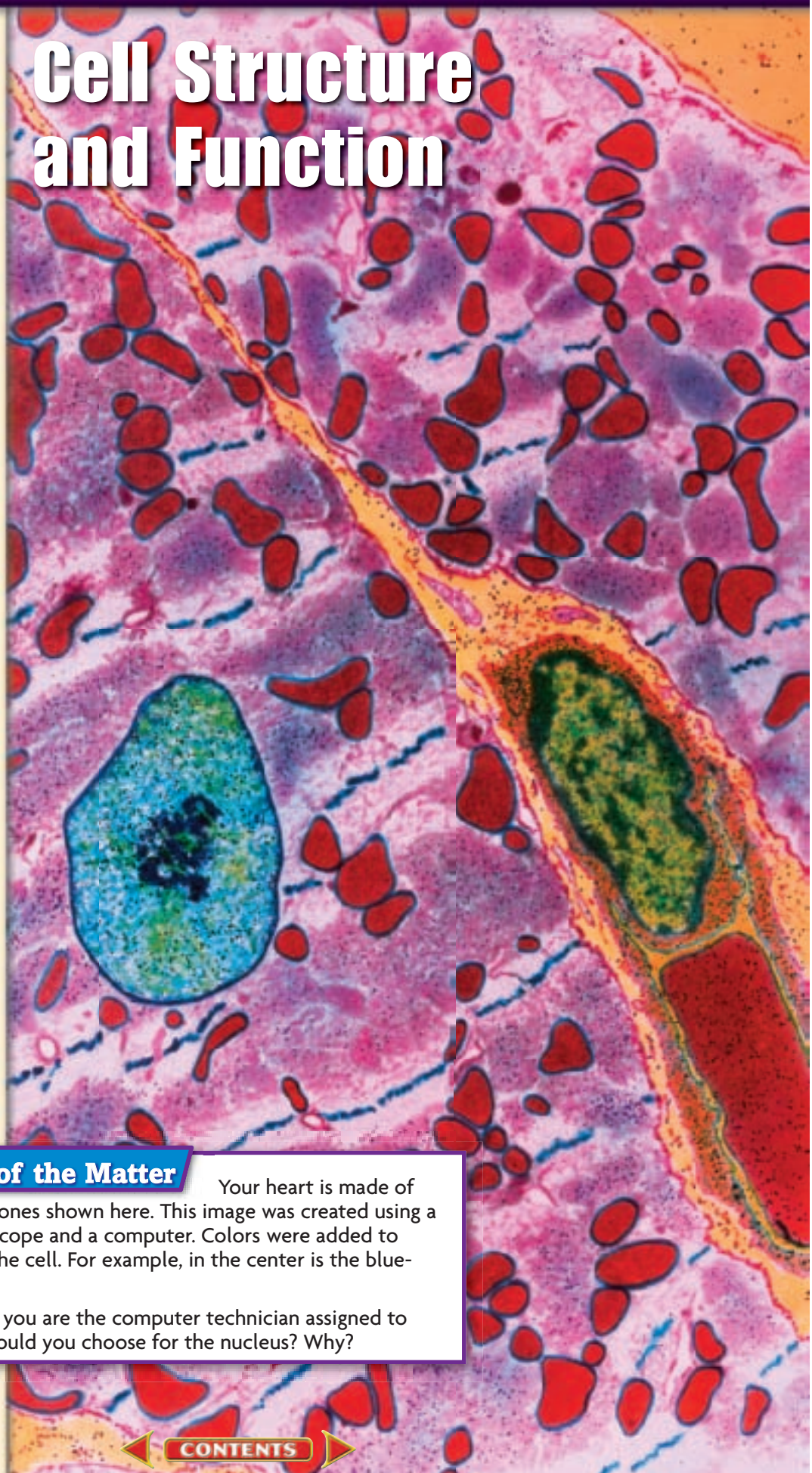


1981
Scanning tunneling microscope (STM) invented by Gerd Binnig and Heinrich Rohrer; magnifies a sample a million times.

1986
Rita Levi-Montalcini and Stanley Cohen are recognized for their work with growth factors responsible for stem cells dividing and becoming different kinds of cells.

CHAPTER 1

Cell Structure and Function



The BIG Idea

The structures in a cell work together and ensure the survival of the cell.

LESSON 1 1.a, 7.a, 7.c

Cells and Life

Main Idea Cells are the smallest unit of life.

LESSON 2

1.a, 1.b, 1.c, 2.e, 7.d

The Cell

Main Idea Cells have structures with specific functions.

LESSON 3

1.d, 7.a, 7.c, 7.d, 7.e

Cells and Energy

Main Idea All cells can release energy from food molecules. Only some cells can make food molecules using light energy.

Getting to the Heart of the Matter

Your heart is made of many types of cells, like the ones shown here. This image was created using a transmission electron microscope and a computer. Colors were added to show the different parts of the cell. For example, in the center is the blue-green nucleus.

Science Journal Imagine you are the computer technician assigned to color this cell. What color would you choose for the nucleus? Why?

CONTENTS

Launch Lab

00:20 minutes

What are we made of?

Some things are so small that you cannot see them without a light microscope. As you begin this chapter, you will use a microscope to observe things you might never have seen before.

Procedure

1. Complete a lab safety form.
2. Obtain a **microscope** and **slides.**
3. Observe the slides using the microscope according to your teacher's instructions.
4. Change magnifications and adjust again.
5. Draw what you observe. Label your drawing with the magnification you used.
6. Compare your drawings to those of your classmates.

Think About This

- **Describe** what you observed.
- **List** the changes you observed when you changed magnification.

7.a, 7.d

Science Online

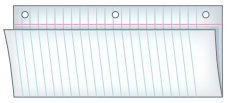
Visit ca7.msscience.com to:

- view Concepts in Motion
- explore Virtual Labs
- access content-related Web links
- take the Standards Check

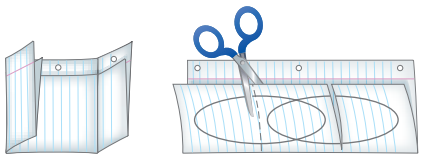
FOLDABLES™ Study Organizer

Cells Make the following Foldable to compare and contrast a plant cell and an animal cell.

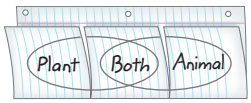
STEP 1 **Fold** a sheet of paper in half lengthwise. Make the back edge about 2 cm longer than the front edge.



STEP 2 **Fold** into thirds. **Unfold** and **cut** along the folds of the top flap to make three flaps.



STEP 3 **Label** the flaps as shown.



Reading Skill

Monitoring Your Comprehension

As you read Lesson 2, write the names of the cell parts found in both plant and animal cells under the center tab. List other cell parts under the tab for the correct cell type.

Get Ready to Read

Preview

1 Learn It! If you know what to expect before reading, it will be easier to understand ideas and relationships presented in the text. Follow these steps to preview your reading assignments.

1. Look at the title and any illustrations that are included.
2. Read the headings, subheadings, and anything in bold letters.
3. Skim over the passage to see how it is organized. Is it divided into many parts?
4. Look at the graphics—pictures, maps, or diagrams. Read their titles, labels, and captions.
5. Set a purpose for your reading. Are you reading to learn something new? Are you reading to find specific information?

2 Practice It! Take some time to preview this chapter. Skim all the main headings and subheadings. With a partner, discuss your answers to these questions:

- Which part of this chapter looks most interesting to you?
- Are there any words in the headings that are unfamiliar to you?
- Choose one of the lesson standards check questions to discuss with a partner.

3 Apply It! Now that you have skimmed the chapter, write a short paragraph describing one thing you want to learn from this chapter.

Reading Tip

As you preview this chapter, be sure to scan the illustrations, tables, and graphs. Skim the captions.

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.

Before You Read A or D	Statement	After You Read A or D
	1 All new cells come from preexisting cells.	
	2 A microscope is needed to see most cells.	
	3 Some living things do not require water to survive.	
	4 Chromosomes are in the nucleus of every cell.	
	5 Bacteria have specialized compartments called organelles.	
	6 The cell wall and cytoplasm determine the shape of a cell.	
	7 Oxygen is not required for cellular respiration.	
	8 Cilia are short, hairlike cellular appendages.	
	9 Most multicellular organisms are not dependent on photosynthesis.	
	10 Plants cells are the only cells that can transform light energy.	

Science Online

Print a worksheet of this page at ca7.msscience.com.

LESSON 1

Science Content Standards

1.a Students know cells function similarly in all living organisms.
7.a Select and use appropriate tools and technology (including calculators, computers, balances, spring scales, microscopes, and binoculars) to perform tests, collect data, and display data.
7.c Communicate the logical connection among hypotheses, science concepts, tests conducted, data collected, and conclusions drawn from the scientific evidence.

Reading Guide

What *You'll Learn*

- **Summarize** the cell theory.
- **Identify** the characteristics of life.
- **Explain** the importance of water in a cell.
- **Describe** the four basic substances of a cell.

Why *It's Important*

Learning about cells will help you understand how living organisms function.

Vocabulary

light microscope
cell theory
homeostasis
protein
nucleic acid
lipid
carbohydrate

Review Vocabulary

cell: basic structural and functional unit of all organisms (Grade 5)

Cells and Life

Main Idea Cells are the smallest unit of life.

Real-World Reading Connection People once thought Earth was flat because they did not have tools to discover that it is round. People also had many wrong ideas about living things on Earth. They did not have the tools to observe very small living things.

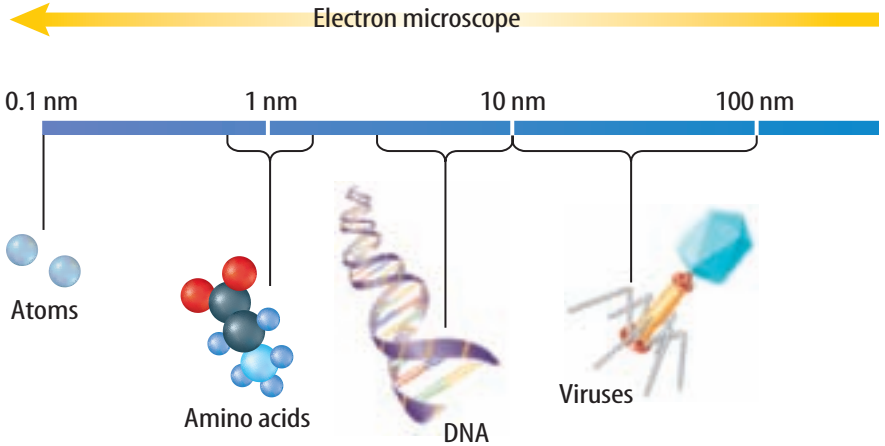
Early Ideas About Cells

Most cells are so small, as shown in **Figure 1,** that you cannot see them without some type of magnifying device. There even was a time when people did not know that cells existed. People also once believed that an egg contained a miniature version of an adult organism. They thought the organism's structures just had to increase in size as the organism grew.

Early Microscopes

After the invention of the light microscope, around 1600, ideas about living things changed. A **light microscope** uses light and has one or more lenses that enlarges an image of something.

Figure 1 Cell Size Most cells can only be seen using some type of microscope.



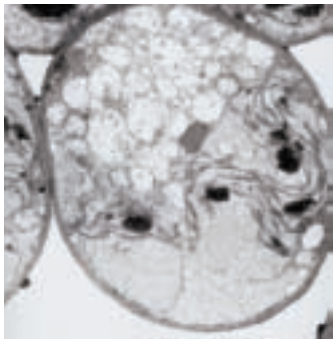
1 billion nanometers (nm) = 1 meter
1 million micrometers (μm) = 1 meter
100 centimeters (cm) = 1 meter
1,000 meters (m) = 1 kilometer (km)

CONTENTS

Modern Microscopes

Most of the structures within a cell are too small to be observed even with a light microscope. The best light microscopes can only enlarge images of objects up to about 1,500 times their original size. With the invention of the electron microscope in the 1930s, scientists were able to see most structures inside a cell, like those shown in **Figure 2.** An electron microscope can enlarge images 100,000 times or more. Improved types of electron microscopes include one that can produce images of atoms on or in surfaces of materials.

Figure 2 Many of the details of a plant cell, such as the cell shown below, are visible only with an electron microscope.



TEM Magnification: 17,000×

Visual Check **Figure 1** What is the smallest image size that can be detected by an electron microscope?

The Cell Theory

Even after the invention of microscopes, scientists were only beginning to understand how cells relate to living things. In the 1830s, a German scientist observed that all plant parts are made of cells. Around the same time, another German scientist made the same observation about animals. Nearly two decades later, a German physician proposed that all cells come from preexisting cells. Together, these ideas became known as the **cell theory,** which is listed below.

- All organisms are made of one or more cells.
- The cell is the smallest unit of life.
- All new cells come from preexisting cells.

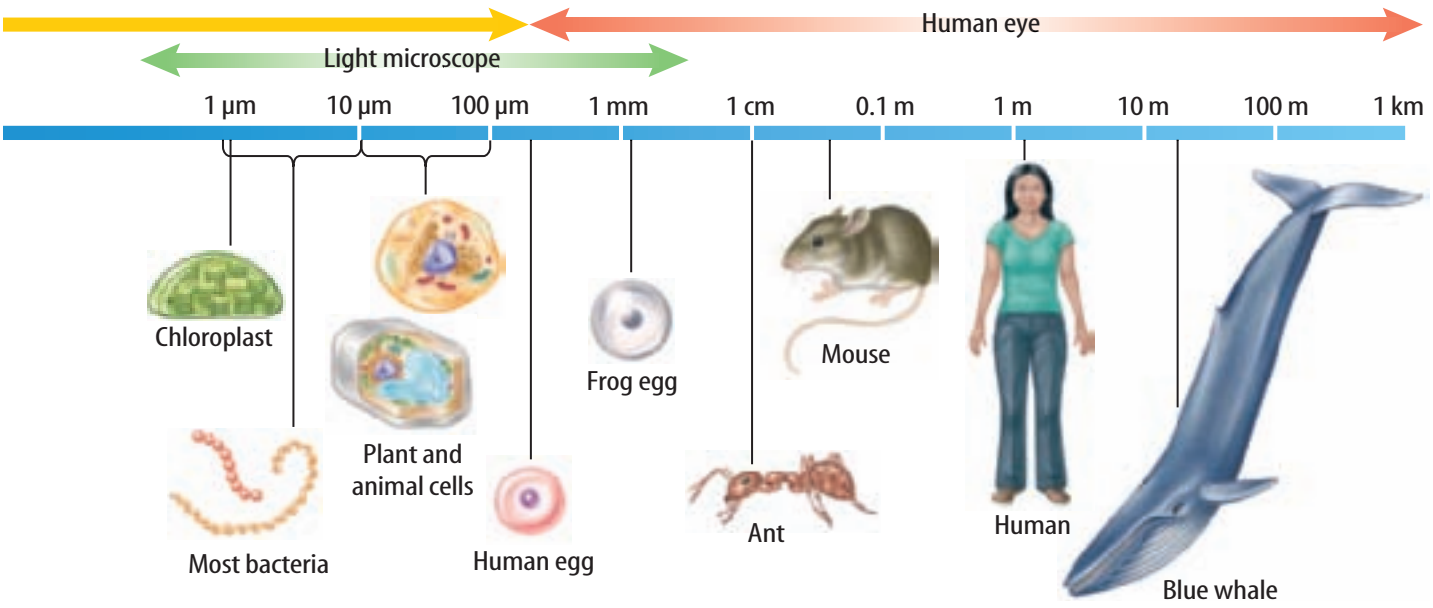


Figure 3 Your environment includes living and nonliving things.
Identify the living or once-living things shown here.

Characteristics of Life

Suppose your class took a field trip to a place like the one shown in **Figure 3.** Your teacher asks you to identify living and nonliving things in the environment. Could you complete this assignment? From observations and evidence gathered over time, scientists agree that all living things, or organisms, have common characteristics. Whether made of one cell or many cells, organisms are organized, respond, grow and develop, reproduce, maintain certain internal conditions, and use energy.

Organization

The rooms and things in your home are organized in some way. The oven and refrigerator are in the kitchen, a sink and toilet are in the bathroom, and clothes and shoes are in the closets. Cells and organisms also are organized. Cells contain structures that have specialized functions similar to the way a house has rooms for different activities. Some organisms have a system of nerves controlled by a brain, much like a house has a system of electrical wires controlled by a circuit-breaker box. You will read more about the organization inside individual cells in the next lesson, and about the organization within organisms in Chapter 2.

Academic Vocabulary
process (PRAH sehs)
(noun) a series of natural activities
New cells form by the process of cell division.

Responses

If someone throws a ball at you, you might try to catch it. This is because you are able to respond to changes in your environment. Another example of the way living things respond is the way your body responds to an invasion by a disease-causing virus or bacterium. There are cells in your body that can recognize these invaders and respond with different **processes** to get rid of them.

Reading Check What characteristics are common to all organisms?

Figure 4 The quino checkerspot butterfly, *Euphydryas editha quino,* undergoes many changes as it grows and develops from a caterpillar to an adult.


Caterpillar


Chrysalis


Butterfly

Growth and Development

Humans grow and develop just as all organisms do. When organisms grow, they increase in size. Growth in multicellular organisms—organisms made of many cells—usually happens as the number of cells increases. An organism that is only one cell also grows because the cell increases in size.

Development includes all the changes that occur in an organism. For example, you might now be able to play a musical instrument or some sport that you could not play ten years ago. Some organisms have extraordinary changes over their lifetime, such as the butterfly shown in **Figure 4.**

Reproduction

You read earlier in this lesson that all cells come from preexisting cells. The same is true for organisms. In order for organisms to continue to exist, they must reproduce and create offspring similar to themselves. Not every organism must reproduce. However, for a type of organism to continue to exist, reproduction must occur among some organisms of that type. Some organisms must have a mate to reproduce but others can reproduce without a mate.

Homeostasis

Have you ever noticed that if you drink more water than usual, you have to use the restroom more often? That is because your body is maintaining **homeostasis** (hoh mee oh STAY sus) or trying to keep its internal conditions within certain limits. All organisms have the ability to maintain homeostasis, but the methods and needs vary depending on the organism and its environment. For example, many freshwater fish would not survive if placed in salt water because they would not be able to control the amount of salt in their bodies. A human maintains a body temperature of about 37°C by sweating, shivering, or changing the flow of blood.

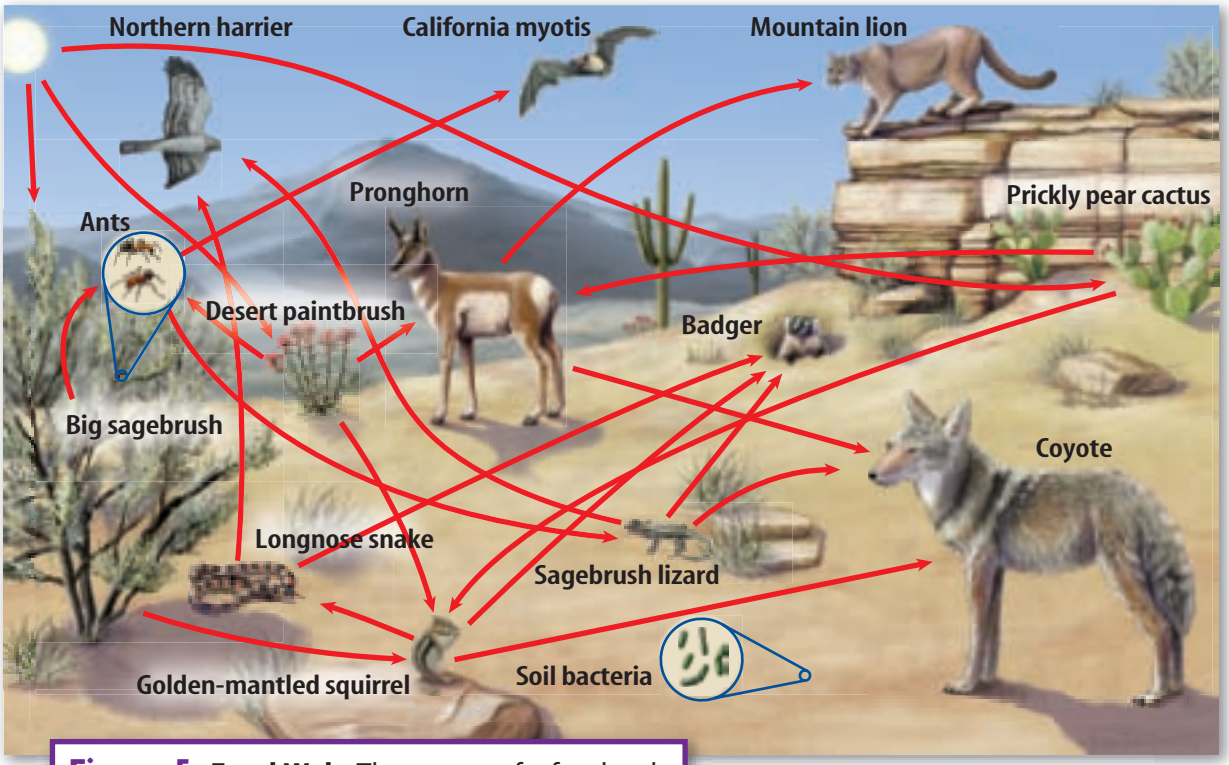


Figure 5 Food Web The arrows of a food web show the transfer of energy in an ecosystem.

Energy

You use energy when you look at the pages of this book, sit at your desk, and when your heart pumps blood throughout your body. Cells continuously use energy to transport substances, make new cells, and perform chemical reactions. Our cells get energy from the food we eat. This energy originally came to Earth from the Sun, as shown in **Figure 5.** The Sun provides energy for nearly all the organisms on Earth. In Lesson 3, you will read about how plants use light energy to make food.

Chemistry of a Cell

When you were younger, you might have played with some kind of building blocks. You probably made many things using different sizes and shapes of blocks. In a similar way, a cell can make different things using atoms and molecules as its building blocks. You might recall from another science class that atoms combine to make molecules. Most of the molecules in living things are made from six kinds of atoms: sulfur, nitrogen, potassium, hydrogen, oxygen, and carbon. The molecules in cells can combine in many ways to make different substances that are used for thousands of different functions.

Reading Check What provides energy for many organisms on Earth?

Science Use v. Common Use

energy

Science Use the capacity of a physical or biological system to do work. *Our cells release energy from the food we eat.*

Common Use an imaginative or lively style. *His writing conveys great energy.*

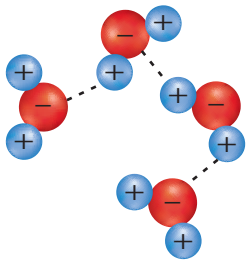
Water—The Main Ingredient

Have you ever wondered what you are made of? About two-thirds of your body's mass is water. Most of that water—67 percent—is inside cells and the rest surrounds cells. The water surrounding cells helps to maintain homeostasis because it helps to insulate your body. Water also can dissolve many different kinds of molecules. This enables your blood, which is mostly water, to transport substances throughout your body.

A unique property of water is that each water molecule has an area that is more negative—called the negative end—than the other area—called the positive end. As shown in **Figure 6,** the negative end of a water molecule is attracted to the positive end of another water molecule, similar to the way magnets are attracted to each other. This attraction is one reason why water can travel from the ground to leaves at the top of trees.

Figure 6 The attraction among water molecules is shown here.

Infer how water molecules are able to move from the ground to the top of a tree.



Water Molecules

Basic Substances

Besides water, cells contain substances that can be classified as proteins, nucleic acids, lipids, or carbohydrates. They also are called macromolecules. The prefix *macro-* means *large.* Macromolecules are large complex molecules usually made of long chains of smaller molecules.

Proteins The molecules necessary for nearly everything cells and organisms do are proteins, such as the examples listed in **Table 1.** There are thousands of different proteins. **Proteins** are folded chains or groups of folded chains of molecules called amino acids. Each protein has a specific sequence of amino acids within its chains. They must be folded correctly for the protein to function properly. Proteins have many functions in organisms and some proteins have the same function in different species of organisms.

Word Origin

protein
from Greek *proteios;* means *the first quality*

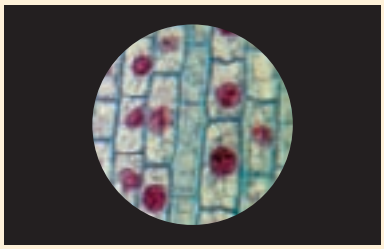
Table 1 Types of Proteins

Name	Function
Keratin (KEH rih tihn)	Provides structural support for hair, horns, and feathers
Hemoglobin (HEE muh gloh bun)	Transports oxygen in the blood of animals with backbones
Casein (KAY seen)	Found in milk; a source of amino acids, phosphorus, and calcium when digested
Insulin (IHN suh lun)	Regulates the amount of sugar in the blood of animals with backbones
Amylase (AM uh lays)	Found in saliva; speeds up the breakdown of starch molecules

DataLab

00:20 minutes

How can you observe DNA in a cell?



Stained LM Magnification: 400×

You have read that DNA is one of the basic substances of cells. In this lab, you will observe and estimate the number of onion root-tip cells with visible DNA. You will collect data similar to the way that scientists do.

Data Collection

1. Complete a lab safety form.
2. Obtain a microscope and slides from your teacher. Use care and properly handle your microscope.
3. Observe the onion root-tip cells at the magnification assigned by your teacher.
4. Determine the approximate number of cells in your field of view and the number of cells with visible DNA.

Data Analysis

1. **Using** your data, find the percentage of cells with visible DNA.
2. **Compare** your results with the results of other students. Are all the results the same? Explain.
3. **Create** a data table for the entire class that lists individual results.
4. **Calculate** the percentage of cells with visible DNA at each magnification.
5. **Explain** why viewing the cells at different magnifications changed the percentage of cells with visible DNA.

1.a, 7.a, 7.c

Nucleic Acids Proteins are important to all cells but they cannot be made without nucleic (noo KLEE ihk) acids. **Nucleic acids** are long chains of molecules called nucleotides. One kind of nucleic acid is deoxyribonucleic (dee AHK sih ri boh noo klee ihk) acid (DNA). It consists of only four types of nucleotides, but there are billions of them in DNA. The arrangement of nucleotides in a cell's DNA is a code that contains the cell's genetic information, or genome. The genetic information in DNA is used to make another kind of nucleic acid—ribonucleic (ri boh noo KLEE ihk) acid (RNA). It is RNA that is used to make proteins. You will read more about DNA in Lesson 2 of this chapter and in other chapters of this book.

Reading Check What is required to make proteins?

Lipids Have you ever tried to mix oil and water? You might have noticed that they do not mix with each other. This is because oil is a lipid. A **lipid** is a large molecule that does not dissolve in water. The main kinds of lipids are fats, phospholipids (fahs foh LIH pids), steroids, and waxes. Fat molecules store large amounts of chemical energy. Phospholipids, and cholesterol, a steroid, are important parts of cells. Waxes help reduce water loss and can form a barrier to invaders like the wax in our ears does.

Carbohydrates Fruits and candy contain different kinds of sugar. Breads and pasta are mostly starch. Vegetables have large amounts of fiber made of cellulose. The shell of a lobster is mostly made of a substance called chitin. What do sugar, starch, cellulose, and chitin have in common? They are all carbohydrates. A **carbohydrate** stores energy and is made of one sugar molecule, a pair of sugar molecules, or a chain of sugar molecules. The energy in sugars and starches can be released quickly through chemical reactions in cells. Most cells cannot release the energy in cellulose and chitin. Carbohydrates make up the structural parts of cells.

What have you learned about cells and life?

You have read in this lesson that

- a light microscope is needed to see most cells;
- a cell is the smallest unit of a living organism;
- the cell theory was developed after many observations by scientists;
- for something to be a living thing, it must have all the characteristics of life;
- all living things depend on water for their survival; and
- cells contain four basic substances—proteins, nucleic acids, lipids, and carbohydrates.

LESSON 1 Review

Summarize

Create your own lesson summary as you organize an **outline.**

1. **Scan** the lesson. Find and list the first **red** main heading.
2. **Review** the text after the heading and list 2–3 details about the heading.
3. **Find** and list each **blue** subheading that follows the **red** main heading.
4. **List** 2–3 details, key terms, and definitions under each **blue** subheading.
5. **Review** additional **red** main headings and their supporting **blue** subheadings. List 2–3 details about each.

ELA7: W 2.5

Standards Check

Using Vocabulary

1. Use the term *homeostasis* in a sentence. 1.a
2. Distinguish between ribonucleic acid and a protein. 1.a

Understanding Main Ideas

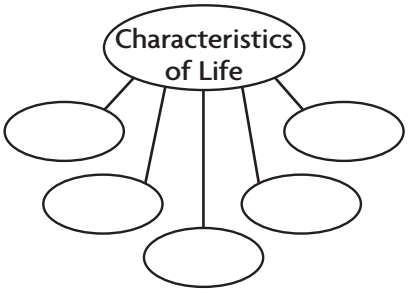
3. Which characteristic of life is shown when you squint in bright light? 1.a

   A. growth and development
   B. reproduction
   C. organization
   D. responses

4. **Assess** the importance of the invention of the microscope to science. 1.a
5. **Summarize** the cell theory in your own words. 1.a
6. **Give an example** for each of the four basic substances of a cell. 1.a
7. **Explain** why water is important to cells. 1.a

Applying Science

8. **Critique** the following statement: A kite is a living thing. 1.a
9. **Organize** Copy and fill in the graphic organizer below. In each of the smaller ovals, list a characteristic of life. 1.a



Science Online

For more practice, visit **Standards Check** at ca7.msscience.com.

LESSON 2

Science Content Standards

1.a Students know cells function similarly in all living organisms.
1.b Students know the characteristics that distinguish plant cells from animal cells, including chloroplasts and cell walls.
1.c Students know the nucleus is the repository for genetic information in plant and animal cells.
2.e Students know DNA (deoxyribonucleic acid) is the genetic material of living organisms and is located in the chromosomes of each cell.
7.d Construct scale models, maps, and appropriately labeled diagrams to communicate scientific knowledge (e.g., motion of Earth's plates and cell structure).

Reading Guide

What *You'll Learn*

- **State** the role of the nucleus in a cell.
- **Compare and contrast** an animal cell and a plant cell.
- **Distinguish** between a prokaryotic cell and a eukaryotic cell.

Why *It's Important*

Learning the functions of the parts of cells will help you understand how they are important in maintaining life.

Vocabulary

cell membrane	cell wall
cytoplasm	cytoskeleton
organelle	nucleus
chromosome	ribosome
mitochondrion	chloroplast
prokaryotic cell	eukaryotic cell

The Cell

Main Idea Cells have structures with specific functions.

Real-World Reading Connection Your body contains different structures that work together to keep you alive and healthy. For example, your skin protects your body, your stomach helps to digest food, and your brain controls your responses. Your cells also have structures that function in each cell.

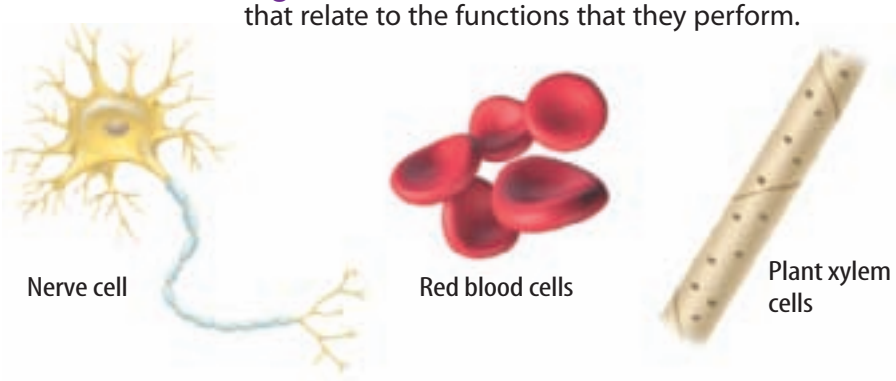
Cell Shape and Movement

Cells in your body have a variety of shapes and sizes, as shown in **Figure 7.** Different shapes relate to different functions. For example, a human red blood cell easily passes into the smallest blood vessels. A nerve cell can send signals over long distances within your body. Other organisms also have cells with shapes that relate to their functions. Some plant cells are hollow and make up tubelike structures that carry water and dissolved substances.

Cell Membrane

Regardless of a cell's shape and function, every cell has a flexible covering that surrounds it called the **cell membrane.** A membrane can be made of one or more layers of linked molecules. The cell membrane protects the inside of a cell from the environment outside the cell. Because of its specific chemical makeup, the cell membrane is selectively permeable. This means the cell membrane does not allow all types of substances into the cell. As shown in **Figure 8,** some things cannot enter a cell and others cannot leave a cell.

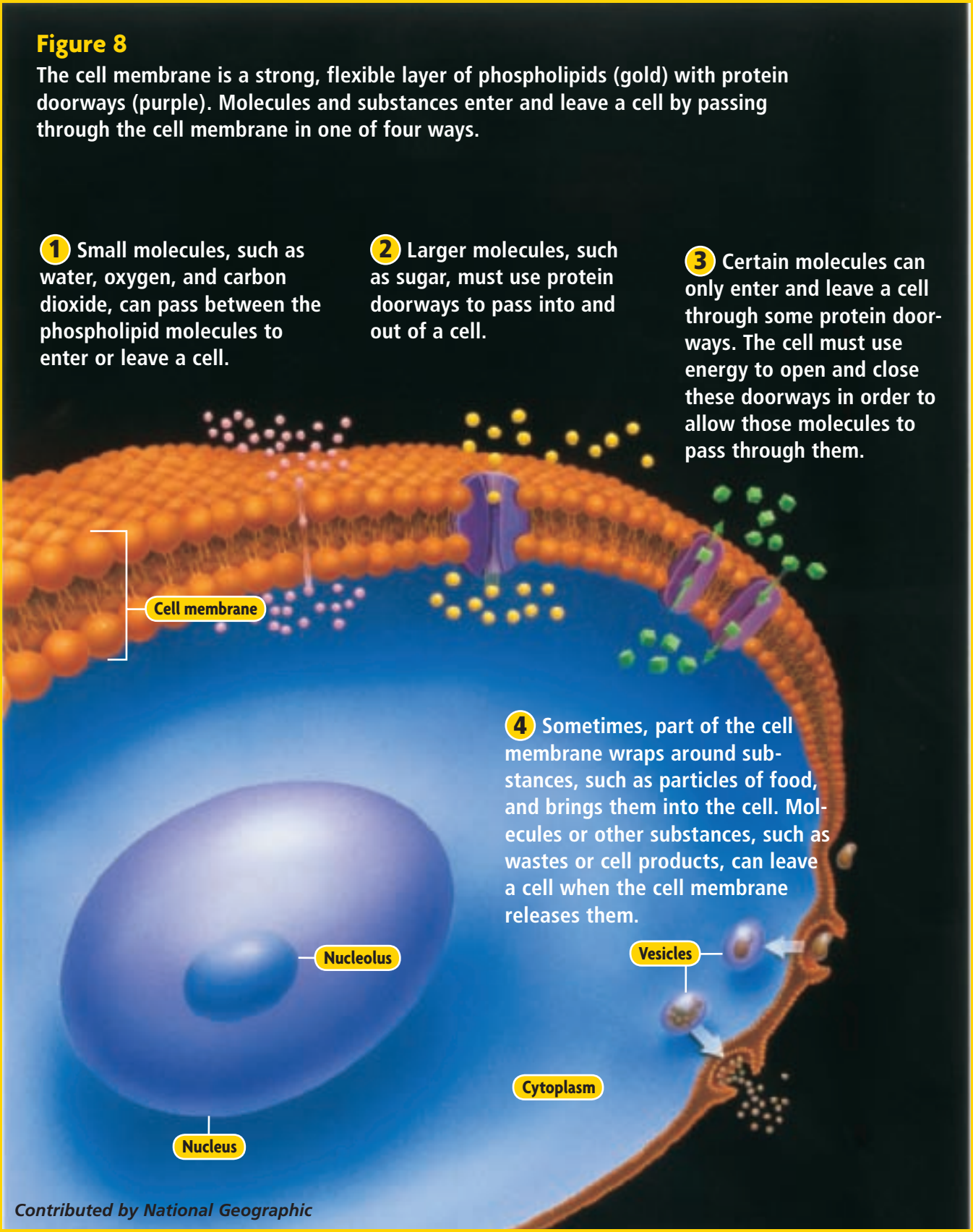
Figure 7 Cell Shape These cells have shapes that relate to the functions that they perform.



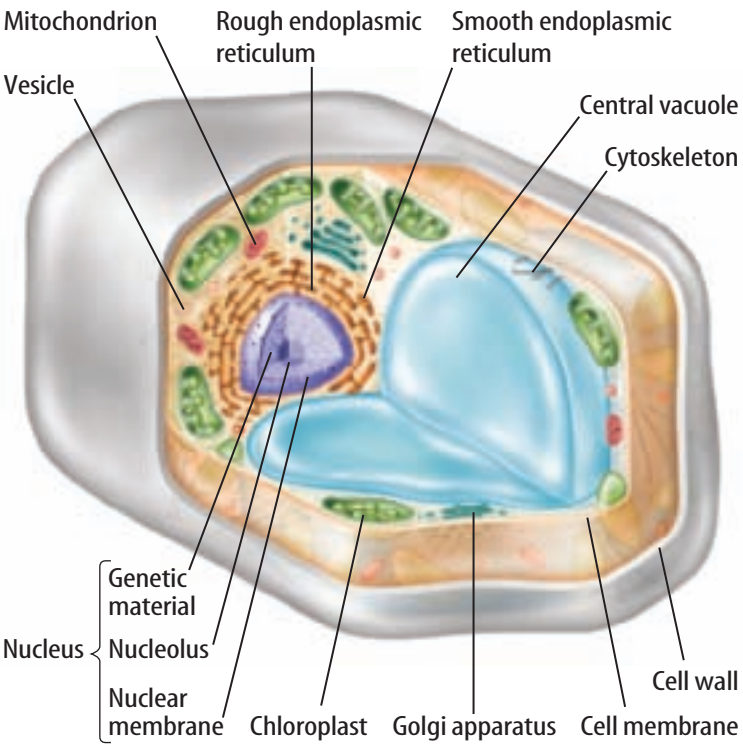
CONTENTS

Visualizing the Cell Membrane

Figure 8
The cell membrane is a strong, flexible layer of phospholipids (gold) with protein doorways (purple). Molecules and substances enter and leave a cell by passing through the cell membrane in one of four ways.



Contributed by National Geographic



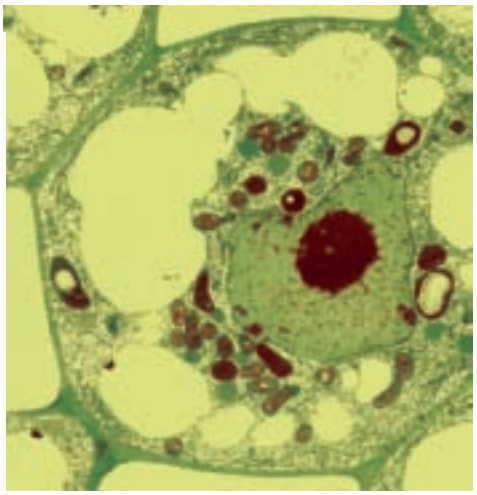


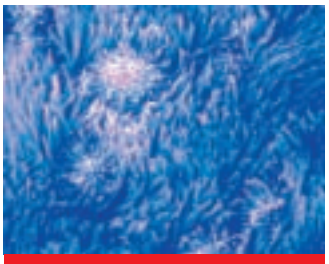
Figure 9 **Plant Cell** The cell wall maintains the shape of a plant cell.

Concepts in Motion
To visualize the parts of a plant cell, visit ca7.msscience.com.

Cell Wall

Some cells, such as those in plants, fungi, and some bacteria, have a rigid **cell wall** that surrounds the cell outside its cell membrane. Plants and fungi can grow upward against the force of gravity because the rigid cell wall maintains the cell's shape, supports, and protects the cell. Substances can pass freely through a cell wall, unlike the cell membrane. Cell walls of plants, as shown in **Figure 9,** are made mostly of cellulose, a carbohydrate. Humans cannot digest cellulose, but cellulose is an important part of our diets. Cellulose stimulates the production of mucus in our intestines, which helps food travel smoothly through them.

Figure 10 A respiratory cell has cilia that help move fluids across the cell's surface.



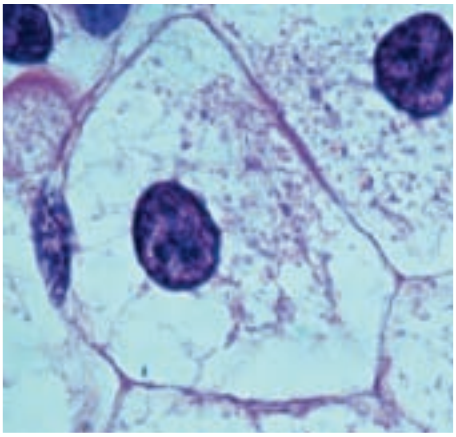
Cilia

Color-enhanced SEM Magnification: 1000×

Cell Appendages

Some animals can run, hop, fly, or swim using appendages such as legs, wings, or fins. Cells can also have appendages. A flagellum (fluh JEH lum) (plural, flagella) is a tail-like appendage. Some single-celled organisms have one or more flagella. Many organisms produce sperm and each sperm moves by using its flagellum.

Cilia (SIH lee uh) (singular, cilium) are short, hairlike appendages. Cilia usually occur in large numbers on a cell, but a cell usually only has one flagellum. Some single-celled organisms move by the coordinated motion of cilia. Cilia also can be on the surface of a cell that does not move, as shown in **Figure 10.** In this case, the cilia help fluids move across the cell's surface.



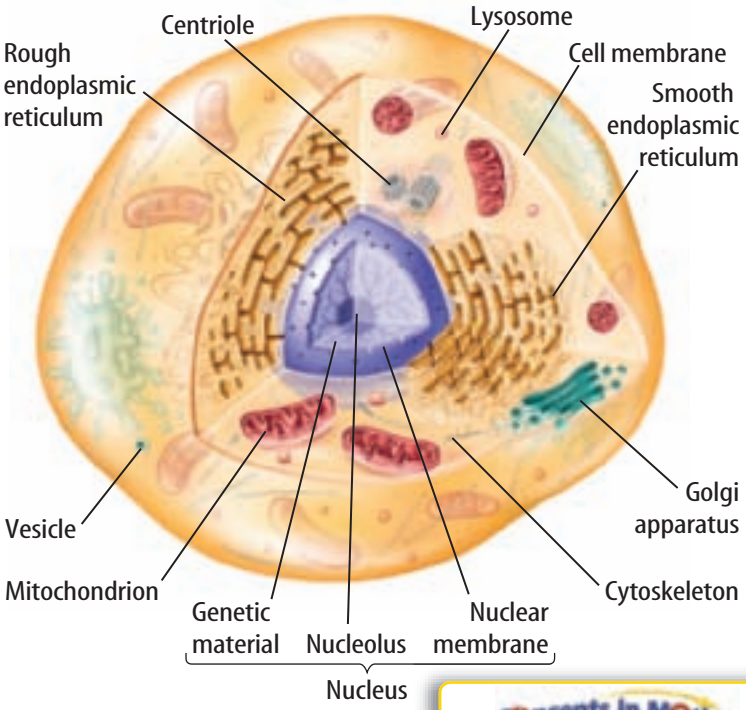


Figure 11 **Animal Cell** Instead of a cell wall, the cytoskeleton maintains the shape of an animal cell.

Find other differences between a plant and an animal cell.

Concepts in Motion

To visualize the parts of an animal cell, visit ca7.msscience.com.

Cytoplasm and the Cytoskeleton

The inside of a cell contains **cytoplasm**—a thick fluid made mostly of water. The structures and substance that are inside a cell, as shown in **Figure 9** and **Figure 11,** are suspended in the cytoplasm.

Your body contains a skeleton and muscles that allow you to move and maintain your shape. Individual cells do not have a skeleton of bones. Instead, cells have a network of fibers called the **cytoskeleton.** The cytoskeleton, shown in **Figure 11,** is like a thick web and plays a role in muscle contraction, cell division, cell movement, and maintenance of cell shape. Both cilia and flagella are able to move because they contain fibers of the cytoskeleton.

Reading Check What is the function of the cytoskeleton?

Word Origin

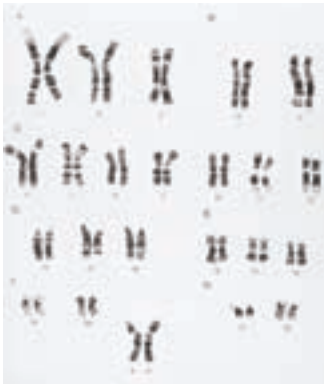
cytoplasm

cyto– from Greek *kytos;* means *a hollow receptacle*

–plasm Greek; means *something molded*

Cell Organelles

What if your school had only one large room? You might be trying to learn about cell organelles, while the teacher standing beside you is conducting the school choir. This would probably make learning nearly impossible. However, your school has classrooms in which different things can occur at the same time without interference. Cells also have many processes going on at the same time. Instead of classrooms, some cells have **organelles**—structures in the cytoplasm that have specific functions. However, the single-celled organisms—commonly called bacteria—do not have these structures.



Human Chromosomes

House Mouse Chromosomes

Figure 12 Each of these photos, called a karyotype, is of chromosomes removed from a nucleus.

Nucleus—The Control Center

A large organelle inside many cells is the **nucleus,** as shown in **Figure 9** and **Figure 11** on the previous two pages. The nucleus (plural, nuclei) contains the genetic material—a chemical code for making all the molecules of a cell. Because of this, the nucleus often is called the control center of the cell. The nucleus is membrane-bound. That means it has a membrane surrounding it. Substances can pass into and out of the nucleus through small holes or pores in the nucleus' membrane. Inside the nucleus is the nucleolus. It helps make structures that make proteins.

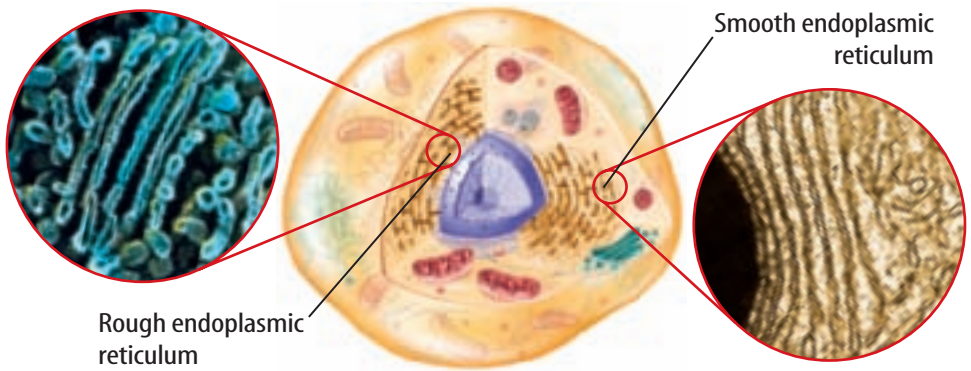
The genetic material in the nucleus is made of long chains of DNA that are coiled into structures called **chromosomes.** Proteins in chromosomes also help the DNA coil. Cells in the same kind of organisms have the same number of chromosomes. For example, humans have 23 pairs of chromosomes in each cell but mice have 20 pairs in each cell, as shown in **Figure 12.**

Manufacturing

A cell makes many kinds of molecules in order to perform different functions. You read in Lesson 1 that proteins are important molecules in cells. Proteins are built within small structures called **ribosomes.** A ribosome is different from other cell organelles because it is not surrounded by a membrane and is found in all cells. For a cell with a nucleus, ribosomes are made in the nucleolus and move into the cytoplasm through the nucleus' membrane. Ribosomes can be attached to an organelle called the endoplasmic reticulum (en duh PLAZ mihk • rih TIHK yuh lum). The endoplasmic reticulum (ER), as shown in **Figure 13,** is a highly-folded membrane that is connected to the nucleus' membrane. ER with ribosomes on its surface is called rough ER. Rough ER is important for making and modifying proteins. ER without ribosomes is called smooth ER. Smooth ER is important for making lipids and helps rid cells of chemicals and poisons.

Figure 13 These electron micrographs show that ribosomes are attached to rough ER but are not attached to smooth ER.

Relate the presence of ribosomes on rough ER to its function.



CONTENTS

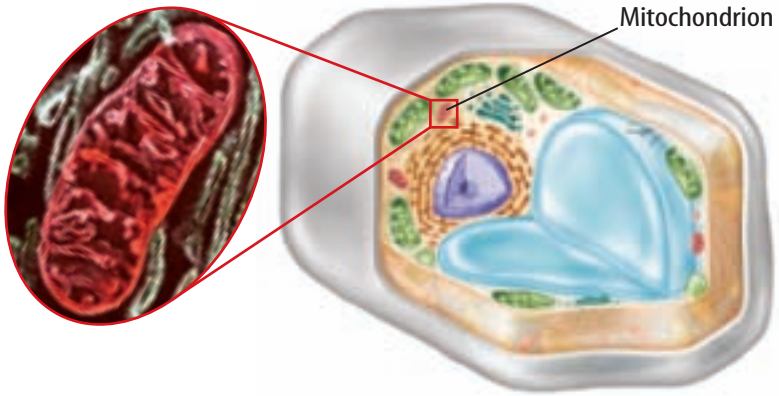


Figure 14 Except for bacteria, all cells have mitochondria. They release the energy used by a cell and an organism.

Energy Processing

Recall that using energy is a characteristic of life. There are two types of organelles that process the energy used by cells.

Chemical processes that release most of the energy used by a cell occur inside membrane-bound organelles called mitochondria. This energy is used for nearly all of a cell's and an organism's functions. A **mitochondrion** (mi tuh KAHN dree uhn) (plural, mitochondria), as shown in **Figure 14,** transforms the unusable energy in food molecules, into a form of usable energy. Mitochondria sometimes are called the power plants of a cell. Cells that require a lot of energy, such as muscle cells, have more mitochondria than cells that require less energy, such as skin cells.

Word Origin
mitochondria
from Greek *mitos* (means *thread*) and *khondrion* (means *little granule*)

Reading Check What kind of cells require more mitochondria?

Some organisms, such as nearly all plants and some single-celled organisms, can make their own food. In plants, this happens in membrane-bound organelles called chloroplasts. A **chloroplast** (KLOR uh plast), as shown in **Figure 15,** uses light energy to make food—a type of sugar—from water and carbon dioxide. Some bacteria can make their own food, but they do not have chloroplasts.

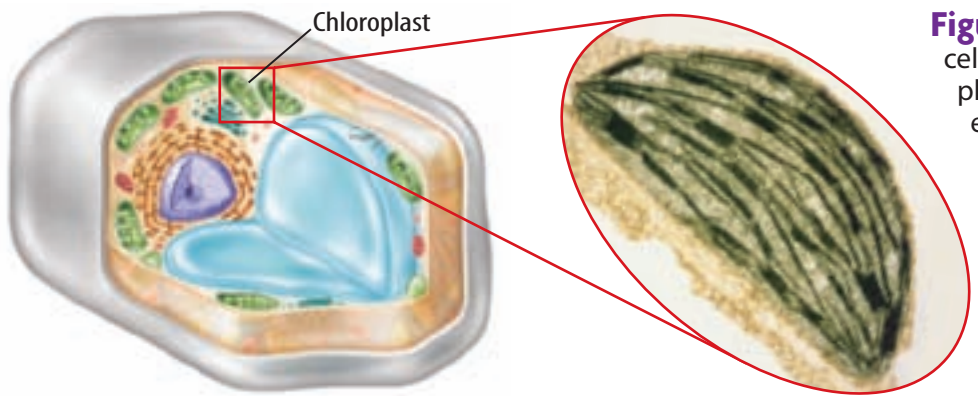


Figure 15 Only plant cells contain chloroplasts. They use light energy to make food.

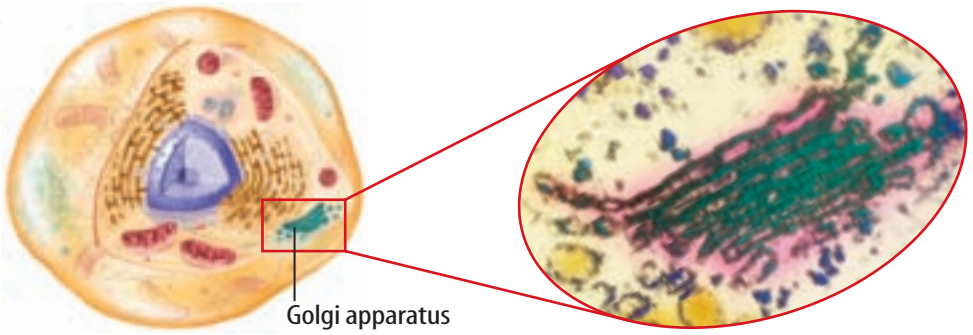


Figure 16 Plant and animal cells contain Golgi apparatuses—flattened stacks of membranes.

ACADEMIC VOCABULARY
modify (MAH deh fi)
(verb) to make minor changes. *The teacher modified her lesson to meet the needs of her students.*

Processing, Transporting, and Storing

The Golgi apparatus, as shown in **Figure 16,** is like a processing factory for the cell. It makes, sorts, and ships molecules. The Golgi apparatus also **modifies,** stores, and directs the movement of molecules made in the ER. Some cells contain large numbers of Golgi apparatuses because the cells secrete substances that are needed by other cells or processes in an organism.

Within the cytoplasm are small, ball-like organelles called vesicles. A vesicle is made of membranes and transports or carries molecules throughout the cytoplasm. They carry substances to the cell membrane where they are released from the cell. Some vesicles form from the Golgi apparatus.

The storage organelles of a cell are vacuoles. Small vacuoles can contain food molecules, water, or waste products from the cell. An animal cell contains a special vacuole called the lysosome that stores digestive enzymes. A plant cell, like the one shown in **Figure 17,** has a large vacuole called the central vacuole. It stores water and other molecules important for a plant cell. The central vacuole enlarges when water enters a plant cell and shrinks when water leaves.

As you have just read, cells are organized and have specialized structures for different functions. Some cell structures are common to all cells, but other structures are found only in certain cell types, as shown in **Table 2** on the next page.

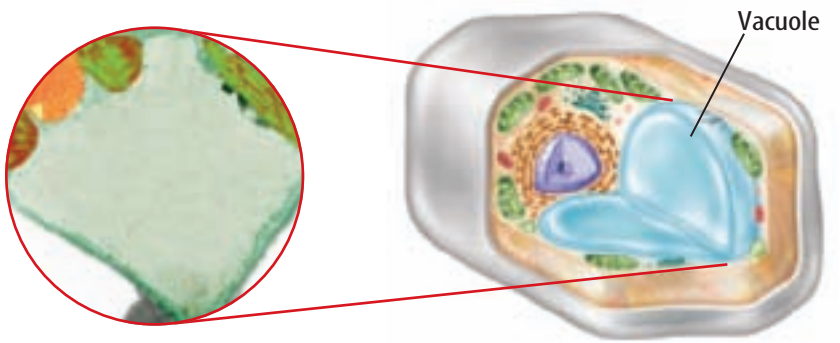
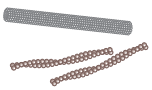


Figure 17 Vacuoles are found in plant and animal cells and are used for the temporary storage of materials. The central vacuole is usually the largest organelle in a plant cell.

Concepts in Motion

Interactive Table To organize information about cell structures, visit Tables at ca7.msscience.com.

Table 2 Cell Structure

Cell Structure	Example	Function	Cell Type
Cell membrane		regulates movement of substances into and out of a cell	all cells
Cell wall		provides shape, protection, and support	plants, fungi, and some bacteria
Flagellum		movement	some single-celled organisms and some sperm
Cilium		movement	some single-celled organisms and some animal cells
Cytoskeleton		cell shape and movement	all cells
Nucleus		controls cell functions	most cells except bacterial cells
Ribosome		site of protein production	all cells
Endoplasmic reticulum		• smooth—makes lipids and gets rid of chemicals and poisons • rough—makes and modifies proteins	most cells except bacterial cells
Mitochondrion		releases energy	most cells except bacterial cells
Chloroplast		makes food	most plant cells
Golgi apparatus		modifies, stores, and directs the movement of molecules made by ER	most cells except bacterial cells
Vesicle		transports substances	most cells except bacterial cells
Lysosome		stores digestive enzymes	most cells except plant and bacterial cells
Central vacuole		stores water and plant substances	plant cells

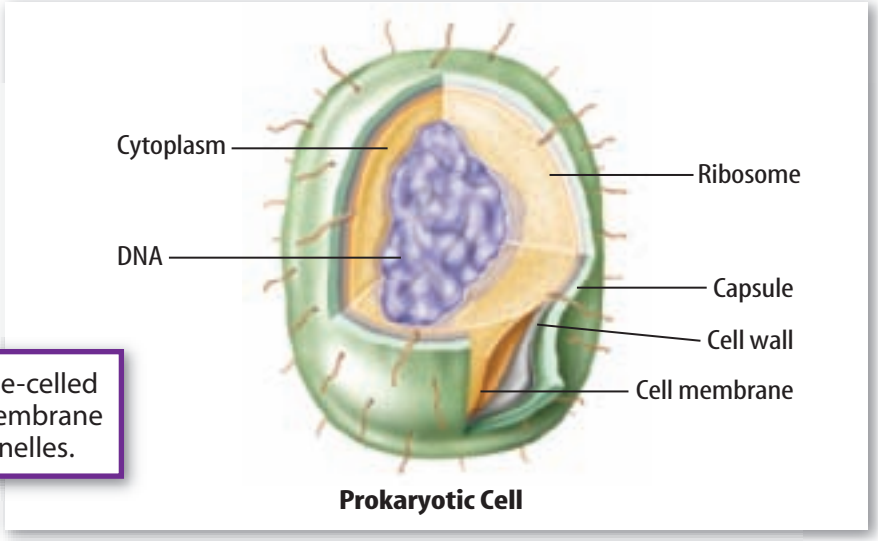


Figure 18 This single-celled organism has a cell membrane and DNA, but no organelles.

Cell Types

You have read that not all cells have organelles. Scientists use this and other facts about cells to classify cells. A cell without a nucleus and most other organelles is classified as a **prokaryotic** (proh kayr ee AH tihk) **cell.** A cell with a nucleus and other organelles is classified as a **eukaryotic** (yew kayr ee AH tik) **cell.**

Prokaryotic Cells

The first living things to inhabit Earth probably were prokaryotic cells. Evidence indicates that they were the only forms of life on Earth for billions of years. Like all cells, a prokaryotic cell has a cell membrane and DNA, as shown in **Figure 18.** Instead of pairs of chromosomes, a prokaryotic cell has a loop of DNA. Prokaryotic cells exist only as single-celled organisms. An organism that is one prokaryotic cell is called a prokaryote (proh KAYR ee oht). Many prokaryotes have cell walls and flagella.

Prokaryotes also are known as bacteria. Some bacteria harm humans, such as *Salmonella* (sal muh NEH la) bacteria that cause food poisoning. Other bacteria are beneficial to humans. Many antibiotics are produced using *Streptomyces* (strep tuh MI seez) bacteria. *Escherichia* (esch uh RIH kee uh) bacteria live in our intestines and protect us from infections caused by other harmful bacteria. They also help us digest food and absorb some nutrients.

Some bacteria in the environment are essential for decomposing dead organisms and recycling nutrients. Other bacteria can survive in extreme environmental conditions, such as extreme hot or cold temperatures or extreme salty conditions. For example, some bacteria, such as the type shown in **Figure 19,** can survive in temperatures up to 85°C (185°F).

Reading Check How are bacteria beneficial to humans?

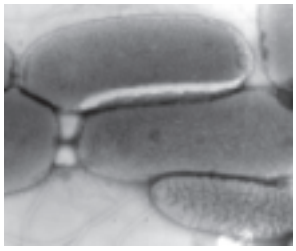


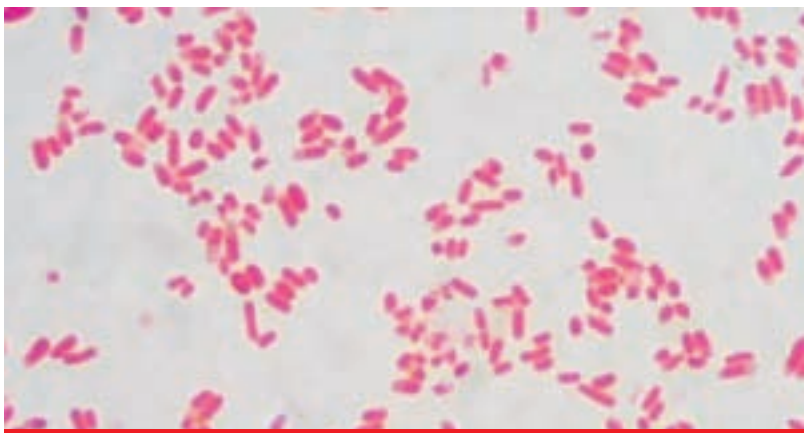
Figure 19 *Thermus thermophilus* (THERM us • ther moh FIH lus) bacteria have been discovered near hydrothermal vents and in some hot springs.

Eukaryotic Cells

The plant and animal cells on pages 18 and 19 are examples of eukaryotic cells. Besides differences in their structures and components, eukaryotic cells are larger than prokaryotic cells, as shown in **Figure 20.** Protists, fungi, plants, and animals all are made of one or more eukaryotic cells so they are called eukaryotes (yew KAYR ee ohts). Many scientists suggest that the eukaryotic cell evolved as a result of one prokaryotic cell becoming part of another prokaryotic cell. Because mitochondria and chloroplasts contain their own DNA, scientists suggest that they might have been prokaryotic cells that became part of another prokaryotic cell. Over time, the mitochondrion and chloroplast lost the ability to exist on their own.

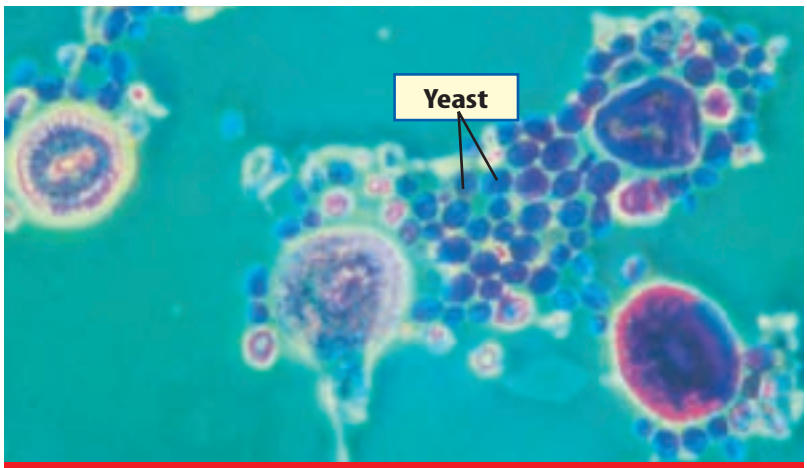
Visual Check **Figure 20** Why do the yeast cells and *E. coli* appear similar in size when *E. coli* are really smaller?

Figure 20 **Size Comparison** Eukaryotic cells are much larger than prokaryotic cells.



Prokaryotic Cells, *E. coli*

Stained LM Magnification: 2000×



Eukaryotic Cells, Yeast

Stained LM Magnification: 250×

MiniLab

00:15 minutes

How can you model a cell?

Procedure

1. Complete a lab safety form.
2. Build the cell type that your teacher assigns your lab group, using available **materials.**
3. Briefly present your group's model to your class.

Analysis

1. **Explain** how you decided what to include in your cell model.
2. **Compare and contrast** this model and your drawings from the Launch Lab.
3. **Justify** structures you included in your cell model.

1.b, 7.d

Word Origin

eukaryotic
from Greek *eu–* (means *well*) and *karyon* (means *nut, kernel*)

What have you learned about the cell?

The parts of a cell have functions that ensure the survival of the cell. The cell membrane controls what enters and exits a cell. The cell wall and cytoskeleton determine the shape of a cell. Most cell organelles are membrane-bound. Chromosomes in a cell's nucleus contain genetic information.

Two cell types are prokaryotic and eukaryotic. Prokaryotic cells do not contain any membrane-bound organelles. Prokaryotic cells live in a wide range of environments and have various roles. Eukaryotic cells have a nucleus and other membrane-bound organelles. Eukaryotic cells have different roles in organisms.

LESSON 2 Review

Summarize

Create your own lesson summary as you write a **newsletter.**

1. **Write** this lesson title, number, and page numbers at the top of a sheet of paper.
2. **Review** the text after the **red** main headings and write one sentence about each. These will be the headlines of your newsletter.
3. **Review** the text and write 2–3 sentences about each **blue** subheading. These sentences should tell *who, what, when, where,* or *why* information about each headline.
4. **Illustrate** your newsletter with diagrams of important structures and processes next to each headline.

ELA7: W 2.5

Standards Check

Using Vocabulary

1. Distinguish between a cell membrane and a cell wall. 1.b
2. Use the term *chromosome* in a sentence.

Understanding Main Ideas

3. Which organelle builds proteins? 1.a
   - **A.** mitochondrion
   - **B.** ribosome
   - **C.** chloroplast
   - **D.** Golgi apparatus
4. **Evaluate** why each of these organelles is necessary for an animal cell: nucleus, mitochondria, endoplasmic reticulum, Golgi apparatus. 1.c, 1.d
5. **Explain** the role of the cytoskeleton. 1.a
6. **Construct** a concept map using the following terms: *cells, circular DNA, eukaryotic, nucleus, membrane-bound organelles, prokaryotic.* 2.e

Applying Science

7. **Form a hypothesis** about why organelles are surrounded by membranes. 1.a
8. **Classify** You use a microscope and observe a cell with a nucleus and a cell wall. How would you classify it? Defend your answer. 1.b
9. **Compare** Copy and fill in the graphic organizer below to compare the structures a plant cell to the structures of an animal cell. 1.b

Structure	Plant Cell (yes or no)	Animal Cell (yes or no)

Science Online

For more practice, visit **Standards Check** at ca7.msscience.com.

Applying Math

Cell Volume and Surface Area

1.g, 7.g

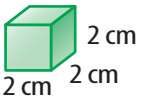
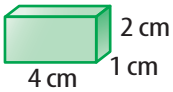
MA7: MG 3.6

The cell membrane controls the type and quantity of substances that enter and leave a cell. As a cell grows, the surface area of its cell membrane and the volume inside the cell increase. When the surface area of a cell's membrane cannot process enough of the substances required by the cell's volume, the cell stops growing. If two cells have the same volume, the cell with the larger surface area can grow larger.

Example

Find the surface areas and volumes of the two solids shown in the table. Which "cell" can grow larger?

1 ***Find the volume of each solid.***

	Solid 1	Solid 2
		
What you know:	$l = 2$ cm, $w = 2$ cm, $h = 2$ cm	$l = 4$ cm, $w = 1$ cm, $h = 2$ cm
What you need to find:	Volume, V	V
Use this equation:	$V_1 = lwh$	$V_2 = lwh$
Substitute:	$V_1 = 2 \times 2 \times 2$ *or* **8 cm³**	$V_2 = 4 \times 1 \times 2$ *or* **8 cm³**
Answer: Both solids have the same volume.		

2 ***Compare the surface areas of the solids.***

	Solid 1	Solid 2
What you need to find:	Surface area, SA	SA
Use this formula:	$SA_1 = 2lw + 2wh + 2lh$	$SA_2 = 2lw + 2wh + 2lh$
Substitute:	$SA_1 = (2 \times 2 \times 2) + (2 \times 2 \times 2) + (2 \times 2 \times 2)$ *or* **24 cm²**	$SA_2 = (2 \times 4 \times 1) + (2 \times 1 \times 2) + (2 \times 4 \times 2)$ *or* **28 cm²**
Answer: *Solid 1* and *Solid 2* have the same volumes but *Solid 2* has a greater surface area than *Solid 1*. Therefore, *Solid 2* can grow larger.		

Practice Problems

1. What is the volume of a solid with a length of 3 cm, a width of 2 cm, and a height of 4 cm?
2. What is this solid's surface area?

Science Online
For more math practice, visit Math Practice at ca7.msscience.com.

LESSON 3

Science Content Standards

1.d Students know that mitochondria liberate energy for the work that cells do and that chloroplasts capture sunlight energy for photosynthesis.
Also covers: 7.a, 7.c, 7.d, 7.e

Reading Guide

What *You'll Learn*

- **Compare and contrast** cellular respiration and photosynthesis.
- **Describe** the basic chemical reaction of photosynthesis.
- **Explain** the importance of pigments in photosynthesis.
- **Relate** photosynthesis to cellular respiration.

Why *It's Important*

All organisms must transform and use energy in order to survive.

Vocabulary

cellular respiration
ATP
glycolysis
fermentation
photosynthesis

Review Vocabulary

energy: the capacity to do work (Grade 6)

Cells and Energy

Main Idea All cells can release energy from food molecules. Only some cells can make food molecules using light energy.

Real-World Reading Connection When gasoline burns in a car engine, energy is released. It is transformed in many ways, making the car function as it should. Carbon dioxide, water vapor, and other waste gases from the burning gasoline exit through the exhaust pipe. Mitochondria are like engines in cells. Wastes are also produced when mitochondria release energy from food molecules.

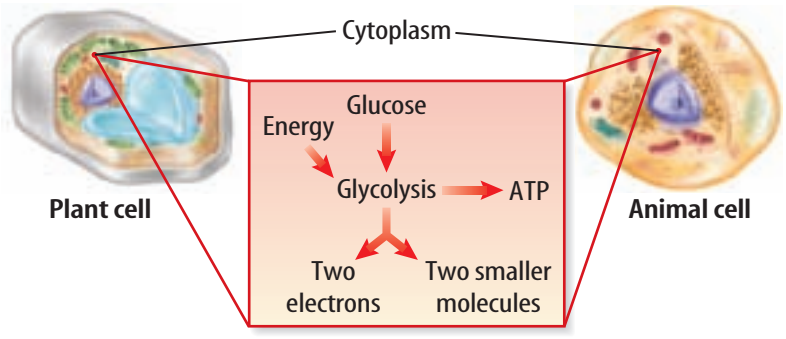
Cellular Respiration

Automobiles cannot use the crude oil that comes out of the ground as fuel. It must be processed and refined into gasoline or diesel fuel. As you read in the previous lesson, the energy stored in the food molecules is not in a form that cells can use. **Cellular respiration** is a series of chemical reactions that transforms the energy in food molecules to usable energy. The usable energy is in molecules of **ATP**—adenosine triphosphate (uh DEN uh seen • tri FAHS fayt).

Reactions in the Cytoplasm

Cellular respiration happens in three steps. The first step is **glycolysis** (gli KAH lih sis) and it happens in a cell's cytoplasm. Glycolysis breaks down a glucose molecule—a type of sugar—into two smaller molecules, as shown in **Figure 21.** The chemical reactions of glycolysis require energy and release electrons that are used in the last step of cellular respiration.

Figure 21 In all cells, glycolysis is the beginning of energy release.



CONTENTS

Concepts in Motion
To see animation of the steps of cellular respiration, visit ca7.msscience.com.

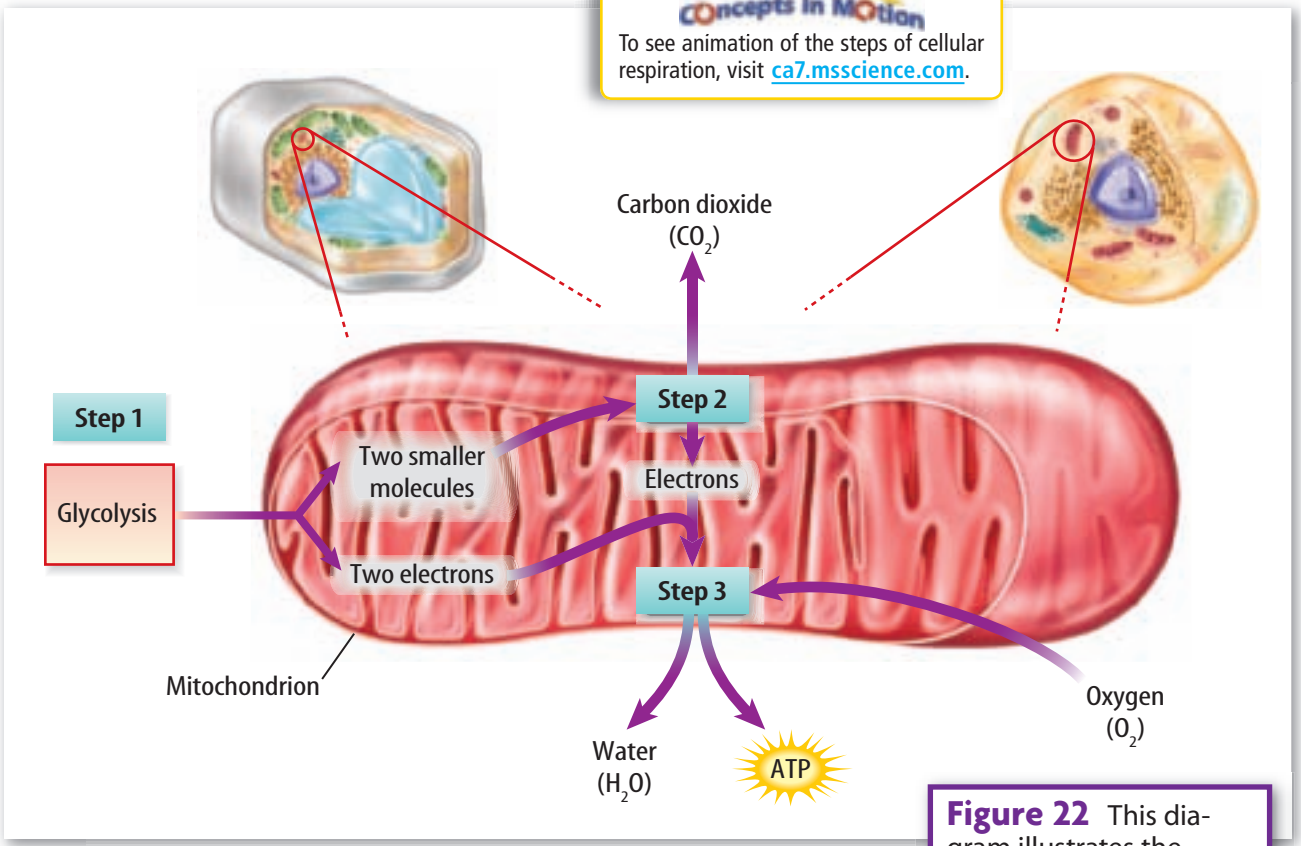


Figure 22 This diagram illustrates the three steps of cellular respiration.

Infer Why can't prokaryotes perform cellular respiration?

Reactions in Mitochondria

The second step of cellular respiration happens in mitochondria and uses the smaller molecules produced by glycolysis. The smaller molecules are broken down into molecules of carbon dioxide—a waste product—and more electrons are released.

The third and final step of cellular respiration requires the presence of oxygen, as shown in **Figure 22.** This step uses the electrons released during the first two steps. It produces large amounts of ATP—usable energy—and water—a waste product.

Fermentation

Some cells can release energy from food molecules using a chemical process called **fermentation.** This process begins and ends in the cytoplasm and does not involve mitochondria or use oxygen. However, all types of fermentation produce fewer molecules of ATP than cellular respiration.

Lactic Acid Fermentation

When our muscles use oxygen faster than our lungs and blood can deliver it to them for cellular respiration, they can release energy by lactic acid fermentation. This process releases energy from glucose and produces lactic acid and carbon dioxide as wastes. Cheese and yogurt are made using fungi and bacteria that perform lactic acid fermentation.

Table 3 Processes that Release Cellular Energy

Process	Oxygen Required	Number of ATP Molecules Available to a Cell	Waste Products
Cellular respiration	Yes	36	Water, carbon dioxide
Lactic acid fermentation	No	2	Lactic acid, carbon dioxide
Alcohol fermentation	No	2	Alcohol, carbon dioxide

ACADEMIC VOCABULARY
evidence (EH vuh duhns)
(noun) an outward sign
His sneezes and watery eyes were evidence of his allergies.

Alcohol Fermentation

Did you know that bread is made by using yeast? Why is yeast necessary? Yeast are single-celled fungi that can perform alcohol fermentation—another kind of fermentation that releases energy, as shown in **Table 3.** This kind of fermentation is similar to lactic acid fermentation except it produces ethanol (a kind of alcohol) instead of lactic acid. Like lactic acid fermentation, alcohol fermentation produces carbon dioxide but fewer ATP molecules than cellular respiration. Now do you know why yeast is needed to make the bread?

Visual Check **Table 3** Which process requires oxygen?

Photosynthesis

You read in Lesson 1 that we get energy from the food that we eat. You also read that some organisms can make their own food using energy from the Sun or other light sources. **Photosynthesis** is a series of chemical reactions that makes food in these organisms.

Light and Pigments

We see things because light reflects off them. Light from the Sun contains all colors: red, orange, yellow, green, blue, indigo, and violet. A rainbow is **evidence** of this. The color of an object is the result of that object reflecting only that color of light. The object absorbs the other colors of light. For example, a red shirt only reflects red light and absorbs all the other colors of light. The same is true for living things. Plants contain substances called pigments that reflect and absorb light. Chloroplasts contain the pigment chlorophyll that reflects green light. When leaves appear green, it is because they contain more chlorophyll than other pigments. Have you ever seen leaves change colors in the fall? This happens because the chlorophyll in leaves breaks down and is not replaced. So, you see colors reflected by the other pigments in leaves, like the yellow pigments in the grape leaves shown in **Figure 23.**

Figure 23 When plants stop producing chlorophyll, the light reflected from other pigments can be seen.

CONTENTS

Concepts in Motion To see animation of the steps of photosynthesis, visit ca7.msscience.com.

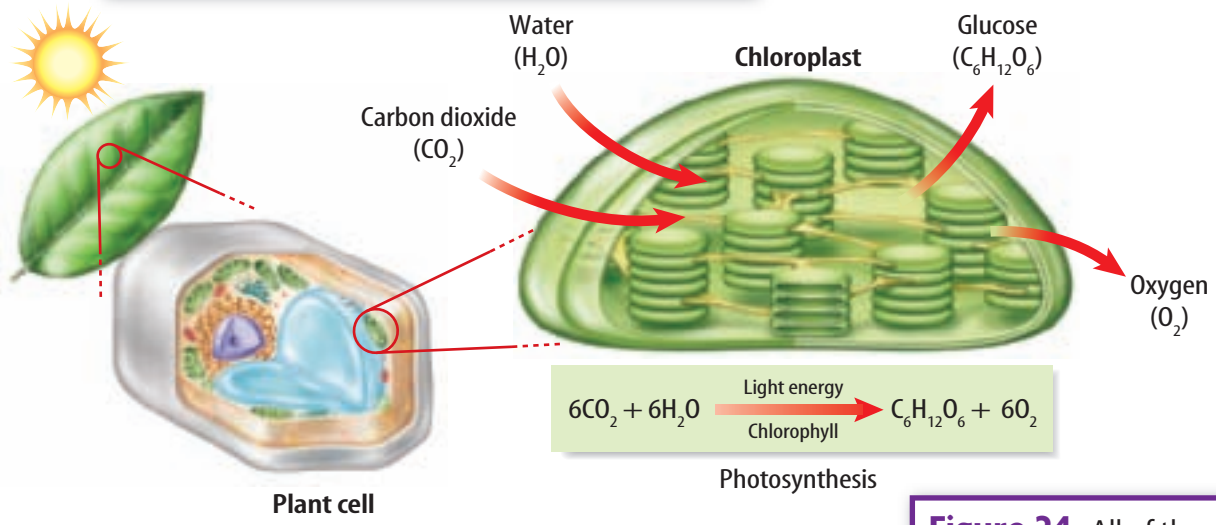


Figure 24 All of the steps of photosynthesis happen in chloroplasts.

Reactions in Chloroplasts

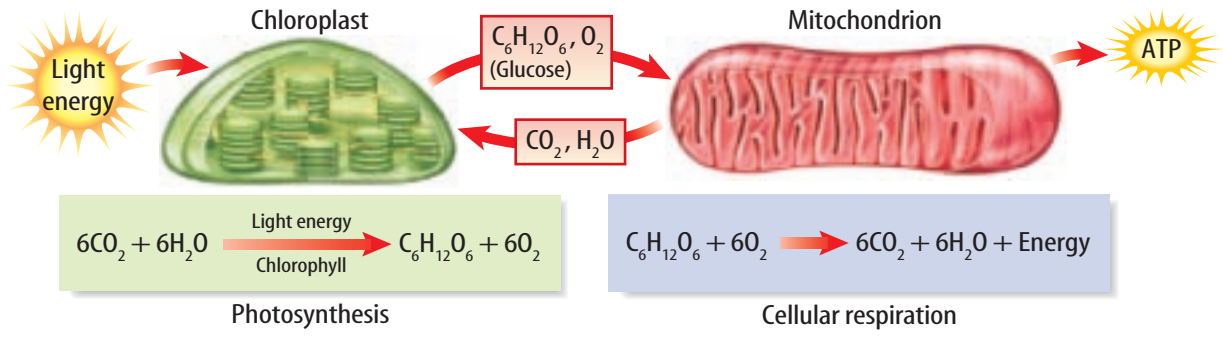
The light energy absorbed by chlorophyll and other pigments powers the chemical reactions of photosynthesis. These reactions occur in chloroplasts. During photosynthesis, light energy, water, and carbon dioxide are used to make sugars. Photosynthesis also produces oxygen that is released into the atmosphere, as shown in **Figure 24.**

Word Origin
photosynthesis
from German *photo* (means *light*) and *synthese* (means *synthesis*)

Importance of Photosynthesis

The fruits and vegetables we eat grow because of photosynthesis. The cells of most organisms, even most bacteria, use sugars made by photosynthesis. Photosynthesis supplies Earth's atmosphere with oxygen, which we must have for our cells to perform cellular respiration. The carbon dioxide produced by organisms from cellular respiration would become toxic if it were not used during photosynthesis. **Figure 25** illustrates the important relationship between cellular respiration and photosynthesis.

Figure 25 Photosynthesis needs the products of cellular respiration and vice versa.



What have you learned about cells and energy?

Cells perform cellular respiration and transform the unusable energy in large food molecules into usable energy in ATP molecules. Lactic acid fermentation and alcohol fermentation produce ATP molecules without the use of oxygen but fewer ATP molecules than cellular respiration. Light energy powers photosynthesis that produces sugars. Organisms that perform photosynthesis contain pigments that absorb light energy. Almost all organisms are dependent on photosynthesis. Cellular respiration and photosynthesis are important to most life on Earth.

LESSON 3 Review

Summarize

Create your own lesson summary as you design a **visual aid.**

1. **Write** the lesson title, number, and page numbers at the top of your poster.
2. **Scan** the lesson to find the **red** main headings. Organize these headings on your poster, leaving space between each.
3. **Design** an information box beneath each **red** heading. In the box, list 2–3 details, key terms, and definitions from each **blue** subheading.
4. **Illustrate** your poster with diagrams of important structures or processes next to each information box.

ELA7: W 2.5

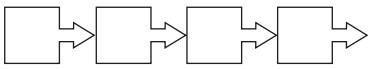
Standards Check

Using Vocabulary

1. Distinguish between cellular respiration and fermentation. 1.d
2. In your own words, write a definition of *glycolysis*. 1.d

Understanding Main Ideas

3. What pigment in plants reflects green light? 1.d
   - **A.** DNA
   - **B.** carbon dioxide
   - **C.** lactic acid
   - **D.** chlorophyll
4. **Relate** photosynthesis and cellular respiration. 1.d
5. **List** the three steps of cellular respiration. 1.d
6. **Give an example** of how fermentation is used in the food industry. 1.d
7. **Sequence** Draw a graphic organizer like the one below to sequence the processes of cellular respiration. Describe each step in each box. 1.d



8. **Summarize** photosynthesis using an equation. 1.d

Applying Science

9. **Predict** what you think would happen if your cells could not perform lactic acid fermentation.
10. **Evaluate** the importance of plants to other organisms and the environment. 1.d
11. **Form a hypothesis** about the differences in the air quality of a busy city and a forest. 1.d

Science Online

For more practice, visit **Standards Check** at ca7.msscience.com.

MiniLab

Try at Home

00:30 minutes

How can you see photosynthesis?

Even using the most powerful microscope, you cannot observe the chemical processes taking place inside a cell. However, it is possible to observe what happens when chemical processes do not occur.

Procedure

1. Read and complete a lab safety form.
2. Obtain a **potted plant** from your teacher.
3. Using **scissors,** cut a piece of **aluminum foil** about the same length and width of a leaf.
4. Fold the foil in half lengthwise and place it around a leaf. The foil should cover about half of the leaf. Use a **paper clip** to hold the foil in place.
5. Place the plant in a sunny location for at least four days.
6. Predict the appearance of the leaf under the foil after the four days. Record your prediction.
7. On the fifth day, remove the foil and observe the leaf. Record your observation.

Analysis

1. **Compare and contrast** your prediction about the leaf and your observation of the leaf.
2. **Infer** whether cellular respiration or photosynthesis was most affected by the presence of foil.
3. **Form a hypothesis** to explain if covering an edible leaf, such as spinach, would affect its taste.

Science Content Standards

1.d Students know that mitochondria liberate energy for the work that cells do and that chloroplasts capture sunlight energy for photosynthesis.

7.c Communicate the logical connection among hypotheses, science concepts, tests conducted, data collected, and conclusions drawn from the scientific evidence.

Lab

Exploring the Unknown

Materials

compound light microscope
prepared slide of an unknown cell

Safety Precautions

Science Content Standards

1.b Students know the characteristics that distinguish plant cells from animal cells, including chloroplasts and cell walls.
7.a Select and use appropriate tools and technology (including calculators, computers, balances, spring scales, microscopes, and binoculars) to perform tests, collect data, and display data.
Also covers: 7.c, 7.d, 7.e

Problem

A cell biologist collected an unknown cell while on an expedition. Using the scientific observation skills you have used in this chapter's labs, determine if the cell is prokaryotic or eukaryotic and the type of organisms that it came from.

Form a Hypothesis

Consider the diversity of life on Earth. Before you observe the cell sample, predict what it will be. What hypothesis would be supported if your prediction is true? What hypothesis would be supported if your prediction is false?

Collect Data and Make Observations

1. Read and complete a lab safety form.
2. Create a data page similar to one below to record your observations.
3. Observe a prepared slide of an unknown cell at low and high magnifications. Sketch your cell at each magnification.
4. Record any special adaptations the cell has that might indicate the cell's function.

Sample Data Page

Sketch of Cell at Low Magnification	Sketch of Cell at High Magnification
Cell Organelles Observed	
Adaptations/Function	
Conclusion	

Analyze and Conclude

1. **Describe** what you observed on your data page. Is the unknown cell similar to something you have seen before? What?
2. **Explain** how the presence or absence of organelles affects your identification. Recall how you made decisions about organelles when you built your model.
3. **Summarize** the information you have about the unknown cell.
4. **Create** a table to compare and contrast the unknown cell with plant and animal cells.
5. **Draw a conclusion** about the unknown cell.

Communicate

WRITING in Science ELA7: W 2.3

Prepare a 500–700-word report to share your conclusion with the class. In the report, detail what observations you made and what types of lab work helped you reach your final conclusion. Use the information on your data page to defend your decision.

Real World Science

Science & Career

From Cells to Organelles

A cell biologist studies the structure of cells and how they function whether alone or within an organism. Some cell biologists might focus on particular organelles, like ribosomes or mitochondria. Others study processes vital to cell function, like cellular respiration, homeostasis, or DNA reproduction.

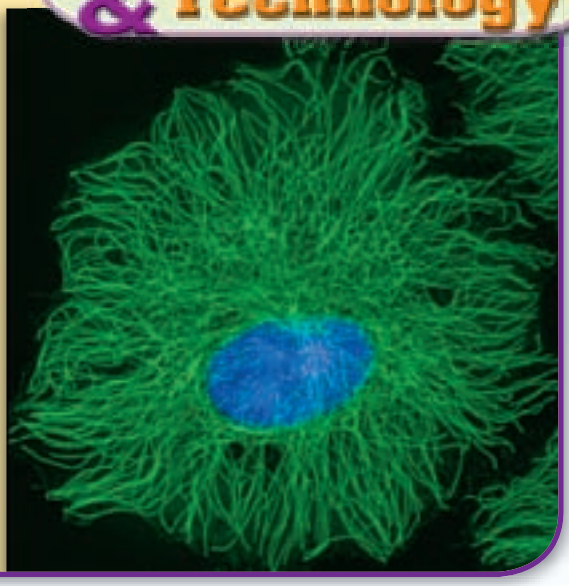
Write a 500–700-word newspaper article describing a recent finding in cell biology. The finding can be real or imagined. Make sure to add quotes and make the story exciting.

ELA7: W 2.1

Science & Technology

Confocal Laser Scanning Microscopy

Confocal laser scanning microscopy has been used since the 1980s. It uses a laser beam to scan a biological specimen that has been treated with substances that give off fluorescent light when exposed to the laser beam. Confocal microscopy can create a high-quality three-dimensional microscopic image by scanning a thick sample in layers.

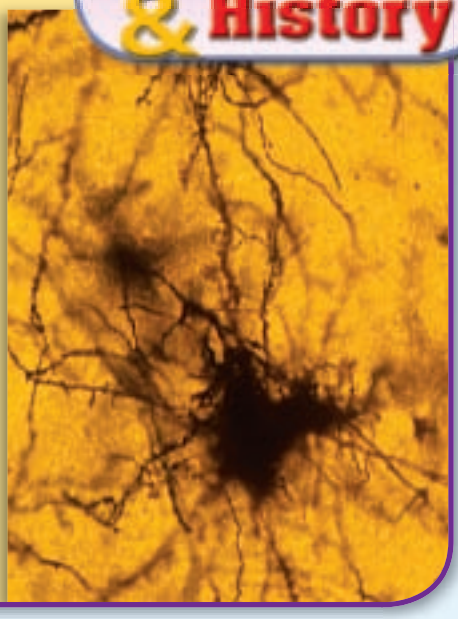


Create a table documenting the different types of microscopes that scientists use today. Include a short description of each microscope, who invented it and when, and its uses.

Science & History

Golgi's "Black Reaction"

Toward the end of the nineteenth century, Italian physician Camillo Golgi invented a method to stain nerve cells and follow their paths through the brain. The stain, which Golgi called the black reaction, uses a chemical substance called silver nitrate to stain cells. Golgi's studies won the Nobel Prize in Physiology or Medicine in 1906.



Golgi won the Nobel Prize with Santiago Ramón y Cajal. Research the project that won Cajal the 1906 Nobel Prize. Prepare and present a mock acceptance speech for the 1906 prize, posing as either Golgi or Cajal.

ELA7: LS 2.1

Science & Society

Putting Organisms to Good Use

Bioreactors provide the proper environmental conditions to support the growth of organisms like bacteria and yeast. For example, the EPA has designed bioreactors to help break down waste in landfills more efficiently. Scientists control air and moisture in a landfill bioreactor to promote bacterial growth and activity, which increase the rate of waste breakdown.

How will bioreactors play a role in the future? Visit Society at ca7.msscience.com to research bioreactor landfills. Write a 500-word essay describing one way bioreactors can help society.

CHAPTER 1

Standards Study Guide

The BIG Idea The structures in cells work together and ensure the survival of the cell.

Lesson 1 Cells and Life

1.a, 7.a, 7.c

Main Idea **Cells are the smallest unit of life.**

- A microscope is needed to see most cells.
- The cell is the smallest unit of a living organism.
- A living thing has all of the characteristics of life.
- Water is essential to all living things.
- Cells contain four basic substances: proteins, nucleic acids, lipids, and carbohydrates.

- **carbohydrate** (p. 54)
- **cell theory** (p. 49)
- **homeostasis** (p. 51)
- **light microscope** (p. 48)
- **lipid** (p. 54)
- **nucleic acid** (p. 54)
- **protein** (p. 53)

Lesson 2 The Cell

1.a, 1.b, 1.c, 2.e, 7.d

Main Idea **Cells have structures with specific functions.**

- The cell membrane controls what enters and exits a cell.
- The cell wall and cytoskeleton determine the shape of a cell.
- The genetic information of a cell is in the chromosomes in the nucleus.
- The organelles of a cell have specialized functions.
- Prokaryotic cells do not contain membrane-bound organelles.
- Prokaryotic cells live in a wide range of environments and have various roles.
- Eukaryotic cells have a nucleus and other membrane-bound organelles.

- **cell membrane** (p. 56)
- **cell wall** (p. 58)
- **chloroplast** (p. 61)
- **chromosome** (p. 60)
- **cytoplasm** (p. 59)
- **cytoskeleton** (p. 59)
- **eukaryotic cell** (p. 64)
- **mitochondrion** (p. 61)
- **nucleus** (p. 60)
- **organelle** (p. 59)
- **prokaryotic cell** (p. 64)
- **ribosome** (p. 60)

Lesson 3 Cells and Energy

1.d, 7.a, 7.c, 7.d, 7.e

Main Idea **All cells can release energy from food molecules. Only some cells can make food molecules using light energy.**

- Cells perform cellular respiration and make usable ATP energy from larger food molecules.
- Lactic acid fermentation and alcohol fermentation produce ATP without the use of oxygen.
- Light energy powers photosynthesis that produce sugars and oxygen.
- Photosynthesis and cellular respiration are related chemical reactions.

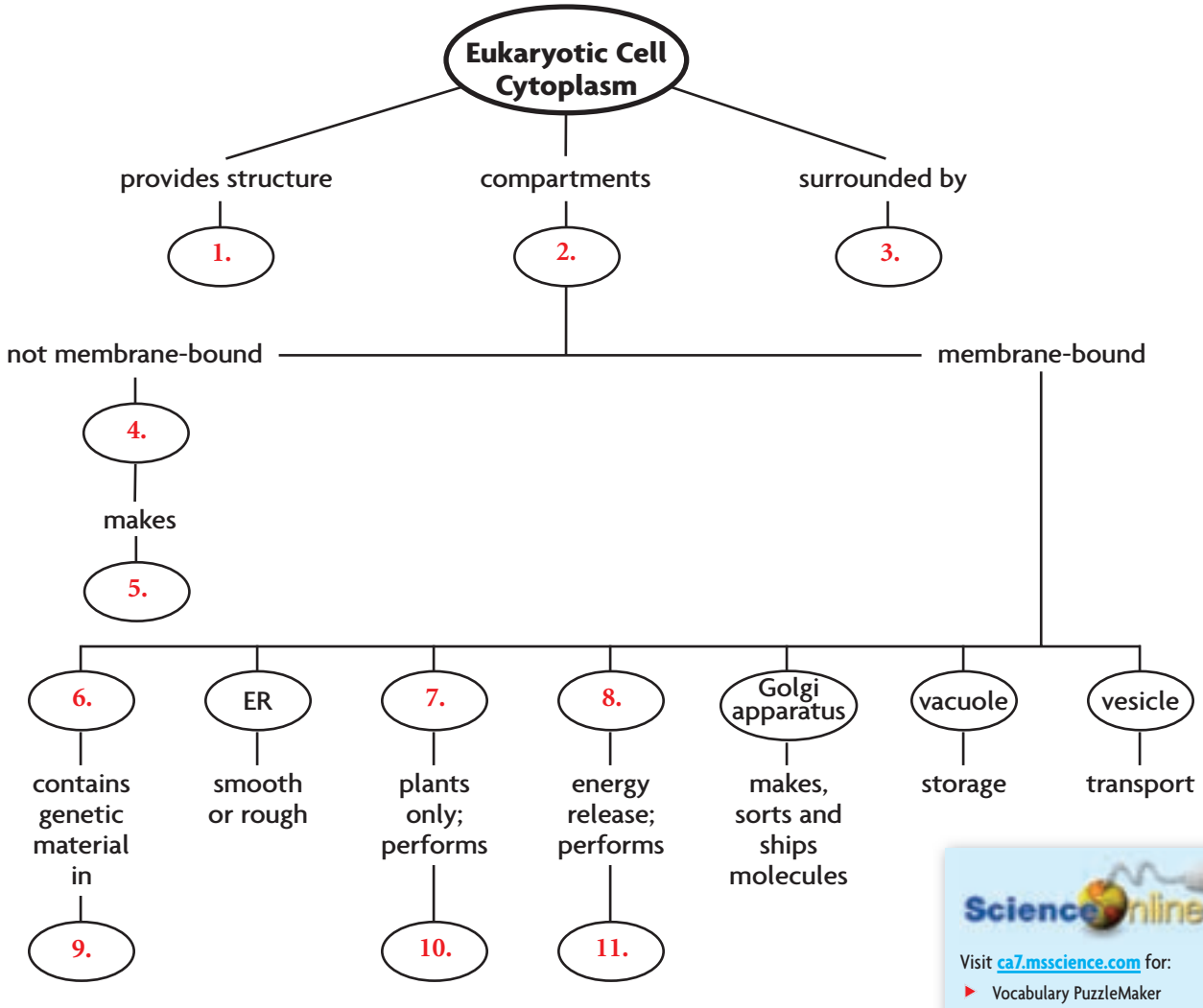
- **ATP** (p. 68)
- **cellular respiration** (p. 68)
- **fermentation** (p. 69)
- **glycolysis** (p. 68)
- **photosynthesis** (p. 70)

STUDY TO GO

Download quizzes, key terms, and flash cards from ca7.msscience.com.

Linking Vocabulary and Main Ideas

Use vocabulary terms from page 78 to complete this concept map.



Using Vocabulary

Fill in the blanks with the correct vocabulary terms. Then read the paragraph to a partner.

A series of chemical reactions called ___12.___ transforms food molecules to usable cellular energy. The usable cellular energy is found in molecules called ___13.___. The first step of cellular respiration is ___14.___, and it happens in a cell's ___15.___. Sometimes, our muscles use oxygen faster than our lungs and blood can deliver it. When this happens, our muscle cells can release energy by using a type of ___16.___. Some organisms can make their own food using energy from the Sun or other light sources by performing ___17.___.

Understanding Main Ideas

Choose the word or phrase that best answers the question.

1. Which is not a characteristic of all living things?
A. growth
B. homeostasis
C. response
D. breathing — 1.a

2. Which would enable you to study the membranes of a chloroplast?
A. a light microscope — 7.a
B. a telescope
C. a hand lens
D. an electron microscope

3. Some cells have structures that enable them to move from one place to another.

What structures enable the cell shown above to move?
A. flagella — 1.a
B. ribosomes
C. cilia
D. vesicles

4. What absorbs the light energy needed for photosynthesis?
A. pigments
B. cell walls
C. mitochondria
D. vacuoles — 1.d

5. Which is produced during photosynthesis?
A. carbon dioxide — 1.d
B. glucose
C. water
D. lactic acid

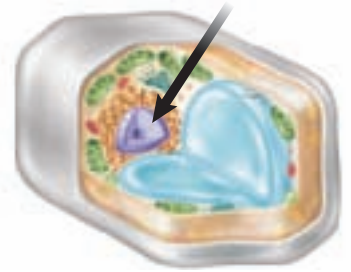
6. Which can be observed only in a plant cell?
A. cell membrane
B. cell wall
C. nucleus
D. ribosome — 1.b

7. What kind of cell would be most likely to live in an extremely hot spring?
A. plant
B. animal
C. eukaryotic
D. prokaryotic — 1.a

8. Where are nucleic acids in a cell?
A. cell membrane — 2.e
B. cytoskeleton
C. vacuole
D. nucleus

9. Which process produces the most ATP?
A. photosynthesis — 1.d
B. cellular respiration
C. lactic acid fermentation
D. alcohol fermentation

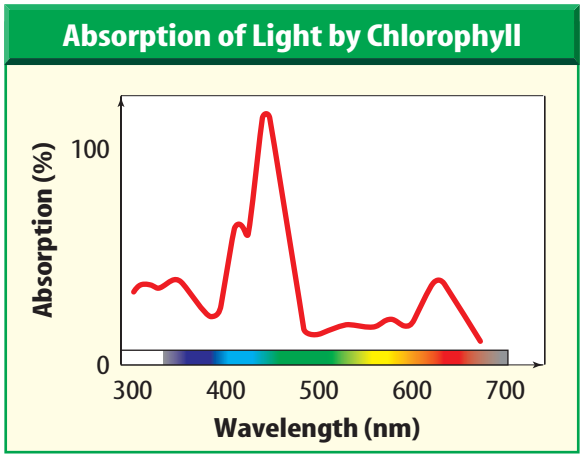
10. Each organelle in a cell has a specific function.



What is the function of the organelle at the end of the arrow?
A. stores genetic information — 1.c
B. makes proteins
C. cell structure and movement
D. releases energy

Applying Science

11. Pigments absorb and reflect different colors of light.



Interpret Use the graph above to explain why chlorophyll appears green. 1.d

12. **Explain** how water helps an organism maintain homeostasis. 1.a

13. **Give an example** of how organisms grow and develop. 1.a

14. **Compare and contrast** a light microscope and an electron microscope. 7.a

15. **Justify** the characteristic of life that you think is the most important for living organisms. 1.a

16. **Distinguish** between a eukaryotic and prokaryotic cell. 1.a

17. **Compare and contrast** a plant cell and an animal cell. 1.b

18. **List** the steps of cellular respiration. 1.d

19. **Compare** lactic acid fermentation and alcohol fermentation. 1.d

20. **Determine** which energy-releasing process would be best if you needed a lot of energy. Explain. 1.d

21. **Hypothesize** why plant cells contain more than one kind of pigment. 1.d

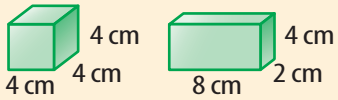
WRITING in Science

22. **Write** a paragraph that analyzes the following statement. "If we eat only meat, then we do not need plants." ELA7: W 2.1

Applying Math

23. The height, width, and length of one solid are 3 cm, 4 cm, and 3 cm and, for another solid, 1 cm, 3 cm, and 12 cm. Find and compare the two volumes. MA7: MG 2.1

Use the illustration below to answer question 24.



24. Find the volume of each solid. MA7: MG 2.1

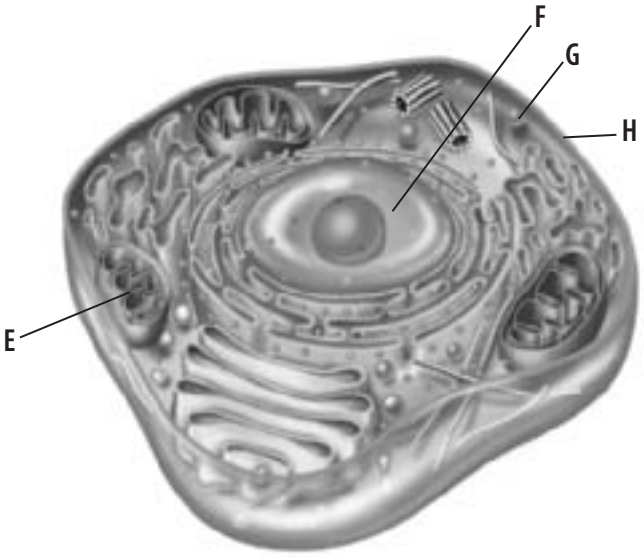
25. Two solids with the same volumes have the dimensions 1 cm × 3 cm × 8 cm and 4 cm × 2 cm × 3 cm. How do their surface areas compare? MA7: MG 2.1

26. What is the surface area of the solid with dimensions 2 cm × 4 cm × 5 cm? MA7: MG 2.1

27. What is the surface area of the solid with dimensions 2 cm × 2 cm × 8 cm? MA7: MG 2.1

Standards Assessment

A typical animal cell is shown below. Use this diagram to answer questions 1 and 2.



1 **Which letter corresponds to the organelle containing DNA?**

A E

B F

C G

D H 2.e

2 **Which letter corresponds to the part of the cell that helps control what enters and leaves the cell?**

A E

B F

C G

D H 1.a

3 **Which describes the function of the central vacuole in plant cells?**

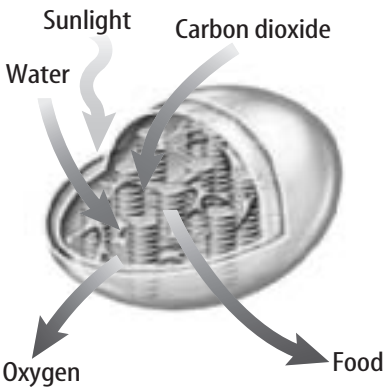
A It helps during reproduction.

B It helps regulate water content.

C It plays a key role in photosynthesis.

D It plays a key role in cellular respiration. 1.b

Use the diagram of the cell organelle to answer questions 4 and 5.



4 **Where might you find this organelle?**

A in a brain cell

B in a hair cell

C in a plant cell

D in a bacterial cell 1.b

5 **What process is taking place in this organelle?**

A cellular respiration

B photosynthesis

C food storage

D fermentation 1.d

6 **You exhale carbon dioxide that is a product of**

A osmosis.

B DNA synthesis.

C photosynthesis.

D cellular respiration. 1.d

7 **Which is needed for cellular respiration?**

A oxygen

B lactic acid

C chlorophyll

D lipids 1.d

8 **Which structure is part of a prokaryotic cell?**

A chloroplast

B Golgi apparatus

C mitochondrion

D ribosome 1.a

9 **The equation below represents photosynthesis.**

$$6CO_2 + 6H_2O + \text{energy} \xrightarrow{\text{chlorophyll}} C_6H_{12}O_6 + 6O_2$$

What energy transformation occurs?

A light energy to chemical energy

B light energy to electrical energy

C light energy to mechanical energy

D light energy to nuclear energy 1.d

10 **Which process releases the most energy?**

A fermentation

B glycolysis

C photosynthesis

D cellular respiration 1.d

The images below show the same organelle. Use these images to answer questions 11 and 12.

11 **What organelle is shown?**

A chloroplast

B mitochondrion

C nucleus

D ribosome 1.d

12 **What is its primary function?**

A capturing light energy

B directing cell processes

C releasing energy

D making proteins 1.d

13 **What do a bacterial cell, a plant cell, and a nerve cell have in common?**

A cell wall and mitochondria

B cytoplasm and ribosomes

C nucleus and cell membrane

D flagella and chloroplasts 1.a