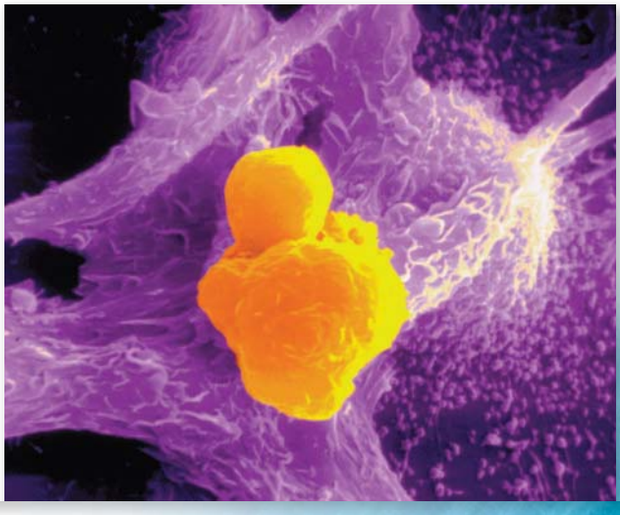
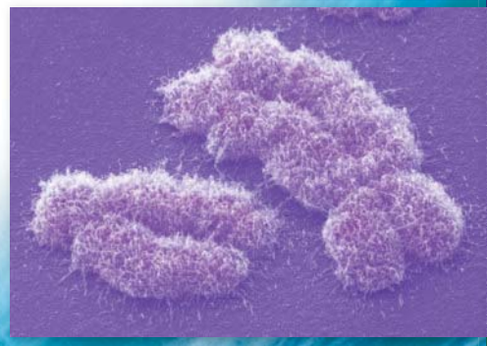
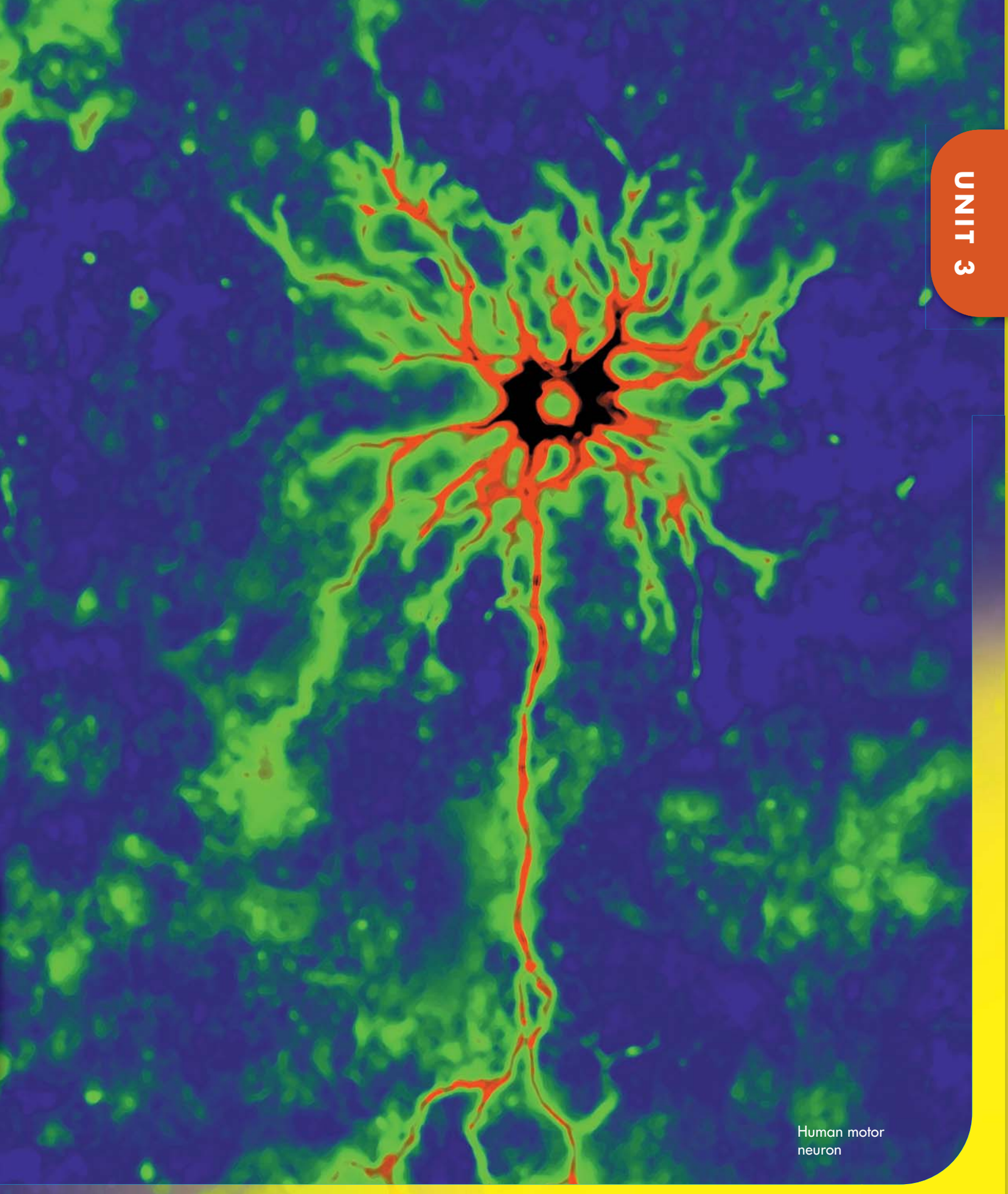
UNIT 3 Cells



Macrophage (purple) attack on a cancer cell (yellow)



Sex chromosomes of a human male: Y (left) and X (right)



Human motor neuron

DISCOVERIES IN SCIENCE

Cell Biology

1665

Robert Hooke builds a microscope to look at tiny objects. He discovers cells after observing a thin piece of cork under a microscope. He also finds cells in plants and fungi.

Hooke's microscope

1772

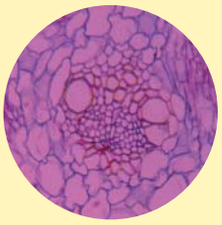
British clergyman and chemist, Joseph Priestly, presents his paper, *On Different Kinds of Air,* in which he describes his discovery of oxygen and other previously-unknown gases found in air. He also demonstrates that oxygen is produced by plants.

1839

Theodor Schwann shows that all animal tissue is made of cells. With plant biologist, Matthias Schleiden, Schwann identifies cell components, such as membranes and a nucleus common, to many eukaryotic cells.

1855

Rudolf Virchow publishes a theory stating that all cells come from another cells. He explains, "Where a cell exists, there must have been a preexisting cell."



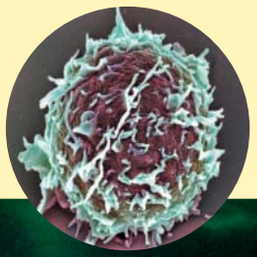
Animal cells

1945

Keith R. Porter, Albert Claude, and Ernest F. Fullam publish the first electromicrograph of a cell. Small organelles, such as the endoplasmic reticulum and the Golgi apparatus, are visible for the first time.

LATE 1950s

Canadian scientists Ernest McCulloch and James Till begin research on stem cells in rodents. Bone marrow stem cells can produce several types of blood cells.



Bone marrow stem cell

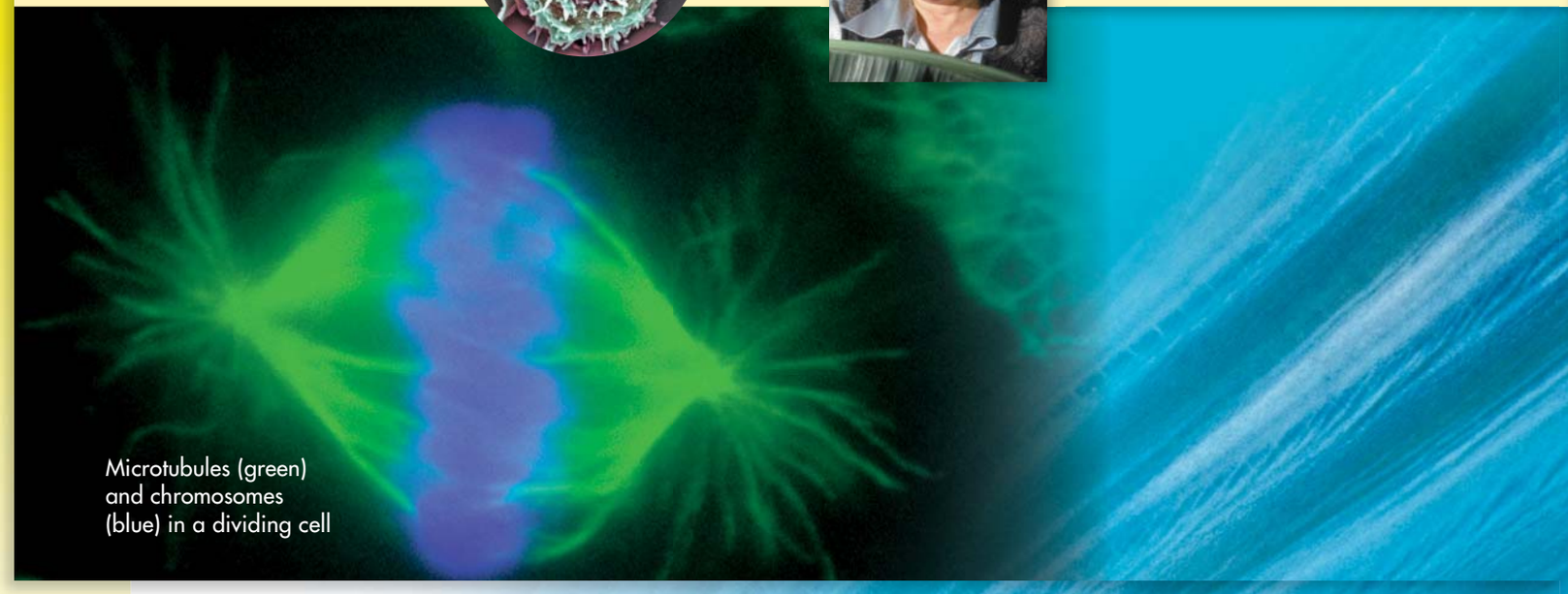
1971

Lynn Margulis proposes the endosymbiotic theory of the origins of cell organelles. This theory states that chloroplasts and mitochondria in eukaryotes evolved from prokaryotes.

Lynn Margulis

2004

Richard Axel, and Linda Buck earn the Noble Prize in Medicine or Physiology for their discovery of how olfactory cells detect odors and how the brain processes information to provide a sense of smell.



Microtubules (green) and chromosomes (blue) in a dividing cell

BIOLOGY CAREER

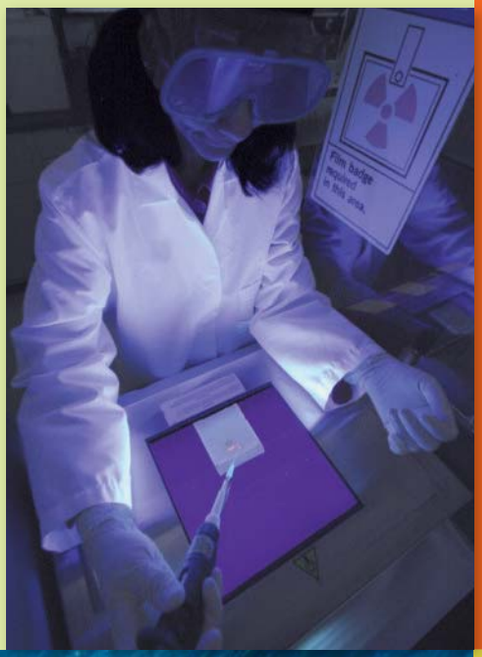
Cell Biologist

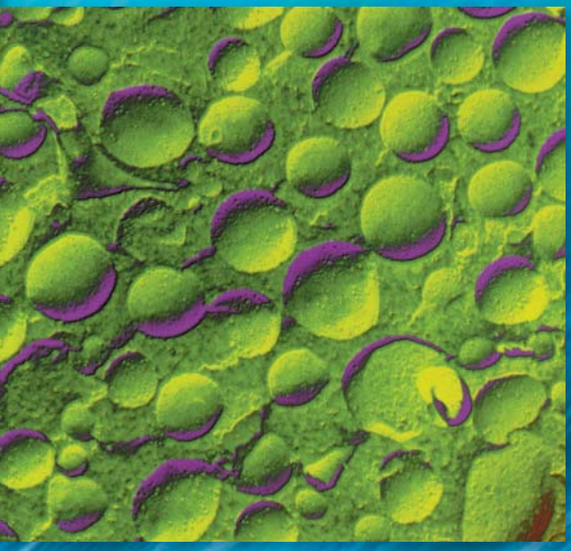
Shubha Govind

Shubha Govind is a professor of biology at City College, City University of New York. Govind considers her most important scientific contribution to be developing a model system for using genetic tools to study the molecular basis of host-parasite interaction in fruit flies. She is studying how blood cells of fruit flies are formed and how they guard against infections when flies are attacked by parasites. She is also studying how parasites have evolved to overcome the immune reactions of the fly.

Govind grew up in India, and her family traveled a lot. As she traveled, she was impressed with the diversity of flora and fauna in different parts of the country. By the time she reached middle school, she knew that she wanted to be a biologist.

Apart from science, Govind enjoys reading, listening to music and spending time with family and friends.





Freeze fracture of cell

Chapter Planner 7

Cell Structure

		Standards	Teach Key Ideas
CHAPTER OPENER, pp. 148–149	15 min.	*National Science Education Standards*	
SECTION 1 Introduction to Cells, pp. 151–155 › The Discovery of Cells › Looking at Cells › Cell Features	45 min.	LSCell 1, LSCell 2, LSCell 3, LSCell 4, LSCell 6, LSGene 1, LSEvol 4, UCP1, UCP2, UCP5, HNS1, HNS2, HNS3	**Bellringer Transparency** **Transparencies** A10 Metric Units of Length and Equivalents • A4 Objects Size and Magnifying Power of Microscopes • A5 Compound Light Microscope • B2 Relationship Between Surface Area and Volume • B8 Structure of Lipid Bilayer • B9 Organelles **Visual Concepts** Types of Microscopes • Magnification and Resolution • Parts of a Light Microscope • Cell Theory • Cell Membrane • Cytoplasm • Ribosomes • Internal Organization of a Cell • Parts of a Prokaryotic Cell • Parts of a Cell Wall
SECTION 2 Inside the Eukaryotic Cell, pp. 156–161 › The Framework of the Cell › Directing Cellular Activity › Protein Processing › Storage and Maintenance › Energy Production	60 min.	LSCell 1, LSCell 2, LSCell 3, LSCell 4, LSCell 5, LSGene 1, LSMat 2, LSMat 4, UCP1, UCP5, SI1	**Bellringer Transparency** **Transparencies** B13 Processing of Proteins • B12 Mitochondrion **Visual Concepts** Cytoskeleton • Nucleus of a Cell • Endoplasmic Reticulum (ER) and Ribosomes • Golgi Apparatus • Mitochondrion • Chloroplasts • Vacuoles
SECTION 3 From Cell to Organism, pp. 162–166 › Diversity in Cells › Levels of Organization › Body Types	90 min.	LSCell 4, LSCell 5, LSCell 6, LSMat 4, LSMat 6, UCP1, UCP5, SI1, SI2	**Bellringer Transparency** **Transparencies** B4 Animal Cells **Visual Concepts** Structure of Cilia and Flagella • Comparing Prokaryotes and Eukaryotes • Parts of an Animal Cell • Comparing Plant and Animal Cells • Parts of a Plant Cell
			See also PowerPoint® Resources

Chapter Review and Assessment Resources

- SE Super Summary, p. 168
- SE Chapter Review, p. 169
- SE Standardized Test Prep, p. 171
- Review Resources
- Chapter Tests A and B
- Holt Online Assessment

CHAPTER FastTrack

Thorough instruction will require the times shown.

Basic Learners

- TE Magnification, p. 152
- TE What Am I?, p. 158
- TE 3-D Representations, p. 159
- TE Body Systems, p. 164
- Directed Reading Worksheets*
- Active Reading Worksheets*
- Lab Manuals, Level A*
- Study Guide* ■
- Note-taking Workbook*
- Special Needs Activities and Modified Tests*

Advanced Learners

- TE Specimen Size, p. 153
- TE Mitochondria, p. 160
- TE Behavior of Cell Colonies, p. 165
- Critical Thinking Worksheets*
- Concept Mapping Worksheets*
- Science Skills Worksheets*
- Lab Datasheets, Level C*

Key

SE Student Edition
TE Teacher's Edition
Chapter Resource File
Workbook
Transparency
CD or CD-ROM
* Datasheet or blackline master available
■ Also available in Spanish

All resources listed below are also available on the Teacher's One-Stop Planner.

Why It Matters	Hands-On	Skills Development	Assessment
Build student motivation with resources about high-interest applications.	SE **Inquiry Lab** Is It Alive?, p. 149*■	TE **Reading Toolbox** Assessing Prior Knowledge, p. 148 SE **Reading Toolbox,** p. 150	
TE **Bacteria in Yogurt,** p. 151 SE **Cell Shape,** p. 152 TE **Prokaryote Diversity,** p. 154	**Quick Lab** Modeling Cells: Surface Area to Volume* **Skills Practice Lab** Using a Microscope*	TE **Reading Toolbox** Visual Literacy, p. 152 TE **Math Skills** Surface Area–to-Volume Ratio, p. 153 SE **Reading Toolbox** Word Parts, p. 155 TE **Reading Toolbox** Word Parts, p. 155	SE **Section Review** TE **Formative Assessment** **Spanish Assessment*■** **Section Quiz■**
TE **Amoeboid Movement,** p. 156 TE **Demonstration** Observing Cell Structure, p. 157 TE **Lysosmal Malfunction,** p. 158 TE **Filtering Out Toxins,** p. 158 TE **History Connection,** p. 159	SE **Quick Lab** Model Cell Parts, p. 160*■	SE **Reading Toolbox** Process Chart, p. 158 TE **Reading Toolbox** Process Chart, p. 158	SE **Section Review** TE **Formative Assessment** **Spanish Assessment*■** **Section Quiz■**
TE **Diversity,** p. 162 TE **Endosymbiosis,** p. 163 TE **Career Development,** p. 164 TE **Cryogenics,** p. 165	SE **Quick Lab** Colonies On the Move, p. 165*■ SE **Skills Practice Lab** Plant Cell Observation, p. 167*■	TE **Reading Toolbox** Fold Notes, p. 162 SE **Reading Toolbox** Similes, p. 164 TE **Reading Toolbox** Similes, p. 164	SE **Section Review** TE **Formative Assessment** **Spanish Assessment*■** **Section Quiz■**
	See also Lab Generator		**See also Holt Online Assessment Resources**

Resources for Differentiated Instruction

English Learners

TE Paired Reading, p. 157
TE Reading Organizer, p. 163
Directed Reading Worksheets*
Active Reading Worksheets*
Lab Manuals, Level A*
Study Guide*■
Note-taking Workbook*
Multilingual Glossary

Struggling Readers

TE TE Paired Reading, p. 157
Directed Reading Worksheets*
Active Reading Worksheets*
Lab Manuals, Level A*
Study Guide*
Note-taking Workbook*
Special Needs Activities and Modified Tests*

Special Education Students

TE Cell Model, p. 154
Directed Reading Worksheets*
Active Reading Worksheets*
Lab Manuals, Level A*
Study Guide*■
Note-taking Workbook*■
Special Needs Activities and Modified Tests*

Alternative Assessment

TE Fold Notes, p. 157
Science Skills Worksheets*
Section Quizzes*■
Chapter Tests A, B, and C*■

Chapter 7

Overview

The purpose of this chapter is to describe the relationships between structure and function at the cellular and sub-cellular levels of an organism. The structural features of cells and the differences between prokaryotes and eukaryotes are described. A study of cell organelles confirms that proper functioning of all cell structures is needed to maintain homeostasis.

READING TOOLBOX

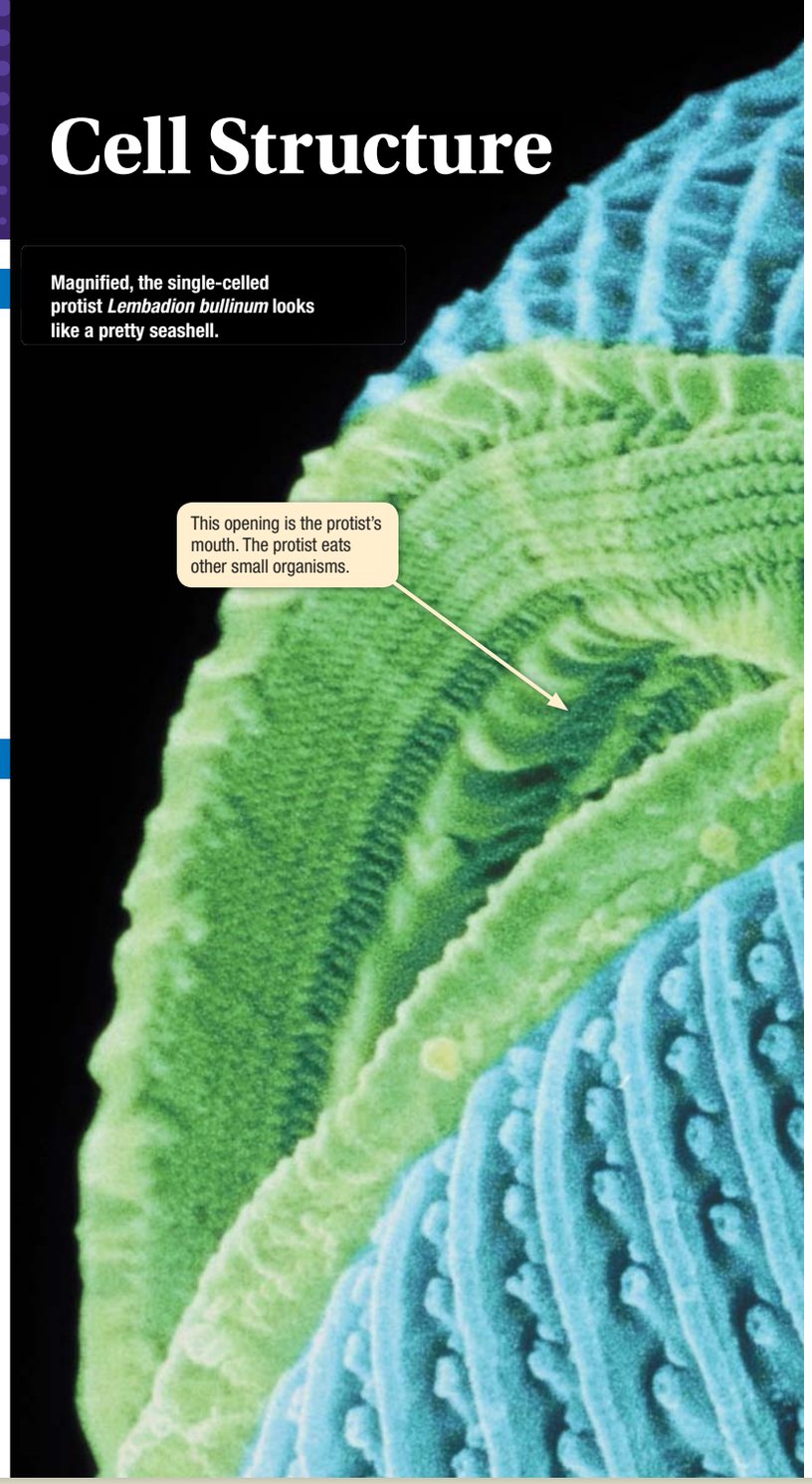
Assessing Prior Knowledge Students should understand the following concepts:

- the function of ATP
- microscope use and slide preparation
- micro measurements
- surface area and volume

Visual Literacy Ask students to study the picture of *Lembadion bullinum.* What features does this organism have that would indicate that it is living? (It has a mouth.) Explain that this organism is a predatory protist—a type of single-celled organism. It preys on smaller single-celled organisms that exist in its environment. Its large mouth allows it to engulf its prey. When the prey is larger, populations of *Lembadion bullinum* are composed of larger individuals. Have interested students research this organism.

Chapter 7

Cell Structure



Magnified, the single-celled protist *Lembadion bullinum* looks like a pretty seashell.

Preview

Why It Matters

All living things are made of cells. Scientists study how cells work to understand life.

Chapter Correlations

National Science Education Standards

LSCell 1 Cells have particular structures that underlie their functions.

LSCell 2 Most cell functions involve chemical reaction.

LSCell 3 Cells store and use information to guide their functions.

LSCell 4 Cell functions are regulated.

LSCell 5 Plant cells contain chloroplasts, the site of photosynthesis.

LSCell 6 Cells can differentiate and form complete multicellular organisms.

LSGene 1 In all organisms, the instructions for specifying the characteristics of the organisms are carried in DNA.

LSEvol 4 The millions of difference species of plants, animals, and microorganisms that live on earth today are related by descent from common ancestors.

LSMat 2 The energy for life primarily derives from the sun.

LSMat 4 The complexity and organization of organisms accommodates the need for obtaining, transforming, transporting, releasing, and eliminating the matter and energy used to sustain the organism.

LSMat 6 As matter and energy flows through different levels of organization of living systems-cells, organs, communities-and between living systems and the physical environment, chemical elements are recombined in different ways.

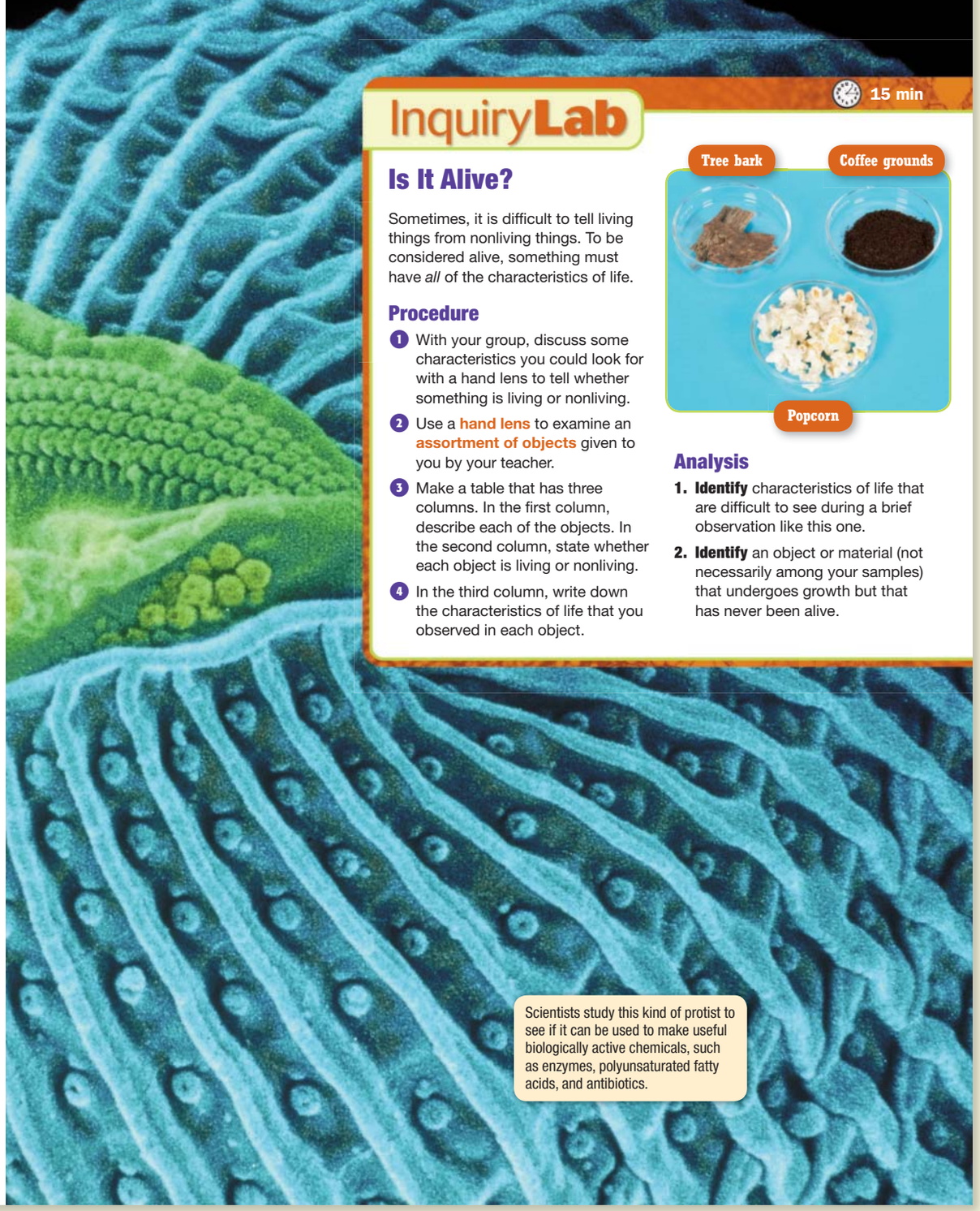
UCP1 Systems, order, and organization

UCP2 Evidence, models, and explanation

UCP5 Form and function

SI1 Abilities necessary to do scientific inquiry

SI2 Understandings about scientific inquiry



15 min

InquiryLab

Is It Alive?

Sometimes, it is difficult to tell living things from nonliving things. To be considered alive, something must have *all* of the characteristics of life.

Procedure

1. With your group, discuss some characteristics you could look for with a hand lens to tell whether something is living or nonliving.
2. Use a **hand lens** to examine an **assortment of objects** given to you by your teacher.
3. Make a table that has three columns. In the first column, describe each of the objects. In the second column, state whether each object is living or nonliving.
4. In the third column, write down the characteristics of life that you observed in each object.

Analysis

1. **Identify** characteristics of life that are difficult to see during a brief observation like this one.
2. **Identify** an object or material (not necessarily among your samples) that undergoes growth but that has never been alive.

Scientists study this kind of protist to see if it can be used to make useful biologically active chemicals, such as enzymes, polyunsaturated fatty acids, and antibiotics.

InquiryLab

Teacher's Notes Provide students with a variety of objects, both living and nonliving. Objects might include plants, seeds, a goldfish, mineral crystals, and so on.

Materials
- assorted objects
- hand lens

Answers to Procedure

Students' tables should accurately describe objects and materials. If students conclude that an object (such as a plant or a goldfish) is living, students should have noted that the object displays (or potentially displays) all of the characteristics of life (Living things are composed of cells, maintain homeostasis, take in and use energy, grow and develop, respond to the environment, reproduce and pass traits to offspring, and evolve over generations.)

Answers to Analysis

1. Students should be guided to realize that it is difficult to see most characteristics of life in a cursory examination. Students may acknowledge that they infer that certain things, such as a goldfish or a plant, are living based on experience. Students may realize that with more powerful magnification than a hands lens, the cellular structure of living things can be seen. And under certain conditions and in a relatively short term, homeostasis, metabolism, response to the environment, and even reproduction might be observed. Evolution is not likely to be observable in real time.
2. Sample answer: mineral crystals, clouds

HNS1 Science as a human endeavor
HNS2 Nature of scientific knowledge
HNS3 Historical perspectives

READING TOOLBOX

Using Words

1. to make a group of parts work together
2. An organelle functions like a small organ, or is one of the working parts of an organ.

Using Language

1. The *cytoskeleton* supports the cell, much like your bones make up the skeleton that supports your body.
2. A mitochondria is like an electric plant that turns the energy of coal into electricity, a more easily used form of energy.

Using Science Graphics

Proteins are produced at the rough endoplasmic reticulum (ER).

↓

ER membrane pinches off forming a vesicle around the protein.

↓

Vesicles move to the Golgi apparatus.

↓

Vesicle membrane fuses with the Golgi membrane.

↓

Enzymes modify the proteins as they move through the Golgi apparatus.

↓

Finished proteins are enclosed in new vesicles that bud from the surface of the Golgi apparatus.

↓

Vesicles move to the cell membrane.

↓

Vesicle membrane fuses with the cell membrane and releases the protein outside the cell.

READING TOOLBOX

These reading tools can help you learn the material in this chapter. For more information on how to use these and other tools, see **Appendix: Reading and Study Skills.**

Using Words

Word Parts Knowing the meanings of word parts can help you figure out the meanings of words that you do not know.

Word Parts

Word part	Type	Meaning
organ	root	a group of parts that work together
-ize	suffix	to make or become
-elle	suffix	small part

Your Turn Use the information in the table to answer the questions that follow.

1. Use the table to write your own definition for *organize*.
2. What do you think an organelle does in a cell?

Using Language

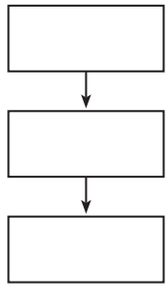
Similes Similes help relate new ideas to ideas that you already know. Often, similes use the terms *like* or *as*. For example, if you were describing a motorcycle to someone who had never seen one, you might say that it is like a bicycle that has a motor.

Your Turn Use information in the chapter to answer the questions that follow.

1. Find a simile to describe a cytoskeleton.
2. Write a simile to describe the function of a mitochondrion.

Using Science Graphics

Process Chart Science is full of processes. A process chart shows the steps that a process takes to get from one point to another point. This tool can help you visualize a process and remember the steps.



Your Turn Make a process chart to help you remember the steps of protein packaging.

1. Draw a box. In the box, write the first step of the process.
2. Under the box, draw another box and an arrow connecting the two boxes. In the second box, write the next step of the process.
3. Keep adding boxes and arrows until each step of the process has been included.

Section 1

Introduction to Cells

Key Ideas	Key Terms	Why It Matters
❯ How were cells discovered? ❯ What defines cell shape and size? ❯ What enables eukaryotes to perform more specialized functions than prokaryotes do?	cell membrane cytoplasm ribosome prokaryote eukaryote nucleus organelle	Cells are the basic unit of life. By studying cells, biologists can better understand life's processes.

All life-forms on our planet are made up of cells. The bacteria that live in our gut and the cells that make up our body are built from the same chemical machinery. This machinery allows living things to obtain and use energy, to respond to their environment, and to reproduce. In all organisms, cells have the same basic structure.

The Discovery of Cells

How do living things differ from nonliving things? The discovery of cells was an important step toward answering this question. Most cells are too small to see with the naked eye. As **Figure 1** shows, microscopes have become an important tool for studying biology.

❯ **Microscope observations of organisms led to the discovery of the basic characteristics common to all living things.**

In 1665, Robert Hooke, an English scientist, used a crude microscope to look at a thin slice of cork. His microscope could magnify objects to only 30 times their normal size. Hooke saw many "little boxes" in the cork. They reminded him of the small rooms in which monks lived, so he called them *cells*. Hooke later discovered cells in the stems and roots of plants. Ten years later, Anton van Leeuwenhoek, a Dutch scientist, used a more powerful microscope that could magnify objects 300-fold. He discovered many living creatures in pond water. He named them *animalcules,* or "tiny animals." Today, we know that they were not animals. They were single-celled organisms.

❯ **Reading Check** ***How powerful was Hooke's microscope? (See the Appendix for answers to Reading Checks.)***

Figure 1 A student looks through a light microscope. Euglena (inset) are single-celled organisms that are commonly found in pond water.

Key Resources

Transparencies
- A10 Metric Units of Length and Equivalents
- A4 Object Size and Magnifying Power of Microscopes
- A5 Compound Light Microscope
- B2 Relationship Between Surface Area and Volume
- B8 Structure of Lipid Bilayer
- B9 Organelles

Visual Concepts
- Types of Microscopes
- Magnification and Resolution
- Parts of a Light Microscope
- Cell Theory
- Cell Membrane
- Cytoplasm
- Ribosomes
- Internal Organization of a Cell
- Parts of a Prokaryotic Cell
- Parts of a Cell Wall

Section 1

❯Focus

This section introduces students to the discovery of the cell and the development of the cell theory. Cell features are presented. The similarities and differences of prokaryotic and eukaryotic cells are discussed.

Bellringer

Use the Bellringer transparency to prepare students for this section.

❯Teach

Teaching Key Ideas

Overview of Cells Display micrographs of various cells. Have students make deductive statements about the cells they observe. Why are there so many varieties of cells? (Cells with different structures have different functions.) LS Visual/Verbal

Why It Matters

Bacteria in Yogurt Smear yogurt with live cultures on a microscope slide. Mix a drop of water into the yogurt and add a coverslip. Allow students to examine the slide under high power using a compound light microscope. They should see *Lactobacillus.* Ask them to compare the size and shape of these cells with prepared slides of human and plant tissue cells and the *Euglena* shown in **Figure 1.** (Euglena are approx. 25µm in length.) LS Kinesthetic

Teach, *continued*

Why It Matters

Cell Shape A study of micrographs of cell structures shows that common shapes of true bacterial cells include cocci (circular) bacilli (rod-shaped) and spirilli (squiggly). Human epithelial cells (cells lining the interior and exterior surfaces of the body) are also classified by shape: squamous (flattened), cuboidal (cube-shaped), or columnar (taller than wide). The cells are classified as *simple* if they are arranged in a single layer, or *stratified* if they are arranged in several layers. Specialized cells routinely have a unique shape, such as an axon or dendrite, or additional structures, such as multiple nuclei in a skeletal muscle cell or cilia on cells lining the respiratory system.

READING TOOLBOX

Visual Literacy Help students classify the cells shown in the photographs by shape.
- plant cell – columnar or cuboidal
- skin cells – flat; scale-like

Answer to Quick Project

The largest eukaryotic cell in the world is about the size of a baseball! By volume, the largest single cell is the yolk of an ostrich egg.

Cell Theory It took more than 150 years for scientists to fully appreciate the discoveries of Hooke and Leeuwenhoek. By the 1830s, microscopes were powerful enough to resolve structures only 1 μm apart. In 1838, Matthias Schleiden, a German botanist, concluded that cells make up every part of a plant. A year later, Theodor Schwann, a German zoologist, discovered that animals are also made up of cells. In 1858, Rudolph Virchow, a German physician, proposed that cells come only from the division of existing cells. The observations of Schleiden, Schwann, and Virchow form the *cell theory:*

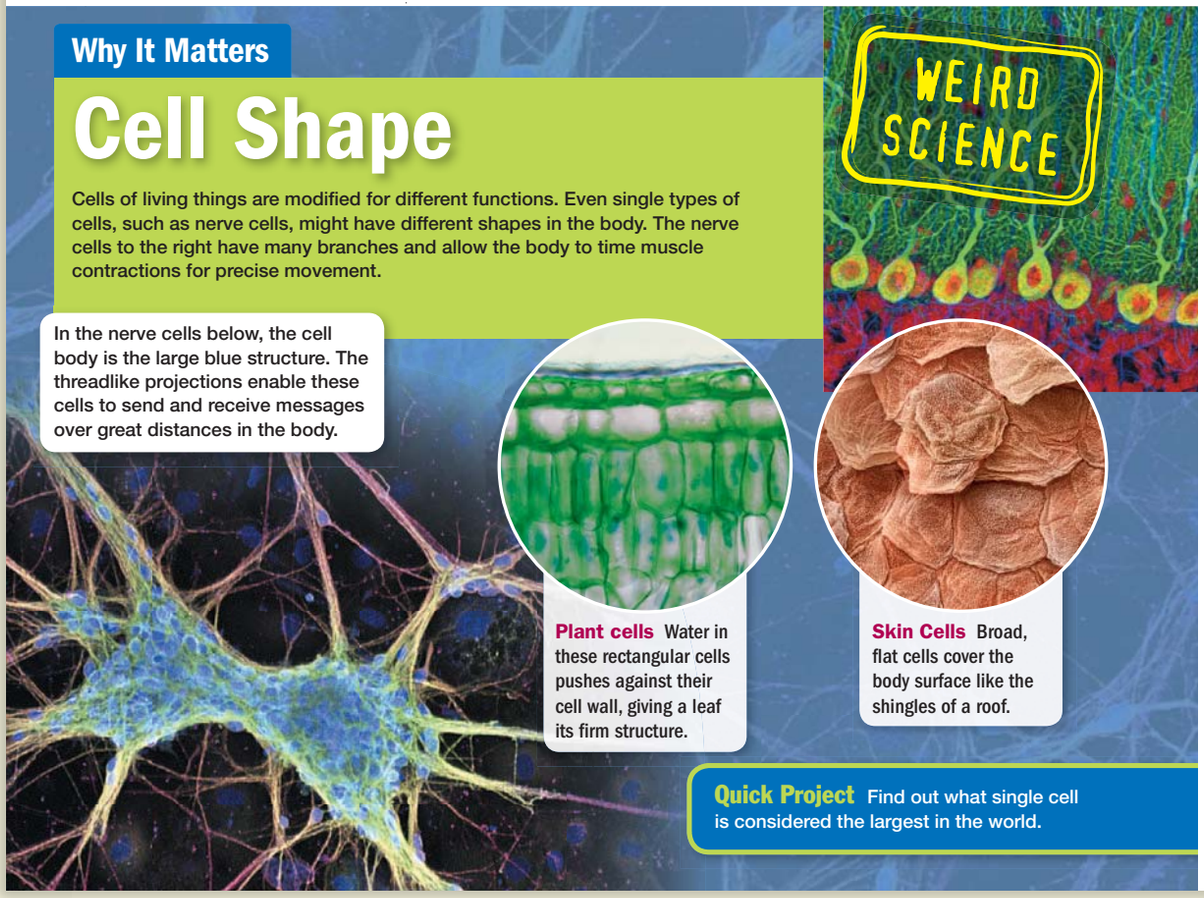
- All living things are made up of one or more cells.
- Cells are the basic units of structure and function in organisms.
- All cells arise from existing cells.

The cell theory has withstood the rigorous examination of cells by scientists equipped with today's high-powered microscopes. As new tools and techniques are invented, scientists will learn more about the characteristics of cells.

Why It Matters

Cell Shape

Cells of living things are modified for different functions. Even single types of cells, such as nerve cells, might have different shapes in the body. The nerve cells to the right have many branches and allow the body to time muscle contractions for precise movement.



In the nerve cells below, the cell body is the large blue structure. The threadlike projections enable these cells to send and receive messages over great distances in the body.

Plant cells Water in these rectangular cells pushes against their cell wall, giving a leaf its firm structure.

Skin Cells Broad, flat cells cover the body surface like the shingles of a roof.

Quick Project Find out what single cell is considered the largest in the world.

Differentiated Instruction

Basic Learners

Magnification Remind students that microscopes magnify objects, making them appear larger than their actual size. Pair students, and ask each pair to calculate the diameter of a Lincoln penny if it were magnified 270 times. Have students report their answers in meters and using a comparison to another object. (A Lincoln penny is 2 cm wide. Magnified 270 times, it would appear 5.4 m wide, about as wide as a large room.) LS **Logical**

Math Skills Ratio of Surface Area and Volume

A ratio compares two numbers by dividing one number by the other number. A ratio can be expressed in three ways:

x to y $\qquad \frac{x}{y} \qquad x:y$

You can improve your understanding of a cell's surface area–to-volume ratio by practicing with cubes of various sizes. What is the surface area–to-volume ratio of a cube that has a side length (l) of 4 mm?

Surface Area and Volume

Side length	Surface area	Volume	Surface area–to-volume
1 mm	6 mm²	1 mm³	6:1
2 mm	24 mm²	8 mm³	3:1
4 mm	96 mm²	64 mm³	3:2

1. Find the surface area of the cube. A cube has six square faces. The surface area of one face is $l \times l$, or l^2.
   - *total surface area of cube* $= 6 \times l^2$
   - *total surface area of cube* $= 6 \times (4\text{ mm})^2 = 96\text{ mm}^2$
2. Find the volume of the cube.
   - *volume of cube* $= l^3$
   - *volume of cube* $= (4\text{ mm})^3 = 64\text{ mm}^3$
3. Divide the total surface area by volume:
   - *surface area–to-volume ratio* $= \frac{\text{total surface area}}{\text{volume}}$

Reduce both numbers by their greatest common factor:

- *surface area–to-volume ratio* $= \frac{(96 \div 32)}{(64 \div 32)} = \frac{3}{2}$

Looking at Cells

Cells vary greatly in size and in shape. **A cell's shape reflects the cell's function.** Cells may be branched, flat, round, or rectangular. Some cells have irregular shapes, while other cells constantly change shapes. These differences enable different cells to perform highly specific functions in the body. There are at least 200 types of cells. The human body is made up of about 100 trillion cells, most of which range from 5 to 20 µm in diameter. Why are cells so small?

Cell Size All substances that enter or leave a cell must pass through the surface of the cell. As a cell gets larger, it takes up more nutrients and releases more wastes. These substances must move farther to reach their destination in a larger cell. **Cell size is limited by a cell's surface area–to-volume ratio.**

Scientists can estimate a cell's ability to exchange materials by calculating the cell's surface area–to-volume ratio. Cells with greater surface area–to-volume ratios can exchange substances more efficiently. When cells that are the same shape as one another are compared, the smaller cells have greater surface area–to-volume ratios than larger cells do.

Cell Shape Larger cells often have shapes that increase the surface area available for exchange. A cell may grow large in one or two dimensions but remain small in others. For example, some skin cells are broad and flat. Some nerve cells are highly extended and can be more than 10,000 times as long as they are thick. In both of these types of cells, the surface area–to-volume ratio is larger than it would be if the cells were spheres.

Reading Check ***How does a cell's size affect the cell's function?***

Academic Vocabulary

dimension a measurement in a particular direction

Demonstration

Surface Area and Volume Cut three cubes of varying sizes from a potato. Pour food coloring into three beakers, and place a cube in each beaker. After about five minutes, remove each cube and cut it in half. Have students observe the results. Ask them to determine how the surface area–to-volume ratio of each cube affected the penetration of the food coloring. (The food coloring traveled the same distance in each cube. However, the smallest cube will be more completely colored than the others because it has the greatest surface area–to-volume ratio.) LS **Visual**

Math Skills

Surface Area–to-Volume Ratio Give students game dice that are three different sizes. Have them measure the sides of the dice. Then, have them calculate the surface area–to-volume ratios of the dice and compare their results. LS **Logical**

Differentiated Instruction

Advanced Learners/GATE

Specimen Size Have students prepare wet mounts of *Paramecium* to view under compound light microscopes. Have students determine how they can best estimate the size of the *Paramecium* using a thin centimeter ruler that is placed on the microscope stage. Have them calculate the surface area–to-volume ratio of the *Paramecium* assuming that the width and depth of the organism is $\frac{1}{3}$ of its length. (A *Paramecium* spreads its volume over a large area. Student answers should fall in the range of 2 to 4.) LS **Kinesthetic**

Teach, *continued*

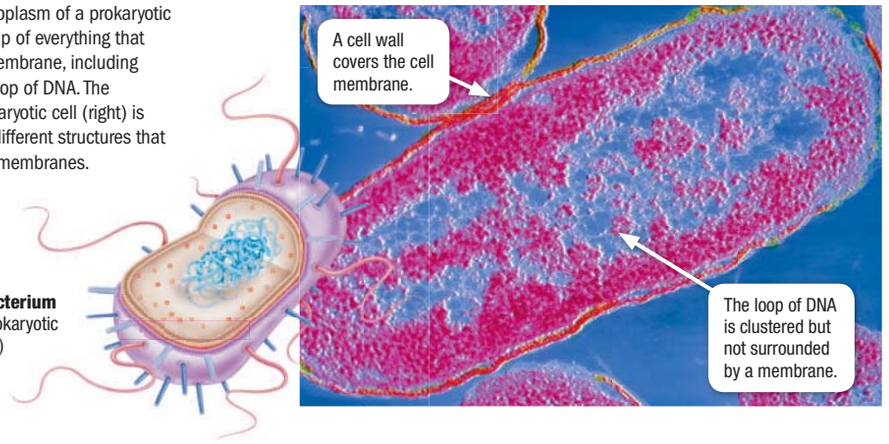
Teaching Key Ideas

Interpreting Graphics Draw students' attention to **Figure 2.** Tell students that any color shown in electron micrographs is usually digitally applied; that is, the colors are "painted" by computers. These colors are artificial; the cell is not colored as is shown in the micrograph. Ask students why colorized electron micrographs might be useful. (to highlight or point out structures) Ask students which structures are shown in **Figure 2.** (cell wall and DNA) What other structures are in the cytoplasm of this cell that is not visible in the micrograph? (ribosomes)

LS Visual

Features of Prokaryotic and Eukaryotic Cells

Figure 2 The cytoplasm of a prokaryotic cell (left) is made up of everything that is inside the cell membrane, including ribosomes and a loop of DNA. The cytoplasm of a eukaryotic cell (right) is made up of many different structures that are surrounded by membranes.



SCILINKS
www.scilinks.org
Topic: Cell Features
Code: HX80238

cell membrane a phospholipid layer that covers a cell's surface and acts as a barrier between the inside of a cell and the cell's environment

cytoplasm (SIET oh PLAZ uhm) the region of the cell within the membrane

ribosome (RIE buh SOHM) a cell organelle where protein synthesis occurs

prokaryote a single-celled organism that does not have a nucleus or membrane-bound organelles

eukaryote an organism made up of cells that have a nucleus and membrane-bound organelles

nucleus in a eukaryotic cell, a membrane-bound organelle that contains the cell's DNA

organelle one of the small bodies that are found in the cytoplasm of a cell and that are specialized to perform a specific function

Cell Features

All cells—from bacteria to those in a berry, bug, or bunny—share common structural features. All cells have a cell membrane, cytoplasm, ribosomes, and DNA. The **cell membrane** is the cell's outer boundary. It acts as a barrier between the outside environment and the inside of the cell. The *cytosol,* the fluid inside the cell, is full of dissolved particles. The **cytoplasm** includes this fluid and almost all of the structures that are suspended in the fluid. Many ribosomes are found in the cytoplasm. A **ribosome** is a cellular structure on which proteins are made. All cells also have DNA, the genetic material. DNA provides instructions for making proteins, regulates cellular activities, and enables cells to reproduce.

Features of Prokaryotic Cells The bacterium shown in **Figure 2** is an example of a **prokaryote,** an organism that is a single prokaryotic cell. A prokaryotic cell is quite simple in its organization. The genetic material is a single loop of DNA, which looks like a tangled string and usually lies near the center of the cell. Ribosomes and enzymes share the cytoplasm with the DNA.

Prokaryotic cells have a cell wall that surrounds the cell membrane and that provides structure and support. Some prokaryotic cell walls are surrounded by a *capsule,* a structure that enables prokaryotes to cling to surfaces, including teeth, skin, and food.

Scientists think that the first prokaryotes may have lived 3.5 billion years ago or more. For millions of years, prokaryotes were the only organisms on Earth. They were very simple and small (1 to 2 μm in diameter). Like their ancestors, modern prokaryotes are also very small (1 to 15 μm), and they live in a wide range of habitats. Prokaryotes make up a very large and diverse group of cells.

Reading Check *What is a ribosome?*

Why It Matters

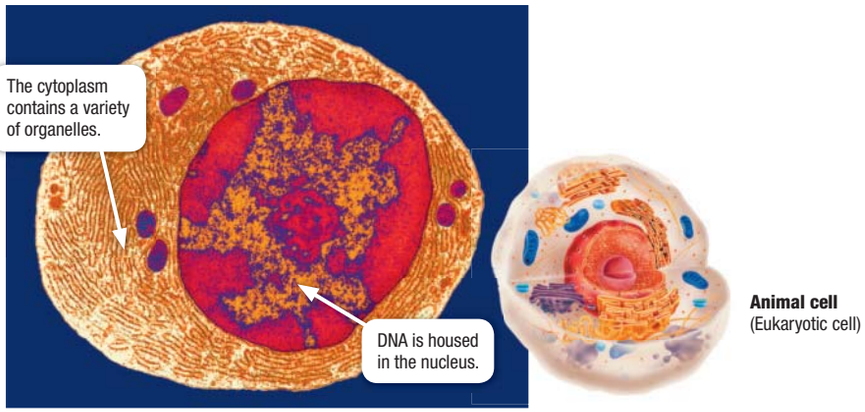
Prokaryote Diversity Modern prokaryotes include archaea (archaebacteria) and bacteria (eubacteria). They can be found in nearly any environment on Earth, including volcanic vents at the bottom of the ocean and ice in Arctic and Antarctic regions. Some archaeae seem to thrive in harsh conditions. These types of organisms are referred to as *extremophiles.*

Many bacteria live in or on the bodies of other organisms, including humans. They can cause bacterial infection, but in most cases the organisms are harmless or even beneficial to the host.

Differentiated Instruction

Special Education Students

Cell Model Have students use food to make a model of a eukaryotic cell. Students should use their understanding of the organelle structures to choose appropriate foods to represent them. Gelatin (cytoplasm) could be poured into a large, clear cellophane bag (cell membrane). Organelles can be represented by kidney beans (mitochondria), poppy seeds (ribosomes), sections of lasagna noodles (ER and Golgi apparatus), peppercorns (lysosomes), spaghetti noodles (cytoskeleton), and an orange (nucleus). LS Kinesthetic



Animal cell
(Eukaryotic cell)

Features of Eukaryotic Cells A **eukaryote** is an organism that is made up of one or more eukaryotic cells. Some eukaryotes live as single cells. Others are multicellular organisms. In fact, all multicellular organisms are made up of eukaryotic cells. **› Because of their complex organization, eukaryotic cells can carry out more specialized functions than prokaryotic cells can.**

Primitive eukaryotic cells first appeared about 1.5 billion years ago. As shown in the animal cell in **Figure 2,** a eukaryotic cell contains compartments that are separated by membranes. The cell's DNA is housed in an internal compartment called the **nucleus.**

In addition to having a membrane, cytoplasm, ribosomes, and a nucleus, all eukaryotic cells have membrane-bound organelles. An **organelle** is a structure that carries out specific activities inside the cell. The animal cell in **Figure 2** shows many of the organelles found in eukaryotic cells. Each organelle performs distinct functions. Many organelles are surrounded by a membrane. Some of the membranes are connected by channels that help move substances within the cell.

READING TOOLBOX

Word Parts The root *kary* means "kernel," which describes the nucleus. *Eu-* means "true," so a eukaryotic cell has a true nucleus. If *pro-* means "before," what does prokaryotic mean?

Section 1 **Review**

› KEY IDEAS

1. **List** the three parts of the cell theory.
2. **Describe** the importance of a cell's surface area–to-volume ratio.
3. **Compare** the structure of a eukaryotic cell with that of a prokaryotic cell.

CRITICAL THINKING

4. **Explaining Relationships** The development of the cell theory is directly related to advances in microscope technology. Why are these two developments related?
5. **Making Comparisons** How do the membrane-bound organelles of a eukaryotic cell act in a manner similar to the organs in a multicellular organism?

METHODS OF SCIENCE

6. **Extraterrestrial Cells** You are a scientist with NASA. Some samples of extraterrestrial material containing living things have arrived on your spaceship. Your first job is to determine if the samples contain prokaryotic or eukaryotic cells. How will you proceed?

Teaching Key Ideas

Eukaryotic Cells All multicellular plants and animals are composed of eukaryotic cells. Stress that the eukaryotic cell can exist independently, not just as a component of a larger organism. Have students research single-celled eukaryotic organisms, such as yeast or a single-celled protist. Have them compare the single-celled eukaryotes with eukaryotic cells that are *part* of a multicellular plant or animal. Students should include drawings and record their findings on a fact sheet. LS Verbal/Visual

READING TOOLBOX

Word Origins *Prokaryotic* means "existing before the development of the nucleus."

› Close

Formative Assessment

Cells of unknown origin are examined and found to contain DNA, proteins, and enzymes. A cell wall is present along with a cluster of stringy material in the cytoplasm. No other components are visible. The cells are most likely ____.

A. sperm cells (Incorrect. Sperm cells have very distinct tails.)
B. skin cells (Incorrect. Animal cells do not have cell walls.)
C. prokaryotic cells (Correct. Prokaryotes contain ribosomes which produce protein, and enzymes in their cytoplasm. The DNA is a single circular molecule that is often located near the center of the cell.)
D. eukaryotic cells (Incorrect. Eukaryotes have distinct nuclei.)

Answers to Section Review

1. All living things are made of one or more cells. Cells are the basic units of structure and function in organisms. All cells arise from existing cells.
2. If the SA-to-V ratio of a cell is too small, substances cannot penetrate or leave the cell quickly enough to meet its needs.
3. Prokaryotic cells lack membrane-bound organelles; eukaryotic cells have organelles, which enable them to carry out unique, specialized functions in organized ways.
4. As microscopes became more powerful, scientists were able to observe the structure and function of cells. These observations led to the development of the cell theory.
5. The membrane-bound organelles of a eukaryotic cell are like separate organs in a multicellular organism in that they differ in structure and function and are adapted for specific and different jobs.
6. Using a microscope, determine if the live material has single-celled organisms, or if the cells form tissues or organs. Focus on one cell and use criteria of size, presence of nucleus, and organelles to distinguish prokaryotes from eukaryotes.

Section 2

Section 2 Inside the Eukaryotic Cell

Key Ideas	Key Terms	Why It Matters
What does the cytoskeleton do? How does DNA direct activity in the cytoplasm? What organelles participate in protein production? What is the role of vesicles in cells? How do cells get energy?	vesicle endoplasmic reticulum Golgi apparatus vacuole chloroplast mitochondrion	Knowing how cells work helps you understand how your body functions and what goes wrong when you get sick.

Focus

This section presents the structure and function of eukaryotic cell organelles and cytoskeleton. Protein processing and energy production are also explained.

Bellringer

Use the Bellringer transparency to prepare students for this section.

Teach

Why It Matters

Amoeboid Movement Have students make wet mounts of live amoebas. Amoeboid movement is a dramatic example of actin-based cell movement. Although students will not be able to see the actin fibers, they will be able to observe the granular cytoplasm streaming into the projection as it begins to form. Explain to students that some of their own white blood cells exhibit such movement to catch and ingest foreign invaders, such as bacteria.
LS Visual

Answers to Caption Questions

Figure 3: Microfilaments, microtubules, and intermediate fibers

The cytoplasm of a eukaryotic cell is packed with all sorts of structures and molecules. Molecules can be concentrated in certain parts of the cell because of the membranes that divide the cytoplasm into compartments. This organization enables each organelle to perform highly sophisticated and specialized functions.

The Framework of the Cell

The *cytoskeleton* is a web of protein fibers, shown in **Figure 3,** found in eukaryotic cells. The cytoskeleton supports the cell in much the same way that bones support your body. **The cytoskeleton helps the cell move, keep its shape, and organize its parts.** There are three kinds of cytoskeleton fibers.

Microfilaments are long, thin fibers that are made of the protein actin. Some are attached to the cell membrane. They contract to pull the membrane in some places and expand to push it out in others. *Microtubules* are thick, hollow fibers that are made of the protein tubulin. Information molecules move through these tubes to various parts of the cell. *Intermediate fibers* are moderately thick and mainly anchor organelles and enzymes to certain parts of the cell.

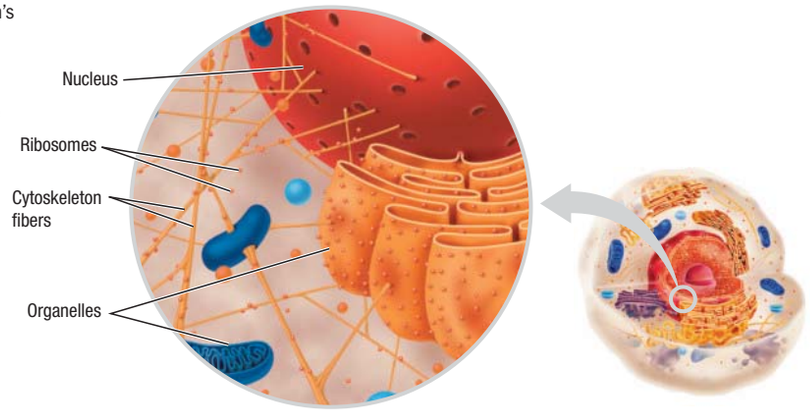


Figure 3 The cytoskeleton's network of protein fibers anchors cell organelles and other components of the cytoplasm. **What are the three types of cytoskeleton fibers?**

Key Resources

Transparencies
B13 Processing of Proteins
B12 Mitochondrion

Visual Concepts
Cytoskeleton
Nucleus of a Cell
Endoplasmic Reticulum (ER) and Ribosomes
Golgi Apparatus
Mitochondrion
Chloroplasts
Vacuoles

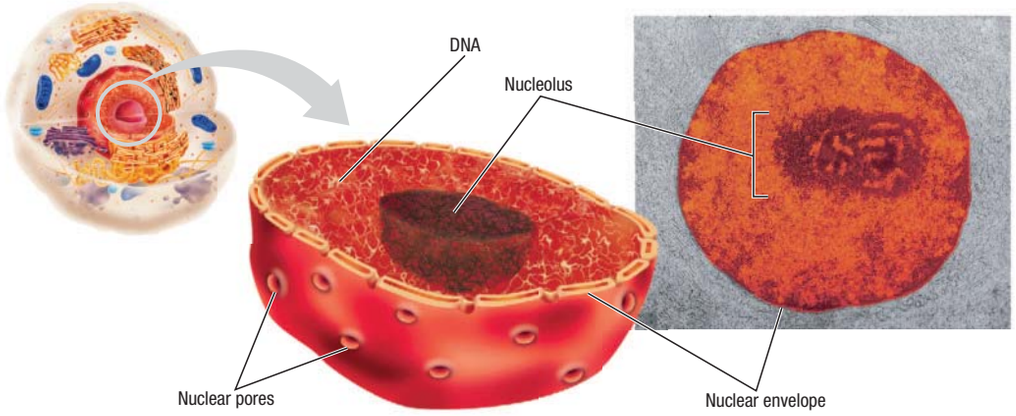


Figure 4 The nucleus stores the cell's DNA. The nuclear envelope is a double membrane that surrounds the nucleus of a cell. Ribosomes are made in the nucleolus. **How do molecules move from the nucleus to the cytoplasm?**

Directing Cellular Activity

Almost all cellular activity depends on the proteins that the cell makes. The instructions for making proteins are stored in the DNA. In a eukaryotic cell, the DNA is packed into the nucleus. This location separates the DNA from the activity in the cytoplasm and helps protect the information from getting lost or destroyed. **DNA instructions are copied as RNA messages, which leave the nucleus. In the cytoplasm, ribosomes use the RNA messages to assemble proteins.**

ACADEMIC VOCABULARY
assemble to fit together parts or pieces; to build

Nucleus As **Figure 4** shows, the nucleus is surrounded by a double membrane called the *nuclear envelope*. The nuclear envelope has many nuclear pores. Nuclear pores are small channels that allow certain molecules to move into and out of the nucleus. Even though the inside of the nucleus appears to be quite jumbled, the DNA is very organized. Within the nucleus is a prominent structure called the *nucleolus*. The nucleolus is the region where ribosome parts are made. These "preassembled" parts of ribosomes pass through the nuclear pores into the cytoplasm. Outside the nucleus, the parts are assembled to form a complete ribosome.

Ribosomes Each ribosome is made of RNA and many proteins. Some ribosomes in a eukaryotic cell are suspended in the cytosol, as they are in prokaryotic cells. These "free" ribosomes make proteins that remain inside the cell, such as proteins that build new organelles or enzymes to speed chemical reactions. Other ribosomes are attached to the membrane of another organelle. These "bound" ribosomes make proteins that are exported from the cell. Some of these proteins are important in cell communication. Bound ribosomes also make proteins that must be kept separate from the rest of the cytoplasm. Ribosomes can switch between being bound or free depending on the kind of protein that the cell needs to make.

Reading Check *What kind of protein do "free" ribosomes make?*

Demonstration

Observing Cell Structures Have students observe a prepared slide of a cheek cell under a light microscope. Then show students electron micrographs of various cell parts and organelles. Ask them to identify the structures in the cheek cell. (The cytoplasm, nucleus, and cell membrane are observed easily.) Then, ask what structures are visible in the micrographs that aren't visible in the cheek cell. Remind students that other structures either are too small to be seen with the light microscope or may need to be stained in a different way to be seen. LS Visual

Teaching Key Ideas

Visual Literacy Draw students' attention to **Figure 4.** Explain that the figure shows an increasing level of detail from left to right. On the left, the entire cell is depicted, with the nucleus circled. The nucleus in the circle is magnified to show a greater level of detail. To the right of the circle is an electron micrograph of the nucleus. The same structures are labeled in both versions of the nucleus. However, the drawing shows the nucleus in three dimensions, which emphasizes its shape and the nuclear pores. The micrograph is a cross-section of a cell. LS Visual

Answers to Caption Questions

Figure 4: Molecules move from the nucleus to the cytoplasm through nuclear pores.

Differentiated Instruction

Alternative Assessment

Fold Notes Ask students to fold a piece of notebook paper in half, vertically, so they can create a listing of the different organelles of a cell. The left side of the chart should include the name and function of each organelle. The right side should list whether the organelle is found in plant cells, animal cells, or both. Student can design posters showing the cell's structural features and organelles. LS Logical/Verbal

Struggling Readers/English Learners

Paired Reading Pair ELL students with native English speakers. Have each student read this page silently. As they read each paragraph, have them note the passages they do not understand with a question mark. Then, have the partners review their individual results and help each other with the passages each did not understand. Ask each pair to write a short paragraph summarizing the structure and function of the nucleus or ribosome. LS Interpersonal

Teach, *continued*

Why It Matters

Filtering Out Toxins Enzymes found in the abundant smooth ER of the liver help detoxify drugs and environmental pollutants. Detoxification usually involves a series of chemical reactions within the smooth ER of the liver that make the drug more water soluble, so it can be excreted in the urine. The ingestion of many drugs, including barbiturates and alcohol, trigger an increase in the amount of smooth ER and accompanying enzymes in liver cells. Have students research this detoxifying function of the smooth ER. LS Verbal

READING TOOLBOX

Process Chart Have students refer to the Reading Tool Box activity at the beginning of the chapter to create a process chart explaining the protein sequence. LS Logical/Visual

vesicle a small cavity or sac that contains materials in a eukaryotic cell

endoplasmic reticulum (EN doh PLAZ mik ri TIK yuh luhm) a system of membranes that is found in a cell's cytoplasm and that assists in the production, processing, and transport of proteins and in the production of lipids

Golgi apparatus (GOHL jee) a cell organelle that helps make and package materials to be transported out of the cell

SCILINKS
www.scilinks.org
Topic: Proteins
Code: HX81241

READING TOOLBOX

Process Chart Make a process chart that shows how the cell digests food particles.

Protein Processing

The proteins produced by cells have many uses. The proteins that are sent outside the cell must be kept separate from the rest of the cytoplasm. To achieve this separation, the cell packages the proteins in vesicles. A **vesicle** is a small, often spherical-shaped sac that is formed by a membrane.

In a eukaryotic cell, two structures are mainly responsible for modifying, packaging, and transporting proteins for use outside the cell. **The endoplasmic reticulum and the Golgi apparatus are organelles that prepare proteins for extracellular export.**

Endoplasmic Reticulum The **endoplasmic reticulum** (ER) is a system of internal membranes that moves proteins and other substances through the cell. The membrane of the ER is connected to the outer membrane of the nuclear envelope.

Rough ER Ribosomes are attached to some parts of the surface of the ER. This *rough ER* has a bumpy appearance when viewed with an electron microscope, as shown in **Figure 5.** 1 As proteins are made, they cross the ER membrane, entering the ER. Then, the ER membrane pinches off to form a vesicle around the proteins.

Smooth ER The rest of the ER, called *smooth ER,* has no attached ribosomes. Thus it appears smooth when viewed with an electron microscope. Enzymes of the smooth ER performs various functions, such as making lipids and breaking down toxic substances.

Golgi Apparatus The **Golgi apparatus** is a set of flattened, membrane-bound sacs. Cell products enter one side of the Golgi apparatus, which modifies, sorts, and packages them for distribution.

Repackaging Vesicles that contain newly made proteins move through the cytoplasm from the ER to the Golgi apparatus. 2 The vesicle membrane fuses with the Golgi membrane. Inside the Golgi apparatus, enzymes modify the proteins as they move through the organelle. On the other side, the finished proteins are enclosed in new vesicles that bud from the surface of the Golgi apparatus.

Exporting Many of these vesicles then migrate to the cell membrane. 3 As the vesicle membrane fuses with the cell membrane, the completed proteins are released to the outside the cell.

Storage and Maintenance

Vesicles have many functions in the cell. Some transport materials within the cell. Others have important storage roles. **Vesicles help maintain homeostasis by storing and releasing various substances as the cell needs them.**

Lysosome A lysosome is a vesicle that contains specific enzymes that break down large molecules. These enzymes can digest food particles to provide nutrients for the cell. They also help recycle materials in the cell by digesting old, damaged, or unused organelles. Lysosomes work by fusing with other vesicles. Lysosomes, made by the Golgi apparatus, prevent the enzymes from destroying the cell.

Why It Matters

Lysosomal Malfunctions Tay-Sachs disease is caused by the deficiency of a lysosomal enzyme that digests lipids. As a result, cells in the brain fill with lipids, eventually causing death. Pompe's disease results when a lysosomal enzyme that breaks down glycogen is absent. Glycogen is the energy storage compound for the body, so it's abundant in muscle. Without the enzyme to break down glycogen, the lysosomes in the heart and skeletal muscle quickly accumulate large amounts of glycogen. These muscles are progressively weakened, especially the heart.

Differentiated Instruction

Basic Learners

What Am I? Have each student choose one cell part or organelle and write a "What Am I?" essay. The essay should be written in the first person and should describe the structure and function of that cell part. Encourage students to be creative in their writing styles. Have students read their essays aloud in class. The class should guess the structure or organelle described in the essay. LS Verbal/Interpersonal

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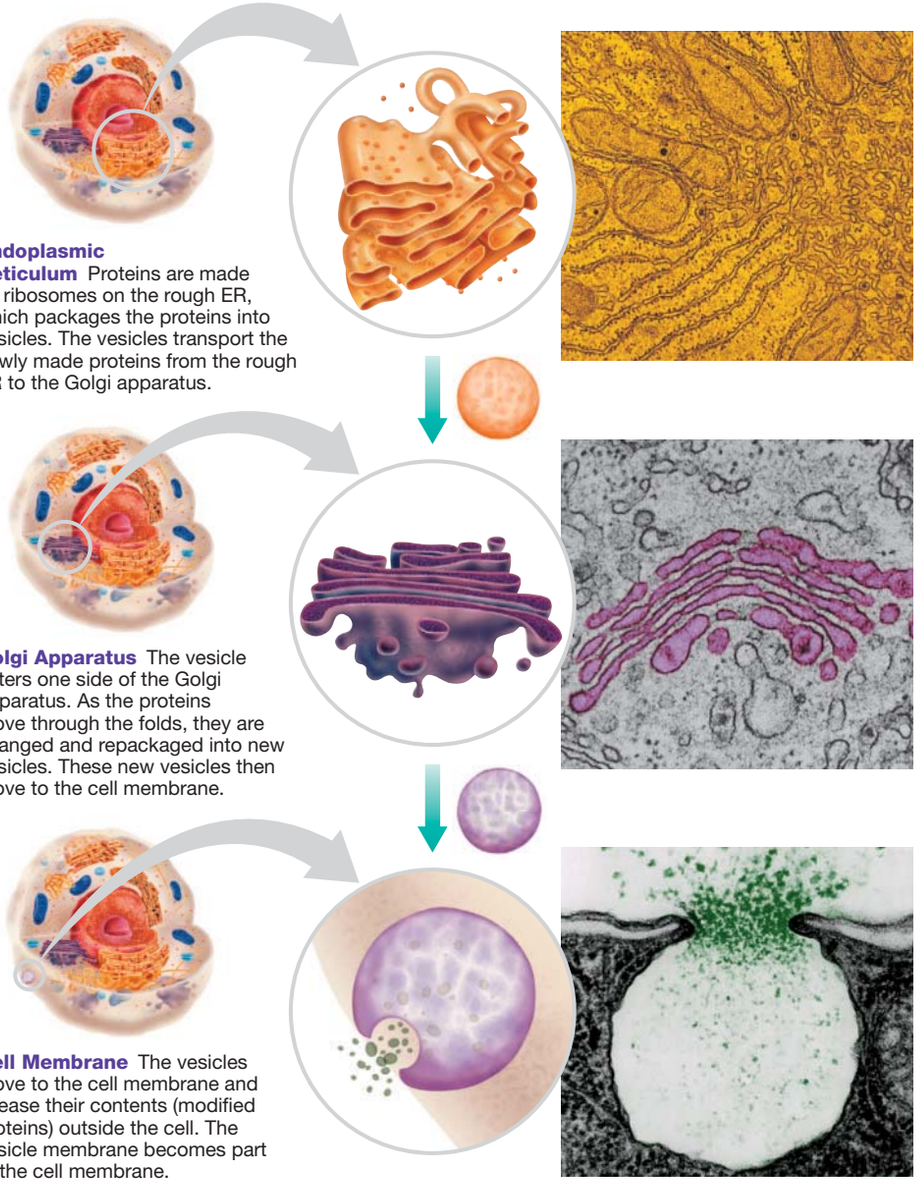
Keyword: HX8CSFF5

Making and Exporting Proteins

Figure 5 The cell manufactures many proteins. Some proteins are used outside the cell that makes them. Many organelles play a role in producing, processing, and packaging these proteins.



1 **Endoplasmic Reticulum** Proteins are made by ribosomes on the rough ER, which packages the proteins into vesicles. The vesicles transport the newly made proteins from the rough ER to the Golgi apparatus.

2 **Golgi Apparatus** The vesicle enters one side of the Golgi apparatus. As the proteins move through the folds, they are changed and repackaged into new vesicles. These new vesicles then move to the cell membrane.

3 **Cell Membrane** The vesicles move to the cell membrane and release their contents (modified proteins) outside the cell. The vesicle membrane becomes part of the cell membrane.

go.hrw.com
interact online

Students can interact with "Making and Exporting Proteins" by going to go.hrw.com and typing in the keyword HX8CSFF5.

Teaching Key Ideas

Visual Literacy Ask students to interpret **Figure 6.** Confirm their understanding of the increasing level of detail at each step of the graphic sequence. Help students relate the 3-dimensional drawings to the 2-dimensional photos. Ask students to identify the organelles involved in the process and the locations in the cell where the process is occurring. (Organelles shown are ribosomes, rough ER, Golgi apparatus, vesicles, and cell membrane. The process starts with the ribosomes on the rough ER, proceeds to the Golgi apparatus, and ends with the release of modified proteins at the cell membrane.) LS Visual

Differentiated Instruction

Basic Learners

3-D Representations Divide the class into three cooperative groups. Assign each group one step of the protein process presented on this page. Ask each group to create a 3-dimensional model on poster board for their portion of the process. Have each group brainstorm ideas for materials that can be used to represent the organelles (twine, small round beads, etc.). Give general size and scale guidelines so that the three panels can be displayed together to create a unified model of the protein process. LS Intrapersonal/ Kinesthetic

Why It Matters

History Connection In 1945, Belgian-American cytologist Albert Claude discovered the endoplasmic reticulum and the detailed structure of mitochondria. Along with Christian de Duve and George E. Palade, Claude was awarded the Nobel Prize in Medicine in 1974 for discoveries of the structural and functional organization of the cell.

Teach, *continued*

QuickLab

Modeling Cell Parts

Teacher's Notes This activity is designed to increase students' understanding the cell's structure and the relationship among some of its parts. Students should imagine the model to be a plant cell.

Materials
- plastic bags with leakproof seals
  - large 1-gallon-size (1)
  - sandwich size (2)
  - jewelry size (2)
- blue food color
- green food color
- adhesive tape, transparent

Answers to Analysis

1. The blue water-filled bag is the central vacuole. The smaller green water-filled bags are chloroplasts. The outer bag represents the cell membrane/wall.
2. The central vacuole pushes against the cell contents (cytosol and chloroplasts) and the cell wall to give the cell its shape.
3. If water is removed from the central bag, there would be less pressure against the outer bag and it would become limp.

Teaching Key Ideas

Chloroplasts Ask students how energy from the sun gets into the food we eat? (sun transfers energy to plants; plants use energy to make food; animals eat plants and obtain energy; we eat animals and plants to obtain this energy) LS Logical

Answers to Caption Questions

Figure 6: Photosynthesis occurs in the chloroplast.

Hands-On

QuickLab

10 min

Cell Parts Model

No space is wasted inside a cell. Packed into the cell are all parts essential to its survival.

Procedure

1. Fill a **sealable plastic sandwich bag** halfway with **tap water.** Add several drops of **blue food dye.** Before you seal the bag, push out any remaining air.
2. Roll this water-filled bag into a cylindrical shape. Use two long strips of **tape** to secure this shape.
3. Fill **two smaller jewelry bags** with water. Before sealing the bags, add several drops of **green food dye** to each bag.
4. Place the large rolled bag and the two smaller jewelry bags into a second **large plastic bag.**
5. Fill this outer bag two-thirds full with water. Push out any remaining air, and seal the bag.

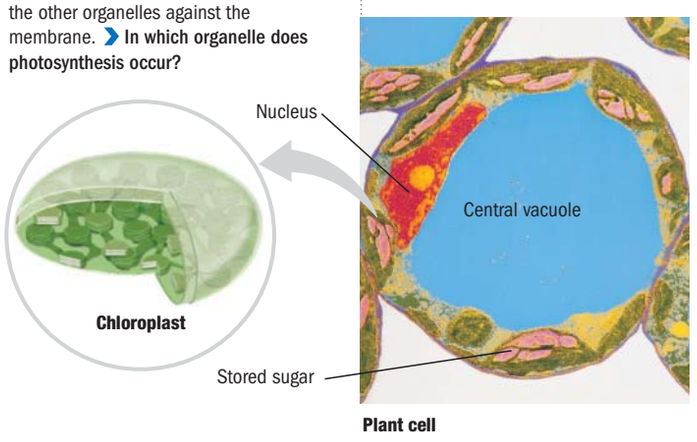
Analysis

1. **State** what each plastic bag in this model represented.
2. **Describe** how the "central vacuole" affects the contents of your cell model.
3. CRITICAL THINKING **Predicting Outcomes** Explain how removing water from the model's central bag might affect the tension and shape of the outer plastic bag.

Central Vacuole Many plant cells contain a large, membrane-bound compartment called the central **vacuole.** This large vacuole stores water, ions, nutrients, and wastes. It can also store toxins or pigments. When water fills the central vacuole, as shown in **Figure 6,** it makes the cell rigid, allowing the plant to stand upright. When the vacuole loses water, the cell shrinks, and the plant wilts.

Other Vacuoles Some protists have contractile vacuoles, which pump excess water out of the cell. This process controls the concentration of salts and other molecules and helps the cell maintain homeostasis. Another type of vacuole forms when the cell membrane surrounds food particles outside the cell and pinches off to form a vesicle inside the cell. When the food vacuole later fuses with a lysosome, the enzymes that digest the stored food are released.

Figure 6 A plant cell may have a large central vacuole and several chloroplasts. When filled, the central vacuole pushes the other organelles against the membrane. ❯ **In which organelle does photosynthesis occur?**



Plant cell

Energy Production

Cells need a constant source of energy. ❯ **The energy for cellular functions is produced by chemical reactions that occur in the mitochondria and chloroplasts.** Nearly all eukaryotic cells contain mitochondria. Chloroplasts are found in plants and some plant-like protists, such as seaweed, but not in animal cells. In both organelles, chemical reactions produce adenosine triphosphate (ATP), the form of energy that fuels almost all cell processes.

Differentiated Instruction

Advanced Learners/GATE

Mitochondria Ask students to speculate on the following questions: "What is the advantage of an infolded mitochondrial membrane?" (Infolding increases the surface area.) "How effective would a mitochondrion be without the folds?" (With less surface area, chemical reactions and ATP production would be affected.) "What might happen to an organism if its mitochondria became only half as efficient?" (Life processes that require energy might not take place, might slow down, or might not be able to sustain themselves.) LS Verbal

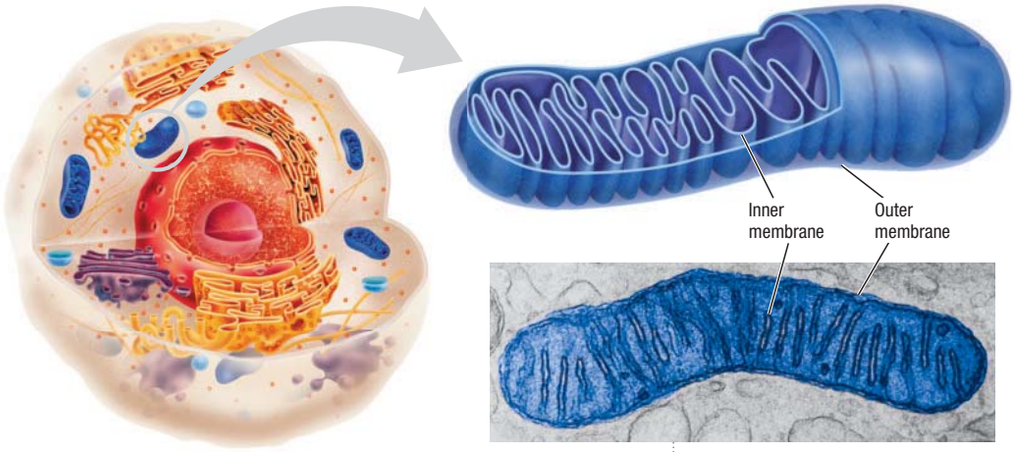


Figure 7 A mitochondrion uses the energy in organic molecules to make ATP for the cell. The mitochondrion has two membranes. **Where in the mitochondrion is ATP produced?**

Chloroplasts A **chloroplast** is an organelle that uses light energy to make sugar from carbon dioxide and water. As **Figure 6** shows, plant cells may have several chloroplasts. Each chloroplast is surrounded by a pair of membranes. Inside the inner membrane are many stacks of flattened sacs. The ATP-producing chemical reactions take place on the membranes of these sacs.

Mitochondria A **mitochondrion** is an organelle that uses energy from organic compounds to make ATP. Although some ATP is made in the cytosol, most of a cell's ATP is made inside mitochondria. Cells that have a high energy requirement, such as muscle cells, may contain hundreds or thousands of mitochondria. As **Figure 7** shows, a mitochondrion has a smooth outer membrane. It also has a greatly folded inner membrane, which divides the organelle into two compartments. Many ATP-producing enzymes are located on the inner membrane.

Reading Check *In what kinds of cells are mitochondria found?*

vacuole (VAK yoo OHL) a fluid-filled vesicle found in the cytoplasm of plant cells or protists

chloroplast an organelle found in plant and algae cells where photosynthesis occurs

mitochondrion (MIET oh KAHN dree uhn) in eukaryotic cells, the cell organelle that is surrounded by two membranes and that is the site of cellular respiration

Section 2 Review

KEY IDEAS

1. **Compare** the functions of the three types of cytoskeletal fibers.
2. **Describe** the nucleus.
3. **Trace** a protein's path through the cell, from assembly to export.
4. **Contrast** vesicles and vacuoles.
5. **Compare** the role of mitochondria and chloroplasts.

CRITICAL THINKING

6. **Constructing Explanations** Is it accurate to say that organelles are floating freely in the cytosol? Why or why not?
7. **Real World** Research Tay-Sachs disease, and explain what goes wrong in diseased cells.

ALTERNATIVE ASSESSMENT

8. **Analogy** Compare the organelles of a eukaryotic cell to the parts of a city. For example, the lysosome could be a recycling center.

Close

Formative Assessment

What is the function of the mitochondria?

A. make carbohydrates (Incorrect. Chloroplasts use the sun's energy, carbon dioxide and water to produce carbohydrates.)

B. make ATP (Correct. The mitochondrion makes ATP, which is important for energy transfer in living things.)

C. make cytoplasm (Incorrect. Mitochondria have no role in cytoplasm formation.)

D. move proteins through the cell (Incorrect. The rough ER, the Golgi apparatus, and vesicles move proteins through the cell.)

MISCONCEPTION ALERT

Mitochondria in Plant Cells Plant cells, as well as animal cells and almost all other eukaryotic cells, contain mitochondria. Some students think that because plants perform photosynthesis, they do not contain mitochondria. However, it is important for students to understand that the products of photosynthesis among other things are used to fuel the manufacture of ATP in the mitochondria. Mitochondrial ATP synthesis takes place in parts of plants that do not undergo photosynthesis, such as the roots, and at night in parts of plants that do undergo photosynthesis, such as the leaves.

Answers to Caption Questions

Figure 7: ATP is produced on the inner membrane.

Answers to Section Review

1. The cell moves and changes its shape by the action of actin microfilaments. Microtubules move molecules to different parts of the cell. Intermediate fibers help anchor organelles and enzymes in certain parts of the cell.
2. A double membrane with many pores surrounds the nucleus. The nucleus contains most of the cell's DNA and a nucleolus, where ribosome parts are made.
3. ribosomes, rough ER, vesicles, Golgi apparatus, vesicles, and cell membrane
4. Vesicles are generally smaller and hold one particular type of molecule. Vacuoles are larger and may hold a variety of different substances.
5. Both mitochondria and chloroplasts are the sites of chemical reactions that produce ATP, the energy currency of cells.
6. Organelles exist within the network of protein fibers that make up the cytoskeleton. This restricts their movement.
7. Nerve cells in affected children accumulate high levels of a glycolipid called ganglioside. The condition results from a missing lysosomal enzyme. The lysosomes of these cells fill with fragments of membranes that contain the undigested ganglioside causing nerve cells to not function. As a result, affected children have mental deterioration, paralysis, and will die within three years.
8. Answers will vary. Sample answer: the mitochondria could be electrical power plants.

Section 3

Section 3 From Cell to Organism

Key Ideas	Key Terms	Why It Matters
What makes cells and organisms different? How are cells organized in a complex multicellular organism? What makes an organism truly multicellular?	flagellum, tissue, organ, organ system, colonial organism	Diverse organisms have unique cells and cellular organization.

Focus

This section introduces students to cellular organization from a single cell to multicellular organisms.

Bellringer

Use the Bellringer transparency to prepare students for this section.

Teach

Why It Matters

Diversity Using either slides or micrographs, provide the students with a variety of different cell types. Include bacteria, protists, yeast, animal, and plant cells with an assortment of specialized cells. Have students group the cells based on criteria of their own choosing. Ask students to explain the reasoning behind their choices.

READING TOOLBOX

Fold Notes Ask students to vertically fold a piece of notebook paper in half. Have them label one side *prokaryote* and the other *eukaryote.* As they read the section, tell them to list the structures found in each type of cell followed by their function. LS Logical/Visual

Answers to Caption Questions

Figure 8: Flagella allow prokaryotes to move through their environment.

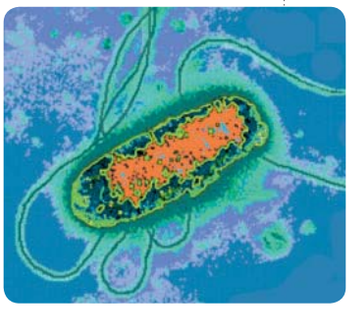
More than 50 million types of organisms live on Earth. Each organism is made up of different types of cells. Differences in cells enable organisms to adapt to their natural environments.

Diversity in Cells

Prokaryotes are always unicellular and limited in size. Eukaryotes are often larger and can be either unicellular or multicellular. Prokaryotic cells lack a nucleus and membrane-bound organelles, which are found in eukaryotic cells. Within both types, cells can have a variety of shapes and structures. Recall that a cell's shape reflects its function. **The different organelles and features of cells enable organisms to function in unique ways in different environments.**

Diversity in Prokaryotes Prokaryotes can vary in shape, the way that they obtain and use energy, the makeup of their cell walls, and their ability to move. Many prokaryotes have **flagella**—long, threadlike structures that rotate to quickly move an organism through its environment. Many prokaryotes have pili. Pili are short, thick outgrowths that allow prokaryotes to attach to surfaces or to other cells. These features are shown in **Figure 8.**

flagellum a long, hairlike structure that grows out of a cell and enables the cell to move



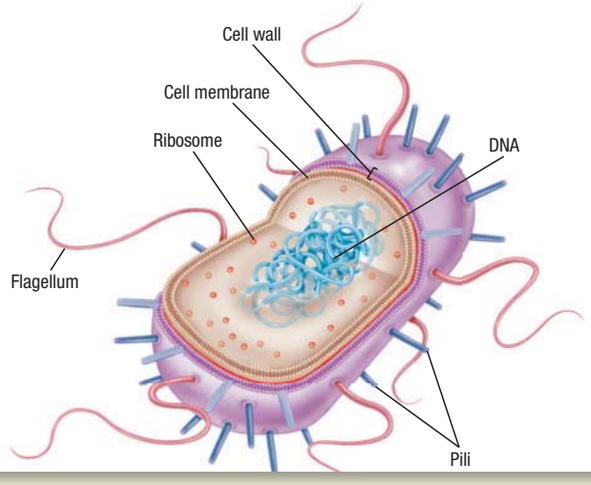


Figure 8 The bacterium *Escherichia coli* is a rod-shaped prokaryote that has both pili and flagella. **What do flagella enable prokaryotic cells to do?**

Key Resources

Transparencies
B4 Animal Cells

Visual Concepts
Structure of Cilia and Flagella
Comparing Prokaryotes and Eukaryotes
Parts of an Animal Cell
Comparing Plant and Animal Cells
Parts of a Plant Cell

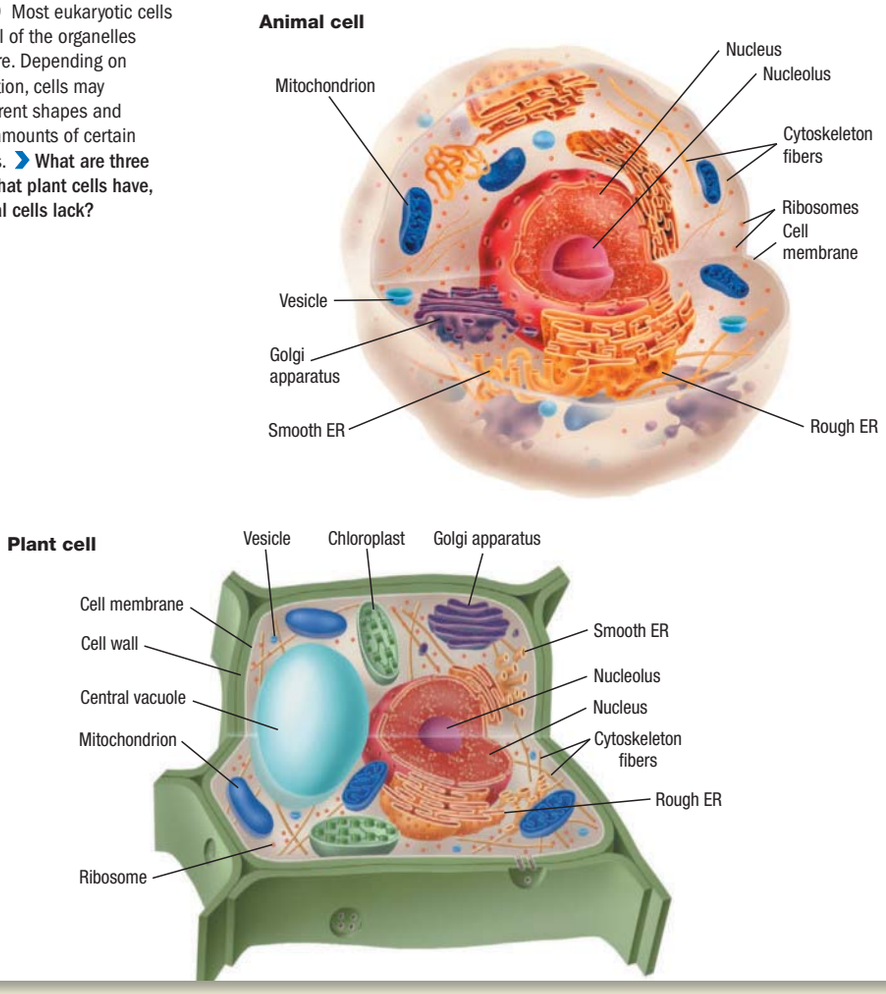
Diversity in Eukaryotic Cells Animal and plant cells are two types of eukaryotic cells, as **Figure 9** shows. Both have many of the same organelles, but plant cells also have chloroplasts, a large central vacuole, and a cell wall that surrounds the cell membrane.

Like prokaryotic cells, eukaryotic cells vary in structure according to their function. Also, some organelles are more prominent in some cell types. By varying in their internal makeup, cells can become specialized for certain functions. For example, muscle cells, which use large amounts of energy, have many mitochondria.

Reading Check *What are flagella?*

Eukaryotic Cells

Figure 9 Most eukaryotic cells contain all of the organelles shown here. Depending on their function, cells may have different shapes and different amounts of certain organelles. **What are three features that plant cells have, but animal cells lack?**



Differentiated Instruction

English Learners

Reading Organizer After students have read about prokaryotes and eukaryotes, ask them design a chart that identifies and describes all of the differences between the two cell types. Encourage ELL students to work with native English speakers. LS Logical

Why It Matters

Endosymbiosis This theory holds that prokaryotes lived in association with other cells but lost their ability to reproduce independently and became organelles of today's eukaryotes. Scientists think that chloroplasts evolved from endosymbiotic photosynthetic bacteria and mitochondria evolved from endosymbiotic aerobic bacteria. This theory is supported by the fact that both chloroplasts and mitochondria have their own DNA and can be inactivated with antibiotics that affect prokaryotes but not eukaryotes.

Teach, continued

Teaching Key Ideas

Visual Literacy Explain that **Figure 11** shows only a few of the microtubules and microfilaments in a cell. In reality, these structures form the dense network, or cytoskeleton, of the cell. Ask students to compare the structures in each cell. What structures found in the plant cell are not in the animal cell? (chloroplasts, central vacuole and cell wall) Ask students to name human cells that have specialized structures to carry out their functions. (Sample answers: Muscle cells have increased numbers of mitochondria for increased ATP production. Sperm cells have tails for mobility.) LS Visual

Answers to Caption Questions

Figure 9: Cell wall, central vacuole, and chloroplasts

Teach, *continued*

READING TOOLBOX

Similes Cells in a multicellular organism are like letters on a written page. Cells form tissues like a group of letters forms a word. Groups of words create a sentence like tissues combine to form organs.

Teaching Key Ideas

Respiratory Systems Help students understand the gas exchange process for plants and animals. The leaf tissue shown in **Figure 12** contains cells that take in carbon dioxide and give off oxygen in the light. For humans, the alveolar cells of the lung are the sites of oxygen/carbon dioxide exchange. The lungs are connected to the bronchi and trachea which allow gases to enter and leave the lungs. LS Visual

Answers to Caption Questions

Figure 10: The respiratory system is an organ system.

Levels of Organization

Multicellular organisms, such as plants and animals, are made up of thousands, millions, or even trillions of highly specialized cells. These cells cooperate to perform a specific task. They assemble together to form structures called tissues and organs. **Plants and animals have many highly specialized cells that are arranged into tissues, organs, and organ systems.** The relationships between tissues, organs, and organ systems are shown in **Figure 10.**

READING TOOLBOX

Similes Write a simile comparing each level of organization to a part of your textbook. (Hint: Cells are like letters.)

Tissues A **tissue** is a distinct group of cells that have similar structures and functions. For example, muscle tissue is a group of many cells that have bundles of cytoskeletal structures. When the bundles contract at the same time, they help animals move. In plants, vascular tissue is made of hollowed cells that are stacked up to make tiny straws. These structures help carry fluids and nutrients to various parts of the plant.

Organs Different tissues may be arranged into an **organ,** which is a specialized structure that has a specific function. In animals, the heart is an organ made of muscle, nerve, and other tissues. These tissues work together to pump blood. In plants, a leaf is an organ. A leaf is made of vascular tissue and other types of plant tissues that work together to trap sunlight and produce sugar.

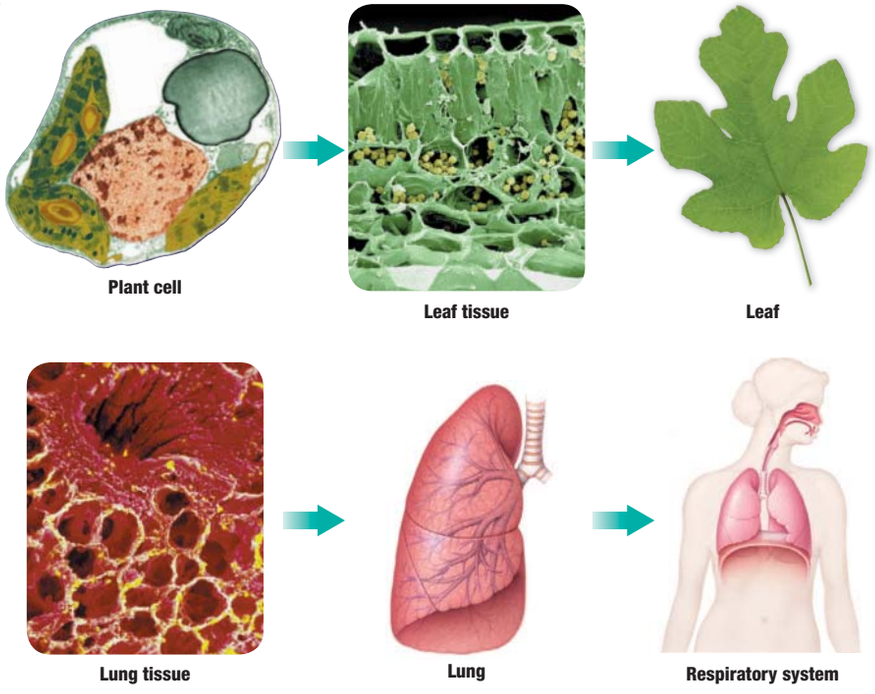


Figure 10 Cells group together to make tissues, which assemble into organs. A leaf is an example of an organ in plants. A lung is an example of an organ in animals. **What level of organization is the respiratory system?**

Why It Matters

Career Development *Cytotechnologists* stain, mount, and study cells to detect malignancies or other abnormal conditions. Invite a *cytotechnologist* from a local hospital to talk to your class. Ask him or her to discuss recommended high school courses, working conditions, employment opportunities, and salary ranges.

A *cytotechnologist* must be able to obtain precise results and work under stress during emergency situations. An undergraduate degree in *cytotechnology* or medical technology is usually needed for entry level positions.

Differentiated Instruction

Basic Learners

Body Systems Have students research a human body system: digestive, respiratory, circulatory, excretory, nervous, or skeletal. Ask them to find the corresponding system in plants. Students should create a poster comparing the two systems. LS Visual/ Verbal

Hands-On

QuickLab

10 min

Colonies on the Move

Volvox is a green colonial alga. A single colony may contain over 500 cells and is visible to the unaided eye.

Procedure

1. With the unaided eye, examine a container of Volvox colonies. What do you see?
2. Use a dropper to transfer some of the colonies to a well slide.
3. Examine the colonies using a light microscope.

Analysis

1. **Draw** the shape and structure of Volvox.
2. **Describe** the motion of a Volvox colony.
3. CRITICAL THINKING **Inferring Relationships** From your observations, do you think that the movements of the colony members are coordinated? Explain.

Organ System Various organs that carry out a major body function make up an **organ system.** One example of an organ system is the circulatory system, which is made up of the heart, the blood vessels, and blood. In plants, the shoot system consists of stems, leaves, and the vascular tissue that connects them.

Body Types

Sometimes, the entire body of an organism is made up of a single cell. This cell must carry out all of the organism's activities, including growing, using energy, responding to the environment, and reproducing. More than half of the biomass on Earth is composed of unicellular organisms.

While single cells cannot grow larger than a certain size, multicellular organisms can be large. **A multicellular organism is composed of many individual, permanently associated cells that coordinate their activities.** Distinct types of cells have specialized functions that help the organism survive. Individual cells cannot survive alone and are dependent on the other cells of the organism.

Cell Groups Some unicellular organisms can thrive independently, but others live in groups. Cells that live as a connected group but do not depend on each other for survival are considered **colonial organisms.** For example, the cell walls of some bacteria adhere to one another after dividing. These formations are not considered multicellular, because the cells can survive when separated.

Another type of cell grouping occurs in certain types of slime molds. These organisms spend most of their lives as single-celled amoebas. When starved, the individual cells form a large mass, which produces spores.

tissue a group of similar cells that perform a common function

organ a collection of tissues that carry out a specialized function of the body

organ system a group of organs that work together to perform body functions

colonial organism a collection of genetically identical cells that are permanently associated but in which little or no integration of cell activities occurs

SCILINKS
www.scilinks.org
Topic: Organ Systems
Code: HX81075

Differentiated Instruction

Advanced Learners

Behavior of Cell Colonies Ask students to research *Volvox* or another colonial organism on the Internet. Ask them to find out what scientific research has been done with the organism. They should review at least four sites and record the information they gather. Have them look for discrepancies in the information among the sites and record the source for each. Have students give oral reports to the class.

LS Logical/ Verbal

Why It Matters

Cryogenics Donated blood is frozen in a special process called cryopreservation. Similar methods are used to preserve human eggs, embryos, and blood from the umbilical cord, a rich source of immune-system cells. The cells are frozen very quickly, which prevents the formation of large ice crystals that would damage the cells.

Teach, *continued*

QuickLab

Teacher's Notes *Volvox* is a green algae that exists as a spherical colony. Individual alga are connected to each other by thin strands of cytoplasm. Each alga has two whip-like flagella that aid in movement of the colony. Each alga also has a red eye spot that is sensitive to light. The colony will move in water to find a spot for the maximum absorption of sunlight.

Materials
- *Volvox* colonies
- medicine dropper
- microscope slide with well
- low-powered compound microscope

Answer to Procedure

Volvox will appear as little green dots in the sample.

Answers to Analysis

1. Drawings should be spherical shapes and may contain smaller spheres inside the larger one.
2. A *Volvox* colony moves with a spinning motion.
3. Movement of the colony appears to be coordinated as the colony moves toward light.

Close

Formative Assessment

Eukaryotic cells vary in structure according to their function. An example of a characteristic of a eukaryotic cell that relates closely to the cell's function is ____.

A. a bacterial cell wall providing support for the cell (Incorrect. A bacterium is a prokaryote.)

B. the trachea aiding in the exchange of gases in the lungs (Incorrect. The trachea is part of an organ system.)

C. muscle cells having an elongated shape (Correct. The cells combine to form fiber bundles, which provide strength to the muscle.)

D. plant cells containing a nucleus (Incorrect. Most eukaryotic cells contain a nucleus, so it is not a special feature.)

Answers to Caption Questions

Figure 11: Prokaryotes are never multicellular.

Protist

Plant

Fungus

Animal

Figure 11 The giant kelp is a multicellular protist. Mushrooms are multicellular fungi. All plants and animals are multicellular organisms. **Can prokaryotes be multicellular?**

Multicellularity True multicellularity occurs only in eukaryotes, such as the organisms shown in **Figure 11.** Some protists, most fungi, and all plants and animals have a multicellular body. The cells of a multicellular body perform highly specific functions. Some cells protect the organism from predators or disease. Others may help with movement, reproduction, or feeding.

Most multicellular organisms begin as a single cell. For example, as a chicken develops from an egg, new cells form by cell division. These cells then grow and undergo differentiation, the process by which cells develop specialized forms and functions. The specialized cells are arranged into tissues, organs, and organ systems, making up the entire organism.

Reading Check *What is differentiation?*

Section 3 **Review**

KEY IDEAS

1. **Relate** the structure of a cell to the cell's function.
2. **Describe** the four levels of organization that make up an organism.
3. **Explain** what makes a group of cells a truly multicellular organism.

CRITICAL THINKING

4. **Comparing** Describe how the circulatory system in animals is similar to the vascular system in plants.
5. **Making Inferences** How would the formation of bacterial colonies be affected if bacterial cells did not contain pili?

WRITING FOR SCIENCE

6. **Cell Group Therapy** Write a short play set in a therapy group that contains cells belonging to a unicellular colony and cells belonging to a multicellular organism. Have the cells discuss issues such as communication and individuality.

Answers to Section Review

1. The structure of the cell is determined by its shape, the organelles within the cell, and the features on its surface. The function of a cell determines its structure.
2. Cells of similar structure make up tissues. Tissues are arranged to form organs. Organs work together to form organ systems.
3. The specialized cells of a multicellular organism are interdependent and cannot survive individually when separated from the rest of the organism.
4. Both systems move water, nutrients, and dissolved gases to cells in every part of each organism.
5. Without pili, the formation of bacterial colonies might not be possible.
6. The cells of a colony would be self-sufficient, with little or no communication with other cells. They would all look the same and perform the same functions. The cells of a multicellular organism would look different and have unique features and perform highly specialized functions. The cells would be communicating constantly. If an individual cell separated from the organism, it would probably die.

Inquiry

Chapter 7 Lab

45 min

Objectives

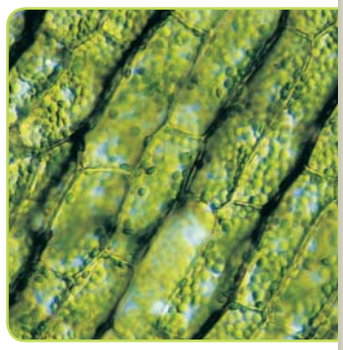
- Identify the structures that you can see in plant cells.
- Investigate factors that influence the movement of cell contents.

Materials

- compound light microscope
- elodea sprig
- forceps
- microscope slides and coverslips
- lamp, incandescent
- dropper bottle of Lugol's iodine solution

Safety

Plant Cell Observation



When you look at cells under a microscope, you often can observe cytoplasmic streaming, or movement of cell contents. This effect occurs only in living cells. In this lab, you will investigate factors that influence cytoplasmic streaming.

Preparation

1. SCIENTIFIC METHODS **State the Problem** How do heat and an iodine solution influence cytoplasmic streaming?
2. SCIENTIFIC METHODS **Form a Hypothesis** Form testable hypotheses that explain how heat and iodine influence cytoplasmic streaming.

Procedure

1. Put on safety goggles, gloves, and a lab apron.
2. **CAUTION: Handle glass slides and coverslips with care.** Using forceps, remove a small leaf near the top of an elodea sprig. Place the whole leaf in a drop of water on a slide, and add a coverslip.
3. Observe the leaf under low power. Switch to high power.
4. Focus on a cell in which you can see the chloroplasts clearly. Draw this cell. Label the cell parts that you can see.
5. If chloroplasts are not moving in any of the cells, briefly warm the slide under a lamp. Look for movement again under high power.
6. **CAUTION: Lugol's solution is toxic and stains skin and clothing. Promptly wash off spills.** Make a wet mount of another leaf with Lugol's iodine solution. Observe the cells under low and high power.
7. Draw a stained elodea cell and label all visible parts.
8. Clean up your lab materials according to your teacher's instructions. Wash your hands before leaving the lab.

Analyze and Conclude

1. **Inferring Relationships** What effect did warming the slide have on the movement of cell contents? Why do you think this is so?
2. SCIENTIFIC METHODS **Inferring Conclusions** What can you conclude about the effect of Lugol's iodine solution on plant cells?

Answers to Procedure

Drawings will vary. For the stained cells, make sure students label the cell wall, cell membrane, chloroplasts, central vacuole, nucleus, and any other visible cell structures.

Answers to Analyze and Conclude

1. Warming the slide caused the cell contents to move more. Possible reasons for this may vary.
2. The chloroplasts stop moving. This suggests that the iodine solution kills the plant cells.

Lab

Time Required

One 45-minute lab period

Ratings

EASY → HARD

Teacher Prep	
Concept Level	
Student Set-Up	
Clean Up	

Safety Cautions

Review all safety symbols and caution statements before beginning the lab. Students must wear safety goggles when working with Lugol's iodine solution because iodine can cause severe eye damage. Lugol's iodine is harmful if swallowed. Avoid breathing vapors. Do not use or store near ammonia.

Tips and Tricks

Set up labeled containers for the disposal of broken glass and materials stained with Lugol's solution. Place enough materials for one class on a supply table. Allow students to take off their safety goggles when looking through the microscope. Have students use a scale of 1 μm = 1 cm when drawing cells. Help students take measurements of cell size.

Disposal Combine all wastes containing Lugol's solution. To this mixture add a few drops of a strong acid, such as 1.0 M sulfuric acid (H_2SO_4), to make the mixture slightly acidic. Then slowly add 0.1 m sodium thiosulfate ($Na_2S_2O_3$) while stirring until the mixture loses its yellowish-orange color. Pour the resulting mixture down the drain.

Key Resources

- Holt Lab Generator
- Lab Datasheet (Levels A, B, C)
- Holt Science Biology Video Labs
- Virtual Investigations

Chapter 7

SUPER SUMMARY

Have students connect the major concepts in this chapter through an interactive Super Summary. Visit **go.hrw.com** and type in the keyword **HX8CSFS** to access the Super Summary for this chapter.

Reteaching Key Ideas

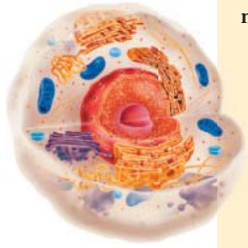
Organelles Pass out copies of electron micrographs of cells. Ask each student to choose three cell organelles, and color them with different colors. Students should name the organelles and describe what each does within the cell. LS Verbal/Visual

Prokaryotes and Eukaryotes Divide the class into two cooperative groups. Group A represents a prokaryotic cell and group B represents a eukaryotic cell. Have each group take turns describing a characteristic of their cell or something that their cell is able to do. Write the responses on the board. Give the other group an opportunity to challenge the responses. LS Interpersonal/Verbal

Chapter 7 Summary

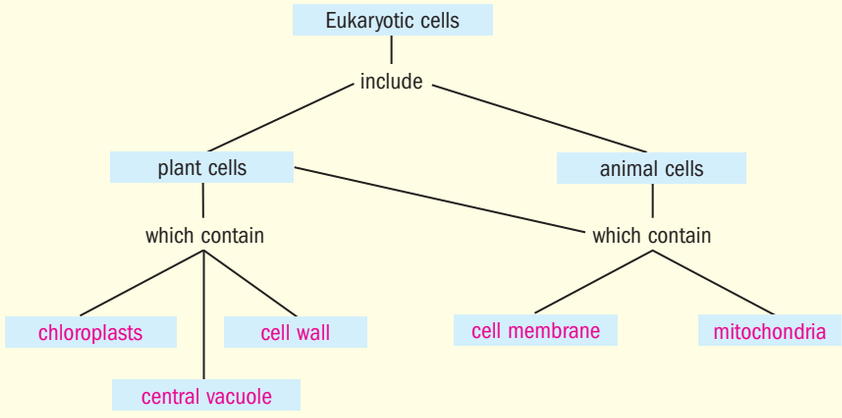
go.hrw.com
SUPER SUMMARY
Keyword: HX8CSFS

Key Ideas	Key Terms
1 Introduction to Cells › Microscope observations of organisms led to the discovery of the basic characteristics common to all living things. › A cell's shape reflects the cell's function. Cell size is limited by a cell's surface area–to-volume ratio. › Because of their complex organization, eukaryotic cells can carry out more specialized functions than prokaryotic cells can.	**cell membrane** (154) **cytoplasm** (154) **ribosome** (154) **prokaryote** (154) **eukaryote** (155) **nucleus** (155) **organelle** (155)
2 Inside the Eukaryotic Cell › The cytoskeleton helps the cell move, keep its shape, and organize its parts. › DNA instructions are copied as RNA messages, which leave the nucleus. In the cytoplasm, ribosomes use the RNA messages to assemble proteins. › The endoplasmic reticulum and the Golgi apparatus are organelles that prepare proteins for extracellular export. › Vesicles help maintain homeostasis by storing and releasing various substances as the cell needs them. › The energy for cellular functions is produced by chemical reactions that occur in the mitochondria and chloroplasts.	**vesicle** (158) **endoplasmic reticulum** (158) **Golgi apparatus** (158) **vacuole** (160) **chloroplast** (161) **mitochondrion** (161)
3 From Cell to Organism › The different organelles and features of cells enable organisms to function in unique ways in different environments. › Plants and animals have many highly specialized cells that are arranged into tissues, organs, and organ systems. › A multicellular organism is composed of many individual, permanently associated cells that coordinate their activities.	**flagellum** (162) **tissue** (164) **organ** (164) **organ system** (165) **colonial organism** (165)



Answer to Concept Map

The following is one possible answer to Chapter Review question 2.



Chapter 7 Review

READING TOOLBOX

1. **Word Families** The prefix *cyto-* means "cell." Find three words in this chapter that belong to this family, and write a definition for each word.
2. **Concept Map** Make a concept map that compares plant cells with animal cells. Include the following terms in your concept map: *cell membrane, cell wall, central vacuole, chloroplasts,* and *mitochondria.*

Using Key Terms

3. Use the following terms in the same sentence: *prokaryote, eukaryote,* and *nucleus.*

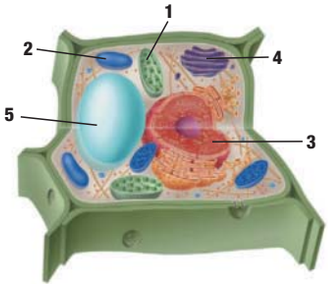
For each pair of terms, explain how the meanings of the terms differ.

4. *organelle* and *organ*
5. *tissue* and *colonial organism*

Understanding Key Ideas

6. The maximum size of a cell is determined by the ratio of the cell's
   a. volume to organelles.
   b. cytoplasm to nucleus.
   c. surface area to volume.
   d. cytoplasm to organelles.
7. What four features do prokaryotic and eukaryotic cells share?
   a. cytoplasm, nucleus, ribosomes, vesicles
   b. DNA, nucleus, ribosomes, mitochondria
   c. nucleus, vesicles, mitochondria, cell membrane
   d. DNA, cytoplasm, ribosomes, cell membrane.
8. What makes up the cytoskeleton?
   a. bones **c.** proteins
   b. flagella **d.** cellulose
9. The function of ribosomes is to
   a. copy DNA. **c.** organize the nucleus.
   b. assemble proteins. **d.** store genetic material.
10. Which specialized structures allow prokaryotes to move quickly through their environment?
    a. pili **c.** flagella
    b. nuclei **d.** mitochondria
11. Which of the following best describes an organ?
    a. a body structure, such as an arm or a leg
    b. a group of cells that have a similar structure
    c. a group of tissues that belong to different systems
    d. a group of tissues that work together to perform a specific job

Use the diagram to answer the following question(s).



12. Which structure helps modify proteins?
    a. structure 1 **c.** structure 3
    b. structure 2 **d.** structure 4
13. What is structure 5?
    a. vacuole **c.** ribosome
    b. nucleus **d.** chloroplast

Explaining Key Ideas

14. **Describe** two observations of early scientists that support the cell theory.
15. **Describe** how the structure of membranes in chloroplasts and mitochondria contributes to the function of these organelles.
16. **Propose** why muscle cells have more mitochondria than other kinds of eukaryotic cells do.
17. **List** four ways in which prokaryotic cells may vary.
18. **Explain** how a unicellular organism and a multicellular organism differ in the way life processes are carried out by an individual cell.

Assignment Guide

Section	Questions
1	1, 3, 4, 6, 7, 14, 19, 20, 26, 27, 29, 32, 33, 34
2	1, 2, 8, 9, 12, 13, 15, 16, 21, 22, 23, 24, 25, 26
3	2, 4, 5, 10, 11, 16, 17, 18, 26, 28, 30, 31, 32, 33, 34

Review

Reading Tool Box

1. cytoplasm–the region of the cell within the membrane; cytosol–the fluid inside of the cell, not including the organelles; cytoskeleton–the web of protein fibers that support the cell
2. See previous page for answer to concept map.

Using Key Terms

3. A *eukaryote* differs from a *prokaryote* in that most eukaryotic cells have a *nucleus.*
4. An *organelle* is a structure inside a cell that performs a specific function for the cell. An *organ* is made of cells and tissues, and performs a specific function for the organism.
5. A *tissue* is a group of similar cells that perform a common function. A *colonial organism* is a collection of genetically identical cells that do not coordinate their activities.

Understanding Key Ideas

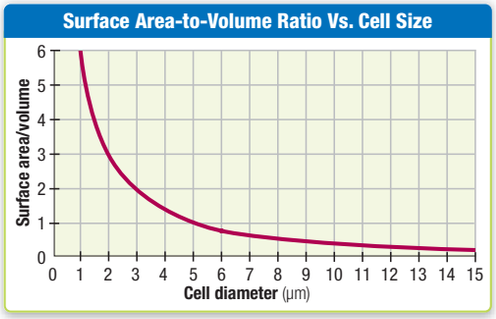
6. c 7. d 8. c 9. b
10. c 11. d 12. d 13. a

Explaining Key Ideas

14. All living things are made of cells. Cells are the basic units of structure and function in living things. Cells arise only from other cells. Schleiden found all plants to be made of cells; Schwann made a similar observation for animals.
15. Chloroplasts and mitochondria both have an inner membrane that is greatly folded. ATP-producing enzymes are located on the folds of the inner membrane. Because the membrane is greatly folded, it can hold many of these enzymes, and the organelle can therefore produce large amounts of ATP.
16. Muscle cells require a great deal of energy (ATP), which is supplied mainly by mitochondria.
17. Prokaryotes may vary in shape, the way they obtain and use energy, the makeup of their cell walls, and their ability to move.
18. A unicellular organism must perform all life functions itself. A multicellular organism has specialized cells to carry out different functions. A single cell of a multicellular organism may be too specific to carry out all life processes individually.

Using Science Graphics

This graph shows the relationship between cell size and surface area–to-volume ratio. Use the graph to answer the following question(s).



19. By what percentage does the surface area–to-volume ratio change when a cell grows from 1 μm to 2 μm in diameter?

a. 10 percent **c.** 50 percent
b. 20 percent **d.** 90 percent

20. What is the maximum diameter that this cell could reach before the surface area–to-volume ratio would fall below 1?

a. 2 μm **c.** 10 μm
b. 5 μm **d.** 15 μm

Critical Thinking

21. Making Connections Connective tissue in the human body holds organs in place. Which structure within a cell is similar to connective tissue?

22. Predicting Outcomes What would happen if the nuclear pores of the cell became blocked?

23. Constructing Explanations Some ribosomes are bound to rough ER, while other ribosomes float freely in the cytoplasm. How would the products of these two types of ribosomes likely differ in appearance, and why?

24. Making Comparisons Compare and contrast the functions of the endoplasmic reticulum and the Golgi apparatus.

25. Explaining Relationships Describe how a food vacuole and lysosome work together to capture and digest food.

26. Comparing Functions Identify the structural elements that hold the shape of a prokaryotic cell, an animal cell, and a plant cell.

27. Applying Information Drugs that rid the body of eukaryotic parasites often have more side effects and are harder on the body than drugs that act on bacterial parasites. Suggest a reason for this difference.

28. Evaluating Hypotheses One of your classmates states a hypothesis that all organisms must have organ systems. Is your classmate's hypothesis valid? Explain your answer.

Methods of Science

29. Technology Explain how the development of the microscope has contributed to the study of biology. Describe how the discovery of cells led to the advancements in technology.

Alternative Assessment

30. Owner's Manual Pick an organ system in the human body. Draw a poster that shows the levels of organization. Write an owner's manual explaining what each part is and how the parts fit together.

31. Advertisement Imagine that you have the ability to convert unicellular organisms into multicellular organisms. Make an advertisement that sells your service to unicellular organisms. Be sure to include at least three advantages of being multicellular.

Math Skills

Volume Suppose that a cube-shaped multicellular organism exists. Each of its cells is a cube that has a volume of 1 cm^3. Each side of the organism is 3 cm long.

32. What is the total volume of this organism?

33. How many cells does this organism have?

34. If each side of the organism doubles in length, how many 1 cm^3 cells will the organism have?

Using Science Graphics

19. c **20.** b

Critical Thinking

21. cytoskeleton *intermediate fibers*

22. The cell would die because mRNA would not be able to pass into the cytoplasm.

23. The products of ribosomes bound to rough ER would be enclosed in a vesicle, while the products of unbound ribosomes would not be.

24. The ER moves proteins to the Golgi apparatus. The Golgi modifies those proteins then moves them to other parts of the cell.

25. A food vacuole is a vesicle containing food particles. A lysosome is a vesicle that contains digestive enzymes. When the membranes of both vesicles fuse, their contents mix and the digestive enzymes break down the food particles into nutrients for the cell.

26. The cell wall holds the shape of a prokaryotic cell. The cytoskeleton helps an animal cell maintain its shape. The cytoskeleton, central vacuole, and cell wall help a plant cell maintain its shape.

27. Antibiotics can kill bacterial cells without harming human cells. Drugs that kill eukaryotic parasites may also harm eukaryotic human cells.

28. not valid; unicellular organisms have no tissues, organs, or organ systems

Methods of Science

29. Microscope technology helped identify the basic unit of living things. It also helped determine the microstructure of the cell and the functions of organelles.

Alternative Assessment

30. Organs in the digestive system would include the stomach and intestines. These organs are made up of tissues, such as muscle tissue and nerve tissue. Muscle tissue is made of cells that can contract and expand to produce movement. Nerve tissue is made up of cells with long extensions that can send electrical impulses.

31. Cell specialization allows some cells to concentrate on digestion while others do respiration or circulation. This allows each cell to function at maximum efficiency. A multicellular organism may grow larger than a unicellular organism. Size can be an advantage in a prey predator scenario. The death of one cell in a multicellular organism does not mean the death of the organism.

Math Skills

32. 3 cm × 3 cm × 3 cm = 27 cm^3.

33. 27 cm^3/1 cm^3 = 27 cells.

34. If each side doubles in length, the organism will have 216 cells (6 cm × 6 cm × 6 cm = 216 cm^3

216 cm^3/1 cm^3 = 216 cells). Students struggling with this question should review the math skills feature and text in section 7.1.

Chapter 7 Standardized Test Prep

TEST TIP When possible, use the text in the test to answer other questions. For example, use a multiple-choice answer to "jump-start" your thinking about another answer.

Science Concepts

1. The discovery of cells is linked most directly with
- **A** the development of the microscope.
- **B** early investigations of causes of disease.
- **C** observations of large, unicellular organisms.
- **D** efforts to reproduce organisms in the laboratory.

2. Eukaryotic cells differ from prokaryotic cells in that eukaryotic cells
- **F** have a nucleus.
- **G** lack organelles.
- **H** lack ribosomes.
- **J** have a cell wall.

3. Which organelle produces proteins that are exported from the cell?
- **A** nucleolus
- **B** rough ER
- **C** free ribosome
- **D** bound ribosome

4. Which structure helps a plant stand upright?
- **F** lysosome
- **G** chloroplast
- **H** central vacuole
- **J** contractile vacuole

5. Ribosome : protein synthesis :: mitochondria :
- **A** cell support
- **B** energy release
- **C** nutrient storage
- **D** protein transport

6. Tissues are composed of distinct types of
- **F** cells.
- **G** organs.
- **H** organelles.
- **J** cytoskeleton fibers.

7. The process by which cells become specialized in form and function during development is called
- **A** association.
- **B** aggregation.
- **C** coordination.
- **D** differentiation.

Math Skills

8. Proportions The Dutch scientist Anton van Leeuwenhoek used a microscope that made objects appear 300 times as large as they were. If a cell appeared to be 6 mm long under the microscope, how long was the cell in real life?
- **F** 0.02 mm
- **G** 0.20 mm
- **H** 0.05 mm
- **J** 0.50 mm

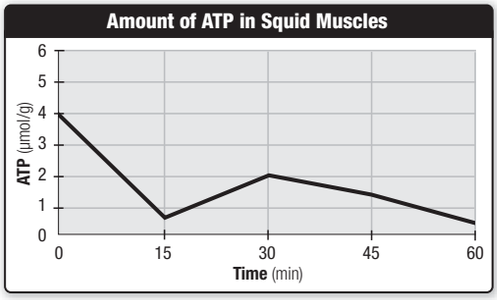
Using Science Graphics

Use the diagram of the cell to answer the following question(s).

9. What is structure 1?
- **A** pilum
- **B** cilium
- **C** flagellum
- **D** mitochondrion

10. What is the function of structure 1?
- **F** to make ATP
- **G** to grab food
- **H** to store energy
- **J** to move the cell

This graph shows the amount of ATP in the muscles of a squid after the squid had been exposed to low oxygen concentrations. Use the graph to answer the following question(s).



11. At what time during the experiment were the mitochondria in the squid's muscles producing the most energy?
- **A** 0 minute
- **B** 15 minutes
- **C** 30 minutes
- **D** 45 minutes

State Resources

For specific resources for your state, visit go.hrw.com and type in the keyword **HSHSTR**.

Test Practice with Guided Reading Development

Answers

1. A	**2.** F	**3.** D
4. H	**5.** B	**6.** F
7. D	**8.** F	**9.** C
10. J	**11.** A	

TEST DOCTOR

Question 2 When considering this question, the word *differ* is important. Because both eukaryotic and prokaryotic cells may have cell walls, **J** is incorrect. Eukaryotic cells contain ribosomes, organelles, and a nucleus which make **G** and **H** incorrect, and make **F** the correct choice.

Question 5 The analogy, ribosome is to protein synthesis, highlights the relationship between an organelle and its function. The function of mitochondria is in energy production. **A, C,** and **D** are incorrect for this reason. **B** is the correct answer.

Question 7 **A** is incorrect because an association is a relationship between two things. **B** is incorrect because an aggregation is a cluster of something, such as cells. **C** is incorrect because coordination is the manifestation of communication between two entities and can occur in living things. Differentiation is the process by which cells become specialized in form and function, therefore **D** is the correct answer.

Question 11 The vertical axis of the graph shows that 4 µmol/g of ATP is the highest level produced. The horizontal axis shows that this took place at 0 minutes. Therefore **A** is correct.