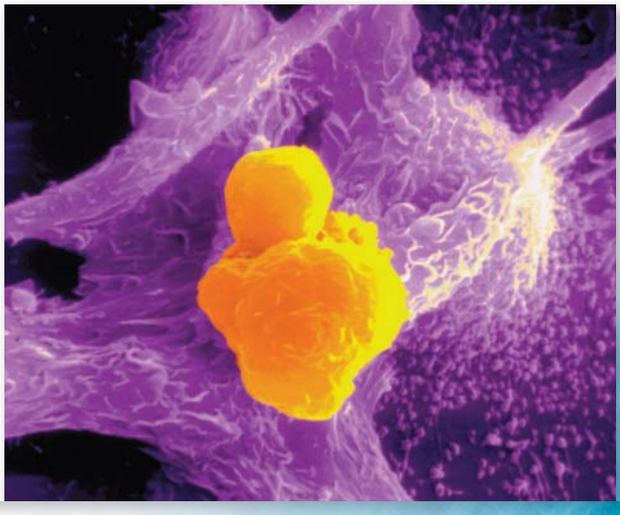
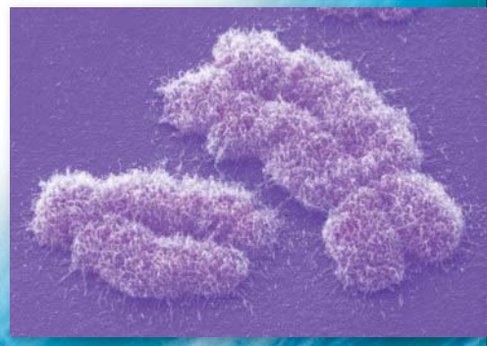
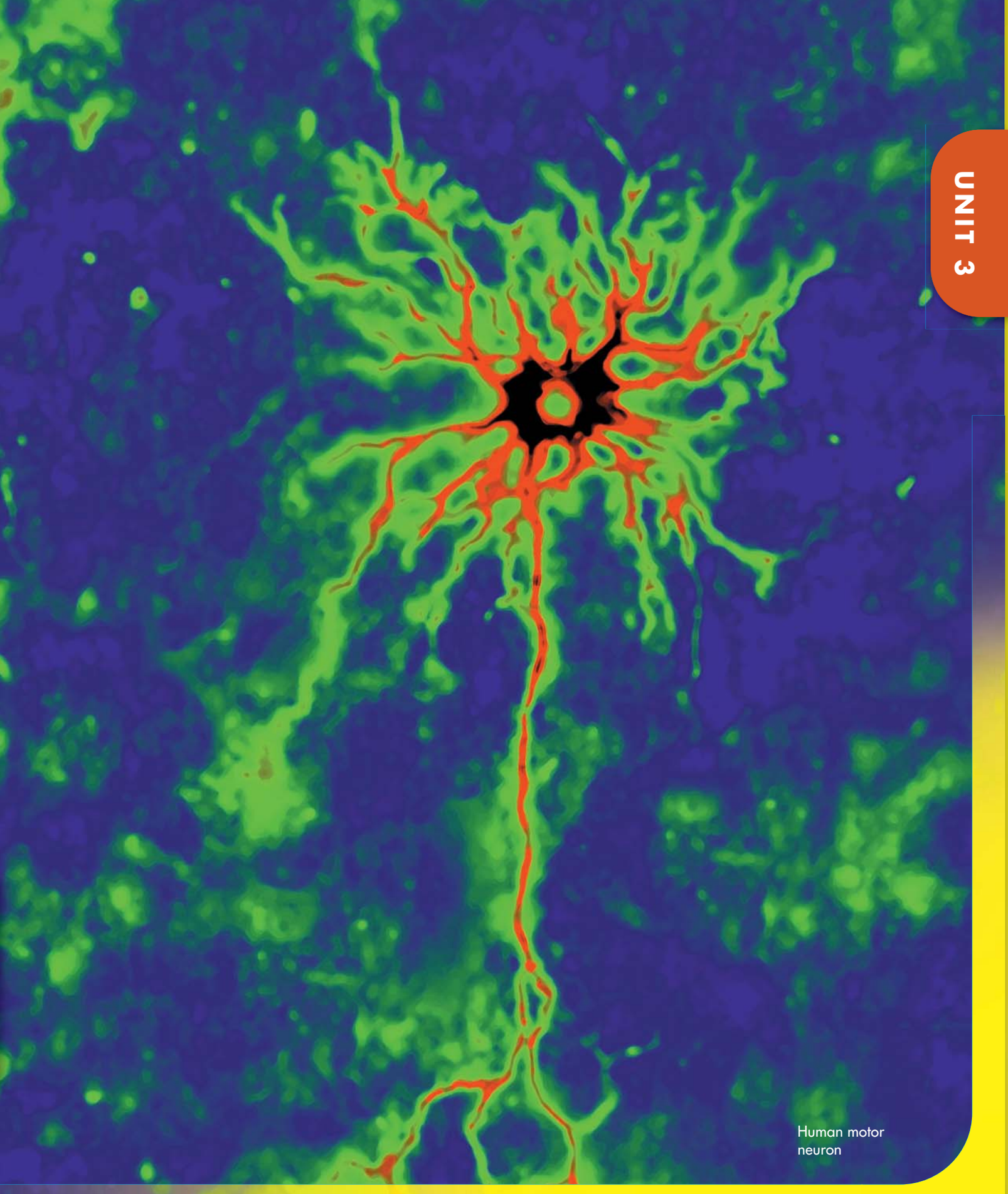
UNIT 3 Cells



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

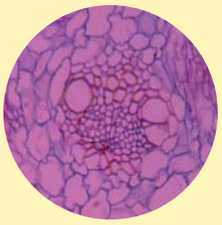
British clergyman and chemist, Joseph Priestly, presents his paper, *On Different Kinds of Air,* in which he describes his discovery of oxygen and other previously-unknown gases found in air. He also demonstrates that oxygen is produced by plants.

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."



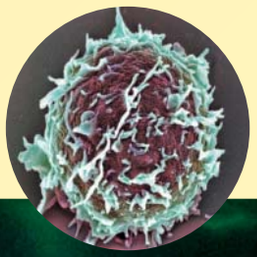
Animal cells

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

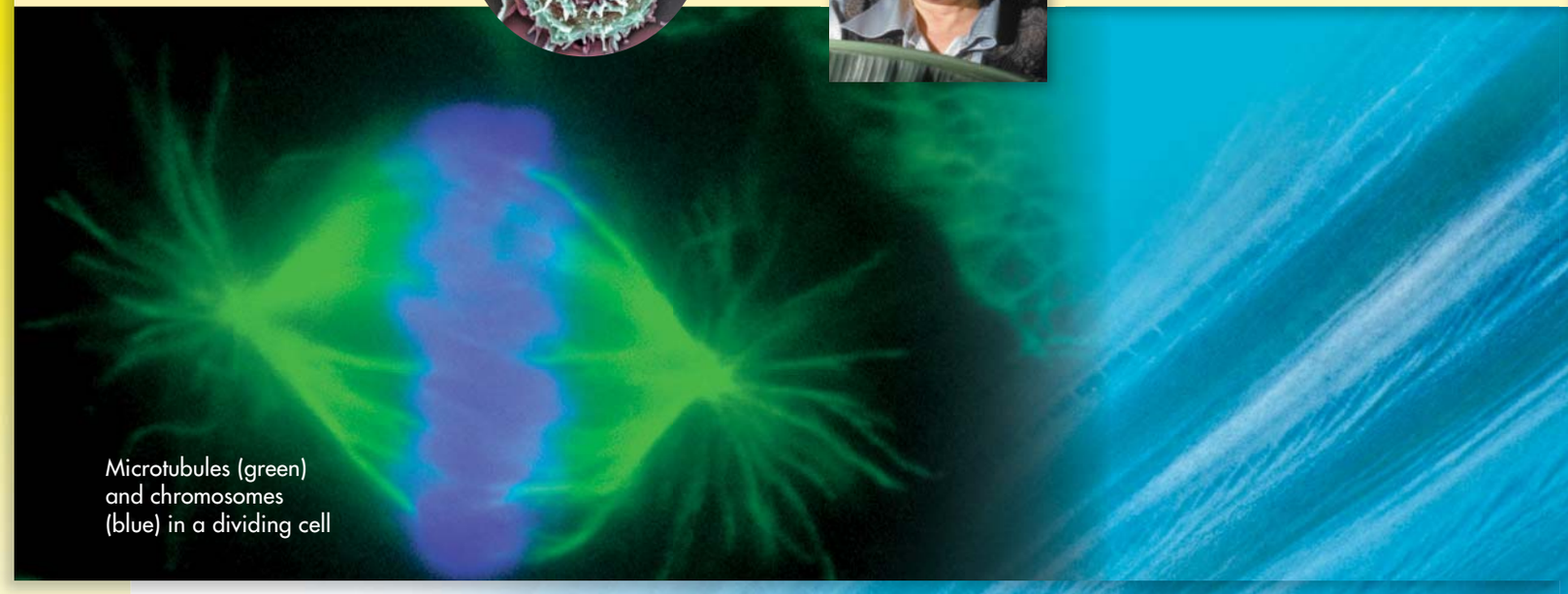
1971

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

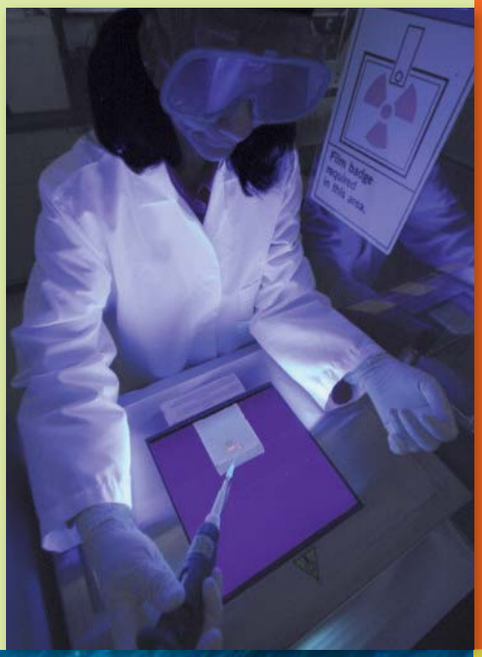
Cell Biologist

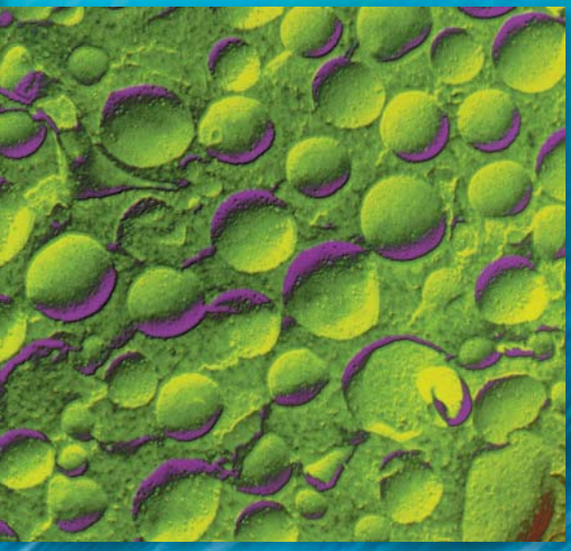
Shubha Govind

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

10 Cell Growth and Division

		Standards	Teach Key Ideas
CHAPTER OPENER, pp. 220–221	15 min.	*National Science Education Standards*	
SECTION 1 Cell Reproduction, pp. 223–227 › Why Cells Reproduce › Chromosomes › Preparing for Cell Division	30 min.	LSCell 1, LSCell 3, LSCell 4, LSCell 6, LSGene 1, LSMat 4, LSMat 6, UCP1	**Bellringer Transparency** **Transparencies** B43 Chromosome Structure **Visual Concepts** Comparing Cell Division in Prokaryotes and Eukaryotes • Gene • Chromosome
SECTION 2 Mitosis, pp. 228–232 › Eukaryotic Cell Cycle › Stages of Mitosis › Cytokinesis	90 min.	LSCell 1, LSCell 3, LSCell 4, LSCell 6, LSGene 1, UCP1, UCP2, UCP5	**Bellringer Transparency** **Transparencies** B47 Stages of Mitosis **Visual Concepts** Cell Cycle Introduction • Cell Cycle – G1 Phase • Cell Cycle – S Phase • Cell Cycle – G2 Phase • Cell Cycle – M Phase • Control of the Cell Cycle • Snapshot of Mitotic Structures • Mitosis • Comparing Cell Division in Plants and Animals
SECTION 3 Regulation, pp. 233–237 › Controls › Checkpoints › Cancer	30 min.	LSCell 4, LSCell 6, LSGene 1, LSGene 3, UCP1, HNS1, HNS2	
			See also PowerPoint® Resources

Chapter Review and Assessment Resources

- SE Super Summary, p. 238
- SE Chapter Review, p. 239
- SE Standardized Test Prep, p. 241
- Review Resources
- Chapter Tests A and B
- go.hrw.com Holt Online Assessment

CHAPTER FastTrack

Thorough instruction will require the times shown. You can eliminate the Quick Labs in Sections 1 and 3.

Basic Learners

- TE Relating Terms, p. 225
- Directed Reading Worksheets*
- Active Reading Worksheets*
- Lab Manuals, Level A*
- Study Guide*■
- Note-taking Workbook*
- Special Needs Activities and Modified Tests*

Advanced Learners

- TE How Many Base Pairs?, p. 224
- 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** Whitefish Cells, p. 221*■	TE **Reading Toolbox** Assessing Prior Knowledge, p. 220 SE **Reading Toolbox,** p. 222	
TE **What If DNA Was Not Coiled?,** p. 224 SE **Replacement Parts,** p. 227	SE **Quick Lab** Chromosome Package, p. 224*■ **Skills Practice Lab** Preparing a Root Tip Squash*	SE **Reading Toolbox** Word Parts, p. 225 TE **Reading Toolbox** Word Parts, p. 225 TE **Reading Toolbox** Visual Literacy, p. 225 TE **Reading Toolbox** Visual Literacy, p. 227	SE **Section Review** TE **Formative Assessment Spanish Assessment*■** **Section Quiz■**
TE **Demonstration** Cell Division Rate, p. 228 TE **Demonstration** Recognizing Mitotic Stages, p. 231	SE **Quick Lab** Number of Cells Resulting from Mitosis, p. 229*■ SE **Skills Practice Lab** Mitosis in Plant Cells, p. 236*■ **Exploration Lab** Mitosis*	TE **Reading Toolbox** Word Origins, p. 230 TE **Reading Toolbox** Visual Literacy, p. 230 SE **Reading Toolbox** Pattern Puzzle, p. 231	SE **Section Review** TE **Formative Assessment Spanish Assessment*■** **Section Quiz■**
	SE **Quick Lab** UV and Sunblock, p. 234*■	SE **Reading Toolbox** Cause and Effect, p. 234 TE **Reading Toolbox** Cause and Effect, p. 234	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 Mitotic Pattern Puzzle, p. 230
TE Traffic Jam, p. 234
Directed Reading Worksheets*
Active Reading Worksheets*
Lab Manuals, Level A*
Study Guide*■
Note-taking Workbook*
Multilingual Glossary

Struggling Readers

TE Relating Terms, p. 225
TE Mitotic Pattern Puzzle, p. 230
TE Traffic Jam, p. 234
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 Chromosome Structure, p. 225
TE Cell Model, p. 231
Directed Reading Worksheets*
Active Reading Worksheets*
Lab Manuals, Level A*
Study Guide*■
Note-taking Workbook*
Special Needs Activities and Modified Tests*

Alternative Assessment

TE Cell Cycle, p. 229
TE Pitfalls of Rapid Cell Divison, p. 234
Science Skills Worksheets*
Section Quizzes*■
Chapter Tests A, B, and C*■

Chapter 10

Overview

This chapter describes the significance and process of cell division. Cell division is necessary for the growth, repair, and maintenance of organisms. There are specific stages and checkpoints as a cell matures and prepares to divide. When an error occurs in the genetic code of a cell, these normal checkpoints are not always recognized and uncontrolled cellular division may ensue. This unregulated cellular division is known as cancer. Any cell that divides can potentially develop into a cancer cell.

READING TOOLBOX

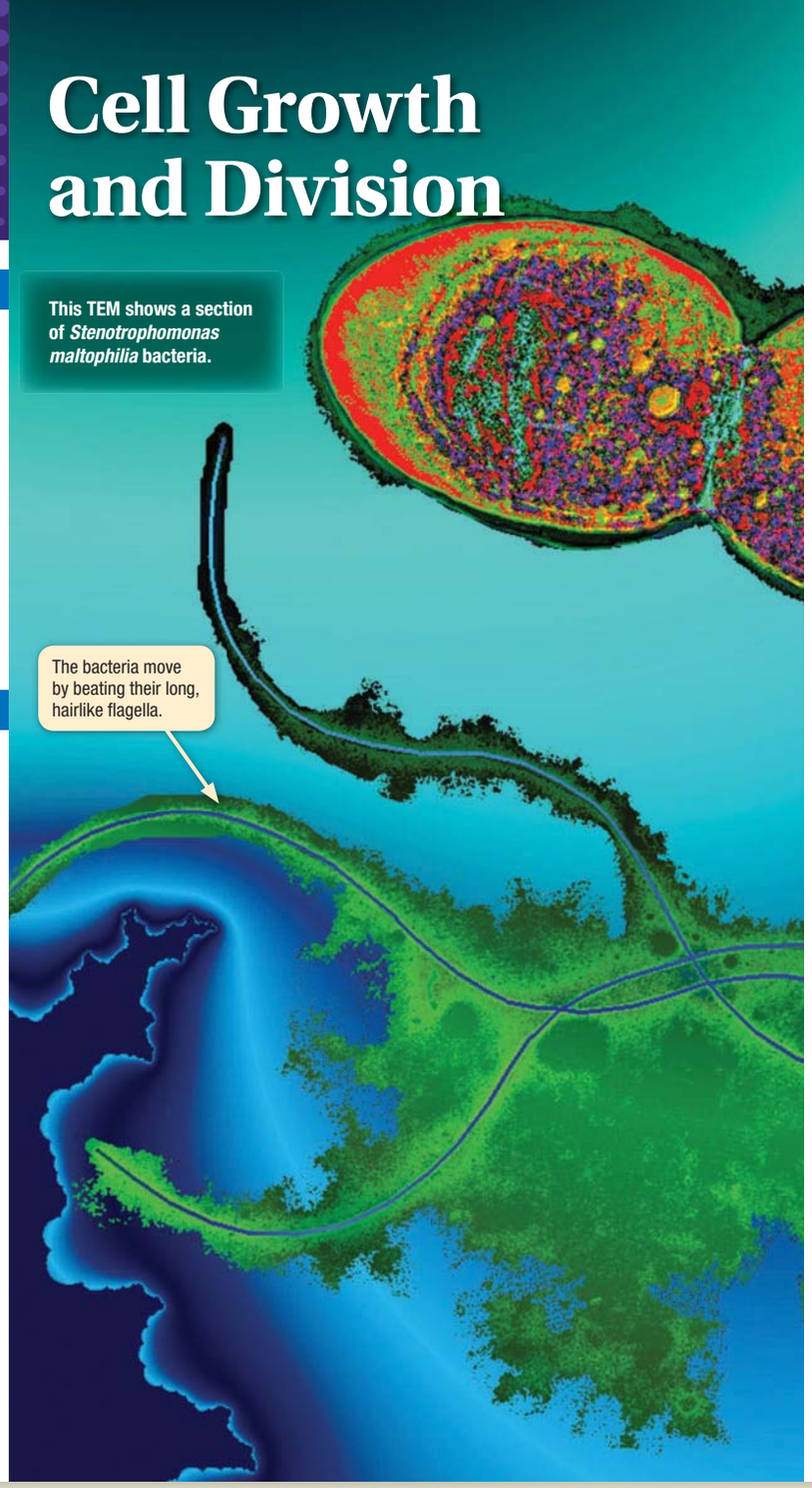
Assessing Prior Knowledge Students should understand the following concepts:

- differences between eukaryotic and prokaryotic cells
- role of DNA in cellular function

Visual Literacy Ask students to describe any differences between the two *Stenotrophomonas maltophilia* bacteria to the right. (The bacteria at the top is nearly divided, having formed two identical cells from the single original.) Explain to students that even the smallest and simplest of cells must divide to reproduce. LS Visual

Chapter 10

Cell Growth and Division



Preview

Why It Matters

The cell is the basic unit of life—common to all living things. The growth and division of cells is essential to the continuity of life.

Chapter Correlations

National Science Education Standards

LSCell 1 Cells have particular structures that underlie their functions.

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

LSCell 4 Cell functions are regulated.

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.

LSGene 3 Changes in DNA (mutations) occur spontaneously at low rates.

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.

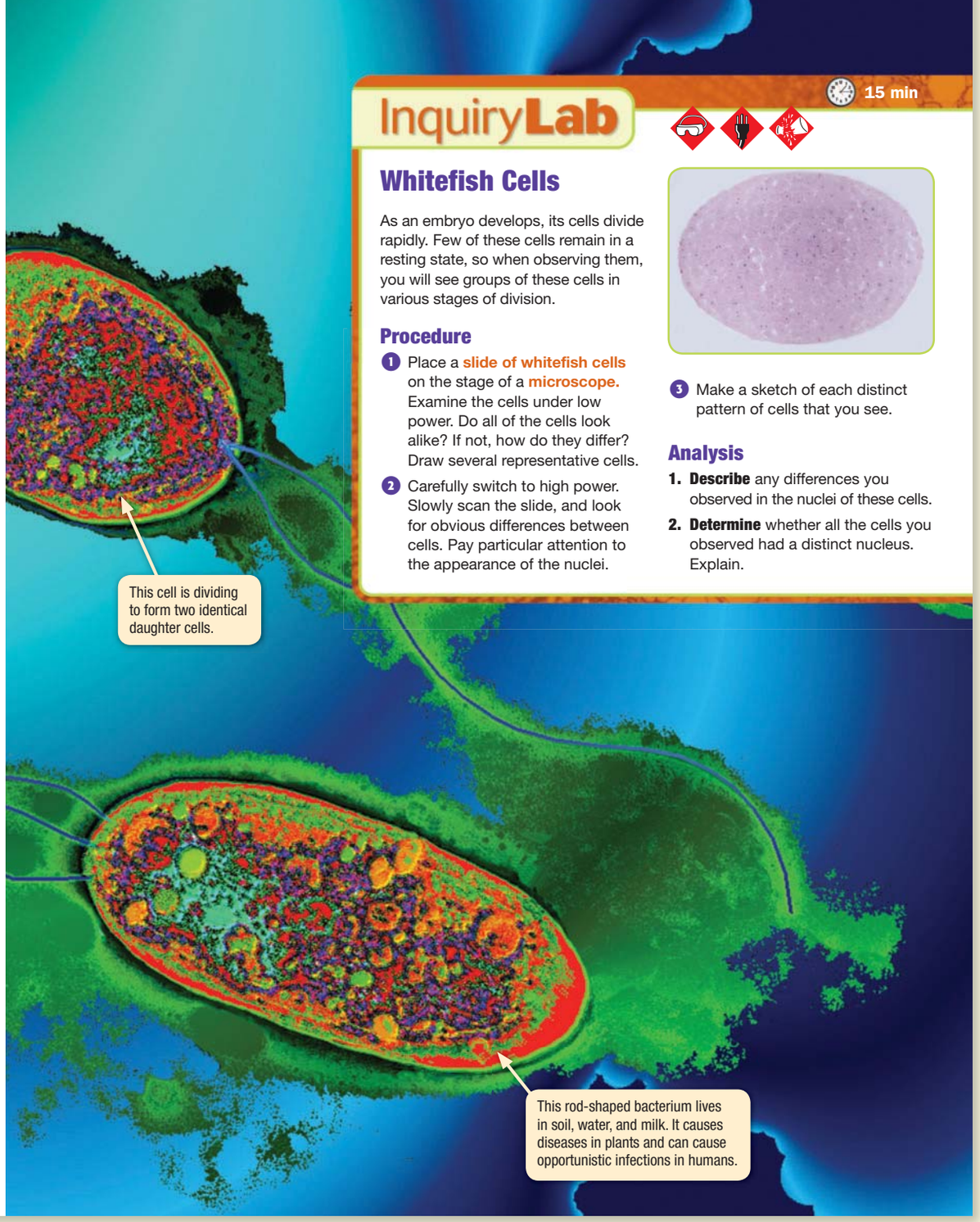
UCP1 Systems, order, and organization

UCP2 Evidence, models, and explanation

UCP5 Form and function

HNS1 Science as a human endeavor

HNS2 Nature of scientific knowledge



InquiryLab

15 min

Whitefish Cells

As an embryo develops, its cells divide rapidly. Few of these cells remain in a resting state, so when observing them, you will see groups of these cells in various stages of division.

Procedure

1. Place a **slide of whitefish cells** on the stage of a **microscope.** Examine the cells under low power. Do all of the cells look alike? If not, how do they differ? Draw several representative cells.
2. Carefully switch to high power. Slowly scan the slide, and look for obvious differences between cells. Pay particular attention to the appearance of the nuclei.
3. Make a sketch of each distinct pattern of cells that you see.

Analysis

1. **Describe** any differences you observed in the nuclei of these cells.
2. **Determine** whether all the cells you observed had a distinct nucleus. Explain.

InquiryLab

Teacher's Note: Whitefish mitosis slides are most often used to demonstrate the stages of division in animal cells. Before the students examine these slides, review the cell features they should be looking for. As a class, identify the characteristics of each stage that can be used to identify it and differentiate it from other stages.

Materials

- prepared whitefish cell slide(s)
- compound microscope

Answers to Analysis

1. Yes, the nucleus varied considerably among the cells. In some, you could observe the chromosomes in various states and positions.
2. No. Only some of the cells had a distinct nucleus surrounded by a nuclear membrane. In the other cells, a distinct nucleus or obvious nuclear membrane was not apparent

Key Resources

Interactive Tutor

READING TOOLBOX

Using Words

1. chromosome – a colored body
2. mitosis – a thread-like condition or process

Using Language

1. The cause is the cold, and the effect is to shiver.
2. The cause is the increasing brightness of light, and the effect is the pupil gets smaller.
3. The cause is the cell passing G_2, and the effect is the cell begins to divides.

Using Pattern Puzzles

The correct order follows:

1. Prophase
2. Metaphase
3. Anaphase
4. Telophase

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 You can tell a lot about a word by taking it apart and examining its prefix and root.

Your Turn Use the information in the table to define the following terms.

1. *chromosome*
2. *mitosis*

Word Parts

Word part	Type	Meaning
mito-	prefix	thread
chromo-	prefix	color
-osis	suffix	condition or process
-some	root	body

Using Language

Cause and Effect In biological processes, one step leads to another step. When reading, you can often recognize these cause-and-effect relationships by words that indicate a result, such as *so, consequently, if-then,* and *as a result.*

Your Turn Identify the cause and effect in the following sentences.

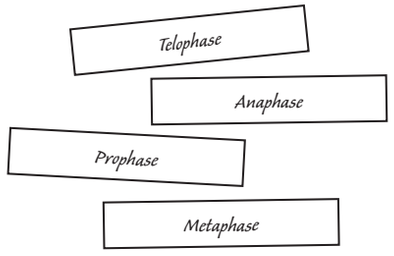
1. People often shiver as a result of being cold.
2. The light got brighter, so the pupil of the eye got smaller.
3. If the cell passes the G_2 checkpoint, then the cell may begin to divide.

Using Graphic Organizers

Pattern Puzzles You can use pattern puzzles to help you remember sequential information. Exchanging puzzles with a classmate can help you study.

Your Turn Make a pattern puzzle for the stages of mitosis.

1. Write down the steps of the process. On a sheet of notebook paper, write down one step per line. Do not number the steps.
2. Cut the sheet of paper into strips so that each strip of paper has only one step. Shuffle the paper strips so that they are out of sequence.
3. Place the strips in their proper sequence. Confirm the order of the process by checking your text or class notes.



Section 1

Cell Reproduction

Key Ideas	Key Terms	Why It Matters
Why do cells divide? How is DNA packaged into the nucleus? How do cells prepare for division?	gene, chromosome, chromatin, histone, nucleosome, chromatid, centromere	Cells are busy making more cells. The reproduction of cells allows you to grow and heal.

The adult human body produces roughly 2 trillion cells per day. The new cells are exact copies of the cells they replace. This process is called *cell reproduction*. Some cells, such as hair and skin cells, are replaced frequently throughout your life. Other cells, such as brain and nerve cells, are rarely produced after infancy.

Why Cells Reproduce

As the body of a multicellular organism grows larger, its cells do not also grow large. Instead, the body grows by producing more cells. New cells are needed to help tissues and organs grow. Even after organisms reach adulthood, old cells die and new cells take their place. This replacement and renewal is important for keeping the body healthy. New cells also replace damaged cells. As **Figure 1** shows, the body repairs a wound by making more cells.

Cell Size A cell grows larger by building more cell products. To do this, the cell must take in more nutrients, process them, and get rid of wastes. Recall that a cell's ability to exchange substances is limited by its surface area–to-volume ratio. As a cell gets larger, substances must travel farther to reach where they are needed.

Cell Maintenance The work of cells is done by proteins. As a cell gets larger, more proteins are required to maintain its function. Recall that the instructions for making these proteins are copied from the cell's DNA. If the cell gets too large, DNA instructions cannot be copied quickly enough to make the proteins that the cell needs to support itself. Thus, cell size is also limited by the cell's DNA.

Making New Cells Cell division can solve the problems of cell size. Each "daughter" cell has a higher surface area–to-volume ratio than its parent does. Each new cell also gets an entire copy of the cell's DNA. **Because larger cells are more difficult to maintain, cells divide when they grow to a certain size.**

Figure 1 When these stitches are removed, this cut will be healed. Cell division enables the body to repair a wound.

Key Resources

Transparencies
B43 Chromosome Structure

Visual Concepts
Comparing Cell Division in Prokaryotes and Eukaryotes
Gene
Chromosome

Section 1

Focus

This section explains the structure of chromosomes and their role in cellular division.

Bellringer
Use the Bellringer transparency to prepare students for this section.

Teach

Teaching Key Ideas

When's the Time to Reproduce? Ask students to list which cells in their body are reproducing. Then, have students share their answers with the class to see if they recognize that cell division is on going. (Most cells are reproducing, but at different rates. Cells in the digestive track, especially the esophagus, reproduce rapidly due to the mechanical shedding involved as food passes by. Also, skin, hair and nail cells reproduce rapidly. Cells of the nervous system reproduce very slowly.) LS **Logical**

Teach, *continued*

QuickLab

Teacher's Notes Prepare the lengths of kite string, as well as the plastic wrap, before class. Make sure students do not unfold the paperclips.

Materials
- kite string, 2 one-meter pieces
- paperclip
- plastic wrap, 2 pieces about 10 cm × 10 cm

Answers to Analysis

1. The string is DNA. The plastic wrap is the nuclear envelope (nucleus), and the paperclip is the protein scaffold.
2. The volume occupied by the string without the paperclip is greater than the volume of the string-wrapped paperclip system.
3. The object that could replace the paperclip could allow for easy winding and a way to secure the string at both ends.

Why It Matters

What If DNA Was Not Coiled? If the DNA inside one cell is stretched out, it would be approximately two meters long (78 in.). If all the bases in the human genome were put in a line 1 mm apart, the genome would stretch from Memphis to Los Angeles (1810 miles; 2919 kilometers).

LS Logical

Hands-On

QuickLab

15 min

Chromosome Package

DNA is condensed to reduce the space that it occupies in the cell. In eukaryotic cells, the linear DNA molecule is condensed by being wrapped around a core of proteins.

Procedure

1. Scrunch a **1 m length of kite string** into a wad. Cover this wad with a piece of **plastic wrap.**
2. Wind another **1 m length of string** tightly and uniformly around a **paper clip.** Cover this shape with another piece of plastic wrap.

Analysis

1. **Identify** what the string, the plastic wrap, and the paper clip represent in each model.
2. **Compare** the volumes of space that the two models occupy.
3. CRITICAL THINKING **Evaluating Models** Describe an object that would be more effective than a paper clip as a core to wrap the string around. Explain your answer.

gene a unit of heredity that consists of a segment of nucleic acid that codes for a functional unit of RNA or protein

chromosome in a eukaryotic cell, one of the structures in the nucleus that are made up of DNA and protein; in a prokaryotic cell, the main ring of DNA

chromatin the substance of which eukaryotic chromosomes are composed

histone a type of protein molecule found in the chromosomes of eukaryotic cells but not prokaryotic cells

nucleosome (NOO klee uh SOHM) a eukaryotic structural unit of chromatin that consists of DNA wound around a core of histone proteins

chromatid one of the two strands of a chromosome that become visible during meiosis or mitosis

centromere the region of the chromosome that holds the two sister chromatids together during mitosis

Chromosomes

Recall that a cell's activity is directed by its DNA. The large molecule of DNA is organized into hereditary units called **genes.** A gene is a segment of DNA that codes for RNA and protein. The simplest organisms have thousands of genes. Each cell has a large amount of DNA that must be condensed into a very small volume. DNA is organized and packaged into structures called **chromosomes.**

Prokaryotic Chromosome A prokaryotic cell has a single circular molecule of DNA. This loop of DNA contains thousands of genes. A prokaryotic chromosome is condensed through repeated twisting or winding, like a rubber band twisted upon itself many times.

Eukaryotic Chromosome The challenge of packaging DNA into the eukaryotic nucleus is much greater. Eukaryotic cells contain many more genes arranged on several linear DNA molecules. A human cell contains 46 separate, linear DNA molecules that are packaged into 46 chromosomes. **Eukaryotic DNA is packaged into highly condensed chromosome structures with the help of many proteins.** The DNA and proteins make up a substance called **chromatin.**

Forms of Chromatin The first level of packaging is done by a class of proteins called **histones.** A group of eight histones come together to form a disc-shaped histone core. As **Figure 2** shows, the long DNA molecule is wound around a series of histone cores in a regular manner. The structure made up of a histone core and the DNA around it is called a **nucleosome.** Under an electron microscope, this level of packaging resembles beads on a string. The string of nucleosomes line up in a spiral to form a cord that is 30 nm in diameter.

Differentiated Instruction

Advanced Learners/GATE

How Many Base Pairs? For a special project have students gather research on the following
- the total number of base pairs present in the human genome
- the length of each nucleotide

They should use this data to calculate the length of the DNA in one cell. LS Logical

Packaging During Cell Division During most of a cell's life, its chromosomes exist as coiled or uncoiled nucleosomes. As the cell prepares to divide, the chromosomes condense even further. This ensures that the extremely long DNA molecules do not get tangled up during cell division. The 30-nm fiber (the nucleosome cord) forms loops that are attached to a protein scaffold. These looped domains then coil into the final, most highly condensed form of the chromosome. Many dense loops of chromatin form the rod-shaped structures that can be seen in regular light microscopes.

Chromosome Structure A fully condensed, duplicated chromosome is shown in **Figure 2.** Each of the two thick strands, called a **chromatid,** is made of a single, long molecule of DNA. Identical pairs, called *sister chromatids,* are held together at a region called the **centromere.** During cell division, the sister chromatids are separated at the centromere, and one ends up in each daughter cell. This ensures that each new cell has the same genetic information as the parent cell.

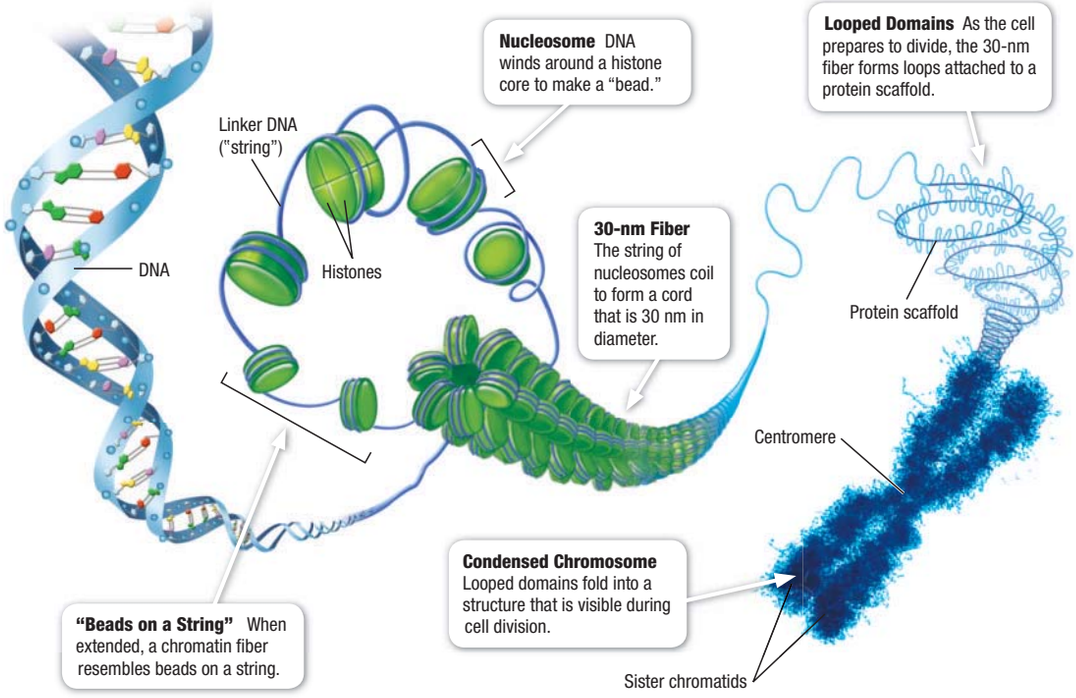
› **Reading Check** ***What is a chromatid? (See the Appendix for answers to Reading Checks.)***

READING TOOLBOX

Word Parts The prefix *tel-* means "end." If *centromere* means a "central part," what do you think *telomere* means?

Figure 2 A eukaryotic chromosome consists of DNA tightly coiled around proteins. As a cell prepares to divide, the duplicated chromosomes are condensed. › **Why do chromosomes condense during cell division?**

Eukaryotic Chromosome Structure



READING TOOLBOX

Word Parts *Telomere* most likely refers to the "end part" or "end result." LS Verbal

Teaching Key Ideas

Is it a Chromosome, Chromatin or Chromatid? Students often become confused when asked to define these three words. Remind them that a *chromosome* is a cellular structure that carries genetic information. Chromosomes may have many forms. *Chromatin* is the substance that makes up chromosomes. Chromatin is DNA wrapped around histones. When chromosomes are duplicated, each copy is called a *chromatid*. When joined, the two chromatids together are considered one chromosome. When separated, each chromatid is considered its own chromosome. LS Verbal

READING TOOLBOX

Visual Literacy Help students understand the chromosome structure model shown in **Figure 2.** Ask them where the diagram begins. (at the DNA strand on the left) What is the diagram showing? (The process of tightly winding DNA in preparation for cell division.) What role do histones play in this process? (Histones provide a surface for winding DNA.) What role do nucleosomes play? (They coil the DNA/histone complexes.) What happens when the chromosome condenses? (Coiled nucleosomes loop around a protein scaffold. These loops coil further to create the condensed form.) LS Visual

Differentiated Instruction

Basic Learners/Struggling Readers

Relating Terms Give students a copy of **Figure 2** that is not labeled. Ask them to identify the following structures on the figure: centromere, chromatid, chromatin, chromosome, DNA, histone, and nucleosome. Then, ask students to select pairs of the terms and write a sentence that describes their relationship. Tell students to write at least four sentences using term pairs. LS Verbal/Visual

Special Education Students

Chromosome Structure To help visually impaired students understand **Figure 2,** create a demonstration model for them. Use the following materials: yarn or lightweight rope with twisted strands for DNA; sewing machine bobbins for histones; a long string of beads wound around a plastic straw could represent the 30-nm fiber; a large spool of sewing thread, twine, or cord could be used for the condensed chromosome. LS Kinesthetic

Close

Formative Assessment

As a cell is preparing to divide, the DNA ___.

A. has copied itself twice so that each daughter cell is diploid (Incorrect. DNA replicates only once. The newly formed cell is already diploid as it has one set of the chromosomes from the mother and one from the father.)

B. has replicated and condensed into chromosomes, each consisting of two sister chromatids (Correct. There must be duplicate material in the old cell before it can divide to form two fully-functional new cells.)

C. has caused the cell to double in size before it must divide (Incorrect. Different cells grow to different proportions of the original cell before they are too large to function properly.)

D. forms one long continuous loop composed of individual chromosomes that are linked together (Incorrect. A bacteria has a single, circular chromosome. Eukaryotes have individual rod-shaped chromosomes that behave independently of each other.)

Cell dividing

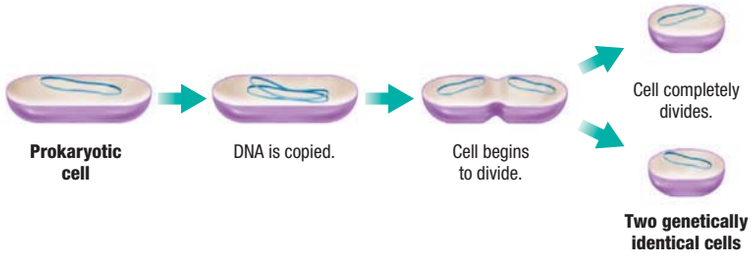


Figure 3 A prokaryotic cell divides by copying its single, circular chromosome and building a cell membrane between the two copies. A new cell wall forms around the membrane, squeezing the cell. Eventually it pinches off into two independent daughter cells.

SCILINKS
www.scilinks.org
Topic: Cell Division
Code: HX80236

ACADEMIC VOCABULARY

complex having many parts or functions

Preparing for Cell Division

All new cells are produced by the division of preexisting cells. The process of cell division involves more than cutting a cell into two pieces. Each new cell must have all of the equipment needed to stay alive. **All newly-formed cells require DNA, so before a cell divides, a copy of DNA is made for each daughter cell.** This way, the new cells will function in the same way as the cells that they replace.

Prokaryotes In prokaryotic cells, the circular DNA molecule is attached to the inner cell membrane. As **Figure 3** shows, the cytoplasm is divided when a new cell membrane forms between the two DNA copies. Meanwhile the cell continues to grow until it nearly doubles in size. The cell wall also continues to form around the new cell membrane, pushing inward. The cell is constricted in the middle, like a long balloon being squeezed near the center. Eventually the dividing prokaryote is pinched into two independent daughter cells, each of which has its own circular DNA molecule.

Eukaryotes The reproduction eukaryotic cells is more complex than that of prokaryotic cells. Recall that eukaryotic cells have many organelles. In order to form two living cells, each daughter cell must contain enough of each organelle to carry out its functions. The DNA within the nucleus must also be copied, sorted, and separated.

Reading Check *Where does a prokaryotic cell begin to divide?*

Section 1 Review

KEY IDEAS

1. **List** two reasons for cell reproduction in multicellular organisms.
2. **Describe** three levels of structure in the DNA packaging system found within a eukaryotic nucleus.
3. **Explain** why daughter cells are identical to the parent cell.

CRITICAL THINKING

4. **Evaluating Conclusions** If cells constantly double in number each time they divide, why doesn't a multicellular organism continue to grow in size?
5. **Inferring Relationships** Why do chromosomes condense before they divide?

MATH SKILLS

6. **Exponents** Imagine you are observing a cell that divides once every hour for 12 h. Assume that none of the cells die during this period. How many cells would exist after each hour? How many cells would exist after 12 h?

Answers to Section Review

1. New cells are needed for tissue and organ growth. Damaged cells, such as those from a wound, need to be replaced.
2. Nucleosomes, 30-nm fibers, and rod-shaped chromosomes enable complex DNA molecules to become compact to fit within a cell.
3. Before a cell divides, a copy of its DNA is produced. Each daughter cell receives an exact copy so that the cell can continue functioning in the same manner as the original parent cell.
4. All of the cells in each generation do not survive. Some cells are dying while new cells are taking their place.
5. so that the extremely long DNA molecules do not get entangled during cell division
6. After 1 hour, 2 cells. After 2 h, 4 cells. After 3 h, 8. Then 16, 32, 64, 128, 256, 512, 1,024, 2,048. After 12 h, 8,192 cells would exist.

Why It Matters

Replacement Parts

If you look closely at the camouflaged green anole lizard at right, you will see that it appears to be growing a new tail. The process by which an organism replaces or restores a lost or amputated body part is called *regeneration.* A series of rapid cell divisions allows certain organisms to regenerate certain lost parts.

Sea Star Comets

To keep sea stars from destroying oyster beds, oyster fishermen used to chop up sea stars and throw the pieces back into the sea. Unfortunately, this practice increased the number of sea stars! Some sea stars can regenerate their entire bodies from just a small piece of arm. Specimens such as the one shown below are sometimes called "comets." The regeneration of these sea stars is possible because they keep their vital organs in their arms.

Tail Regeneration Lizards, such as the gecko at left, are well known for their ability to "release" their tails. Lizards use this ability as a defense mechanism to escape predators. The broken piece of tail twists and wiggles, which diverts the attention of the predator while the lizard escapes. When the tail regenerates, it is made up of cartilage, rather than bone.

Sea star "comet"

Research Investigate and explain compensatory hypertrophy, a process in mammals that is similar to the regeneration of body parts. Identify an organ in humans that is capable of compensatory hypertrophy.

Why It Matters

Teacher's Notes Most sea stars need a significant section of the central disk (body) to regenerate. The exception is the *Linckia,* or Comet Sea Star, which can regenerate its entire body from a single arm. Of the vertebrates, reptile and amphibian limb regeneration is the most common. In addition to aiding in balance, tails serve as storage sites for energy in the form of fat. When an animal looses its tail, it would be like losing the ability to store food in our home refrigerators! When a new tail grows back, it may not match the original coloration and scale pattern of the animal.

Dedifferentiated, (re)differentiated, and *stem cells* are often responsible for the growth and development of the newly forming limbs.

READING TOOLBOX

Visual Literacy Have students describe the characteristics of the gecko tail that indicate its stage of regeneration, from freshly amputated to fully recovered. Then, ask students to propose why one arm of the Sea Star Comet is so large when compared to the rest of its arms and body. LS Visual

Answer to Research

Compensatory hypertrophy is the build up of tissue due to a stress. The human heart is capable of increasing in size when exposed to athletic conditioning, or to offset the stress of vascular or valvular disease. The kidney and skeletal muscle also exhibit this property. LS Logical

Section 2 Mitosis

Key Ideas	Key Terms	Why It Matters
❯ What are the phases of the eukaryotic cell cycle? ❯ What are the four stages of mitosis? ❯ How does cytokinesis occur?	cell cycle, interphase, mitosis, cytokinesis, spindle, centrosome	The events of the cell cycle ensure that new cells will be just like the old cell.

❯ Focus

Students will examine the cell cycle. They will learn that during interphase, cells grow and DNA is replicated. During mitosis each new cell receives the proper assortment of chromosomes. During cytokinesis, the cytoplasm divides and a new cell membrane or cell wall forms.

Bellringer

Use the Bellringer transparency to prepare students for this section.

❯ Teach

Demonstration

Cell Division Rate Display either a model or a photograph of a human brain. Point out that once the brain is fully formed, most of the nerve cells do not divide again. These cells remain in the G_1 phase of the cell cycle. Then display either a model or a photograph of a human bone. Point out that red blood cells are produced from cells in the marrow of long bones. An average red blood cell lives for about 120 days. Each second, about two million red blood cells are produced by cell division in the bone marrow. Cells in the marrow, unlike those in the brain, continue going through the cell cycle as long as a person lives. LS Visual

Answers to Caption Questions

Figure 4: S, G_2, mitosis

Unlike prokaryotic cells, eukaryotic cells cannot simply be pinched into two new cells. The physical division of one cell into two cells requires many preparations.

Eukaryotic Cell Cycle

The **cell cycle** is a repeating sequence of cellular growth and division during the life of a cell. ❯ **The life of a eukaryotic cell cycles through phases of growth, DNA replication, preparation for cell division, and division of the nucleus and cytoplasm.** The cell cycle is made up of five phases, shown in **Figure 4.** The first three phases together are known as **interphase.** The remaining two phases make up cell division.

Interphase During interphase, the cell is not dividing. It is growing and preparing to divide. Different types of cells spend different amounts of time in interphase. Cells that divide often, such as skin cells, spend less time in interphase. Cells that divide seldom, such as nerve cells, spend most of their time in interphase.

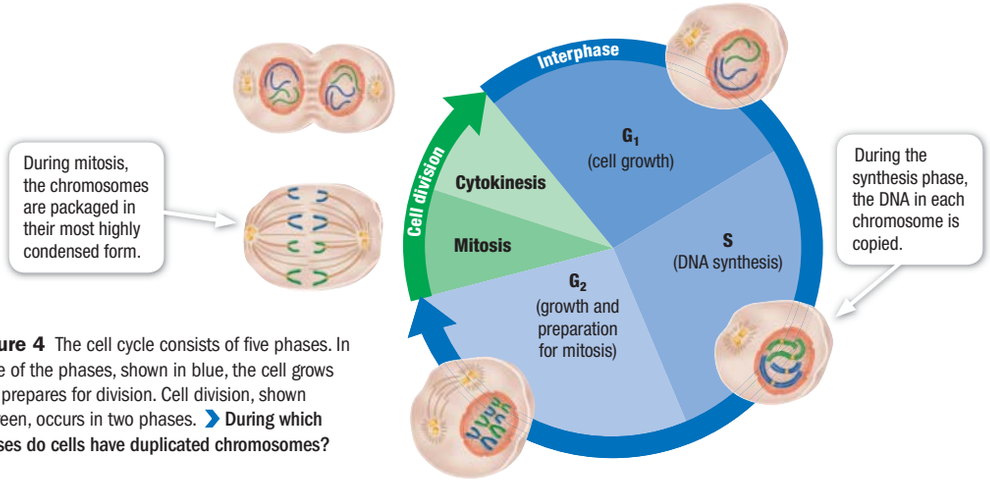


Figure 4 The cell cycle consists of five phases. In three of the phases, shown in blue, the cell grows and prepares for division. Cell division, shown in green, occurs in two phases. ❯ **During which phases do cells have duplicated chromosomes?**

Key Resources

Transparencies
B47 Stages of Mitosis

Visual Concepts
Cell Cycle Introduction
Cell Cycle – G_1 Phase
Cell Cycle – S Phase
Cell Cycle – G_2 Phase
Cell Cycle – M Phase
Control of the Cell Cycle
Snapshot of Mitotic Structures
Mitosis
Comparing Cell Division in Plants and Animals

Data

QuickLab

5 min

Number of Cells Resulting from Mitosis

In the human body, the rate of mitosis is about 25 million (2.5×10^7) cells produced per second. By using this rate, you can calculate the number of cells produced by mitosis in a given amount of time.

Procedure

1. Calculate the number of cells produced by mitosis in the time given. For example, to find the number of cells produced in 3 min, determine how many seconds are in 3 min (because the rate is given in seconds).

$$\frac{60 \text{ seconds}}{1 \text{ minute}} \times 3 \text{ minutes} = 180 \text{ seconds}$$

2. Multiply the rate of mitosis by the time (in seconds) given in the problem (180 s).

$$\frac{2.5 \times 10^7 \text{ cells}}{\text{second}} \times 180 \text{ seconds} = 4.5 \times 10^9 \text{ cells}$$

4.5×10^9 cells = 4,500,000,000 cells = 4.5 billion cells

Analysis

1. **Calculate** the number of cells that would be produced in 1 h.
2. **Calculate** the number of cells that would be produced in 1 day.
3. CRITICAL THINKING **Predicting Patterns** Identify factors that might increase or decrease the rate of mitosis.

- **G_1** During the *first gap phase* (G_1), a cell grows rapidly as the cell builds more organelles. For most organisms, this phase occupies the major portion of the cell's life. Cells that are not dividing remain in the G_1 phase.
- **S** During the *synthesis phase* (S), a cell's DNA is copied. At the end of the S phase, the cell's nucleus has twice as much DNA as it did in the G_1 phase. Each chromosome now consists of two identical chromatids that are attached at the centromere.
- **G_2** During the *second gap phase* (G_2), the cell continues to grow and prepares to divide. The cell forms some special structures that help the cell divide. Hollow protein fibers called *microtubules* are organized in the cytoplasm during G_2 in preparation for division.

Cell Division Each new cell requires a complete set of organelles, including a nucleus. The process of dividing the nucleus into two daughter nuclei is called **mitosis.** The process of separating the organelles and the cytoplasm is called **cytokinesis.**

- **Mitosis** During mitosis, the nucleus divides to form two nuclei. Each nucleus contains a complete set of the cell's chromosomes. The nuclear membrane breaks down briefly. The two sister chromatids of each chromosome are pulled to the opposite sides of the dividing cell.
- **Cytokinesis** As the nucleus divides, the cytoplasm also begins to divide. Each daughter cell receives about half of the original cell's organelles. During cytokinesis, the two daughter cells are physically separated.

› **Reading Check** *What phases are included in interphase?*

cell cycle the life cycle of a cell

interphase the period of the cell cycle during which activities such as cell growth and protein synthesis occur without visible signs of cell division

mitosis in eukaryotic cells, a process of cell division that forms two new nuclei, each of which has the same number of chromosomes

cytokinesis the division of the cytoplasm of a cell

SCILINKS
www.scilinks.org
Topic: Cell Cycle
Code: HX80235

Differentiated Instruction

Alternative Assessment

Cell Cycle Have students write a description of what is happening inside of each of the cell models shown in **Figure 4.** (G_1: cell is growing and functioning normally; S: DNA is copied, there's twice as much DNA shown than in G_1; G_2: microtubules form in preparation for division; mitosis: sister chromatids are separated and travel to opposite sides of the cell; cytokinesis: nucleus and cytoplasm divide.) LS Visual

QuickLab

Teacher's Notes Tell students that the factor label method shown will be used in future science courses (chemistry and physics), so learning the technique now will give them an advantage later.

Answers to Analysis

1. 9×10^{10} cells/h
   2.5×10^7 cells/s $\times$ 60 s/min $\times$ 60 min/h $= 9 \times 10^{10}$ cells/h
2. 2.2×10^{12} cells per day
   9×10^{10} cells/h $\times$ 24 h/day $= 2.2 \times 10^{12}$ cells/day
3. Some factors are the following: the type of cell, the availability of nutrients and chemical energy, the temperature and pH of the environment, the density of cells in area, and whether the cell is attached to a substrate LS Logical

Teaching Key Ideas

Pattern Puzzles Have students read Section 2, and list all the events described during the cell cycle on index cards (one event per card). Draw a large version of **Figure 4** at the front of the room. Call on one student at a time to come to the front of the room, read a card out loud, and then tape the card to the proper stage of the cell cycle. Repeat until all events are shown on the diagram. LS Kinesthetic

Teaching Key Ideas

Cells Are Busy Remind students that during interphase, a cell is not only growing, it is also producing the proteins and carrying out the functions that are characteristic of that type of cell.

Teach, *continued*

READING TOOLBOX

Word Origins To help students with vocabulary, relate the term mitosis to its Greek origin, mitos, meaning "thread." Ask students to explain why mitosis would be related to thread. (The hereditary material consists of long, threadlike molecules.) LS Verbal

go.hrw.com
interact online

Students can interact with the "Stages of Mitosis" by going to go.hrw.com and typing in the keyword HX8CRPF5.

READING TOOLBOX

Visual Literacy Ask students why the drawings look so different from the photos in **Figure 5.** (The drawings are simplified to show representative activities and structures.) The cell's nucleus is clearly visible in the second photo, where is it in the third photo? (The nuclear membrane dissolved and the contents lines up along the cell's equator.) How do the third and fourth photos differ from the drawings? (The spindle at each pole is more symmetrical than shown in the drawings.) How does the photograph of telophase differ from the drawing? (The photo shows that the daughter cells are not equal in size.) LS Visual

Answers to Caption Questions

Figure 5: to move the chromatids of each chromosome to opposite poles

spindle a network of microtubules that forms during mitosis and moves chromatids to the poles

centrosome an organelle that contains the centrioles and is the center of dynamic activity in mitosis

Stages of Mitosis

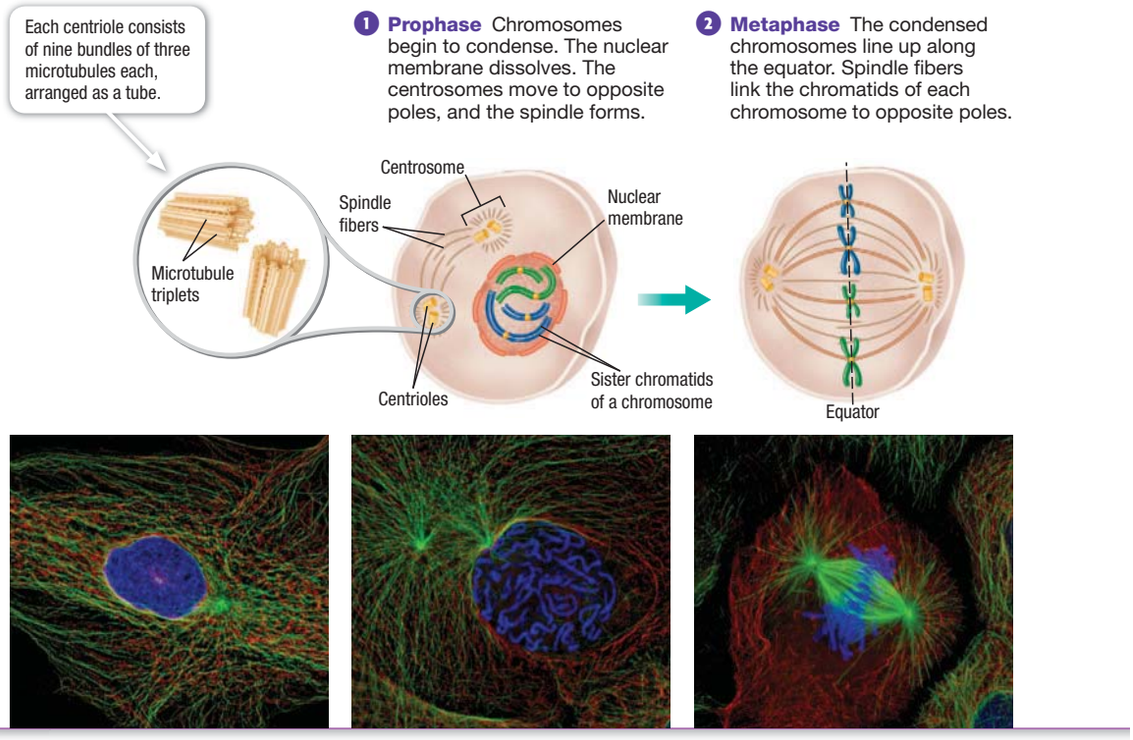
Although mitosis is a continuous process, biologists traditionally divide it into four stages, as shown in **Figure 5.** **Mitosis is a continuous process that can be observed in four stages: prophase, metaphase, anaphase, and telophase.**

Stage 1 Prophase Within the nucleus, chromosomes begin to condense and become visible under a light microscope. The nuclear membrane breaks down. Outside the nucleus, a special structure called the **spindle** forms. The spindle is made up of several spindle fibers. Each spindle fiber in turn is made up of an individual microtubule—a hollow tube of protein. Microtubules organize into a spindle that runs at a right angle to the cell's equator.

Cells have an organelle called the **centrosome,** which helps assemble the spindle. In animal cells, the centrosome includes a pair of centrioles, shown in **Figure 5.** Each centriole is made up of nine triplets of microtubules arranged as a short, hollow tube. Before mitosis, the cell's centrosome is duplicated. During prophase, the centrosomes move to opposite poles of the cell.

Figure 5 During mitosis, the copies (sister chromatids) of each chromosome are separated into two nuclei. **What is the role of the spindle fibers?**

Stages of Mitosis



Differentiated Instruction

Struggling Readers/English Learners

Mitotic Pattern Puzzle Students will need 12 index cards—three cards per mitotic stage labeled as follows: (A) the stage, (B) a sketch of the events occurring during that stage, and (C) a narrative of the events occurring during that stage. Each student should have A, B, and C cards for each of the four stages. Students should then shuffle their cards and trade them with a partner. Draw the following grid on the board. Each student organizes the "traded" cards to match the grid.

Stage	1	2	3	4
Name				
Drawing				
Description				

LS Visual, Verbal and Logical

Stage 2 Metaphase During metaphase, the chromosomes are packaged into their most condensed form. The nuclear membrane is fully dissolved, and the condensed chromosomes move to the center of the cell and line up along the cell's equator. Spindle fibers form a link between the poles and the centromere of each chromosome.

Stage 3 Anaphase Once all of the chromosomes are lined up, the spindle fibers shorten. The spindle fibers shorten by breaking down the microtubules bit by bit. Sister chromatids move toward opposite poles as the spindle fibers that are attached continue to shorten. Each pole now has a full set of chromosomes.

Stage 4 Telophase A nuclear envelope forms around the chromosomes at each pole of the cell. Chromosomes, now at opposite poles, uncoil and change back to their original chromatin form. The spindle dissolves. The spindle fibers break down and disappear. Mitosis is complete.

Reading Check *What is the spindle composed of?*

READING TOOLBOX

Pattern Puzzles Cut each piece of the pattern puzzle that you made for the stages of mitosis so that each strip describes one of the events that occurs. Shuffle the strips and match the events with the correct stage.

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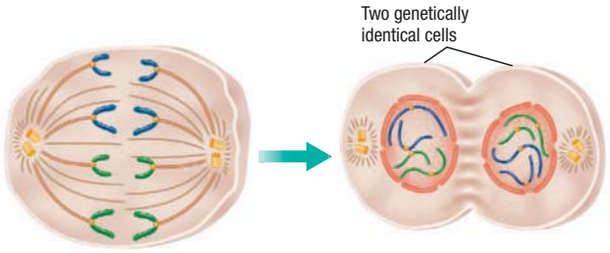
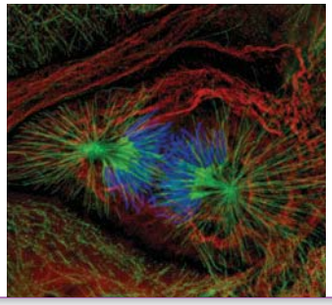
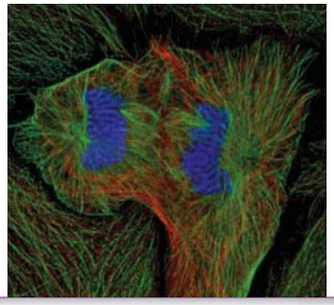
interact online
Keyword: HX8CRPF5

3 Anaphase As the spindle fibers shorten, the chromatids are pulled toward opposite poles of the cell.

4 Telophase A new nuclear envelope forms at each pole. The spindle dissolves, and the chromosomes uncoil. Cytokinesis begins.







Differentiated Instruction

Special Education Students

Cell Model Provide visually-impaired students with yarn to represent chromosomes, nuclear envelopes, and cell membranes; tie tabs to represent centromeres and string to represent spindle fibers. Have them recreate a cell undergoing mitosis on their desktops. LS Kinesthetic

Demonstration

Recognizing Mitotic Stages Set up several numbered stations with microscopes that have prepared slides of cells at various stages of mitosis. The stations will not be in the proper sequence of events. Have students view the slides and use the station numbers to record the proper order of events. If microscopes and slides are not available, the various stages can be shown with photographs or drawn on the board, out of order and labeled. LS Visual, Kinesthetic, Logical

Teaching Key Ideas

Visual Literacy Lead students through each stage shown in **Figure 5,** focusing on the behavior of chromosomes. Point out that the various stages are not of equal duration. Using movie film as an analogy, help students avoid the misconception that mitosis "jumps" from stage to stage. Although a movie consists of individual frames of film, the images on the film appear to change continuously. Explain that mitosis progresses in a similar fashion. LS Visual

Teach, *continued*

Teaching Key Ideas

Mitosis Versus Cytokinesis Students may think that mitosis is the same as cell division. Be sure they understand that mitosis refers strictly to the division of chromosomes, whereas cytokinesis refers to the division of the cytoplasm. Ask students to think of a memory device that will help them keep the terms straight. (Cytokinesis goes with cytoplasm. Both terms have the word part *cyto-*.) Remind students that cell division is just one of the four events that make up the cell cycle.

LS Verbal

Close

Formative Assessment

Once a new cell forms, the stages of development that follow are____.

A. S, G_2, G_1, Mitosis, Cytokinesis (Incorrect. Synthesis occurs after G_1.)

B. Mitosis, Cytokinesis, G_1, S, G_2 (Incorrect. Mitosis can not occur until the cell has developed and reproduced its DNA.)

C. G_1, S, G_2, Mitosis, Cytokinesis (Correct! The cell grows, replicates DNA, grows, and creates two new cells.)

D. S, G_2, Mitosis, Cytokinesis, G_1 (Incorrect. A cell must mature before it can duplicate its DNA.)

Answers to Section Review

1. G_1 is the growth stage. S is the DNA replication stage. During G_2, the cell grows and prepares for division. During mitosis the nucleus divides. Cytokinesis is the stage in which the cytoplasm divides.

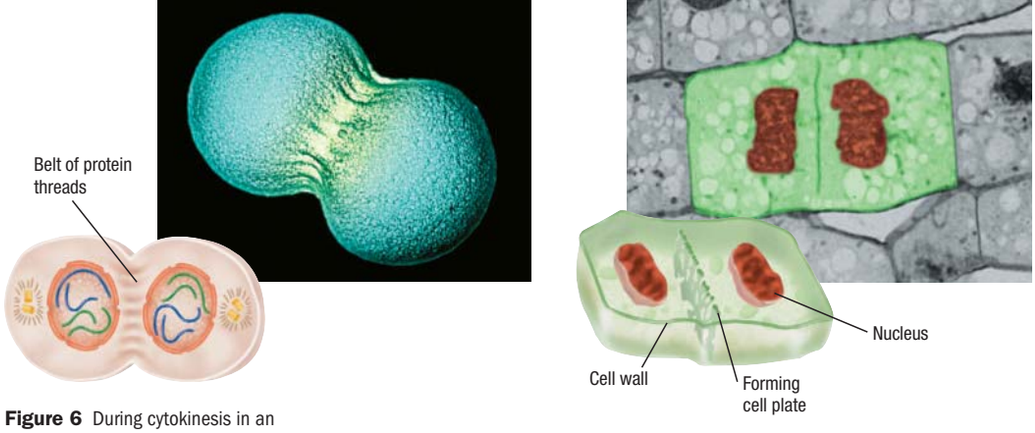


Figure 6 During cytokinesis in an animal cell (left), the cell membrane is pinched in half by a belt of protein threads. During cytokinesis in plant cells (right), a cell plate forms down the middle of the dividing cell.

ACADEMIC VOCABULARY
rigid stiff, firm, inflexible

Cytokinesis

As mitosis ends, cytokinesis begins. The cytoplasm is separated, and two cells are formed. **During cytokinesis, the cell membrane grows into the center of the cell and divides it into two daughter cells of equal size. Each daughter cell has about half of the parent's cytoplasm and organelles.** The end result of mitosis and cytokinesis is two genetically identical cells in place of the original cell.

Separating the Cytoplasm In animal cells and other cells that lack cell walls, the cell is pinched in half by a belt of protein threads, as **Figure 6** shows. In plant cells and other cells that have rigid cell walls, the cytoplasm is divided in a different way. Vesicles holding cell wall material line up across the middle of the cell. These vesicles fuse to form a large, membrane-bound cell wall called the *cell plate*, shown in **Figure 6.** When it is completely formed, the cell plate separates the plant cell into two new plant cells.

Continuing the Cell Cycle After cytokinesis is complete, each cell enters the G_1 stage of interphase. The daughter cells are about equal in size—about half the size of the original cell. The activity of each cell continues because each has its own DNA and organelles. The cell cycle continues for each new cell.

Reading Check ***What is a cell plate?***

Section 2 **Review**

KEY IDEAS

1. **Describe** the five phases of the cell cycle.
2. **List** in order the four stages of mitosis and the changes that occur during each stage.
3. **Compare** the products of cytokinesis.

CRITICAL THINKING

4. **Evaluating Information** Why are individual chromosomes more difficult to see during interphase than they are during mitosis?
5. **Predicting Results** What would happen if the cell did not have spindle fibers?
6. **Making Connections** Compare cell division in prokaryotic cells with cell division in eukaryotic cells.

ALTERNATIVE ASSESSMENT

7. **Animated Flipbook** Make a series of drawings that show the cell cycle of a plant cell. Be sure to include the five phases of the cell cycle and the four stages of mitosis.

2. Prophase – chromosomes condense; nuclear membrane dissolves; centrosomes move to the opposite poles; spindle forms

   Metaphase – chromosomes line up on the equator; spindle fibers link chromatids to opposite poles

   Anaphase – spindle fibers shorten; chromatids travel to the opposite poles

   Telophase – nuclear envelope forms at poles; spindle dissolves; chromosomes uncoil; cytokinesis begins

3. The parent cell became two equally-sized daughter cells, each with half the parent's cytoplasm and organelles.

4. Chromosomes condense right before a cell divides in mitosis. During most of interphase, chromosomes are not condensed and are harder to see with a microscope.

5. Without spindle fibers, the sister chromatids would not separate, and each daughter cell would not receive a complete set of genes.

6. Both cell types undergo growth, DNA replication, and physical separation. For eukaryotic cells, the chromosomes are sorted and separated within the nucleus, so that each daughter cell has all the necessary organelles.

7. Student flipbooks should include five phases of the cell cycle and the four stages of mitosis.

Section 3

Regulation

Key Ideas	Key Terms	Why It Matters
❯ What are some factors that control cell growth and division? ❯ How do feedback signals affect the cell cycle? ❯ How does cancer relate to the cell cycle?	cancer tumor	Understanding how to control cell growth could be the key to curing cancer!

Your body grows when more cells are added to the tissues and organs that make up the body. To stay healthy, cells continue to divide as needed to replace or renew tissues. How is the cell cycle regulated?

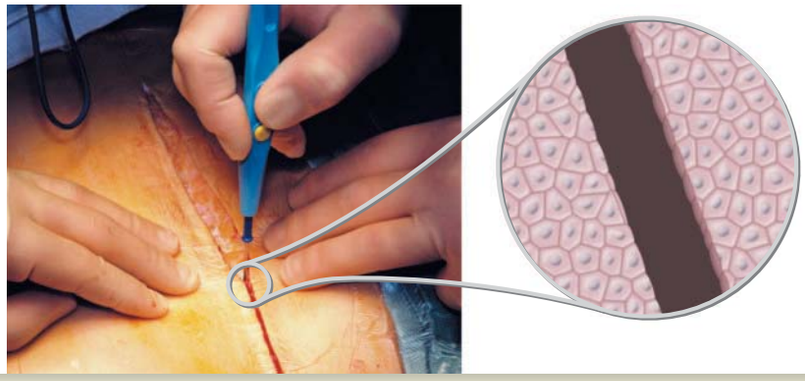
Controls

Scientists study the cell cycle by observing cells in a culture medium. When a few healthy cells are placed in a dish with plenty of nutrients, they divide rapidly. But when they come in contact with one another or with the edge of the dish, the cells stop dividing.

These observations apply to real life. For example, when you cut your skin or break a bone, your cells start growing and dividing more rapidly to repair the wounds. The cells shown in **Figure 7** will begin dividing to replace the cells cut by the scalpel. As more cells form, the new cells come into contact with each other and close the wound. When the wound is healed, the cells slow down or stop dividing.

Cell division is highly controlled. ❯ **Cell growth and division depend on protein signals and other environmental signals.** Many proteins within the cell control the phases of the cell cycle. Signals from surrounding cells or even from other organs can also regulate cell growth and division. Environmental conditions, including the availability of nutrients, also affect the cell cycle.

❯ **Reading Check** *What are two factors that affect the cell cycle?*



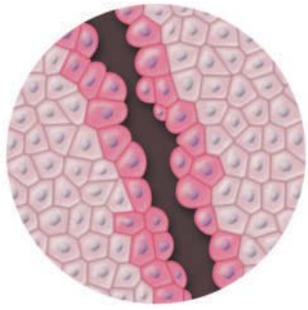


Figure 7 The cells surrounding this surgical incision will begin dividing more often to fill in the gap. ❯ **What signals the cells to stop dividing when the wound is healed?**

Section 3

❯ Focus

This section focuses on the mechanisms regulating the cell cycle and how cancer relates to malfunctions in those mechanisms.

Bellringer

Use the Bellringer transparency to prepare students for this section.

❯ Teach

Teaching Key Ideas

Knowing When to Stop Ask students to describe when they got a cut or scrape. Ask how the wound changed as it healed. Then, ask does the body continued to grow cells where the wound occurred? (no) How does the body know to stop growing cells in that area? Discuss possible cues that would let the body know it is time to start or stop making new cells. Tell students that a process called contact inhibition signals cell division to stop. LS Verbal

Answers to Caption Questions

Figure 7: contact with other cells

Teach, *continued*

QuickLab

Teachers Notes UV sensitive beads are found in science supply catalogues. Make sure there is no UV absorbing film on the glass of the window that you use.

Safety Caution Some students may have PABA allergies. Students should wear disposable gloves and goggles.

Materials
- UV-sensitive beads (30)
- sun-block, one tablespoon

Answers to Analysis

1. The beads are clear and transparent.
2. No. Household light bulbs do not emit UV radiation.
3. Those without sun-block changed colors. Those with sun-block either did not change color, or their color change was minimal due to exposure from the sides of the dish.
4. Sun-block limits exposure to UV radiation thus reducing the risk of it damaging the DNA in cells.

READING TOOLBOX

Cause and Effect

G_1 Checkpoint
Cause: Cell is not healthy, too small, or conditions are unsuitable for division.
G_2 Checkpoint
Cause: Recognizes mistakes that occurred when the DNA was copied or cell is still too small.
Metaphase Checkpoint
Cause: Chromosomes are not properly aligned to spindle fibers.

LS **Verbal**

Hands-On

QuickLab

30 min

UV and Sunblock

Prolonged exposure to the sun's UV radiation can damage DNA, disrupting the cell cycle and causing skin cancer.

Procedure

1. In a dimly lit room, expose **UV-sensitive beads** to a bright, incandescent light source. Record any changes that you observe.
2. Thoroughly coat five beads in a thick covering of **sunblock.** Place these beads on one side of a **paper plate.** Place five uncoated beads on the other side.
3. Expose the plate to direct sunlight for a moment. Examine the beads in dim surroundings. Record any changes that you observe.

Analysis

1. **Describe** the appearance of the beads before they were exposed to bright light sources.
2. **Determine** whether exposure to the artificial light source affected their appearance.
3. **Describe** how direct sunlight affected the beads.
4. CRITICAL THINKING **Making Inferences** How can using sunblock protect you from getting cancer?

READING TOOLBOX

Cause and Effect At each checkpoint, identify a cause that would result in a delay of the next phase of the cell cycle.

Checkpoints

During the cell cycle, a cell undergoes an inspection process to ensure that the cell is ready for the next phase in the cell cycle.

› Feedback signals at key checkpoints in the cell cycle can delay or trigger the next phase of the cell cycle. There are three main checkpoints in the cell cycle, as **Figure 8** shows.

G_1 Checkpoint Before the cell copies its DNA, the cell checks its surroundings. If conditions are favorable and the cell is healthy and large enough, the cell enters the synthesis phase. If conditions are not favorable, the cell goes into a resting period. Certain cells, such as some nerve and muscle cells, remain in this resting period for a long time. They do not divide very often.

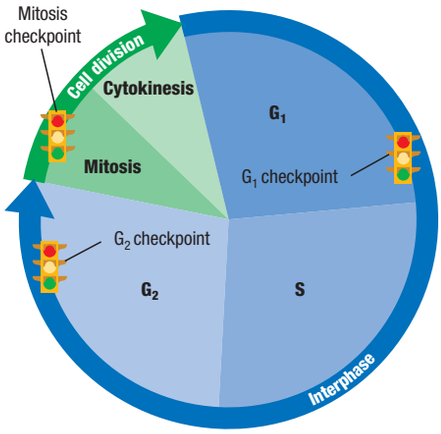


Figure 8 The eukaryotic cell cycle has three checkpoints. Many proteins play a role in controlling the cell cycle.

G_2 Checkpoint Before mitosis begins, the cell checks for any mistakes in the copied DNA. Enzymes correct mistakes that are found. This checkpoint ensures that the DNA of the daughter cells will be identical to the DNA of the original cell. Proteins also double-check that the cell is large enough to divide. If the cell passes the G_2 checkpoint, then the cell may begin to divide. Once past this checkpoint, proteins help to trigger mitosis.

Mitosis Checkpoint During the metaphase stage of mitosis, chromosomes line up at the equator. At this point, the cell checks that the chromosomes are properly attached to the spindle fibers. Without this point, the sister chromatids of one or more chromosomes may not separate properly. This checkpoint ensures that the genetic material is distributed equally between the daughter cells.

› Reading Check ***What happens at the G_2 checkpoint?***

Differentiated Instruction

English Learners/Struggling Readers

Traffic Jam Struggling readers and students learning English may not understand the traffic light analogy shown in **Figure 8.** Model a stop and go process for them, such as crossing a busy street. Engage them in a discussion that makes the point that one can proceed safely only after checking for oncoming traffic.

LS **Visual/Kinesthetic**

Alternative Assessment

Pitfalls of Rapid Cell Division Cancer therapies target rapidly dividing cells. Hair loss, nausea, anemia, and low white cell count are some of the common side effects of chemotherapy and radiation therapy. Ask students what might be causing these symptoms. (Cell division rates are higher for cells in hair follicles, the stomach, and in bone marrow. As a result, these cells are also targets during treatments causing the unpleasant side effects.)

Cancer

Each year, more than 1 million Americans are diagnosed with cancer. **Cancer** is a group of severe and sometimes fatal diseases that are caused by uncontrolled cell growth. **Uncontrolled cell growth and division can result in masses of cells that invade and destroy healthy tissues.** Preventing or curing cancer requires an understanding of how a healthy person's cells can become cancerous.

Figure 9 A doctor often can see a lung tumor on an X ray. Tumors are masses of cells (inset) that divide out of control.

Loss of Control Normally, a cell responds properly to signals and controls. However, damage to a cell's DNA can cause the cell to respond improperly or to stop responding. The cell cycle can no longer be controlled. The defective cell divides and produces more defective cells, such as the cells in **Figure 9.** Eventually, these cells can form a mass called a **tumor.**

Development A *benign tumor* does not spread to other parts of the body and can often be removed by surgery. A *malignant tumor* invades and destroys nearby healthy tissues and organs. Malignant tumors, or cancers, can break loose from their tissue of origin and grow throughout the body. This process is called *metastasis*. Once a cancer has metastasized, it becomes more difficult to treat.

Treatment Some cancers can be treated by using drugs that kill the fast-growing cancer cells. Because drugs are chemicals, this method of treatment is called *chemotherapy,* or "chemo" for short. Some cancers can be treated by surgery to remove the affected organ. In radiation therapy, high-energy rays are focused on an area in order to destroy cancerous cells. Doctors choose the most effective treatment for a particular kind of cancer.

Prevention The best way to prevent cancer is to avoid things that can cause cancer. Ultraviolet radiation in sunlight can damage genes that control the cell cycle. Chemicals in cigarette smoke also affect how cell growth and division is regulated.

Reading Check ***What causes cells to lose control of the cell cycle?***

cancer a group of diseases characterized by uncontrolled growth and spread of abnormal cells

tumor a growth that arises from normal tissue but that grows abnormally in rate and structure and lacks a function

Section 3 Review

KEY IDEAS

1. **Describe** the effect of environmental conditions on the cell cycle.
2. **Summarize** the events of each of the three checkpoints of the cell cycle.
3. **Distinguish** between a benign tumor and a malignant tumor.

CRITICAL THINKING

4. **Applying Concepts** Propose an example of a situation in which an environmental condition might signal cell division in an organism.
5. **Logical Reasoning** The three checkpoint steps that a cell goes through allow the cell cycle to proceed correctly. What would happen if these steps did not function properly?

WRITING FOR SCIENCE

6. **Research** Use library resources or the Internet to research factors that increase the risk of cancer and the types of cancer that they could lead to. Why are factors in lifestyle or the environment difficult to identify? How can people protect themselves from exposure to known risk factors?

Teaching Key Ideas

Which Cells Become Cancerous? Tell students that all dividing cells have the potential to become cancer cells. Mechanisms in the replication pathway tell the cell when it is time to divide and stop dividing. Changes in these instructions are caused by mutations within the DNA, and others are caused by a virus that injects a new strand of RNA into a cell. This viral RNA is transcribed into DNA, through reverse transcription, and inserted into the cell's genome. The new DNA changes the instructions for when and how the cell replicates, transforming a normal cell into a cancer cell. **LS Logical**

Close

Formative Assessment

Checkpoints in the cell cycle ___.

A. signal cell death (Incorrect. Checkpoints monitor the readiness for division.)

B. maintain the homeostatic environment of the cells interior (Incorrect. Checkpoints do not control daily cellular activity.)

C. check that cell division occurs when the cell is of suitable size and has met the necessary internal conditions (Correct! Specific cell criteria are monitored during checkpoints to determine if division should proceed.)

D. limit the occurrence of cancer cell development to only 1% of cell reproduction events (Incorrect. Cancer is caused by damaged DNA, which overrides the checkpoints of the cell cycle.)

Answers to Section Review

1. Cells grow and divide depending on signals from other cells, from organs, as well as the availability of nutrients and proteins. The cell cycle is interrupted if the environment is not optimal for division.
2. G1 checkpoint – checks size and surroundings before entering the S phase. G2 checkpoint – checks size and for mistakes after copying its DNA, and corrects mistakes before the cell goes into mitosis. Mitosis checkpoint – checks that chromosomes are properly attached to the spindle fibers so that separation can occur properly.
3. A benign tumor is a defective growth of cells that does not spread to other parts of the body. They are generally removed by surgery. A malignant tumor is one that has invaded and destroyed nearby healthy tissue and organs. If cells break loose from the tumor and travel through the body forming additional tumors, they are said to have metastasized and are very difficult to treat.
4. Some plants grow when the weather gets warm. Temperature could be an environmental condition that signals cell division in some plant cells.
5. If the cell cycle does not function properly at any checkpoint then the cell may not divide properly. This would result in an unequal distribution of genetic material into the daughter cells. The inspection process controls the cell cycle so that the cell is ready for each successive stage.
6. People can protect themselves from exposure to known risk factors by not smoking, drinking only moderate amounts of alcohol, eating a healthy low-fat diet, wearing sunscreen, exercising, and avoiding exposure to carcinogenic chemicals and radiation.

Lab

Skills Practice

Chapter 10 Lab

Time Required

One 45-minute lab period

Ratings

EASY → HARD

Teacher Prep
Student Setup
Concept Level
Cleanup

Safety Cautions

Have students handle glass slides with care.

Tips and Tricks

Preparing Your Own Slides You can prepare your own slides with the following materials:

- aceto-orcein stain
- cork
- forceps
- glass dish
- onions
- paper towels
- scalpel
- slides and cover slips
- 2 M HCl

Wear disposable gloves and goggles. Place the onion root tips in water for several days before the lab to initiate root-tip lengthening. About one-half hour before the lab, use a sharp scalpel to cut root tips that are 3 mm long. Pour 2 M HCl into a beaker that is in a fume hood. Place the root tips in the beaker for 10 minutes. Use forceps to transfer the soaked root tips to slides. Add a drop of aceto-orcein stain to each slide. Use a scalpel to mince the tips and then cover the specimens with coverslips. Put a paper towel and a cork over the coverslip and press gently but firmly until the tips are flattened. Flattening an improperly prepared root tip can break a glass coverslip. If the tip cannot be flattened, return it to the acid for 10 more minutes and try again.

Mitosis Projection Students often have trouble identifying the phases of mitosis. It is helpful to project a slide or CD-ROM image of root tip mitosis for reference during the lab.

Disposal If you throw the prepared slides of the onion tip away, make sure they are deposited in biohazard/glass safety bin. This type of bin can be purchased from a medical supply house.

Objectives

- Examine the dividing root-tip cells of an onion.
- Identify the phase of mitosis that each cell in an onion root tip is undergoing.
- Determine the relative length of time each phase of mitosis takes in onion root-tip cells.

Materials

- compound light microscope
- prepared microscope slide of a longitudinal section of *Allium* (onion) root tip

Safety

Mitosis in Plant Cells

Look at the photograph of a longitudinal section of an onion root tip. In the tips of plant roots and shoots, mitosis is ongoing in growth regions called *meristems.* Mitosis occurs in four phases: prophase, metaphase, anaphase, and telophase. In this lab, you will determine the relative length of time each phase of mitosis takes in onion root-tip cells. To do this, you will count the number of cells undergoing each phase of mitosis in the meristem of an onion root section.

Procedure

Identify the Phases of Mitosis

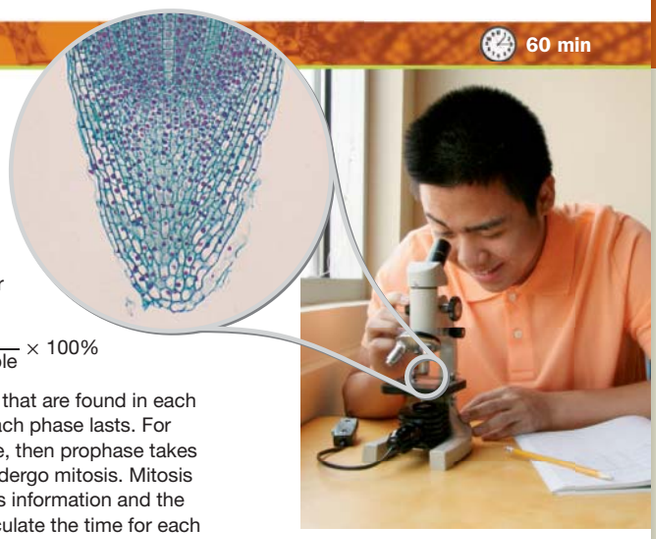
1. **CAUTION: Put on safety goggles, gloves, and a lab apron.**
2. **CAUTION: Handle glass slides and cover slips with care.** Using low power on your microscope, bring the meristem region on your slide into focus.
3. Examine the meristem carefully. Choose a sample of about 50 cells. Look for a group of cells that appear to have been actively dividing at the time that the slide was made. The cells will appear to be in rows, so it should be easy to keep track of them. The dark-staining bodies are the chromosomes.
4. For each of the cells in your sample, identify the stage of mitosis. Make a data table of the relative duration of each phase of mitosis. Record your observations in the data table.

Relative Duration of Each Phase of Mitosis

Phase of mitosis	Tally marks	Count	Percentage of all cells	Time (min)
Prophase				
Metaphase				
Anaphase				
Telophase				

Calculate the Relative Length of Each Phase

5. When you have classified each cell in your sample, count the tally marks for each phase and fill in the "Count" column. In which phase of mitosis was the number of cells the greatest? In which phase of mitosis was the number of cells the fewest?



6. Calculate what percentage of all cells were found in each phase. Divide the number of cells in a phase by the total number of cells in your sample, and multiply by 100%. Enter these figures under the "Percentage" column.

$$\text{Percentage} = \frac{\text{number of cells in phase}}{\text{total number of cells in sample}} \times 100\%$$

7. The percentage of the total number of cells that are found in each phase can be used to estimate how long each phase lasts. For example, if 25% of the cells are in prophase, then prophase takes 25% of the total time that a cell takes to undergo mitosis. Mitosis in onion cells takes about 80 min. Using this information and the percentages you have just determined, calculate the time for each phase and record it in your data table.

$$\text{Duration of phase (in minutes)} = \frac{\text{percentage}}{100} \times 80 \text{ min}$$

8. Make another table to record the data for the entire class. Collect and add the counts for each phase of mitosis for the entire class. Fill in the percentage and time information by using these data.

9. Clean up your lab materials according to your teacher's instructions. Wash your hands before leaving the lab.

Class Data

Phase of mitosis	Count	Percentage of all cells	Duration (min)
Prophase			
Metaphase			
Anaphase			
Telophase			

Analyze and Conclude

1. **Identifying Structures** What color are the chromosomes stained?
2. **Recognizing Relationships** How can you distinguish between early and late anaphase?
3. SCIENTIFIC METHODS **Making Systematic Observations** According to your data table, which phase takes the least amount of time? Which phase of mitosis lasts the longest? Why might this phase require more time than other phases of mitosis do?
4. SCIENTIFIC METHODS **Summarizing Data** How do your data compare with the data of the entire class?
5. SCIENTIFIC METHODS **Critiquing Procedures** In this investigation, you assumed that the percentage of the total time that any given phase takes is equal to the percentage of the total number of cells in that phase at any moment. Why might this not be true for very small samples of cells?

Extensions

6. **Applying Methods** Cancerous tissue is composed of cells undergoing uncontrolled, rapid cell division. How could you develop a procedure to identify cancerous tissue by counting the number of cells undergoing mitosis?

Answers to Procedure

5. The number of tally marks beside each stage will vary. The greatest number of cells in the sample should be in prophase. The fewest number of cells should be in anaphase, but answers may vary.
6. Answers should reflect the data. Roughly 85 percent of the cells should be in prophase, 8 percent in metaphase, 3 percent in anaphase, and 4 percent in telophase.
7. Answers should reflect the data. Roughly 68 minutes are spent in prophase, 6 minutes in metaphase, 2 minutes in anaphase, and 3 minutes in telophase.
9. Class data and calculations based on class data will vary.

Answers to Analyze and Conclude

1. Chromosomes are often stained pink or purple, depending on the stain used.
2. In early anaphase, the chromosomes are just beginning to pull away from the midline. In late anaphase, the chromosomes are near the poles.
3. Answers may vary, but usually anaphase or telophase takes the least amount of time. Prophase usually takes the longest time. More events occur during prophase, which is why it is longer.
4. Answers may vary depending on class data.
5. Simply by chance, a small area might have an overrepresentation of one mitotic phase. Larger samples would yield more representative data.

Answers to Extensions

6. Students would have to find out the percentage of cells undergoing mitosis at any given time in a normal tissue sample and compare it with the cancerous tissue sample.

Key Resources

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

Chapter 10

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 **HX8CRPS** to access the Super Summary for this chapter.

Reteaching Key Ideas

Cell Parts and Reproduction Ask students to differentiate each of the following terms using both definitions and drawings: *chromosomes, chromatids, DNA,* and *genes.* Students should label their sketches. (chromosomes – coiled DNA and associated proteins; chromatids – condensed chromatin; DNA – the chain of nucleic acids containing genetic code; genes – the sequences of DNA that code for specific proteins or RNA.) LS Verbal/Visual

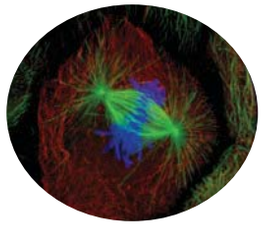
Parts of the Cell Cycle Assign students to groups and have each group draw a stage in the cell cycle. Each group displays their drawing in a circle that you've drawn to represent the cell cycle. LS Visual

Chapter 10 Summary

go.hrw.com
SUPER SUMMARY
Keyword: HX8CRPS

Key Ideas	Key Terms
1 Cell Reproduction	**gene** (224) **chromosome** (224) **chromatin** (224) **histone** (224) **nucleosome** (224) **chromatid** (225) **centromere** (225)
2 Mitosis	**cell cycle** (228) **interphase** (228) **mitosis** (229) **cytokinesis** (229) **spindle** (230) **centrosome** (230)
3 Regulation	**cancer** (235) **tumor** (235)

- Because larger cells are more difficult to maintain, cells divide when they grow to a certain size.
- Many proteins help package eukaryotic DNA into highly condensed chromosome structures.
- All newly-formed cells require DNA, so before a cell divides, a copy of its DNA is made for each daughter cell.

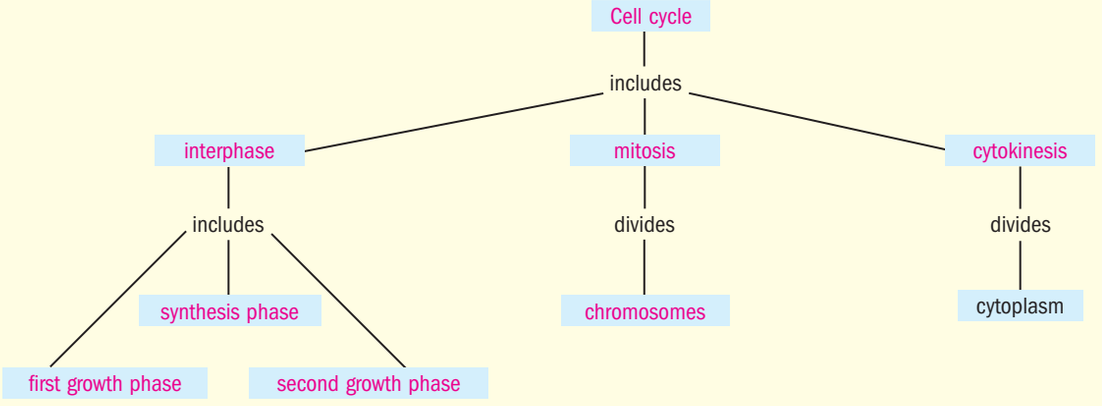


- The life of a eukaryotic cell cycles through phases of growth, DNA replication, preparation for cell division, and division of the nucleus and cytoplasm.
- Mitosis is a continuous process that can be observed in four stages: prophase, metaphase, anaphase, and telophase.
- During cytokinesis, the cell membrane grows into the center of the cell and divides it into two daughter cells of equal size. Each daughter cell has about half of the parent's cytoplasm and organelles.

- Cell growth and division depend on protein signals and other environmental signals.
- Feedback signals at key checkpoints in the cell cycle can delay or trigger the next phase of the cell cycle.
- Uncontrolled cell growth and division results in tumors, which can invade surrounding tissues and cause cancer.

Answer to Concept Map

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



Chapter 10 Review

READING TOOLBOX

1. **Word Parts** Find out the meaning of the prefixes *ana-*, *meta-*, *pro-*, and *telo-*.
2. **Concept Map** Make a concept map that shows the events in the cell cycle. Try to include the following words in your map: *cell cycle, interphase, synthesis phase, chromosomes, cytokinesis, mitosis, second gap phase,* and *first gap phase.*

Using Key Terms

3. Explain the relationship between *gene* and *chromosome.*
4. Use the following terms in the same sentence: *tumor* and *cancer.*

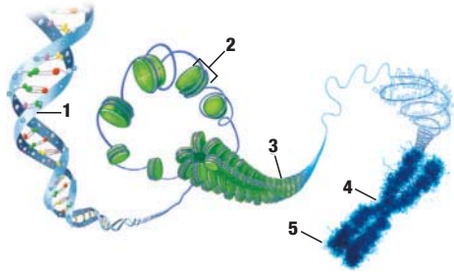
For each pair of terms, explain how the meanings of the terms differ.

5. *chromatin* and *chromatid*
6. *centromere* and *centrosome*

Understanding Key Ideas

7. Which of the following is a reason that the size of a cell is limited?
   - **a.** Larger cells are easier for an organism to produce than smaller cells.
   - **b.** The cell's ability to exchange substances is limited by its surface area–to-volume ratio.
   - **c.** The larger the cell becomes, the easier it is for substances to reach where they are needed.
   - **d.** The size of a cell has no relationship to the cell's function in a multicellular organism.
8. What is a gene?
   - **a.** a large molecule of chromosomes
   - **b.** a protein that directs the activity of a cell
   - **c.** a segment of DNA that codes for RNA and protein
   - **d.** a segment of RNA that moves from the nucleus to the cytoplasm
9. During which stage of mitosis do the chromosomes line up along the equator?
   - **a.** anaphase
   - **b.** metaphase
   - **c.** prophase
   - **d.** telophase
10. What factors can cause cells to divide in a culture medium?
    - **a.** protein signals
    - **b.** lack of nutrients
    - **c.** contact with other cells
    - **d.** contact with the edge of the dish
11. What is the importance of feedback signals at key checkpoints within the cell cycle?
    - **a.** to indicate the end of the cycle
    - **b.** to indicate the presence of proteins
    - **c.** to identify the meiosis and mitosis indicators
    - **d.** to delay or trigger the next phase of the cycle

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



12. Which structure is a nucleosome?
    - **a.** Structure 1
    - **b.** Structure 2
    - **c.** Structure 3
    - **d.** Structure 4
13. What is Structure 5 called?
    - **a.** histone
    - **b.** spindle
    - **c.** chromatid
    - **d.** scaffold protein

Explaining Key Ideas

14. **Propose** why a new cell would need an entire copy of the old cell's DNA.
15. **Define** the importance of mitosis and cytokinesis in the life cycle of a eukaryotic cell.
16. **Contrast** cytokinesis in animal and plant cells.
17. **Identify** the events that occur at the G_2 checkpoint.
18. **Summarize** how normal cells can become cancerous.

Assignment Guide

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

Review

Reading Toolbox

1. ***ana–*** up/back/again/throughout; ***meta–*** wih/after/beyond; ***pro–*** before; ***telo–*** end
2. See previous page for answers to concept map.

Using Key Terms

3. *Genes* are segments of DNA that code for RNA and protein. *Chromosomes* are structures of DNA wrapped around proteins. Many genes are located on a chromosome.
4. *Tumor* cells that have metastasized form *cancer.*
5. *Chromatin* describes a substance of DNA and proteins. A *chromatid* is one of two copies of a chromosome and is made of chromatin.
6. The *centromere* is the region where sister chromatids are held together. The *centrosome* is the organelle that helps assemble the spindle during mitosis.

Understanding Key Ideas

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

Explaining Key Ideas

14. A new cell would need the exact instructions of the cell it is replacing to continue functioning in the same manner to keep the body healthy.
15. Each daughter cell requires a nucleus and organelles. Mitosis divides the parent cell's nucleus; cytokinesis divides the parent cell's cytoplasm and organelles.
16. Animal cells do not have cell walls, so the cell is pinched in half by a belt of protein threads. In plant cells that have rigid cell walls, a cell plate is formed across the middle of the plant cell. When completed, the cell plate fuses with the original cell wall, and completely separates the original cell into two daughter cells.
17. The cell checks for mistakes in the copied DNA. Enzymes correct mistakes that are found. Proteins check that the cell has enough cytoplasm to divide into two cells. If these conditions are met, the cell releases proteins that help trigger mitosis.

18. Normal cells can become cancer cells if a genetic mutation impairs a cell's ability to regulate cell growth and division. The mutation leads to cancer, or uncontrolled cell growth.

Using Science Graphics

19. c
20. d

Critical Thinking

21. Most nerve cells are permanently resting in interphase G_1. They do not undergo mitosis, so most damaged nerve cells are not replaced.
22. The plant spindle forms without centrioles and mitosis continues successfully.

Writing Skills

23. Cells from large tumors often have unusually short telomeres. Telomerase, an enzyme that catalyzes the lengthening of telomeres, stabilizes telomere length, especially in cancer cells. Researchers are focusing on telomerase as a target for cancer diagnosis and chemotherapy.

Methods of Science

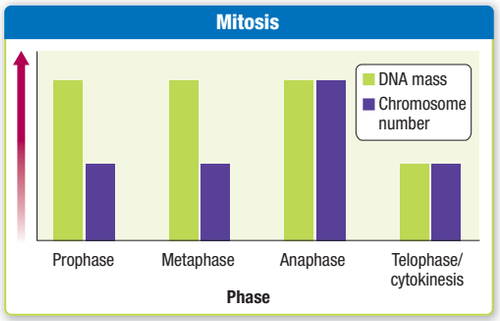
24. d
25. c
26. The vertical axis (*y* axis) is the yeast colonies, and the horizontal axis (*x* axis) is the length of exposure.
27. Colonies exposed longer to the UV light had fewer surviving yeast cells.

Math Skills

28. Nine chromosomes (The number of chromosomes doubles after anaphase. If cell B has six chromosomes after mitosis, cell B began with three chromosomes. If cell A has three times as many chromosomes as cell B, then cell A should have nine chromosomes.)

Using Science Graphics

The graph shows the relative mass of DNA and chromosome number for a cell undergoing mitosis. Use the graph to answer the following questions.



19. In which phase of mitosis do chromatids separate and become individual chromosomes?
- **a.** prophase
- **b.** metaphase
- **c.** anaphase
- **d.** telophase/cytokinesis

20. What process occurs that leads to the decrease in the cell's DNA mass?
- **a.** prophase
- **b.** metaphase
- **c.** anaphase
- **d.** telophase/cytokinesis

Critical Thinking

21. Evaluating Conclusions Damage to the brain or spinal cord is usually permanent. Use your knowledge of the cell cycle to explain why damaged cells in the brain or spinal cord are not replaced.

22. Analyzing Information Mitosis is similar in plants and animals, although plants lack centrioles. How might the absence of centrioles in plant cells have influenced scientists' thinking about the function of centrioles in mitosis?

Writing for Science

23. Communicating Information Scientists have determined that telomeres (the tips of chromosomes) are shaved down slightly every time a cell divides. When its telomeres become too short, a cell may lose its ability to divide. Find out what scientists have recently discovered about the relationship between telomere length, cell division and cancer. Prepare a written report to share with your class.

Methods of Science

Yeast cells are frequently used to study how cancer cells can form. Exposing cells to ultraviolet light during formation of new cells can affect new cell growth. Use the data in the table to answer the questions that follow.

Yeast colony identification code	Length of exposure to UV light (min)	Surviving yeast colonies
A	2	18
B	10	10
C	15	11
D	30	9
E	40	5
F	50	2
G	60	0

24. Identify the independent variable in this experiment.
- **a.** length of darkness (time)
- **b.** light intensity (brightness)
- **c.** yeast cell colonies (number)
- **d.** length of exposure to light (time)

25. Identify the dependent variable in this experiment.
- **a.** length of darkness (time)
- **b.** light intensity (brightness)
- **c.** yeast cell colonies (number)
- **d.** length of exposure to light (time)

26. Using the data in the table, construct a graph that plots surviving yeast colonies versus length of exposure.

27. Describe what happens to the yeast cell colonies when they are exposed to UV light.

Math Skills

28. Cell A has 3 times as many chromosomes as cell B has. Cell B undergoes mitosis, and has 6 chromosomes before cytokinesis is completed. How many chromosomes does cell A have?

Chapter 10 Standardized Test Prep

TEST TIP Slow, deep breathing may help you relax. If you suffer from test anxiety, focus on your breathing in order to calm down.

Science Concepts

1. Prokaryotic chromosomes
- **A** have two chromatids.
- **B** are connected at the centromere.
- **C** consist of a circular DNA molecule.
- **D** are made of DNA wrapped around histone proteins.

2. In what stage of the cell cycle is the DNA copied?
- **F** G_1
- **G** S
- **H** G_2
- **J** mitosis

3. Mitosis could not proceed if a mutation interrupted the assembly of the
- **A** cell wall.
- **B** spindle fibers.
- **C** cell membrane.
- **D** nuclear envelope.

4. What might happen if cytokinesis were omitted from the cell cycle?
- **F** The daughter cells would die.
- **G** The cell would lose its mitochondria.
- **H** The daughter cells would not have nuclei.
- **J** The cell would not divide into two daughter cells.

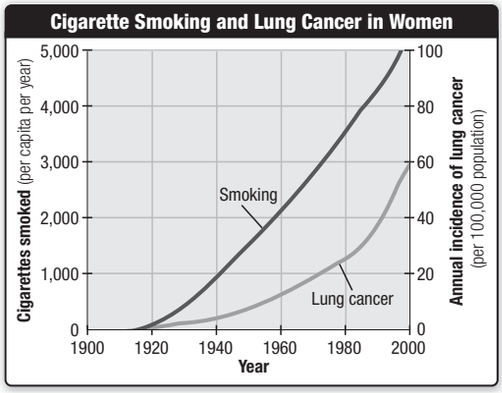
5. G_1 checkpoint : DNA replication :: G_2 checkpoint :
- **A** mitosis
- **B** cell size
- **C** cytokinesis
- **D** mistakes in DNA

Using Science Graphics

This diagram shows a model of cell division. Use the diagram to answer the following question(s).

6. What type of cell undergoes this type of cell division?
- **F** a plant cell
- **G** an animal cell
- **H** a eukaryotic cell
- **J** a prokaryotic cell

The graph shows the number of cigarettes smoked per capita per year between 1920 and 2000 and the annual incidence of lung cancer among women. Use the graph to answer the following question(s).



7. What was the relationship between the number of cigarettes smoked and the incidence of lung cancer?
- **A** There was no relationship between cigarette smoking and lung cancer.
- **B** As the number of cigarettes smoked decreased, the incidence of lung cancer increased.
- **C** As the number of cigarettes smoked increased, the incidence of lung cancer increased.
- **D** As the number of cigarettes smoked increased, the incidence of lung cancer decreased.

Writing Skills

8. Extended Response For a cell to function efficiently, its surface area must be high relative to its volume. Explain how cell division maintains the relationship between surface area and volume. How does a stable ratio of surface area to volume help maintain proper cell functioning?

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. C **2.** G **3.** B
4. J **5.** A **6.** J
7. C
8. As cell size decreases, the ratio of surface area–to-volume increases. Cell division produces two smaller cells. With a stable ratio between surface area and volume, cells are able to maintain homeostasis efficiently through osmosis and diffusion.

TEST DOCTOR

Question 1 Choices A and B require students to recognize the chromosome differences between prokaryotes and eukaryotes. **A** is incorrect because prokaryotic DNA is not packaged into chromatids. **B** is incorrect, because centromeres connect rod-shaped chromosomes in eukaryotes. **C** is correct, because bacterial DNA consists of a single large loop of DNA molecule. **D** is incorrect. Bacterial DNA is not wrapped around histone complexes, although it still coils densely around itself.

Question 3 **A** is incorrect, because the cell wall forms in plants during cytokinesis, which follows mitosis. **B** is correct, because spindle fibers provide the path and force for the separation of chromosomes to the poles of the dividing cell. **C** is incorrect, because the cell membrane forms during cytokinesis, which follows mitosis. **D** is incorrect, because the separation of chromosomes is complete before the nuclear envelope reforms.

Question 5 The analogy focuses on the action that follows the checkpoint. **A** is correct, because the G_2 checkpoint *directly precedes* mitosis. **B** is incorrect, because the G_2 checkpoint does not regulate or influence cell size. **C** is incorrect, because cytokinesis occurs after mitosis which occurs after the G_2 checkpoint. **D** is incorrect, because the G_2 checkpoint checks that any mistakes in DNA replication have been corrected. The G_1 checkpoint does not check to verify that DNA replication has occurred.