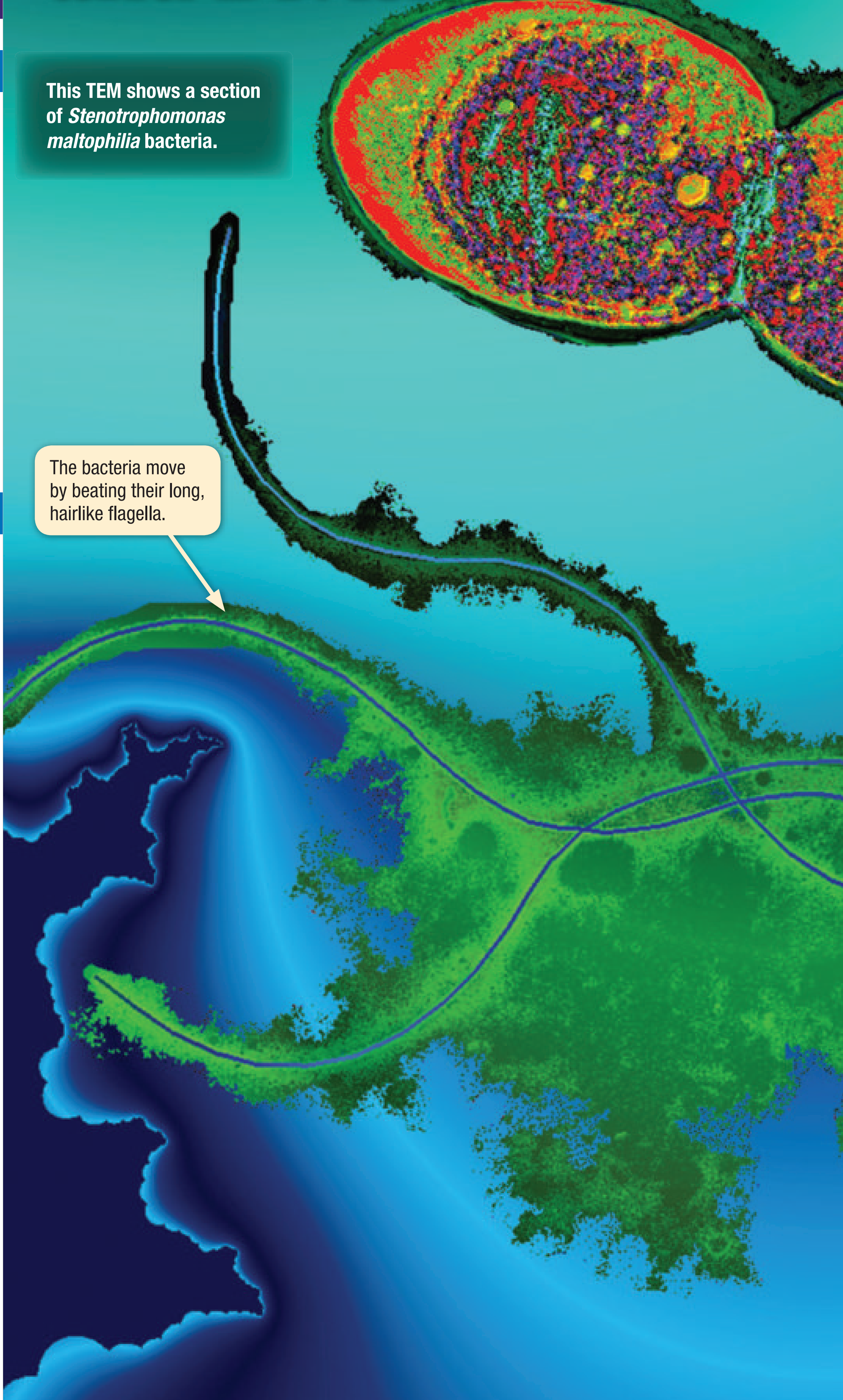
Chapter 10

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.



This TEM shows a section of *Stenotrophomonas maltophilia* bacteria.

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.

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.

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 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.

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

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.

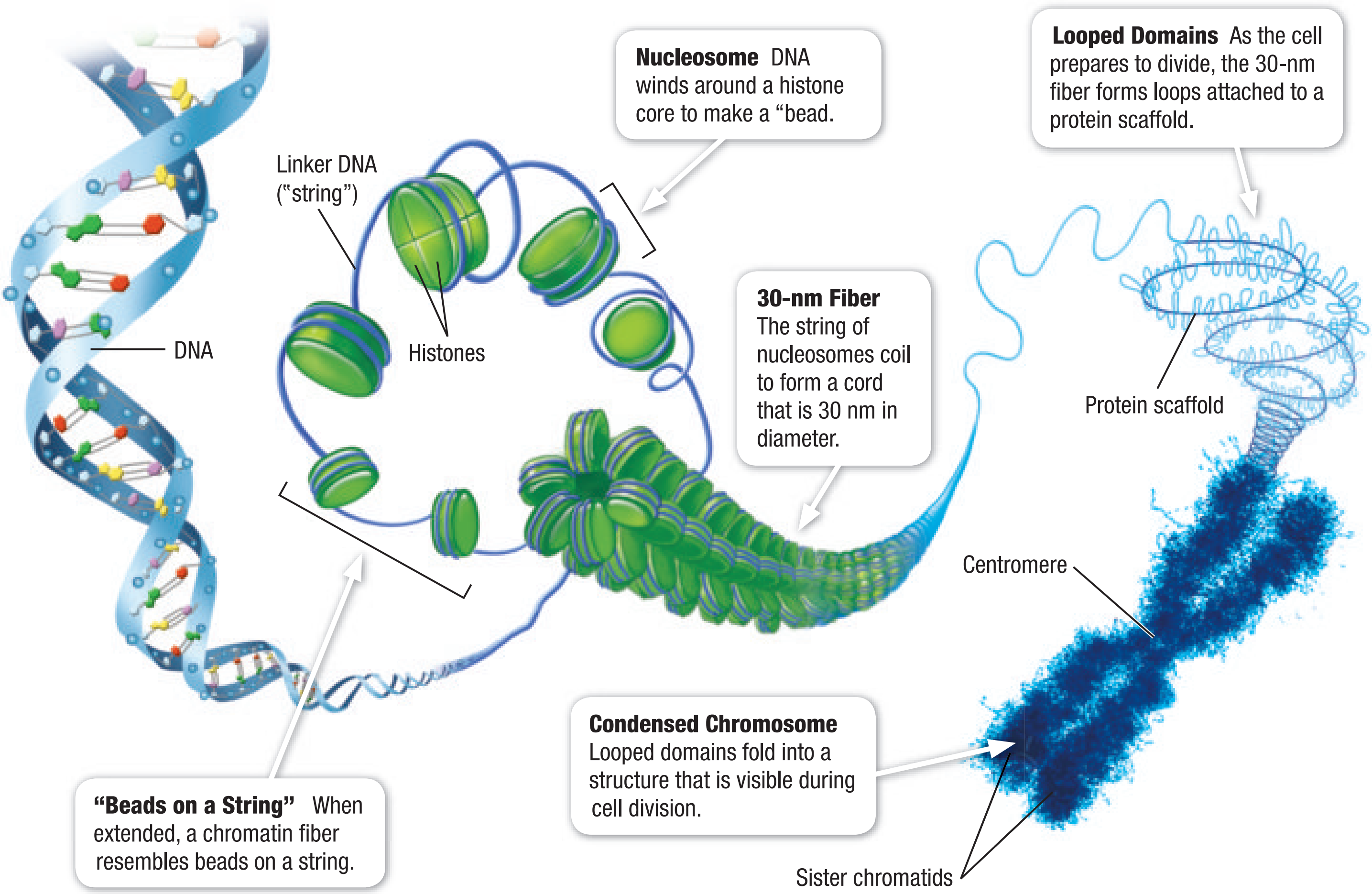
› **Reading Check** ***What is a chromatid? (See the Appendix for answers to Reading Checks.)***

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



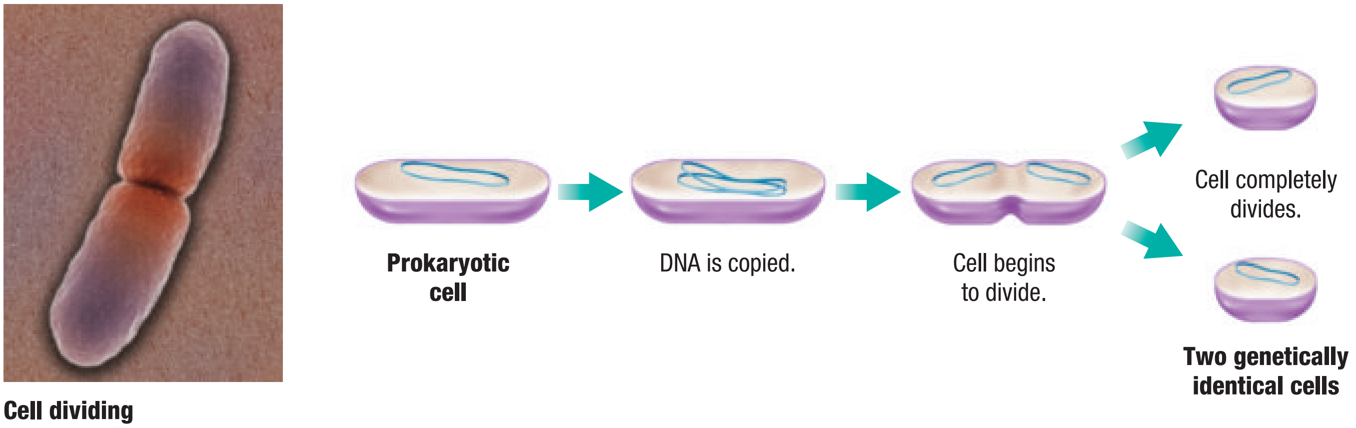


Figure 3 A prokaryotic cell divides by copying its single, circular chromosome and building a cell membrane between the two copies. A new cell wall forms around the membrane, squeezing the cell. Eventually it pinches off into two independent daughter cells.

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Code: HX80236

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.

ACADEMIC VOCABULARY

complex having many parts or functions

❯ **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?

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.

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.

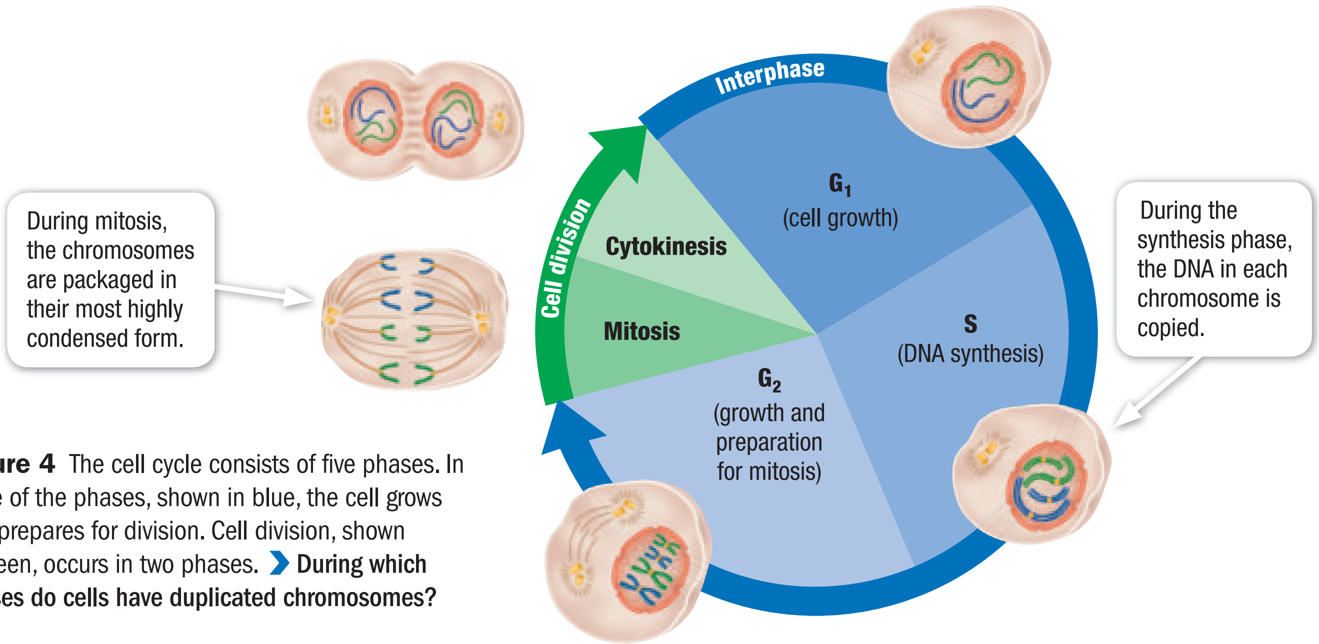

Figure 4 The cell cycle consists of five phases. In three of the phases, shown in blue, the cell grows and prepares for division. Cell division, shown in green, occurs in two phases. ❯ **During which phases do cells have duplicated chromosomes?**

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).

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

$$4.5 \times 10^9 \text{ cells} = 4{,}500{,}000{,}000 \text{ cells} = 4.5 \text{ billion cells}$$

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

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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.

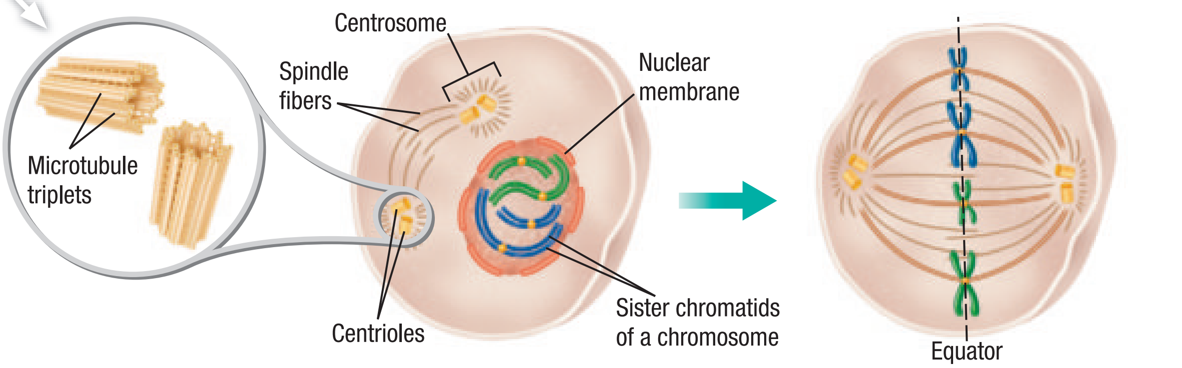
Figure 5 During mitosis, the copies (sister chromatids) of each chromosome are separated into two nuclei. **What is the role of the spindle fibers?**

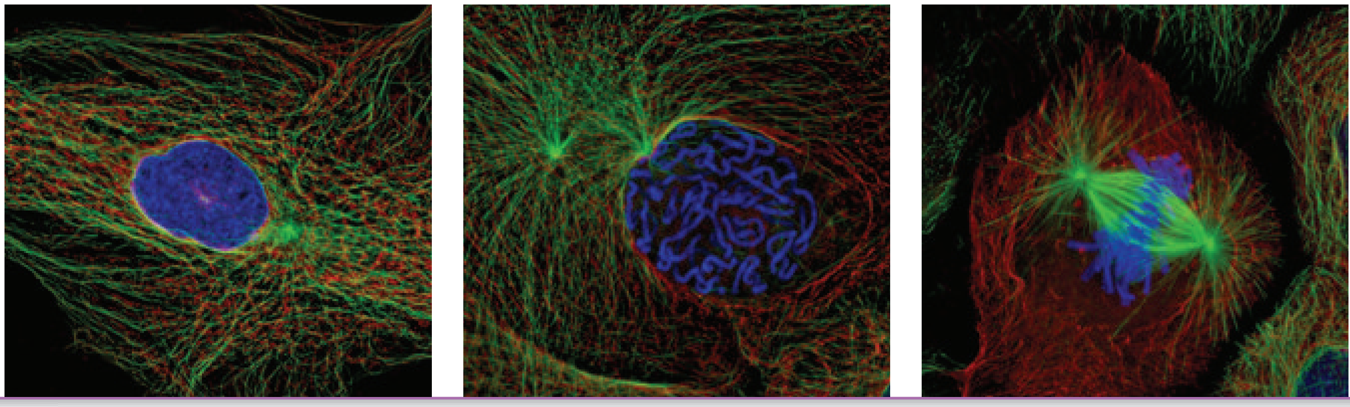
Stages of Mitosis

Each centriole consists of nine bundles of three microtubules each, arranged as a tube.

1 Prophase Chromosomes begin to condense. The nuclear membrane dissolves. The centrosomes move to opposite poles, and the spindle forms.

2 Metaphase The condensed chromosomes line up along the equator. Spindle fibers link the chromatids of each chromosome to opposite poles.





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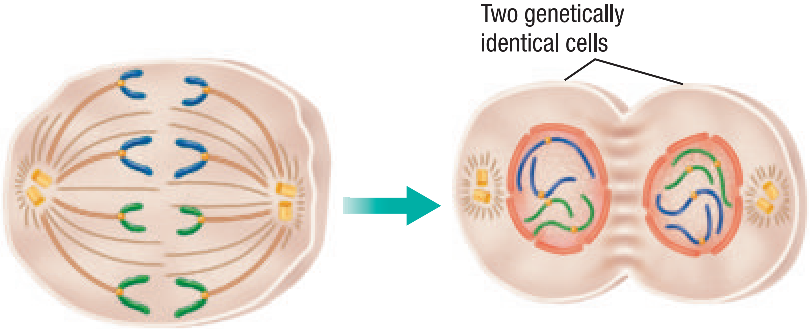
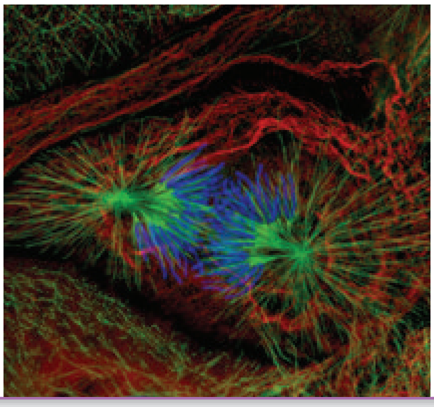
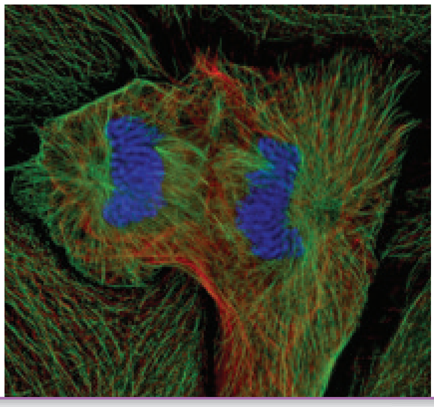
3 Anaphase As the spindle fibers shorten, the chromatids are pulled toward opposite poles of the cell.

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







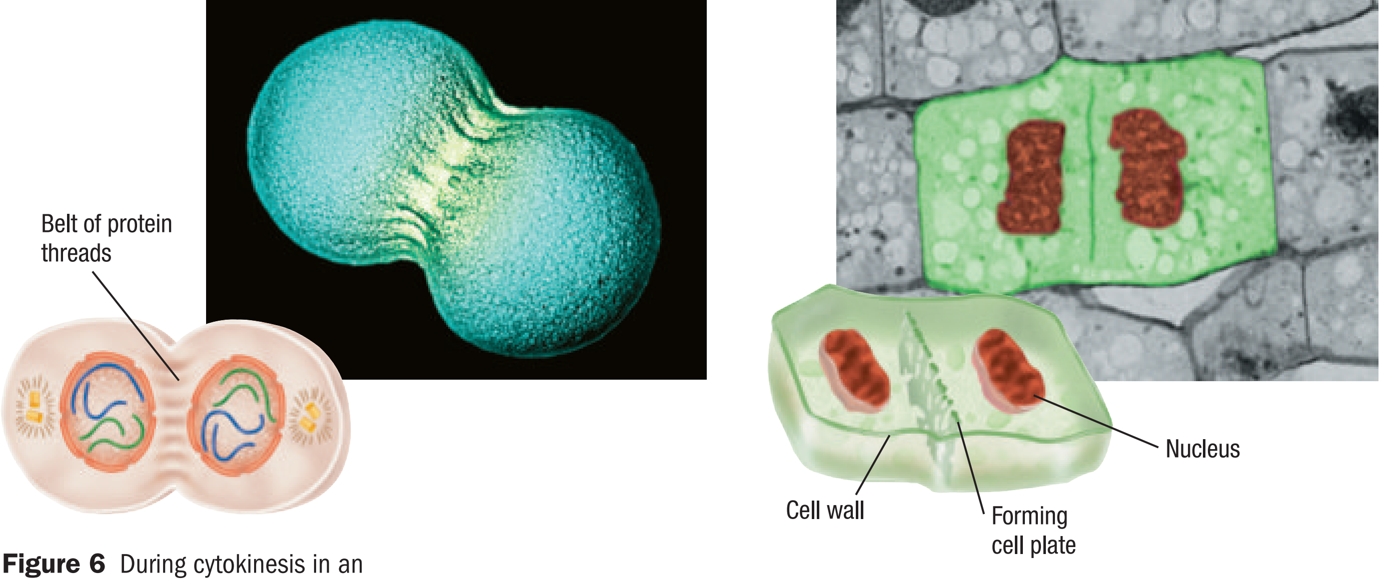


Figure 6 During cytokinesis in an animal cell (left), the cell membrane is pinched in half by a belt of protein threads. During cytokinesis in plant cells (right), a cell plate forms down the middle of the dividing cell.

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.

ACADEMIC VOCABULARY

rigid stiff, firm, inflexible

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.

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

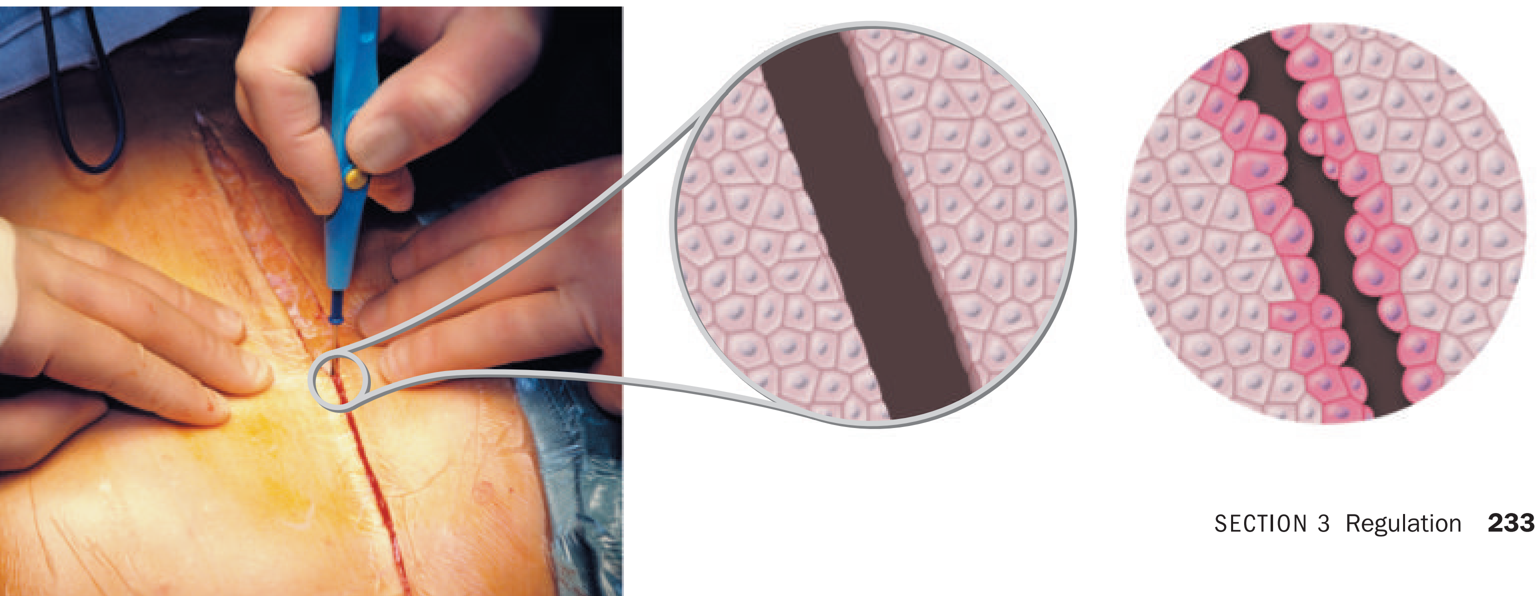
Scientists study the cell cycle by observing cells in a culture medium. When a few healthy cells are placed in a dish with plenty of nutrients, they divide rapidly. But when they come in contact with one another or with the edge of the dish, the cells stop dividing.

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?**



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 three 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 affect 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

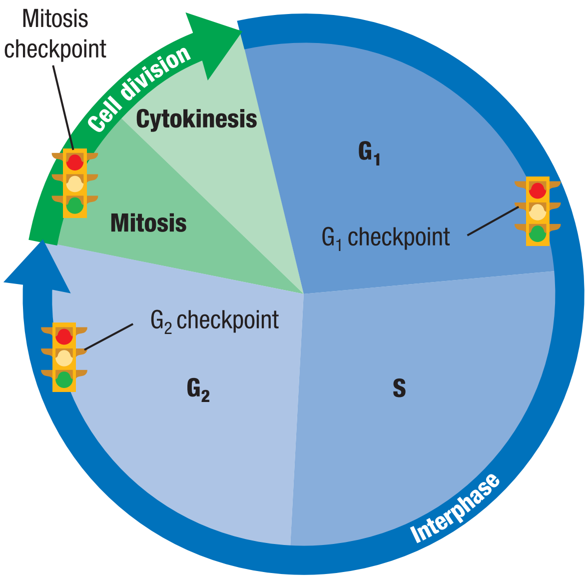
Cause and Effect At each checkpoint, identify a cause that would result in a delay of the next phase of the cell cycle.

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?*

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.

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.**

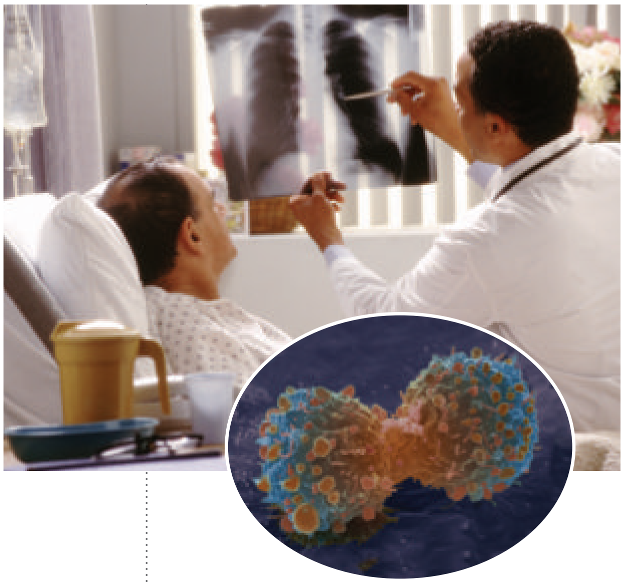


Figure 9 A doctor often can see a lung tumor on an X ray. Tumors are masses of cells (inset) that divide out of control.

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 difficult to treat.

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

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 of 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?***

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?

Chapter 10 Summary

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SUPER SUMMARY
Keyword: HX8CRPS

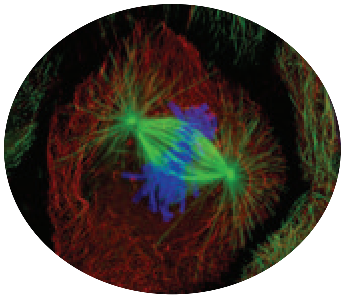
Key Ideas	Key Terms

1 Cell Reproduction

- 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.

Key Terms: **gene** (224), **chromosome** (224), **chromatin** (224), **histone** (224), **nucleosome** (224), **chromatid** (225), **centromere** (225)

2 Mitosis

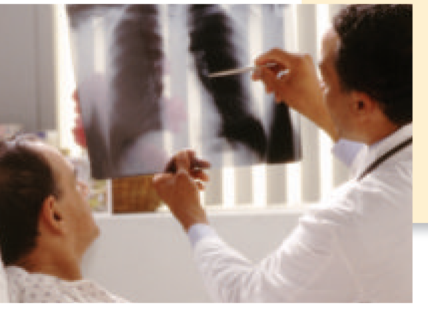


- The life of a eukaryotic cell cycles through phases of growth, DNA replication, preparation for cell division, and division of the nucleus and cytoplasm.
- Mitosis is a continuous process that can be observed in four stages: prophase, metaphase, anaphase, and telophase.
- During cytokinesis, the cell 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.

Key Terms: **cell cycle** (228), **interphase** (228), **mitosis** (229), **cytokinesis** (229), **spindle** (230), **centrosome** (230)

3 Regulation

- 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.



Key Terms: **cancer** (235), **tumor** (235)