SECTION

5.1 The Cell Cycle

KEY CONCEPT Cells have distinct phases of growth, reproduction, and normal functions.

The cell cycle has four main stages.

Cells grow and divide in a regular pattern, or cycle*. If you cut your finger, your cells grow and divide to make more cells. This is how your finger heals.

The **cell cycle** is a regular pattern of growth, DNA duplication*, and cell division* that occurs in eukaryotic cells. Recall that your cells are eukaryotic cells, and they have a nucleus. There are four main stages of the cell cycle:

- gap 1—normal growth
- synthesis—DNA is copied
- gap 2—more growth
- mitosis—nuclear division

Together, these three stages make up a part of the cell cycle called interphase.

Each stage is described below.

Gap 1 (G_1) In G_1 cells do their normal functions. For example, your muscle cells contract, and intestinal cells absorb nutrients.

Synthesis (S) *Synthesis* means "the combining of parts to make a whole." During the S stage, a cell puts together, or synthesizes, a whole copy of its nuclear DNA. In eukaryotes, DNA is in the nucleus. At the end of this stage, there are two complete sets of DNA in a cell's nucleus.

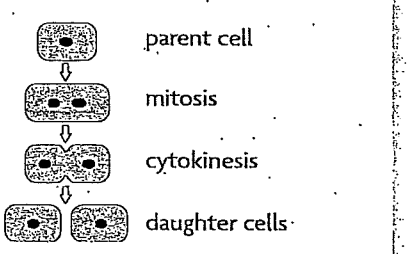
Gap 2 (G_2) In G_2 cells grow and continue their normal functions. If the cell is healthy, it will continue to the next stage.

Mitosis (M) There are two parts of this stage: mitosis and cytokinesis. **Mitosis** (my-TOH-sihs) is the division of the cell nucleus and the DNA inside it. **Cytokinesis** (sy-toh-kuh-NEE-sihs) is the division of the contents of the rest of the cell—the cytoplasm.

These four main stages are shown in the graph at the top of page 75.

VISUAL VOCAB

Mitosis is the division of the cell nucleus and its contents.



Cytokinesis divides the cell cytoplasm.

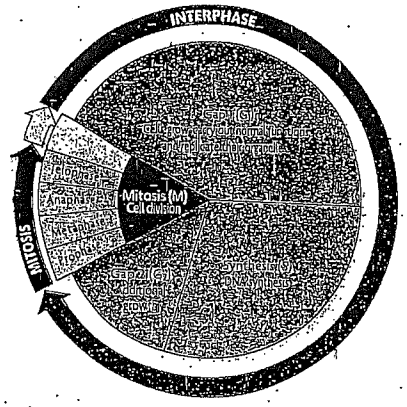
Daughter cells is a term to describe these resulting cells, but it does not mean that they are female.

* ACADEMIC VOCABULARY

cycle a pattern of events that is repeated

duplication the process of doubling, or copying

division separating



Cells grow and copy their DNA during interphase. During M stage, both the nucleus (in mitosis) and cytoplasm (in cytokinesis) are divided.

INSTANT REPLAY On the figure above, circle the terms for the four stages of the cell cycle.

Cells divide at different rates.

Different types of eukaryotic cells take different amounts of time to go through the cell cycle. The table at right lists the life span—or how long until a cell dies—for different types of human cells. Also, cells divide at different rates depending on a person's age. Children's cells divide faster than do cells in adults. In adults, many cells divide only if there is an injury or cell death.

INSTANT REPLAY How long does it take for a cell to go through the cell cycle?

_____

CELL LIFE SPAN

CELL TYPE	APPROXIMATE LIFE SPAN
Skin cell	2 weeks
Red blood cell	4 months
Liver cell	300–500 days
Intestine—internal lining	4–5 days
Intestine—muscle and other tissues	16 years

This chart shows the life span of five different types of human cells. Each type of cell divides at a different rate.

Cell size is limited.

A cell must be big enough to fit all of the molecules and organelles it needs to live. A cell also must be small enough to quickly transport nutrients and wastes into and out of the cell across the cell membrane. As a cell gets bigger, its volume* increases faster than its surface area*. If a cell gets too big, there is not enough surface area of the cell membrane to transport nutrients and wastes for such a big volume. The upper limit on cell size depends on its surface area-to-volume ratio. The surface area-to-volume ratio is the size of the surface area compared to the size of the volume.

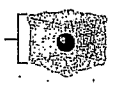
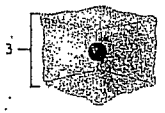
ACADEMIC VOCABULARY

volume the amount of space in a three-dimensional object

surface area the total amount of area on the surfaces of an object

RATIO OF SURFACE AREA TO VOLUME IN CELLS

As a cell grows, its volume increases more rapidly than does its surface area.

Relative size	1 	2 	3 
Surface area (length × width × number of sides)	6	24	54
Volume (length × width × height)	1	8	27
Ratio of surface area to volume	$\frac{6}{1}$ = 6:1	$\frac{24}{8}$ = 3:1	$\frac{54}{27}$ = 2:1

INSTANT REPLAY Can a cell get too big? Explain.

_____

5.1 Vocabulary Check

Mark It Up

Go back and highlight each sentence that has a vocabulary word in **bold**.

cell cycle cytokinesis
mitosis

Fill in the blanks with the correct term from the list above.

1. _____ is the division of the nucleus and its contents.
2. The _____ is a pattern of growth, DNA duplication, and division.
3. The division of the cell cytoplasm is called _____.

5.1 The Big Picture

4. During which stage of the cell cycle is DNA copied? _____
5. Do all cells take the same amount of time to divide? Explain. _____

_____

6. How does the surface area-to-volume ratio limit cell size? _____

_____

SECTION

5.2 Mitosis and Cytokinesis

KEY CONCEPT Cells divide during mitosis and cytokinesis.

Chromosomes condense* at the start of mitosis.

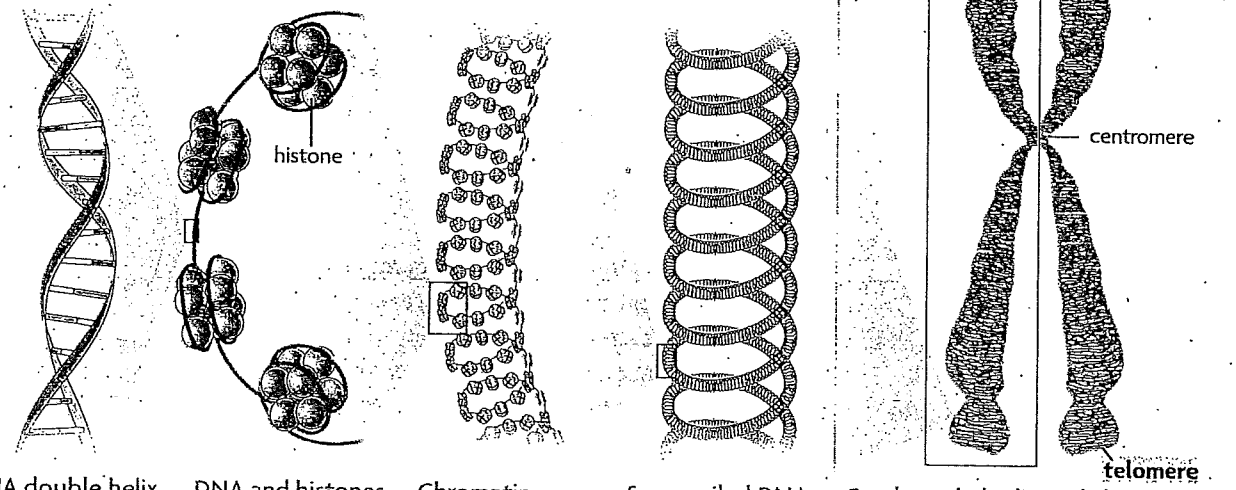
DNA is a double-stranded molecule, like a twisted ladder. A **chromosome** is one long piece of DNA. Every one of your body cells has 46 chromosomes. The DNA in each chromosome has many genes.

During interphase, when the cell is not dividing, the chromosomes are loose—kind of like 46 pieces of spaghetti. During mitosis, the DNA is condensed* and organized. This helps the chromosomes to stay untangled while the cell divides.

The figure below shows how the DNA strand turns into the very condensed form of a chromosome during mitosis.

CHROMOSOME STRUCTURE

DNA condenses tightly during the early stages of mitosis.



DNA double helix
Each continuous, double-stranded DNA molecule makes one chromosome.

DNA and histones
DNA wraps around proteins called **histones,** forming **chromatin.**

Chromatin
Interactions between parts of the histones further compact the DNA.

Supercoiled DNA
The chromatin coils more and more tightly around organizing proteins.

Condensed, duplicated chromosome
The condensed, duplicated chromosomes can be lined up and separated during mitosis.

Look at the picture of the condensed, duplicated chromosome. Recall that the chromosomes are copied during the S stage that happens before mitosis. This condensed, duplicated chromosome looks like an "X." The right half of the X and the left half are copies of each other.

* ACADEMIC VOCABULARY

condense to make something smaller or more compact

They are identical. Each half of a duplicated chromosome is called a chromatid (KROH-muh-tihd). Together, the two identical chromatids are called sister chromatids. The sister chromatids are held together at a place called the centromere (SEHN-truh-MEER).

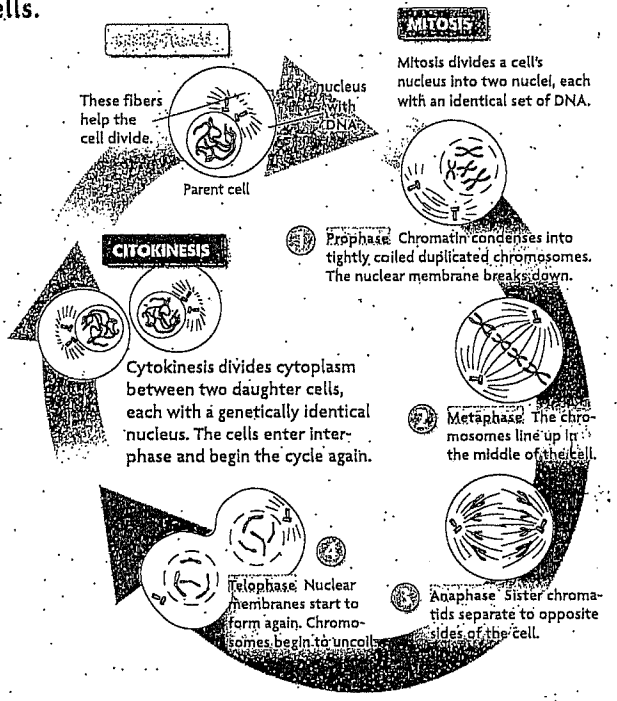
INSTANT REPLAY Explain how a chromatid and a duplicated chromosome are related.

_____

Mitosis and cytokinesis produce two genetically identical daughter cells.

By the end of interphase, a cell is ready to divide. Mitosis divides the DNA, and cytokinesis divides the rest of the cell. The result is two identical cells. Mitosis happens in all of your body cells—except cells that form eggs or sperm. Your cells divide for growth, development, and repair. Single-celled organisms use cell division to reproduce.

Mitosis and cytokinesis are continuous processes. They do not happen in steps. However, scientists have divided the processes into steps to make them easier to understand and discuss. The four main phases of mitosis are prophase, metaphase, anaphase and telophase. Cytokinesis begins at the end of anaphase or in telophase. These steps are shown in the figure to the right.



INSTANT REPLAY What is one reason your body cells need to divide?

_____

5.2 Vocabulary Check

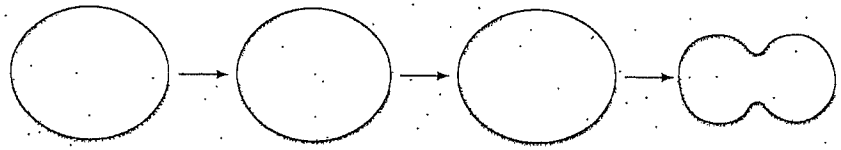
Mark It Up

Go back and highlight each sentence that has a vocabulary word in **bold**.

chromosome	centromere
histone	prophase
chromatin	metaphase
telomere	anaphase
chromatid	telophase

1. Label the diagram below with the terms *chromosome, chromatid, centromere,* and *telomere.*

2. Draw and label each phase of mitosis—*prophase, metaphase, anaphase,* and *telophase*—in the circles below:



3. On the diagram above, in question 2, circle the part of the process in which cytokinesis occurs.
4. The word part *telo-* means "end." How does this word part relate to the meaning of the terms *telomere* and *telophase*? _____

_____

5.2 The Big Picture

1. During which stage of the cell cycle is DNA copied? _____
2. How many chromatids are there in one duplicated chromosome? ____
3. Two identical daughter cells result from mitosis and cytokinesis. In what ways are they "identical"? _____

SECTION

5.3 Regulation of the Cell Cycle

KEY CONCEPT Cell cycle regulation is necessary for healthy growth.

Internal and external factors regulate cell division.

If the cell cycle goes out of control, cancer can result. Cancer is uncontrolled cell division. To regulate means "to control." Regulation of the cell cycle is important for healthy cell growth. Internal means "inside" and external means "outside." Information from both inside and outside the cell—internal and external factors—help regulate the cell cycle.

External Factors

There are external physical and chemical signals that help regulate the cell cycle. For example, a cell that is surrounded by other cells stops dividing. Many cells also release chemical signals that tell other cells to grow. Growth factors are proteins that stimulate* cell division. If you are bleeding, some of your blood cells release a growth factor to help start the healing process.

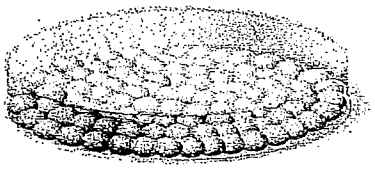
Internal Factors

External factors bind to a receptor on the cell membrane. This starts a response inside the cell. These internal factors include enzymes and proteins that help a cell move through the cell cycle.

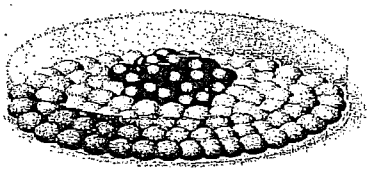
Apoptosis

Just as cells need to grow and divide, other cells need to die. Internal or external signals can start an orderly process of cell death. The cell is broken down and its parts are reused in building other molecules. This process of programmed cell death is called apoptosis (AP-uhp-TOH-sihs).

Normal cell growth



Cancerous cell growth



Normal animal cells (top) stop dividing when they touch each other. Cancer cells (bottom) do not respond to normal signals and, as a result, form clumps of cells.

INSTANT REPLAY Why is regulation of the cell cycle important?

_____

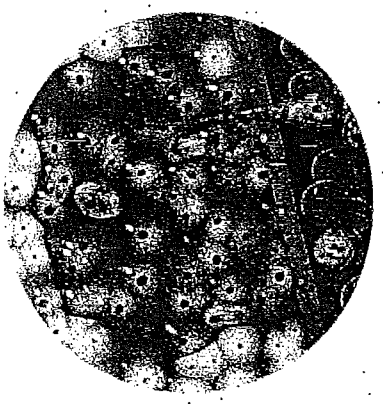
*ACADEMIC VOCABULARY

stimulate to cause something to happen

Cell division is uncontrolled in cancer.

Cancer is the common name for a group of diseases that involve uncontrolled cell division. Cancer cells keep dividing and form clumps called tumors. A **benign** tumor is relatively harmless because the cells stay clumped together and it can be removed. A **malignant** tumor has cancer cells that break away from the tumor. These cells **metastasize** (mih-TAS-tuh-syz), which means they travel to other parts of the body and can form more tumors. When a cancer metastasizes, it is much harder to get rid of.

Cancer cells come from normal cells that have damaged genes. Substances that are known to cause or lead to cancer are called **carcinogens** (kahr-SIHN-uh-juhnz). Tobacco smoke and certain air pollutants are carcinogens.



Cancer cells break away from malignant tumors. They can then be carried in the bloodstream to other parts of the body where they form new tumors.

INSTANT REPLAY

What is the difference between a benign tumor and a malignant tumor?

_____

5.3 Vocabulary Check

growth factor
apoptosis
cancer
benign
malignant
metastasize
carcinogen

Mark It Up

Go back and highlight each sentence that has a vocabulary word in **bold**.

Choose the correct term from the list for each description.

1. substance that causes cancer _____
2. programmed cell death _____
3. a tumor that does not metastasize _____

5.3 The Big Picture

1. What are two ways that cell division is regulated in healthy cells?

   _____

   _____

2. What is one main difference between a normal cell and a cancer cell?

   _____