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CHAPTER 9 The Cellular Basis of Inheritance

Summary of Key Concepts

Concept 9.1 All cells come from cells. (pp. 180–181)

Cell reproduction is an important process. Three functions of cell reproduction are replacing dead cells, repairing injured tissue, and supplying the cells needed for the body's growth.

In some organisms, such as *Paramecium*, reproduction occurs by cell division. The offspring is identical to its one parent. Reproduction that occurs by simple cell division is called *asexual reproduction*. In other organisms, two parents are needed to produce offspring. Each of the parents produces sex cells during a specialized form of cell division. Offspring are produced when these sex cells join. This process, called *sexual reproduction*, results in offspring that are different from either parent.

1. How is cell division involved in growth? _____

_____

2. Describe the two main methods of reproduction. _____

_____

_____

Concept 9.2 The cell cycle multiplies cells. (pp. 182–184)

The genetic material in the nucleus of cells usually forms long, thin fibers called *chromatin*. As a cell gets ready to divide, the chromatin becomes shorter and thicker, forming *chromosomes*. Each species of organism has a certain number of chromosomes in each cell. Human body cells, for example, have 46 chromosomes.

Every chromosome in a cell is copied before the cell divides. The two copies of each chromosome are called *sister chromatids*. They are joined at a middle point called the *centromere*. During cell division, the sister chromatids separate. The two resulting cells each receive one copy of each chromosome.

Cells that divide follow a set of steps known as the *cell cycle*. The cell cycle is divided into periods of time, during which the cell performs certain functions. *Interphase* is the time in which a cell grows and carries out cellular processes in the body. Interphase is divided into G_1, S, and G_2 phases.

The cell divides during the *mitotic phase* of the cell cycle. Mitosis and cytokinesis occur in the mitotic phase. *Mitosis* is the division of the genetic material and the formation of two nuclei. *Cytokinesis* is the division of the cytoplasm, forming two daughter cells.

3. Describe the structure of chromosomes in a cell that is about to divide.

_____

_____

4. Name the stages of the cell cycle. _____

_____

_____

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Concept 9.3 Cells divide during the mitotic phase. (pp. 185–189)

A structure called the *spindle* guides the chromosomes during mitosis. The spindle is a framework of microtubules that grows from two regions of cytoplasmic material called *centrosomes*. In animal cells, the centrosomes contain structures called centrioles.

The mitotic phase of the cell cycle can be divided into four main stages. *Prophase* is the first stage of mitosis. During prophase the chromatin condenses and sister chromatids are formed, the nuclear envelope breaks down, and the mitotic spindle forms. The chromatids attach to the spindle and move toward the center of the cell. The second stage of mitosis is *metaphase*. During metaphase the chromosomes are attached to the spindle and are lined up across the middle of the cell. During *anaphase*, the third phase of mitosis, the sister chromatids separate and move toward the edges of the cell. After separation, the chromatids are called daughter chromosomes. In the last stage of mitosis, *telophase,* the spindle disappears and two nuclear envelopes are formed. The chromosomes uncoil, and the genetic material once again forms long, thin strands. The nucleoli reappear in the newly formed daughter nuclei.

Cytokinesis is the division of the cytoplasm. Cytokinesis usually happens at the same time as telophase. In animal cells, cytokinesis occurs when a band of microfilaments in the middle of the cell pinches the cell in two. In plant cells, a structure called a *cell plate* forms in the middle of the cell. The cell plate contains cell wall material. As the cell plate grows outward, two daughter cells form.

5. Name the four stages of mitosis. _____

_____

6. Describe how cytokinesis differs between plant and animal cells. _____

_____

_____

_____

Concept 9.4 Cancer cells grow and divide out of control. (pp. 190–191)

Though cell reproduction usually happens in a controlled way, cells sometimes reproduce at the wrong time or in the wrong place. Uncontrolled cell reproduction produces a mass of cells called a tumor. A *benign tumor* contains normal cells. Other tumors, called *malignant tumors,* are composed of cancer cells. *Cancer* is a disease in which the controls on the cell cycle do not work.

Malignant tumors are dangerous because cells from the tumor can spread to other parts of the body. These cells can form more tumors. The spread of cancer in the body is called *metastasis*.

There are three main forms of cancer treatment. Surgery is often used to remove malignant tumors from the body. To treat remaining cancer cells, physicians can use radiation or chemotherapy. Both techniques disrupt cell division. Since cancer cells divide more frequently than normal cells, they are more likely to be destroyed by radiation and chemotherapy than normal cells.

7. Compare and contrast benign and malignant tumors. _____

_____

_____

_____

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8. Describe how radiation and chemotherapy destroy cancer cells. _____

_____

_____

Concept 9.5 Meiosis functions in sexual reproduction. (pp. 192–197)

Meiosis is a type of cell division that produces four cells, each with half of the number of chromosomes as the parent cell. In humans meiosis occurs in the sex organs.

A *karyotype* is a display of the chromosomes in a cell. A human karyotype shows chromosomes in 23 pairs. The chromosomes in each pair are called *homologous chromosomes*. One of the chromosomes in each pair is from the father, and the other is from the mother. Homologous chromosomes carry genetic information about the same traits, arranged in the same order.

In humans, chromosomes in the 23rd pair are called *sex chromosomes*. Females have two X chromosomes in the 23rd pair. Males have an X and a Y chromosome. The X and Y chromosomes have only small homologous portions.

Cells with two homologous sets of chromosomes are *diploid* (indicated as 2*n*). Most human body cells are diploid, containing 46 chromosomes. Egg and sperm cells, called *gametes*, are haploid (*n*). *Haploid* cells contain one set of chromosomes. In *fertilization*, a haploid egg nucleus and a haploid sperm nucleus fuse and form a diploid cell. The fertilized egg is called a *zygote*.

One main difference between meiosis and mitosis is that meiosis produces four haploid cells, while mitosis produces two diploid cells. The second difference is that genetic material is exchanged between homologous chromosomes in meiosis. This exchange of material does not occur in mitosis.

Meiosis has two steps, called meiosis I and meiosis II. Meiosis I produces two haploid cells. In meiosis II, each of the haploid cells splits again. A total of four haploid cells are produced. Both meiosis I and meiosis II are divided into prophase, metaphase, anaphase, and telophase. In prophase I, the paired homologous chromosomes stick together in a structure called a *tetrad,* and crossing over occurs.

9. What are homologous chromosomes? _____

_____

_____

10. Describe two ways in which mitosis and meiosis are different. _____

_____

_____

Concept 9.6 Meiosis increases genetic variation among offspring. (pp. 198–201)

There are two main ways that meiosis increases the genetic variation of offspring. During meiosis I, the way in which the homologous chromosomes line up and separate is a matter of chance. The gametes produced have one chromosome from each pair. The number of possible combinations of chromosomes in a gamete increases with the number of chromosome pairs. In a human gamete, the number of possible combinations is 8 million.

The second way that genetic variation is increased during meiosis is the exchange of genetic information between homologous chromosomes, called

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crossing over. Crossing over that results in a single chromosome with genetic information from both parents is called *genetic recombination*.

Mitosis and meiosis both have important roles in eukaryotic organisms. Mitosis functions in growth, repair, and asexual reproduction. Meiosis produces haploid gametes in organisms that reproduce sexually. Both mitosis and meiosis involve the passing on of genetic information.

11. What are two ways that genetic variation is increased during meiosis?

_____

_____

_____

12. What is one way that mitosis and meiosis are similar? _____

_____

_____

Reading Skills Practice

Writing a summary Write a summary of the similarities and differences between mitosis and meiosis (see pages 200–201). In your summary, state the main ideas from the text and figure in your own words.

Vocabulary Review and Reinforcement

In 1–4, fill in the table that describes the stages of mitosis.

Stage of Mitosis	Description
1. _____	First stage of mitosis, chromosomes visible with microscope, nucleolus disappears, chromosomes attach to spindle
Metaphase	**2.** _____ _____
Anaphase	**3.** _____ _____
4. _____	Fourth stage of mitosis, chromosomes reach poles of spindle, spindle disappears, two nuclear envelopes form

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In 5–15, write the letter of the correct definition on the line next to each term.

_____ **5.** crossing over
_____ **6.** interphase
_____ **7.** cell plate
_____ **8.** benign tumor
_____ **9.** karyotype
_____ **10.** chromatin
_____ **11.** cytokinesis
_____ **12.** sexual reproduction
_____ **13.** metastasis
_____ **14.** mitotic phase
_____ **15.** malignant tumor

a. disk containing cell wall material
b. type of reproduction in which two parents are involved in the production of offspring
c. spread of cancer cells beyond their original site
d. mass of cells that results from the reproduction of cancer cells
e. display of the chromosomes in a cell
f. exchange of genetic material between homologous chromosomes
g. stage of the cell cycle in which a cell carries out its metabolic processes
h. process by which the cytoplasm is divided in two
i. abnormal mass of essentially normal cells
j. stage in the cell cycle when the cell is actually dividing
k. long, thin fibers of genetic material

In 16–24, fill in the blanks with the appropriate terms from the chapter.

16. The two chromosomes in each matching pair in a karyotype are called _____.

17. In humans, the 23rd pair of chromosomes are the _____.

18. Offspring inherit all of their genetic material from just one parent in the process of _____.

19. Before cell division begins, each chromosome consists of two identical joined chromosomes called _____.

20. An orderly sequence of events known as the _____ extends from the formation of a cell until the cell reproduces.

21. Regions called _____ in the cytoplasmic material of animal cells contain centrioles.

22. The nucleus of a haploid sperm cell fuses with the nucleus of a haploid egg cell in the process of _____.

23. Paired chromosomes consisting of four chromatids are referred to as a(n) _____.

24. The result of crossing over is _____.

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WordWise

Find and circle ten Key Terms from the chapter in the puzzle below. Words may appear horizontally, vertically, or diagonally. Then write a definition for each term on a separate sheet of paper.

c	h	r	o	m	o	s	o	m	e	c	h
e	m	q	w	e	o	z	y	g	o	t	e
n	c	h	d	s	p	i	n	d	l	e	s
t	e	a	m	d	l	i	m	s	c	g	d
r	i	p	j	e	d	t	i	t	a	g	i
o	q	l	k	w	i	r	t	f	n	n	o
m	e	o	y	c	b	o	o	h	c	f	l
e	q	i	j	t	i	s	s	c	e	b	p
r	p	d	s	c	y	z	i	i	r	w	i
e	t	e	m	a	g	p	s	u	s	h	d