SECTION

6.1 Chromosomes and Meiosis

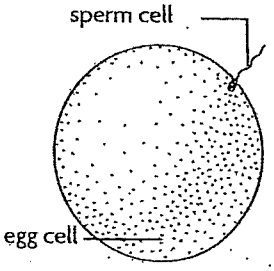
KEY CONCEPT Gametes have half the number of chromosomes that body cells have.

You have body cells and gametes.

All of the different cells in your body can be divided into two groups: somatic cells and germ cells.

- **Germ cells** are the cells in your reproductive organs—the ovaries or testes—that develop into eggs or sperm.
- **Somatic cells** (soh-MAT-ihk), or body cells, are all the other cells in your body.

Somatic cells make up most of your tissues and organs. The DNA in your somatic cells will not be passed on to your children. Only the DNA in the egg or sperm cells gets passed on to offspring. Egg cells and sperm cells are called **gametes**.



Egg cells and sperm cells are called gametes.

Each species has a characteristic number of chromosomes per cell. For example:

- **Humans** have 23 pairs of chromosomes. In other words, there are $23 \times 2 = 46$ chromosomes in all body cells.
- **Fruit flies** have 4 pairs of chromosomes, or 8 chromosomes per cell.
- **Yeast** have 16 pairs of chromosomes, or 32 chromosomes per cell.

The organism currently known to have the most chromosomes is a fern. It has more than 1200 chromosomes. Chromosome number is not related to the size or complexity of an organism.

INSTANT REPLAY Do gametes come from germ cells or somatic cells?

Your cells have autosomes and sex chromosomes.

Suppose you had 23 pairs of gloves. You would have a total of $23 \times 2 = 46$ gloves. You could divide them into two sets: 23 right-hand and 23 left-hand gloves. Similarly, your body cells have 23 pairs of chromosomes, for a total of 46. These can be divided into two sets: 23 from your mother and 23 from your father. Just as you use both gloves if it is cold outside, your cells use both sets of chromosomes to function properly.

Each pair of chromosomes is called a homologous pair. Here, *homologous* means "having the same structure." **Homologous chromosomes** are two chromosomes—one from the mother and one from the father—that are the same size and have copies of the same genes.

Although each chromosome in a homologous pair has copies of the same genes, the two copies may differ. For example, each chromosome in a pair might have a gene that influences eye color. But the gene on one chromosome of the pair may lead to brown eyes and the gene on the other chromosome may lead to green eyes.

One of your 23 pairs of chromosomes is your pair of **sex chromosomes**. These chromosomes control the sex of an organism. Humans, and all mammals, have two different sex chromosomes called X and Y.

- Females have two X chromosomes.
- Males have one X chromosome and one Y chromosome.

The rest of your chromosomes—the other 22 pairs—are called **autosomes**. These chromosomes contain genes for all of the rest of an organism's life functions.

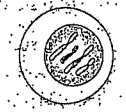
INSTANT REPLAY If a person's pair of sex chromosomes is XY, is the person male or female? _____

Body cells are diploid; gametes are haploid.

Sexual reproduction involves two gametes—an egg and a sperm—joining together. **Fertilization** happens when the egg and sperm actually combine. The nucleus of the egg combines with the nucleus of the sperm to form one nucleus. This new nucleus must have the correct number of chromosomes—46 for humans. Therefore, the egg and sperm each must each have half that number of chromosomes—23 for humans.

VISUAL VOCAB

Diploid cells have two copies of each chromosome: one copy from the mother and one from the father.



Body cells are diploid (2*n*).

Gametes (sex cells) are haploid (*n*).

Haploid cells have only one copy of each chromosome.

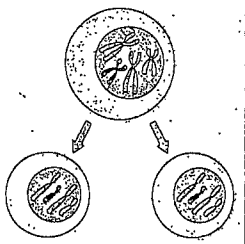
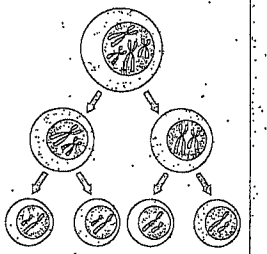
Diploid and Haploid Cells

Gametes—eggs and sperm—are **haploid** (HAP-loyd) cells. Haploid cells have one copy of each chromosome—again, 23 for humans. A sperm and egg join together to form a **diploid** (DIHP-loyd) cell—for a total of 46 chromosomes for humans. Body cells are all diploid. Only gametes are haploid.

Meiosis

The germ cells in your reproductive organs form gametes through a process called meiosis. **Meiosis** (my-OH-sihs) is a process that divides a diploid cell into a haploid cell. In Chapter 5 you learned about mitosis, another process that divides a cell. The figure on the next page shows some of the differences between mitosis and meiosis.

COMPARING MITOSIS AND MEIOSIS

MITOSIS		MEIOSIS	
	Produces genetically identical cells	Produces genetically unique cells	
	Results in diploid cells	Results in haploid cells	
	Takes place throughout an organism's lifetime	Takes place only at certain times in an organism's life cycle	
	Involved in asexual reproduction	Involved in sexual reproduction	

Remember that mitosis results in two identical diploid cells. Mitosis is used for development, growth, and repair. In contrast, meiosis results in four haploid cells that are unique. Meiosis happens only in germ cells to make gametes. Meiosis will be presented in detail in the next section.

INSTANT REPLAY What is the difference between the cells that result from mitosis and the cells that result from meiosis?

_____

6.1 Vocabulary Check

somatic cell
gamete
homologous chromosome
sex chromosome
autosome
sexual reproduction
fertilization
haploid
diploid
meiosis

Mark It Up

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

1. when the nucleus of an egg joins the nucleus of a sperm _____
2. a body cell _____
3. an egg or sperm cell _____
4. any chromosome except a sex chromosome _____

6.1 The Big Picture

5. If a diploid cell with 8 chromosomes goes through meiosis, how many chromosomes will the resulting haploid cells have? _____
6. Circle the sex of a person with the sex chromosomes XX: male / female

SECTION

6.2 Process of Meiosis

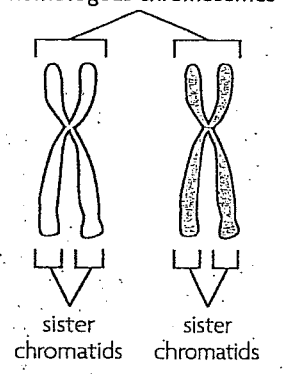
KEY CONCEPT During meiosis, diploid cells undergo two cell divisions that result in haploid cells.

Cells go through two rounds of division in meiosis.

Meiosis begins with a diploid cell that already has duplicated chromosomes. There are two rounds of cell division—meiosis I and meiosis II. The phases of meiosis are similar to the phases of mitosis. To keep the two processes separate in your mind, focus on the big picture. Mitosis results in identical diploid cells, and meiosis results in unique haploid cells.

Homologous Chromosomes and Sister Chromatids

Recall that homologous chromosomes are two separate chromosomes: one from your mother and one from your father. Homologous chromosomes carry the same genes in the same order. However, the copies of the genes may differ. Homologous chromosomes are not copies of each other. In contrast, recall that a duplicated chromosome is made of two sister chromatids, attached at the centromere. Sister chromatids are identical copies of each other.



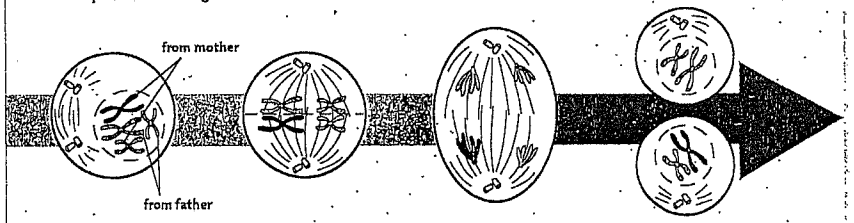
Homologous chromosomes (shown duplicated) are two separate chromosomes—one inherited from the mother, and one from the father.

The Process of Meiosis

Before meiosis begins, DNA has already been copied. Homologous chromosomes are separated in the first half of meiosis—meiosis I. This results in two haploid cells with duplicated chromosomes. These cells are haploid because they each have only one of every pair of homologous chromosomes. Sister chromatids are separated in the second half of meiosis—meiosis II. This results in four haploid cells with undoubled chromosomes. Like mitosis, scientists describe this process in phases. Follow the process of meiosis illustrated on the next page. The figure is simplified, showing only four chromosomes.

MEIOSIS

Meiosis I separates homologous chromosomes.



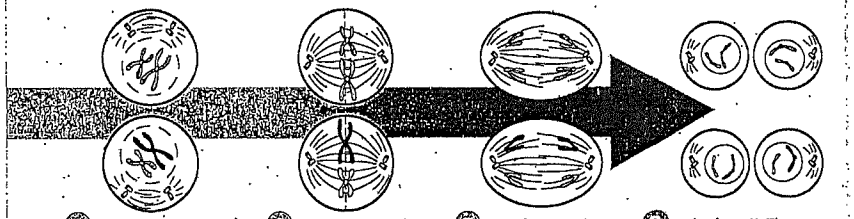
Prophase I The nuclear membrane breaks down. The duplicated chromosomes condense and homologous chromosomes begin to pair up. Notice that there are two pairs of duplicated homologous chromosomes.

Metaphase I The chromosomes line up along the middle of the cell.

Anaphase I The paired homologous chromosomes separate. Sister chromatids remain attached.

Telophase I Cytokinesis separates the cells. Each cell contains only one of each pair of chromosomes—not both. In other words, the cells are now haploid. The chromosomes are still duplicated.

Meiosis II separates sister chromatids. The overall process produces haploid cells.



Prophase II The nuclear membrane breaks down and the cells prepare to divide.

Metaphase II The chromosomes line up along the middle of the cell.

Anaphase II The sister chromatids are separated and move to opposite sides of the cell.

Telophase II The nuclear membranes form again. The result of meiosis is four haploid cells with a combination of chromosomes from both the mother and father.

Now that you've seen how meiosis works, let's review two key differences between the processes of meiosis and mitosis.

- Meiosis has two cell divisions. Mitosis has only one cell division.
- Meiosis results in haploid cells. Mitosis results in diploid cells.

INSTANT REPLAY On the diagram above, circle the part in the process of meiosis when the cells first become haploid.

Haploid cells develop into mature gametes.

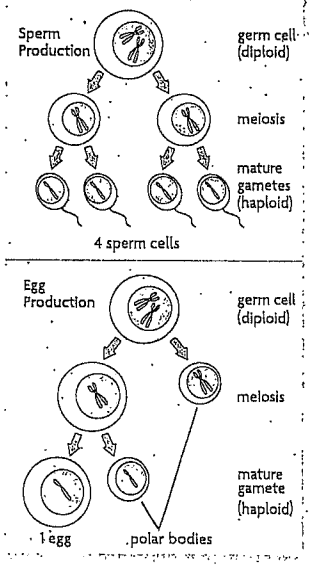
Gametogenesis (guh-MEE-tuh-JEHN-ih-sihs) is the production of gametes—eggs or sperm. Gametogenesis includes both meiosis and other changes that the haploid cells must go through. The sperm cell, the male gamete, is much smaller than the egg, the female gamete. After meiosis, a cell that develops into a sperm will form a compact shape with a long tail, or flagellum, that the cell uses to move. For egg production, only one of the cells from meiosis becomes an egg. It receives most of the cytoplasm and organelles. The other cells produced by meiosis become polar bodies, smaller cells that contain little more than DNA, and are eventually broken down.

INSTANT REPLAY How do mature gametes differ from the immature haploid cells?

_____

_____

GAMETOGENESIS



6.2 Vocabulary Check

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

gametogenesis egg
sperm polar body

Choose the correct term from the list above to complete the sentences below.

1. Sperm and eggs are formed through the process of _____.
2. For egg formation, one of the cells resulting from meiosis becomes an egg and the others become _____.

6.2 The Big Picture

3. What is the end result of meiosis?_____

_____

4. What are two differences between meiosis and mitosis?_____

_____

_____