10 Sexual Reproduction and Genetics

section 1 Meiosis

Biology/Life Sciences 2.a Students know meiosis is an early step in sexual reproduction in which the pairs of chromosomes separate and segregate randomly during cell division to produce gametes containing one chromosome of each type.
Also covers: Biology/Life Sciences 2.b, 2.c, 3.b

Before You Read

Think about the traits that make people unique. Some people are tall, while others are short. People can have brown, blue, or green eyes. On the lines below, list a few traits that make you look different from other people. In this section, you will learn how meiosis rearranges genes.

_____

_____

_____

_____

Meiosis produces haploid genes.

What You'll Learn

- how chromosome number decreases during meiosis
- the stages of meiosis
- how meiosis provides genetic variation

Read to Learn

Chromosomes and Chromosome Number

All students in your class have characteristics passed on to them by their parents. Each characteristic, such as hair color, eye color, and height, is called a trait.

The instructions for each trait are found on chromosomes. Recall from Chapter 7 that chromosomes are found in the nuclei of cells. The DNA on the chromosomes is arranged in sections that control the production of proteins. These DNA sections are called **genes.** Each chromosome has about 1500 genes. Each gene has a role in the characteristics of the cell and how the cell works. Living things have thousands of genes.

Human body cells have 46 chromosomes. Chromosomes come in pairs. You have 23 chromosomes from your father and 23 chromosomes from your mother, making 23 pairs of chromosomes.

Create a Quiz After you have read this section, create a quiz based on what you have learned. After you have completed writing the quiz questions, be sure to answer them.

1. **Calculate** the approximate number of genes humans have. Show your work.

_____

_____

_____

What are homologous chromosomes?

The chromosomes that make up a pair, one from each parent, are called **homologous** (huh MAH luh gus) **chromosomes**. Homologous chromosomes are the same length and have the centromere in the same place. They also carry genes for the same traits at the same place. Look at the picture below, and see if you can spot the homologous pair.

Homologous chromosomes are similar but not identical. For example, the gene for ear shape will be located at the same place on each homologous chromosome. Although these genes code for ear shape, the gene on one chromosome might code for one ear shape. The gene on the other chromosome might code for a different ear shape.

Picture This

2. Identify Circle a pair of homologous chromosomes.

How is chromosome number maintained in a species?

The number of chromosomes does not change from generation to generation. You have the same number of chromosomes as your parents. **Gametes** (GA meets), or sex cells with half the number of chromosomes, ensure the chromosome number stays the same.

The symbol *n* represents the number of chromosomes. In humans, *n* is equal to 23. A cell with *n* number of chromosomes is called a **haploid** cell. Gametes are haploid cells. ☑

The process in which one haploid gamete joins with another haploid gamete is called **fertilization**. After fertilization, the cell has *2n* chromosomes—*n* chromosomes from the female parent plus *n* chromosomes from the male parent. A cell with *2n* chromosomes is called a **diploid** cell. Notice that *n* also represents the number of chromosome pairs in an organism.

Reading Check

3. Identify How many chromosomes are in a human gamete? (Circle your answer.)

a. 46
b. 23
c. 10

Meiosis I

Recall that most cells are formed by mitosis. During mitosis the chromosome number stays the same. Because sex cells need half the number of chromosomes, a different process of cell division is needed. Gametes are formed during a process called meiosis. **Meiosis** is a kind of cell division that reduces the number of chromosomes by half through the separation of homologous chromosomes. Meiosis takes place in the reproductive organs of plants and animals. During meiosis, there are two cell divisions. They are called meiosis I and meiosis II.

What happens during interphase I?

Just as in mitosis, a cell goes through interphase before undergoing meiosis. A cell in interphase carries out a variety of metabolic functions, copies its DNA, and makes proteins.

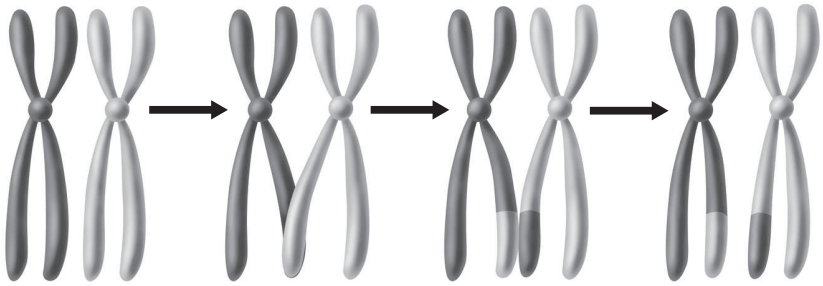
What happens during prophase I?

Meiosis I begins with prophase I. During prophase I, replicated chromosomes, consisting of two sister chromatids, condense. When that happens, the chromosomes become visible under a light microscope.

As the homologous chromosomes condense, they begin to form homologous pairs in a process called synapsis (suh NAP sus). The homologous chromosomes are held tightly together along their lengths by a protein that acts like a zipper. Prophase I continues as the chromosomes move to opposite sides of the cell.

What is crossing over?

During synapsis, the chromosomes often swap pieces of DNA. **Crossing over** occurs when a section of one chromosome changes place with a section of its homologous chromosome. This is shown in the figure below. The centrioles move to the opposite poles of the cell. Spindle fibers form and bind to the sister chromatids at the centromere.



FOLDABLES™

Take Notes Make a folded table Foldable, as shown below. As you read, take notes and organize what you learn about meiosis I and meiosis II.

	Meiosis I	Meiosis II
Prophase		
Metaphase		
Anaphase		
Telophase		
Result		

Picture This

4. Label Circle the part of each chromosome that was swapped during crossing over.

What happens during metaphase I?

The next phase is metaphase I. During metaphase I, the pairs of homologous chromosomes line up in the center of the cell. The spindle fibers attach to the centromere of each homologous chromosome.

What happens during anaphase I?

Next is anaphase I. During anaphase I, each homologous chromosome is guided by the spindle fibers toward opposite poles of the cell. When this happens, the chromosome number is reduced from $2n$ to n. Notice that the sister chromatids do not split during meiosis I. Each homologous chromosome still has two sister chromatids. ☑

Reading Check

5. Identify During what phase is the chromosome number reduced from $2n$ to n?

_____

What is the final stage of meiosis I?

The final stage of meiosis I is telophase I. During telophase I, the homologous chromosomes reach opposite poles of the cell. Each pole contains only one member of a pair of homologous chromosomes.

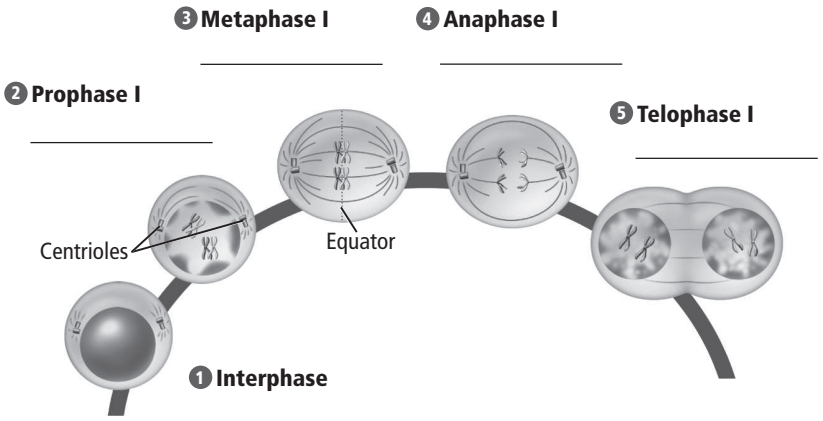
The sister chromatids might not be identical because crossing over might have occurred during synapsis in prophase I. Crossing over is one way that meiosis leads to more genetic diversity. This diversity helps explain how species can change over time.

At the end of telophase I, the cell undergoes cytokinesis, meaning it divides into two cells. The cells then might go into interphase again, but this time, the DNA is not copied during interphase. The events of meiosis I are shown below.

Picture This

6. Label In the space provided, write the chromosome number ($2n$ or n) for each phase.

MEIOSIS I

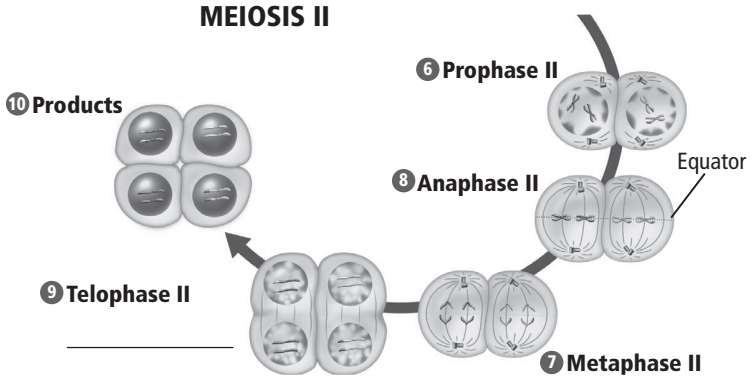


Meiosis II

Meiosis is now half finished. To complete meiosis, the cell must go through meiosis II. Meiosis II is similar to mitosis.

What events occur during meiosis II?

During prophase II, the spindle apparatus forms, and the chromosomes condense. During metaphase II, a haploid number of chromosomes lines up near the center of the cell by the spindle fibers. During anaphase II, the sister chromatids are pulled apart at the centromere by the spindle fibers, and the sister chromatids are pulled to the opposite poles of the cell. In telophase II, the chromosomes reach the poles, and the nuclear membrane and nuclei reform. Cytokinesis, or cell division, occurs. The result is four haploid cells, each with *n* number of chromosomes.



Picture This

7. Label Circle the phase in which the sister chromatids are pulled apart. Count the cells in telophase II, and write the number in the space provided.

The Importance of Meiosis

The figure below shows that meiosis and mitosis have similar steps, but they are different in important ways. An important difference is that mitosis produces two identical diploid daughter cells, while meiosis produces four different haploid daughter cells.

Picture This

8. Compare Fill in the blanks in the table with the number of daughter cells produced.

	Mitosis	Meiosis
Number of cell divisions	one	two
Synapsis of homologous chromosomes	does not occur	occurs during prophase I
Products	_____ identical, diploid cells	_____ nonidentical, haploid cells
Type of cells produced	body cells	reproductive cells
Purpose	growth and repair of body tissues	production of gametes for sexual reproduction

How does meiosis create genetic diversity?

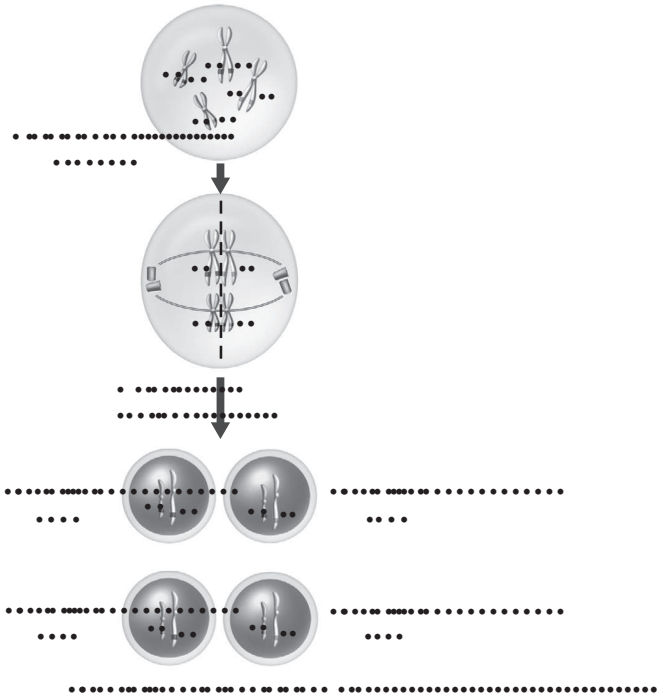
The haploid daughter cells made by meiosis are not identical. Because the daughter cells are different, meiosis results in genetic variation.

One way that meiosis produces non-identical daughter cells occurs during prophase I. When pairs of homologous chromosomes line up at the center of the cell, they do so randomly. This means that each daughter cell gets a different, random assortment of chromosomes. The effect on genetic diversity is illustrated in the figure below.

The other way meiosis creates variation is through crossing over. Fertilization, when two haploid gametes combine, results in even more genetic variation.

Picture This

9. Identify Underline the haploid daughter cells.



Think it Over

10. Compare How is chromosome inheritance different in sexual reproduction?

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_____

_____

_____

Sexual Reproduction v. Asexual Reproduction

Asexual reproduction occurs when the organism inherits all of its chromosomes from one parent. The new organism is genetically identical to its parent. Asexual reproduction does not involve meiosis.

Bacteria reproduce by asexual reproduction. Plants and some simple animals can reproduce sexually or asexually. Complex animals only reproduce sexually.