

Meiosis Worksheet

NAME _____ - _____ PERIOD _____

Do you have ALL your parents' chromosomes?

No, you only received half of your mother's chromosomes and half of your father's chromosomes. If you inherited them all, you would have twice the number of chromosomes that you're supposed to have. Humans typically have 23 pairs of chromosomes. If you received all your parents' chromosomes, you would have 46 pairs!

Introduction to Meiosis

Sexual reproduction combines gametes from two parents. **Gametes** are reproductive cells, such as sperm and egg. As gametes are produced, the number of chromosomes must be reduced by half. Why? The **zygote** must contain genetic information from the mother and from the father, so the gametes must contain half of the chromosomes found in normal body cells. When two gametes come together at fertilization, the normal amount of chromosomes results. Gametes are produced by a special type of cell division known as **meiosis**. Meiosis contains two rounds of cell division without DNA replication in between. This process reduces the number of chromosomes by half.

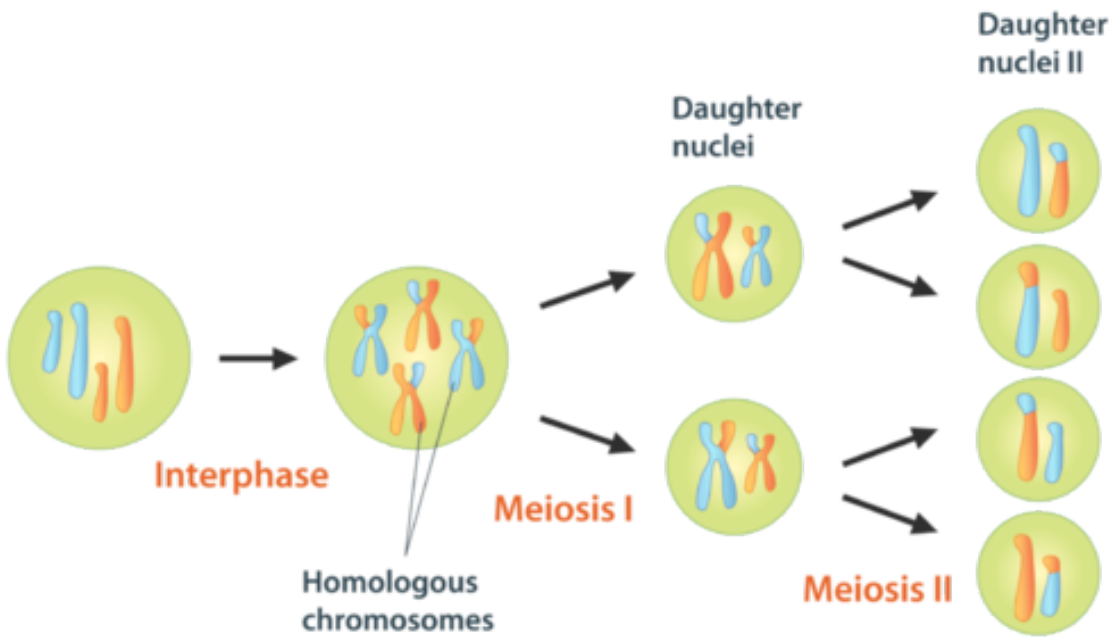
Human cells have 23 pairs of chromosomes, and each chromosome within a pair is called a **homologous chromosome**. For each of the 23 chromosome pairs, you received one chromosome from your father and one chromosome from your mother. **Alleles** are alternate forms of genes found on chromosomes. Homologous chromosomes have the same genes, though they may have different alleles. So, though homologous chromosomes are very similar, they are not identical. The homologous chromosomes are separated when gametes are formed. Therefore, gametes have only 23 chromosomes, not 23 pairs.

Haploid vs. Diploid

A cell with two sets of chromosomes is **diploid**, referred to as $2n$, where n is the number of sets of chromosomes. Most of the cells in a human body are diploid. A cell with one set of chromosomes, such as a gamete, is **haploid**, referred to as n . Sex cells are haploid. When a haploid sperm (n) and a haploid egg (n) combine, a diploid zygote will be formed ($2n$). In short, when a diploid zygote is formed, half of the DNA comes from each parent.

Overview of Meiosis

Before meiosis begins, DNA replication occurs, so each chromosome contains two sister chromatids that are identical to the original chromosome. Meiosis (**Figure below**) is divided into two divisions: Meiosis I and Meiosis II. Each division can be divided into the same phases: prophase, metaphase, anaphase, and telophase. Cytokinesis follows telophase each time. Between the two cell divisions, DNA replication does not occur. Through this process, one diploid cell will divide into four haploid cells.



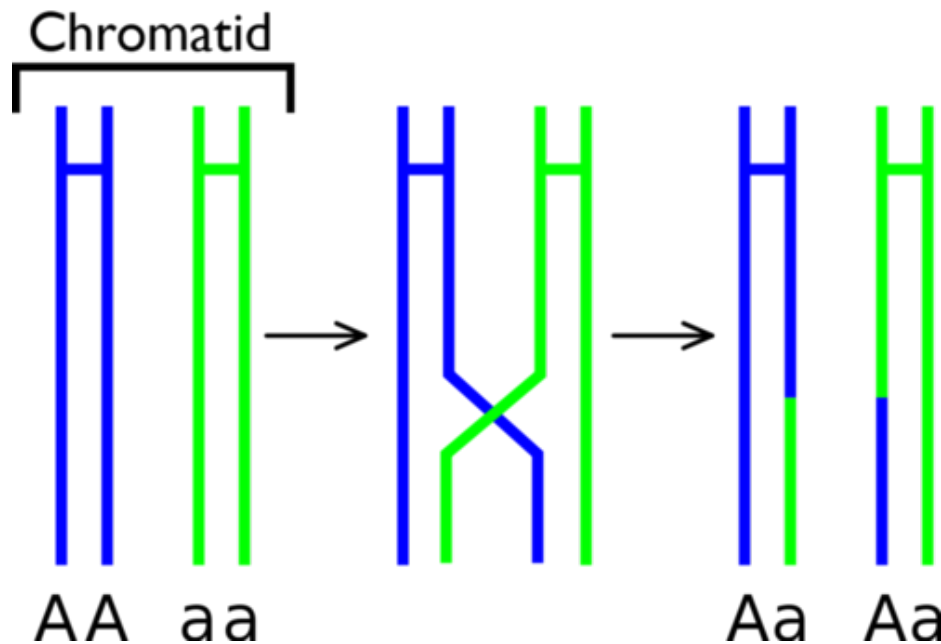
Overview of Meiosis. During meiosis, four haploid cells are created from one diploid parent cell.

Meiosis I

During meiosis I, the pairs of homologous chromosomes are separated from each other. This requires that they line up in their homologous pairs during metaphase I. The steps are outlined below:

1. **Prophase I:** The homologous chromosomes line up together. During this time, a process that only happens in meiosis can occur. This process is called **crossing-over** ([Figure below](#)), which is the exchange of DNA between homologous chromosomes. Crossing-over forms new combinations of alleles on the resulting chromosome. Without crossing-over, the offspring would always inherit all of the alleles on one of the homologous chromosomes. Also during prophase I, the **spindle** forms, the chromosomes condense as they coil up tightly, and the nuclear envelope disappears.
2. **Metaphase I:** The homologous chromosomes line up in their pairs in the middle of the cell. Chromosomes from the mother or from the father can each attach to either side of the spindle. Their attachment is random, so all of the chromosomes from the mother or father do not end up in the same gamete. The gamete will contain some chromosomes from the mother and some chromosomes from the father.
3. **Anaphase I:** The homologous chromosomes are separated as the spindle shortens, and begin to move to opposite sides (opposite poles) of the cell.
4. **Telophase I:** The spindle fibers dissolve, but a new nuclear envelope does not need to form. This is because, after cytokinesis, the nucleus will immediately begin to divide again. No DNA replication occurs between meiosis I and meiosis II because the chromosomes are already duplicated. After cytokinesis, two haploid cells result, each with chromosomes made of sister chromatids.

Since the separation of chromosomes into gametes is random during meiosis I, this process results in ***different combinations of chromosomes (and alleles) in each gamete***. With 23 pairs of chromosomes, there is a possibility of over 8 million different combinations of chromosomes (2^{23}) in a human gamete.



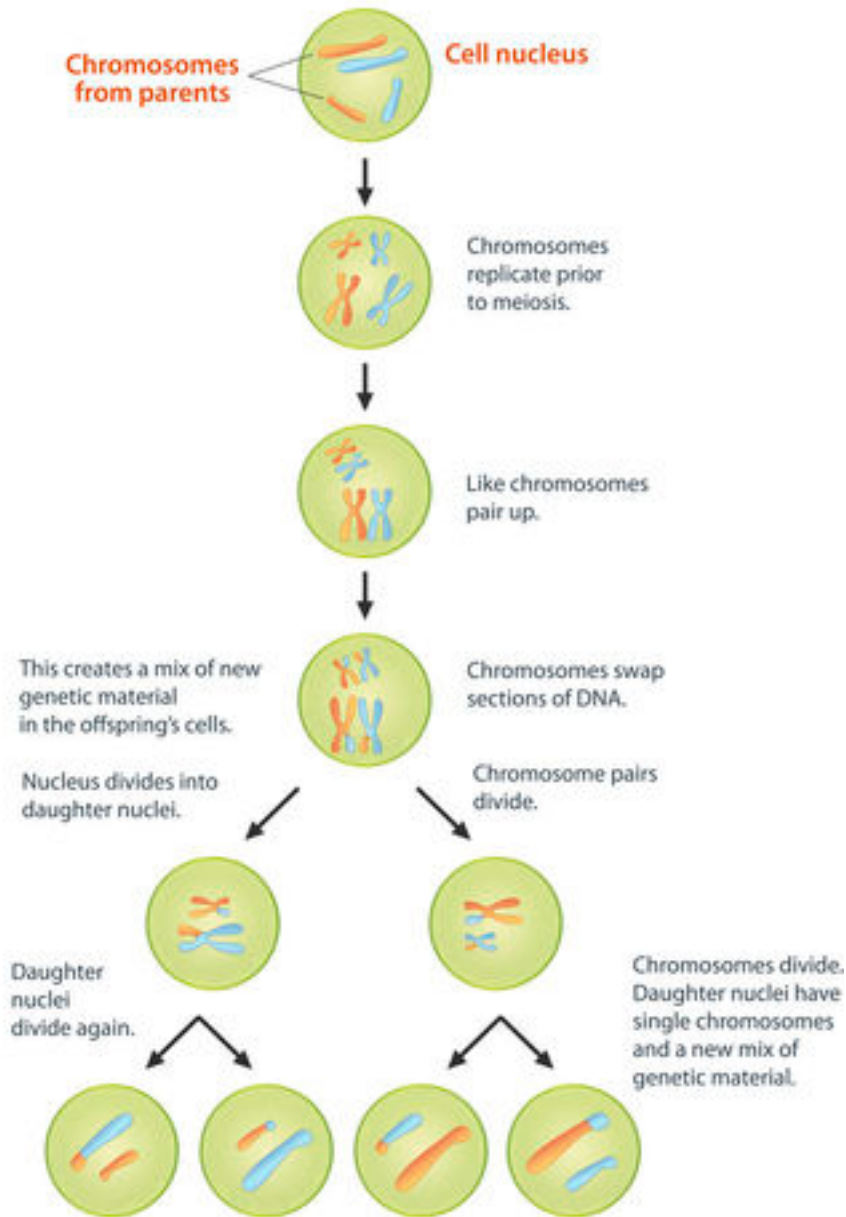
During crossing-over, segments of DNA are exchanged between non-sister chromatids of homologous chromosomes. Notice how this can result in an allele (A) on one chromatid being moved onto the other non-sister chromatid.

Meiosis II

During meiosis II, the sister chromatids are separated and the gametes are generated. This cell division is similar to that of **mitosis**, but results in four genetically unique haploid cells. The steps are outlined below:

1. **Prophase II:** The chromosomes condense.
2. **Metaphase II:** The chromosomes line up one on top of each other along the middle of the cell, similar to how they line up in mitosis. The spindle is attached to the centromere of each chromosome.
3. **Anaphase II:** The sister chromatids separate as the spindle shortens and move to opposite ends of the cell.
4. **Telophase II:** A nuclear envelope forms around the chromosomes in all four cells. This is followed by cytokinesis.

After cytokinesis, each cell has divided again. Therefore, meiosis results in four haploid genetically unique daughter cells, each with half the DNA of the parent cell (**Figure below**). In human cells, the parent cell has 46 chromosomes (23 pairs), so the cells produced by meiosis have 23 chromosomes. These cells will become gametes.



An overview of meiosis.

Summary

- *Meiosis is a process of cell division that reduces the chromosome number by half and produces sex cells, or gametes.*
- *Meiosis is divided into two parts: Meiosis I and Meiosis II. Each part is similar to mitosis and can be divided into the same phases: prophase, metaphase, anaphase, and telophase.*
- *Crossing-over occurs only during prophase I.*
- *Four genetically unique haploid cells result from meiosis.*

VOCABULARY ~ Please complete the following definitions

GAMETES ~

ZYGOTE ~

HOMOLOGOUS CHROMOSOME ~

ALLELE ~

DIPLOID ~

HAPLOID ~

CROSSING OVER ~

SPINDLE ~

REVIEW:

- 1) What is meiosis?

- 2) What is diploid? How many chromosomes are in a diploid human cell?

- 3) What is the difference between a haploid cell and a diploid cell?

- 4) What is a zygote? How does the zygote form the organism?

- 5) Describe crossing-over. When does crossing-over occur? What is the result?

- 6) How many cell divisions occur during meiosis?

- 7) Why are you genetically distinct?