

Web Tutorial 12.1

Meiosis



Textbook sections

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After reading the text material, you should be able to

- Define *karyotype*.
- Explain the notation used to describe the number and type of chromosomes present in an organism or a particular type of cell.
- Explain what is meant by the term *ploidy* and give an example of its use.

After completing this tutorial, you should be able to

- Explain why meiosis is known as a reduction division.
- Name the phases of meiosis and briefly describe what occurs in each one.
- Compare and contrast the processes of mitosis and meiosis.

NARRATION

Chromosome Replication

This is a representation of a cell before it begins *meiosis*, a process in the nucleus that divides the chromosome number in half. For clarity, the nuclear membrane is not shown. Also, the chromosomes are depicted as condensed, although during interphase of the normal cell cycle, they are actually thin and dispersed and not visible under a light microscope.

Before a cell enters meiosis, it first replicates its DNA. After DNA replication, the chromosomes are duplicated so that each has two identical sister *chromatids* connected at a structure called the *centromere*.

Meiosis I

Meiosis consists of two successive cell divisions called *meiosis I* and *meiosis II*, each of which is subdivided into four phases. In the first phase of meiosis I, called *prophase I*, the *homologous chromosomes* (or homologs) in a *diploid* cell come together in a process called *synapsis*. The synapsed pairs are known as *tetrads*. Each tetrad consists of one chromosome inherited from the mother (colored red in the diagram) and one inherited from the father (colored blue).

Where they are synapsed, the chromosomes can cross over each other, forming an X-shaped structure called a *chiasma*. At the crossover sites, the homologous chromosomes exchange segments. This exchange results in genetic variability in the daughter cells.

The second major phase of meiosis I is *metaphase I*. During this phase, the pairs of chromosomes line up in the middle of the cell.

During the third phase—*anaphase I*—the chromosomes of each pair move to opposite poles of the cell.

In *telophase I*, the fourth and final phase, the chromosomes reach the poles of the cell.

When meiosis I is complete, the cytoplasm divides to produce two *haploid* daughter cells, each having just a single set of chromosomes. Even though a duplicated chromosome has two chromatids, the chromatids are bound by a centromere and are considered one chromosome. The number of chromosomes in a cell equals the number of centromeres present.

Note that the two daughter cells are genetically different.

Meiosis II

The second event of meiosis—meiosis II—strongly resembles *mitosis*. During *prophase II*, duplicated chromosomes, consisting of two sister chromatids, begin to move to the middle of the cell.

In *metaphase II*, the chromosomes are arranged along the cell's midplane.

The sister chromatids begin to separate in *anaphase II*, becoming independent chromosomes that move to opposite poles of the cell.

During *telophase II*, the chromosomes reach the poles.

When meiosis II is complete, the cytoplasm of each cell divides to form two daughter cells. The four cells are haploid, each containing a single set of chromosomes.

Note that the four daughter cells are all genetically different from one another.

Comparing Meiosis I to Mitosis

A cell that undergoes mitosis produces daughter cells that are dramatically different from the daughter cells produced by a cell that undergoes meiosis. Let's compare these two processes, beginning with a look at mitosis and meiosis I.

In both mitosis and meiosis I, cells begin with replicated chromosomes, each cell having two chromatids per chromosome.

In meiosis I, the homologous chromosomes pair with each other and come to the middle of the cell together. In mitosis, the homologs move independently of each other.

In mitosis, the chromatids separate. In meiosis I, the homologs separate.

In mitosis, a diploid cell divides to produce genetically identical diploid cells. Each cell contains two complete sets of chromosomes.

In meiosis I, a diploid cell divides to produce genetically unique haploid cells. Each daughter cell now contains just one set of chromosomes. Meiosis I is known as a reduction division because the outcome is a reduction of chromosome number.

Comparing Meiosis II to Mitosis

These two cells are daughter cells produced from meiosis I. Let's use just one of them to compare meiosis II to mitosis.

A cell entering mitosis is diploid, with two complete sets of chromosomes.

A cell entering meiosis II is haploid, with just one complete set of chromosomes. In both cells, each chromosome has two chromatids.

In both mitosis and meiosis II, the chromosomes migrate to the middle of the cell. Then the sister chromatids of each chromosome separate to form independent chromosomes.

In mitosis, a diploid cell divides to produce genetically identical diploid cells, each with two complete sets of chromosomes.

In meiosis II, a haploid cell divides to produce genetically unique haploid cells, each with one complete set of chromosomes. If we consider that meiosis II actually began with two cells, then the result is four genetically unique haploid cells.

In both mitosis and meiosis II, the division is not a reduction division. Only in meiosis I are the number of chromosome sets divided by half.

KEY TERMS & CONCEPTS

anaphase I The third stage of cell division in meiosis I, during which chromosomes move to opposite ends of the cell.

anaphase II The third stage of cell division in meiosis II, during which chromosomes move to opposite ends of the cell.

centromere The attachment structure joining two sister chromatids during mitosis and meiosis.

chiasma The X-shaped structure formed during meiosis by crossing over between adjacent chromatids of a pair of homologous chromosomes.

chromatid One of the daughter strands of a chromosome that has recently been copied (during mitosis or meiosis) and that is still connected to the other daughter strand. Upon separation from each other, the chromatids become chromosomes.

diploid Having two sets of chromosomes. Diploid cells have two alleles of each gene—one on each of the homologous pairs of chromosomes.

haploid Having a single set of chromosomes. Haploid cells have just one allele of each gene; they do not contain homologous chromosomes.

homologous chromosomes (homologs) Chromosomes of the same type, with the same genes in the same locations.

meiosis Cell division that leads to a halving of the chromosome number. One diploid parent cell produces four haploid reproductive cells. During meiosis, chromosome pairs synapse and can exchange genes via crossing over.

meiosis I The first of two major cell-division events in meiosis, during which two genetically different haploid daughter cells are produced.

meiosis II The second of two major cell-division events in meiosis, during which four genetically different haploid daughter cells are produced.

metaphase I The second stage of cell division in meiosis I, during which chromosomes line up in the middle of the cell.

metaphase II The second stage of cell division in meiosis II, during which chromosomes line up in the middle of the cell.

mitosis Nuclear division in eukaryotes that produces two daughter nuclei that are genetically identical to the parent.

prophase I The first stage of cell division in meiosis I, during which chromosomes begin to move to the middle of the cell.

prophase II The first stage of cell division in meiosis II, during which chromosomes begin to move to the middle of the cell.

synapsis The physical pairing of two homologs during prophase I of meiosis. Crossing over occurs during synapsis.