

Zoo-352 Principles of genetics
Lecture 5

Meiosis

Overview of meiosis

- ❖ In the sexual reproduction process, two gametes fuse during fertilization to produce a zygote.
- ❖ Meiosis is a specialized type of cell division which **reduces** the chromosome number by **half**.
- ❖ This process occurs in animals and plants.
- ❖ Meiosis occurs only in germ cells.
- ❖ **Mitosis** can occur in either **haploid** or **diploid** cells, but **meiosis** is restricted to **diploid** cells.

- ❖ Meiosis takes place solely in the **testes (males)** and **ovaries (females)** to produce haploid sex cells or gametes.
- ❖ Meiosis is a **two** division process that produces **four** haploid cells from each diploid parental cell.
- ❖ These two divisions are known as **meiosis I** (a reductional division) and **meiosis II** (an equational division).

The first meiotic division, meiosis I

❖ Meiosis I is divided into **four phases**:

1) prophase I 2) metaphase I

3) anaphase I 4) telophase I

❖ Prior to meiosis, chromosome **duplication** occurs during the **S** of the interphase stage in order to **double the sister** chromatid pairs.

❖ The sister chromatids remain associated at the centromeres; consequently, each set of chromosomes is composed of two identical sister chromatids.

❖ Prophase I can be sub-classified into **five** stages (figure 1):

1) leptotene 2) zygotene 3) pachytene

4) diplotene 5) diakinesis.

The stages of prophase I

1) Leptotene:

- The duplicated sister chromatids start to condense and coil.
- The chromosomes become shorter and thicker.

2) Zygotene:

- The homologous chromosomes draw close to each other by a special structure called the **synaptonemal complex**, which begins to form between paired homologous chromosomes in a process termed **synapsis**.
- As a result, the pairs of chromosomes consist of **four chromatids**, with **one** chromosome coming from each parent.
- Each pair of homologous chromosomes is known as a **bivalent** (**Tetrad**).

3) Pachytene:

- **Synapsis** is complete and the paired chromosomes are held together tightly with the aid of the **synaptonemal complex** and structures termed **chiasma** (plural: chiasmata).
- The chiasma is the physical link between **nonsister** chromatids.
- **Crossing over** between homologous chromosomes occurs and DNA is exchanged between the bivalents in a process called **homologous recombination**.
- One consequence of crossing over is the generation of a new combination of genetic material in the **gametes**.
- The two chromatids in a single chromosome are **sister chromatids**, but chromatids from each of the homologous chromosomes are called **nonsister chromatids** (Figure 2).

4) Diplotene:

- The homologous chromosomes begin to separate in a process called **desynapsis**, but remain connected through sister chromatid cohesion and chiasmata until anaphase I.

5) Diakinesis:

- The synaptonemal complex has completely dissociated, the chromosomes continue to condense further.
- The nuclear membrane breaks down.
- The duplicated centrosomes are at opposite poles.

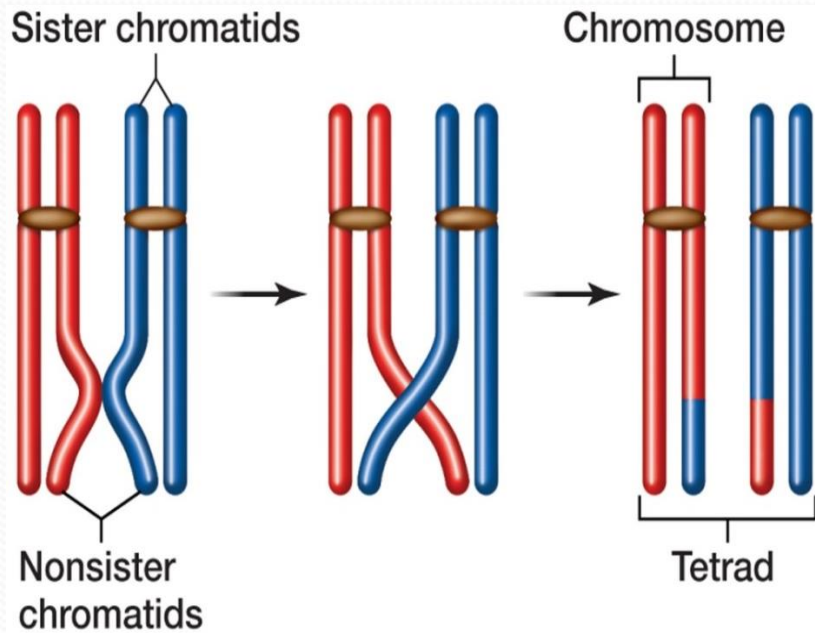
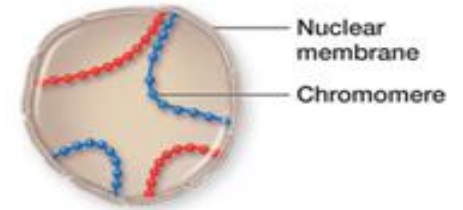
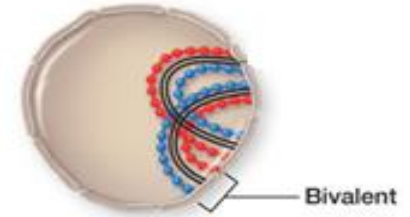


Figure 2: Crossing over in a tetrad during prophase of meiosis I

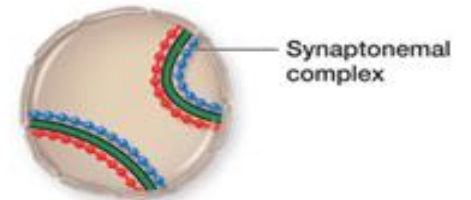
Leptotene stage



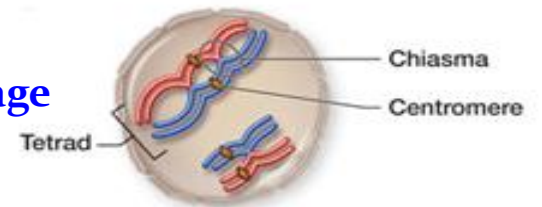
Zygotene stage



Pachytene stage



Diplotene stage



Diakinesis

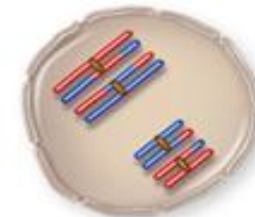


Figure 1: Prophase I of meiosis

The phases of Meiosis I

2- Metaphase I

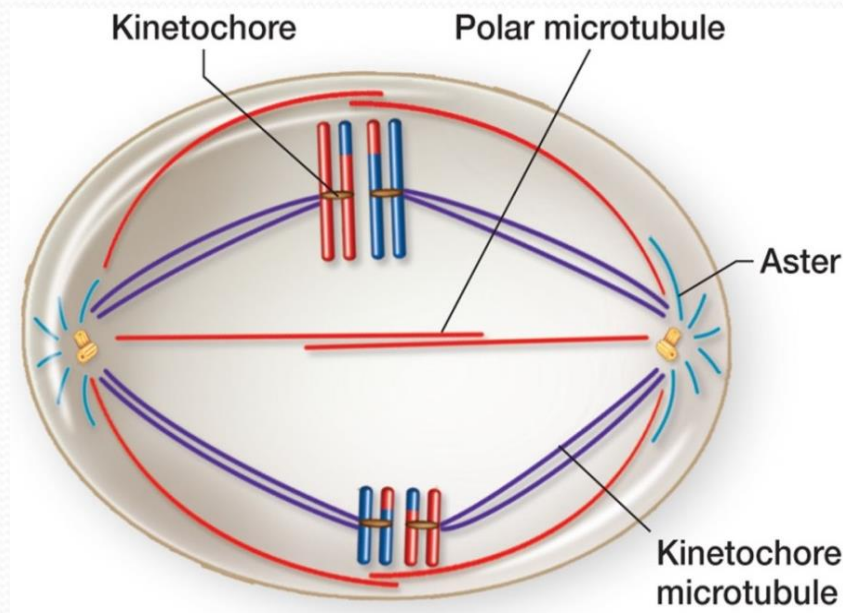


Figure 3: Metaphase of meiosis I

- ❖ Sister chromatids are attached to kinetochore microtubules from the same centrosome or pole.
- ❖ The **tetrads** are aligned in a **double row** along the **metaphase plate** of the cell (figure 3).

3- Anaphase I

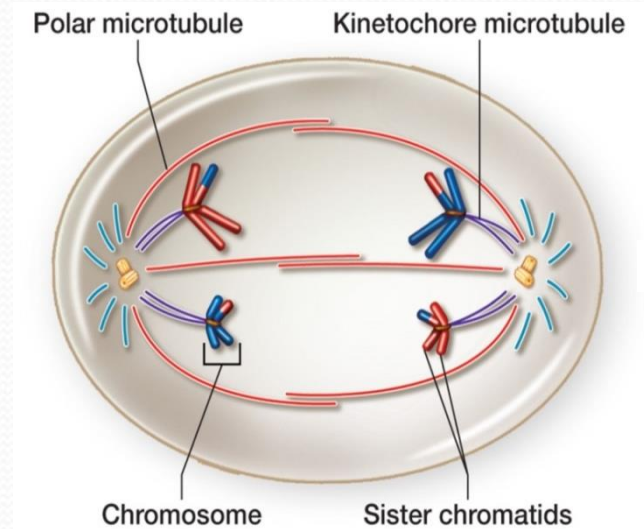


Figure 4: Anaphase of meiosis I

- ❖ The **chiasmata** between homologous chromosomes are **separated**.
- ❖ Sister chromatid **cohesion** along the chromosome arms is **resolved**, but the sister chromatids remain bound to each other at the **centromeres** until the beginning of **anaphase II** (figure 4).
- ❖ The microtubules pull one set of homologous chromosomes toward the opposite poles of the cell.
- ❖ This meiotic division is called **a reductional division** because it reduces the number of chromosomes ($2n$) by half in each daughter cell (n).

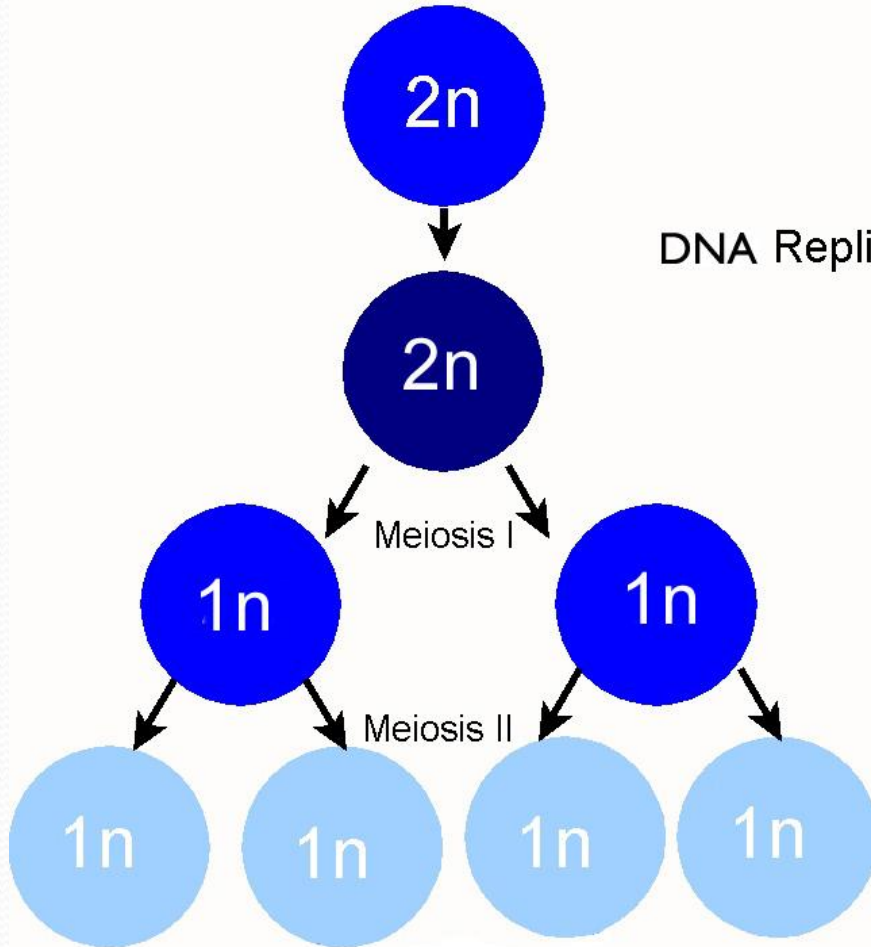
4- Telophase I

- ❖ The nuclear membrane **reforms** around the chromosomes.
- ❖ **cytokinesis** takes place.

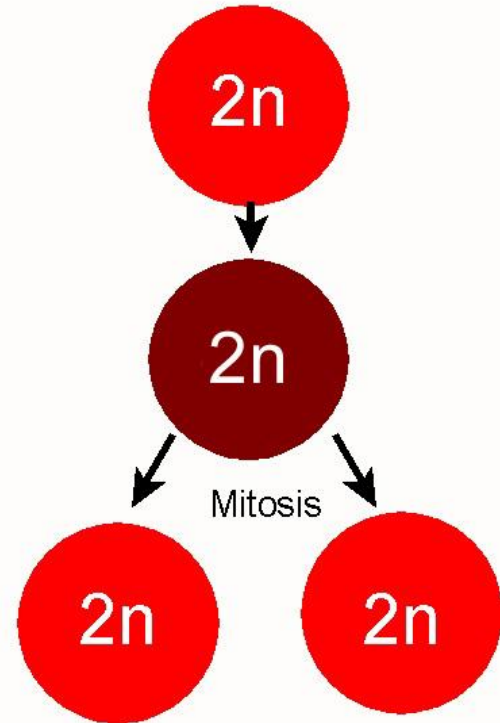
The second meiotic division, meiosis II

- ❖ Meiosis II is basically a **mitotic-like division**.
- ❖ It is called the **equational division** because the chromosome number remains the same in each cell before and after the second division.
- ❖ Meiosis II **does not** further reduce the chromosome number.
- ❖ Meiosis II **reduces the amount of genetic material** per cell by half through separation of the sister chromatids.
- ❖ It is **shorter** than meiosis I, although it consists of **four phases**: prophase II, metaphase II, anaphase II, and telophase II.
- ❖ It occurs **without** further **DNA replication**.

Meiosis

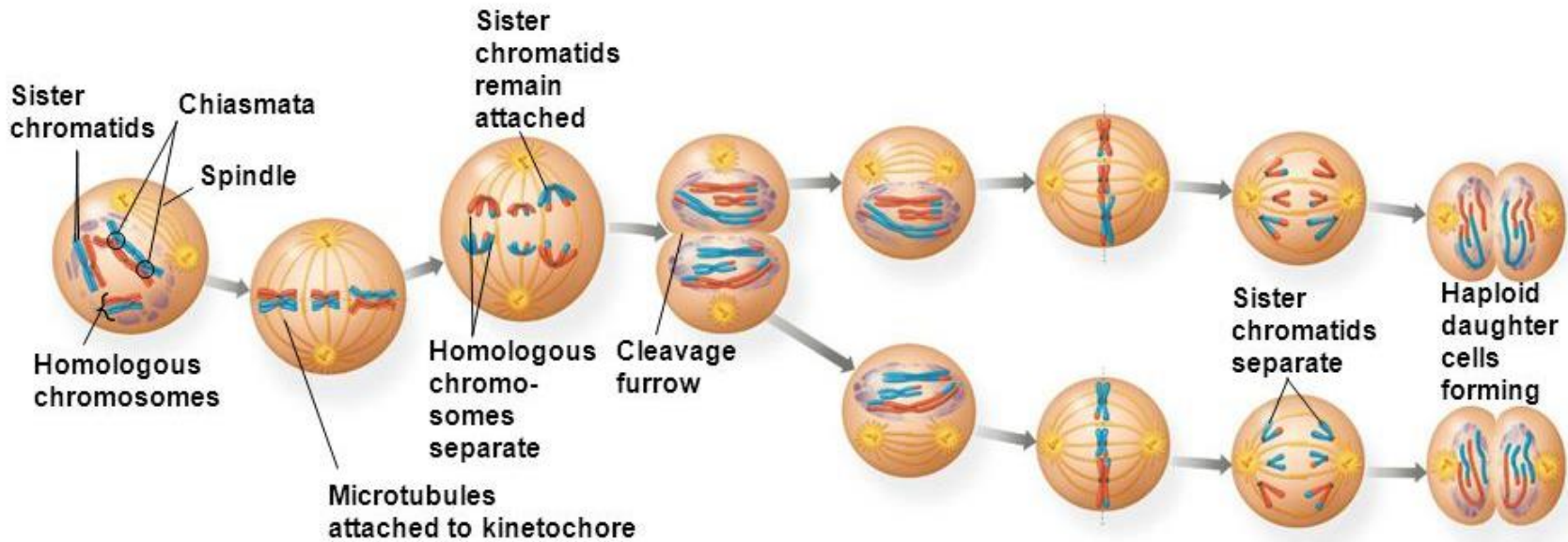


Mitosis



Overview of Meiosis

MEIOSIS I: Separates homologous chromosomes				MEIOSIS II: Separates sister chromatids			
Prophase I	Metaphase I	Anaphase I	Telophase I and Cytokinesis	Prophase II	Metaphase II	Anaphase II	Telophase II and Cytokinesis



Meiosis I = “reductional division” as chromosome number goes from **diploid** to **haploid**

Meiosis II = “equational division” as sister chromatids separate (start double-stranded, **centromeres break** and become single-stranded)

Comparison between mitosis and meiosis

Mitosis	Meiosis
Occurs in haploid or diploid cells.	Occurs in diploid cells.
Occurs in somatic cells.	Occurs in sex (reproductive) cells.
Consists of one round of cell division.	Consists of two rounds of cell division.
Results in two identical daughter cells.	Results in four daughter cells, which are not identical.
The resulting (daughter) cells have the same number of chromosomes as in the parent (original) cells.	The resulting cells have half the number of chromosomes as in the parent cells.
Prophase is short and does not comprise any phase.	Prophase I is very long and comprises five phases.
There is no pairing of chromosome, synapsis, or crossing over during prophase.	Pairing, synapsis and crossing over before homologous chromosomes occurs during prophase I.
Synaptonemal complex is not found.	Synaptonemal complex is found during the zygotene of prophase I.
Anaphase involves the separation of the two sister chromatids of each chromosome.	During anaphase I, the homologous chromosome separate, while the sister chromatids remain attached at their centromere. During anaphase II, the sister chromatids separate as a result of the separation of the centromere.
Necessary for repair and growth of a cell.	Necessary for sexual reproduction.

Significance of meiosis

- 1) Meiosis produces haploid gamete required for sexual reproduction from diploid cells.
- 2) It reduces the diploid number of chromosomes by half.
- 3) Meiosis produces genetic diversity.

Videos

http://highered.mheducation.com/sites/007298760x/student_view0/chapter3/stages_of_meiosis.html

http://highered.mheducation.com/sites/007298760x/student_view0/chapter3/meiosis_with_crossing_over.html

http://highered.mheducation.com/sites/007298760x/student_view0/chapter3/unique_features_of_meiosis.html

http://highered.mheducation.com/sites/007298760x/student_view0/chapter3/how_meiosis_works.html

<http://highered.mheducation.com/novella/MixQuizProcessingServlet>

http://highered.mheducation.com/sites/007298760x/student_view0/chapter3/comparison_of_meiosis_and_mitosis_quiz_1.html