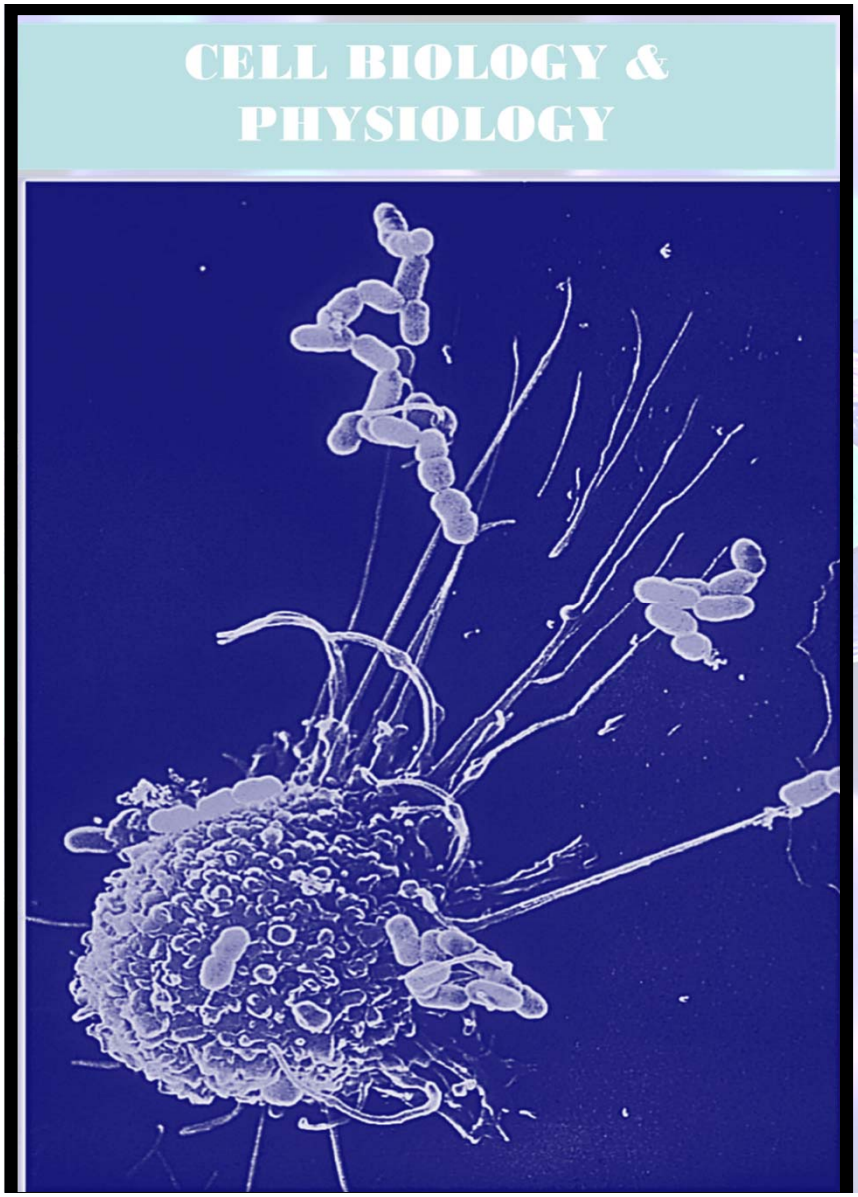


جامعة الملك سعود
King Saud University

college of sciences
Zoology Department

Cell Biology and Physiology

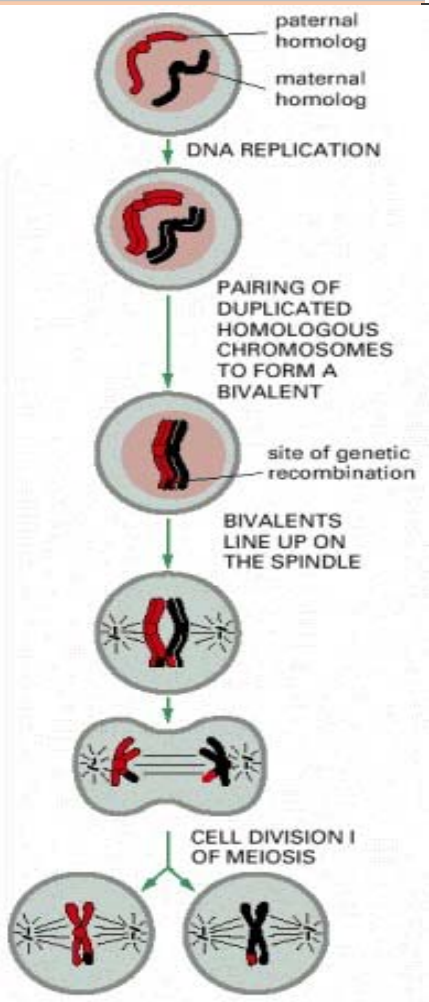
ZOO (242)

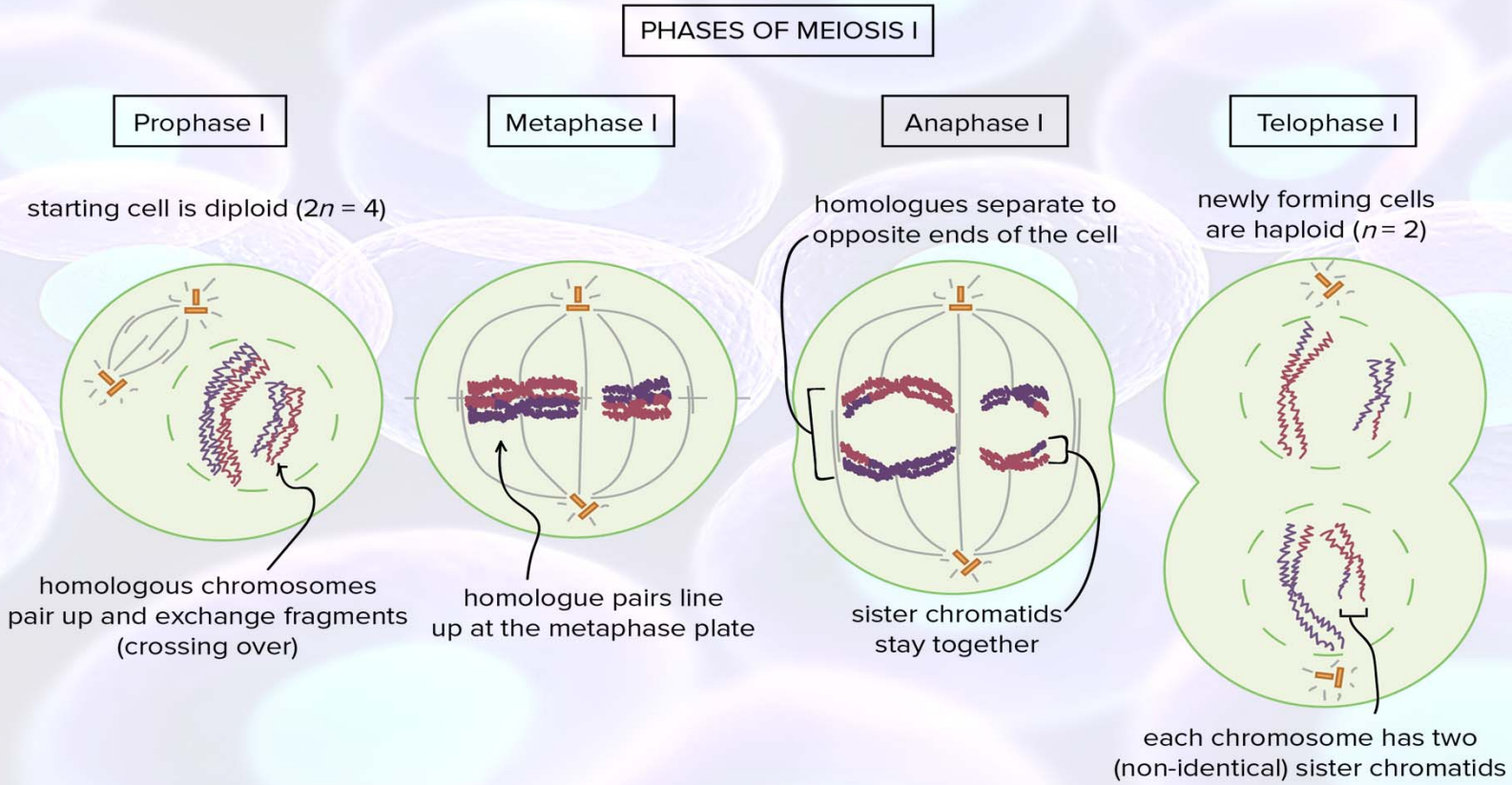
Introduction

- In the sexual reproduction process, two gametes fuse during fertilization to produce a zygote.
- Meiosis occurs only in germ cells testes (males) and ovaries (females) to produce a special cells (Egg and Sperm) each contains half on normal cells. (reduces the chromosome number by half).
- This process occurs in animals and plants..
- Mitosis can occur in either haploid or diploid cells, but meiosis is restricted to diploid cells.
- 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.




PHASES OF MEIOSIS I
Prophase I
Metaphase I
Anaphase I
Telophase I
starting cell is diploid (2n = 4)
homologous chromosomes pair up and exchange fragments (crossing over)
homologue pairs line up at the metaphase plate
homologues separate to opposite ends of the cell
sister chromatids stay together
newly forming cells are haploid (n = 2)
each chromosome has two (non-identical) sister chromatids

Prophase I is sub-classified into five stages:

1) leptotene 2) zygotene 3) pachytene

4) diplotene 5) diakinesis.

- Prophase I is sub-classified into five stages:
- 1) leptotene 2) zygotene 3) pachytene
- 4) diplotene 5) diakinesis.
- **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.

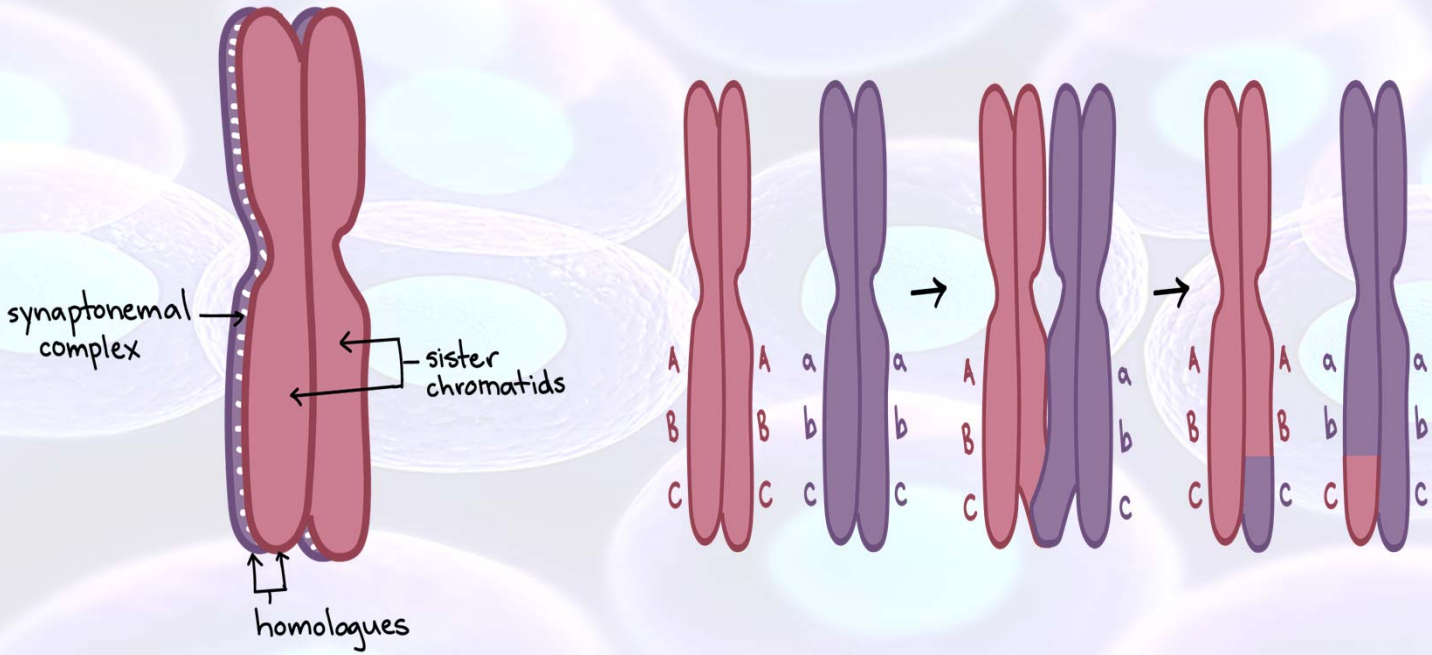
•The two chromatids in a single chromosome are sister chromatids, but chromatids from each of the homologous chromosomes are called nonsister chromatids.

4) Diplotene:

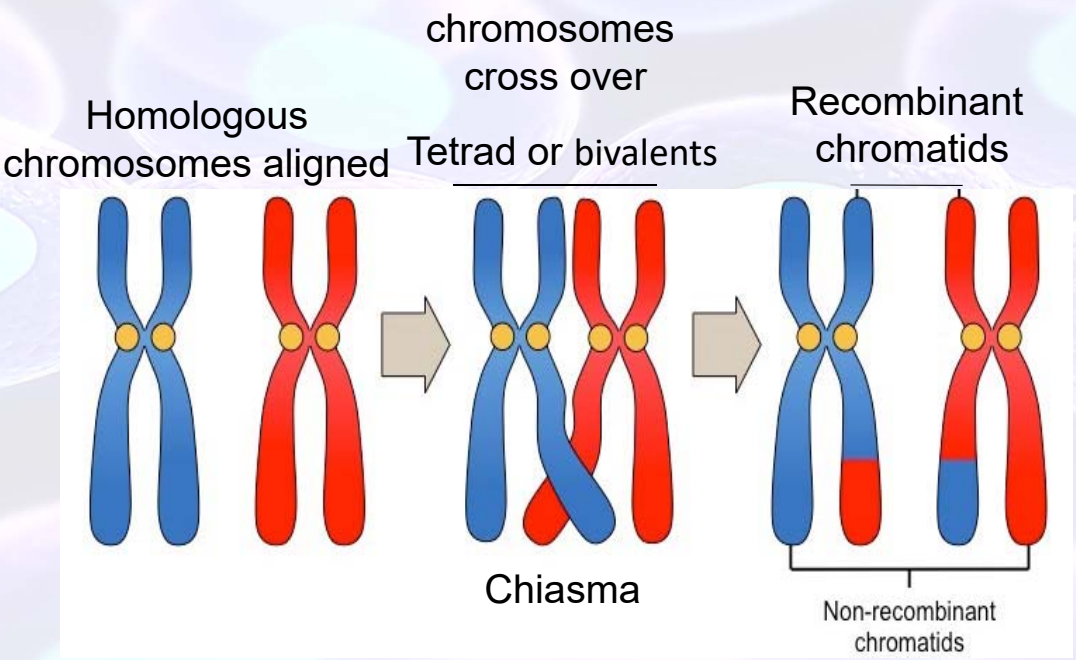
- The homologous chromosomes begin to separate in a process called desynapsis, but remain connected through sister chromatid cohesion and chiasmata until anaphase I.

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.



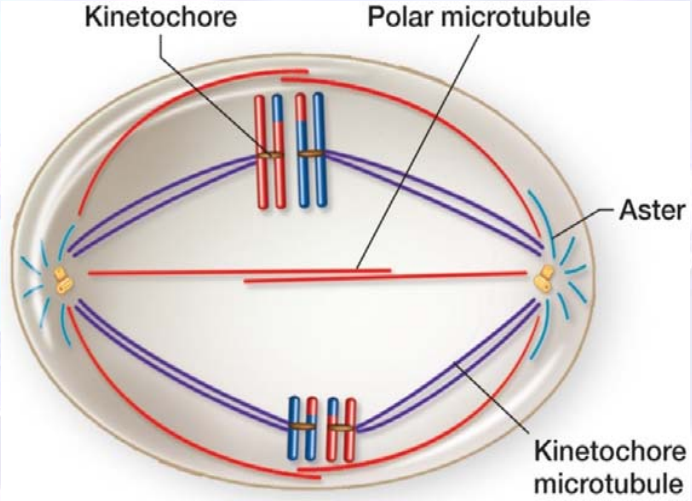
Crossover occurs between non-sister chromatids of homologous chromosomes



Crossing over in a tetrad during prophase of meiosis I

The phases of Meiosis I

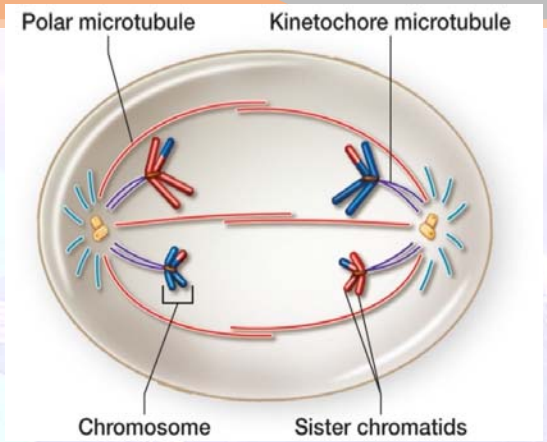
2- Metaphase I



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 .

3- Anaphase I



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 .

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.

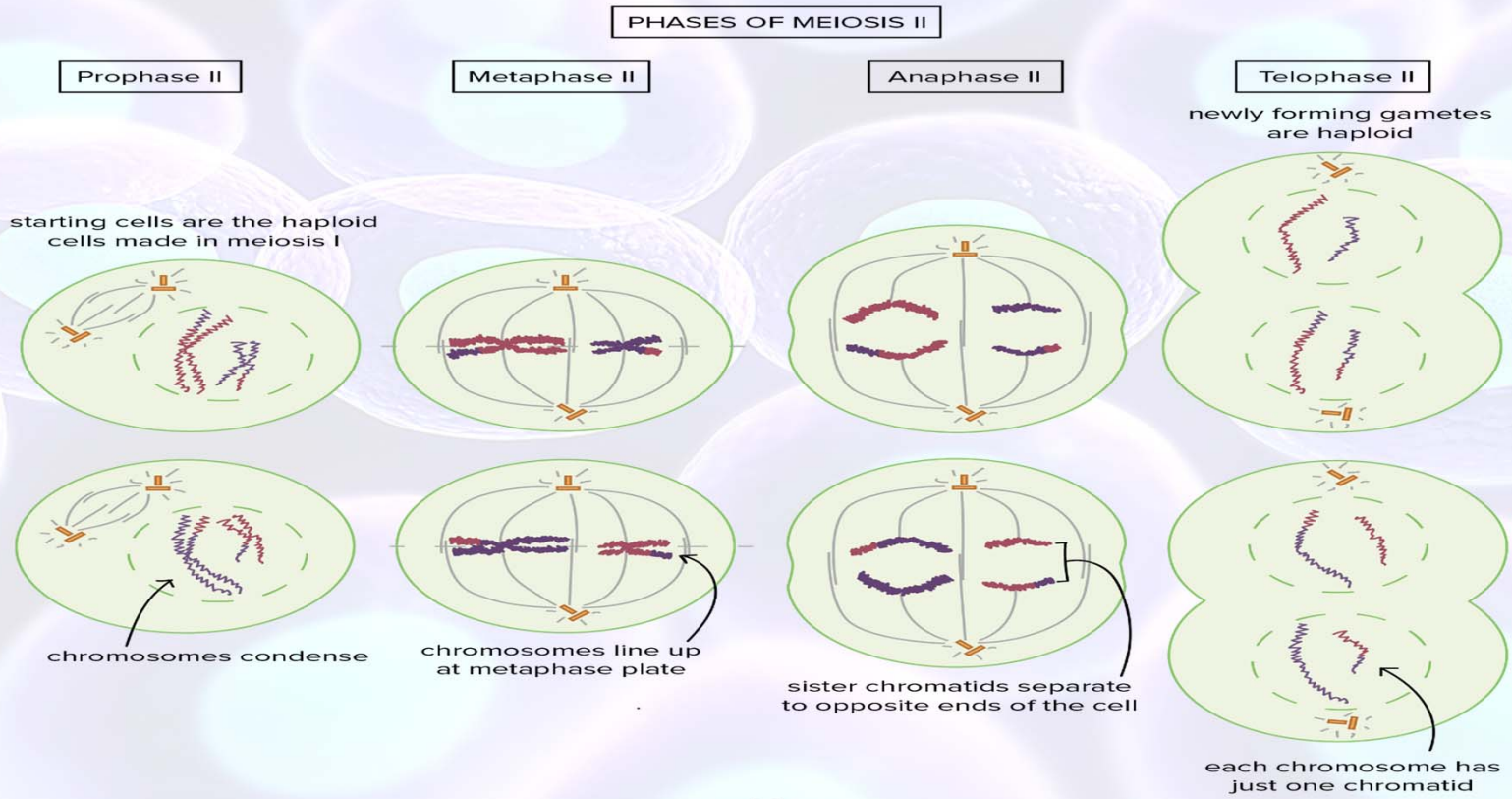
It is called the equational division because the chromosome number remains the same in each cell before and after the second division.

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.

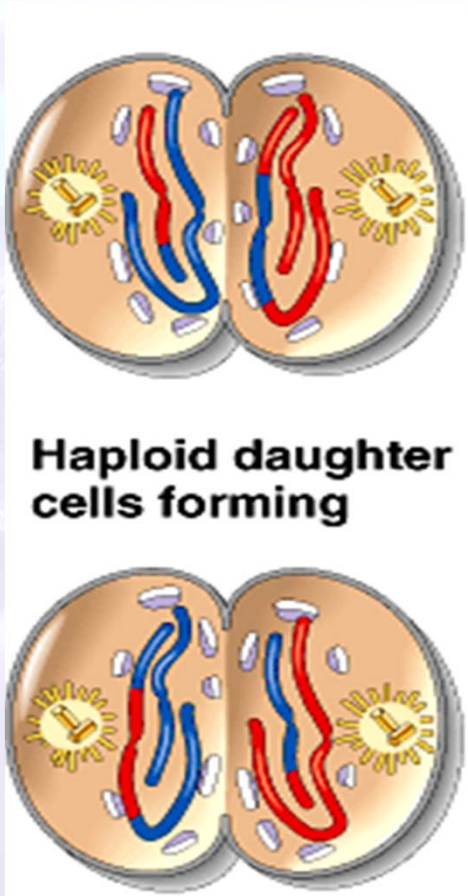
It occurs without further DNA replication.


PHASES OF MEIOSIS II
Prophase II
Metaphase II
Anaphase II
Telophase II
newly forming gametes are haploid
starting cells are the haploid cells made in meiosis I
chromosomes condense
chromosomes line up at metaphase plate
sister chromatids separate to opposite ends of the cell
each chromosome has just one chromatid

Cytokinesis

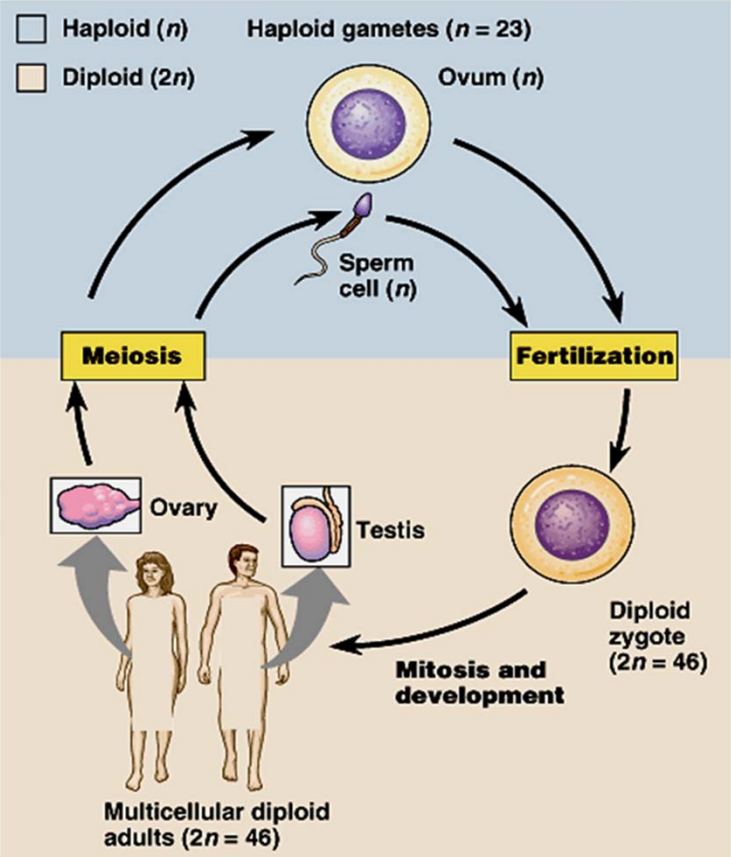
separates the cytoplasm.

At the end of meiosis, there are four haploid daughter cells



The Variety of Sexual Life Cycles

- Fertilization restores the diploid condition by combining two haploid sets of chromosomes.
- Gametes, produced by meiosis, are the only haploid cells.
- Gametes undergo no divisions themselves, but fuse to form a diploid zygote that divides by mitosis to produce a multicellular organism



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 contain any phase.	Prophase I is very long and contains 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.

Summary

- **Offspring acquire genes from parents by inheriting chromosomes.** Each **gene** in an organism's DNA exists at a specific **locus** on a certain chromosome.
- We inherit one set of chromosomes from our mother and one set from our father. In **asexual reproduction**, a single parent produces genetically identical offspring by mitosis. **Sexual reproduction** combines sets of genes from two different parents, leading to genetically diverse offspring.
- As seen in a **karyotype**, normal human **somatic cells** are **diploid**. They have 46 chromosomes made up of two sets of 23—one set from each parent.
- **Meiosis reduces the number of chromosome sets from diploid to haploid.** The two cell divisions of meiosis, **meiosis I** and **meiosis II**, produce four haploid daughter cells. The number of chromosome sets is reduced from two (diploid) to one (haploid) during meiosis I, the reductional division.

- Meiosis is distinguished from mitosis by three events of meiosis I:
- **Prophase I:** Each homologous pair undergoes **synapsis** and **crossing over** between non-sister chromatids with the subsequent appearance of **chiasmata**.
- **Metaphase I:** Chromosomes line up as homologous pairs on the metaphase plate.
- **Anaphase I:** Homologs separate from each other; sister chromatids remain joined at the centromere.
- **Meiosis II separates the sister chromatids.**
- The combination of sister chromatid cohesion and crossing over leads to chiasmata, which hold homologs together until anaphase I. Cohesins are cleaved along the chromatid arms at anaphase I, allowing the homologs to separate, and at the centromeres in anaphase II, allowing sister chromatids to separate

References

- **"meiosis and sexual life cycle" chapter 13 Biology** by Jane B Reece; Neil A Campbell; et al Boston : Benjamin Cummings / Pearson, ©2011. English : 9th ed.