Zoo-352 -Principles of Genetics
Lecture 5

Meiosis

Reminder

The 1st Midterm Exam is on Sunday 16/02/2025 at 1:00 pm

Lectures 1-5 are included in the exam.

Outlines:

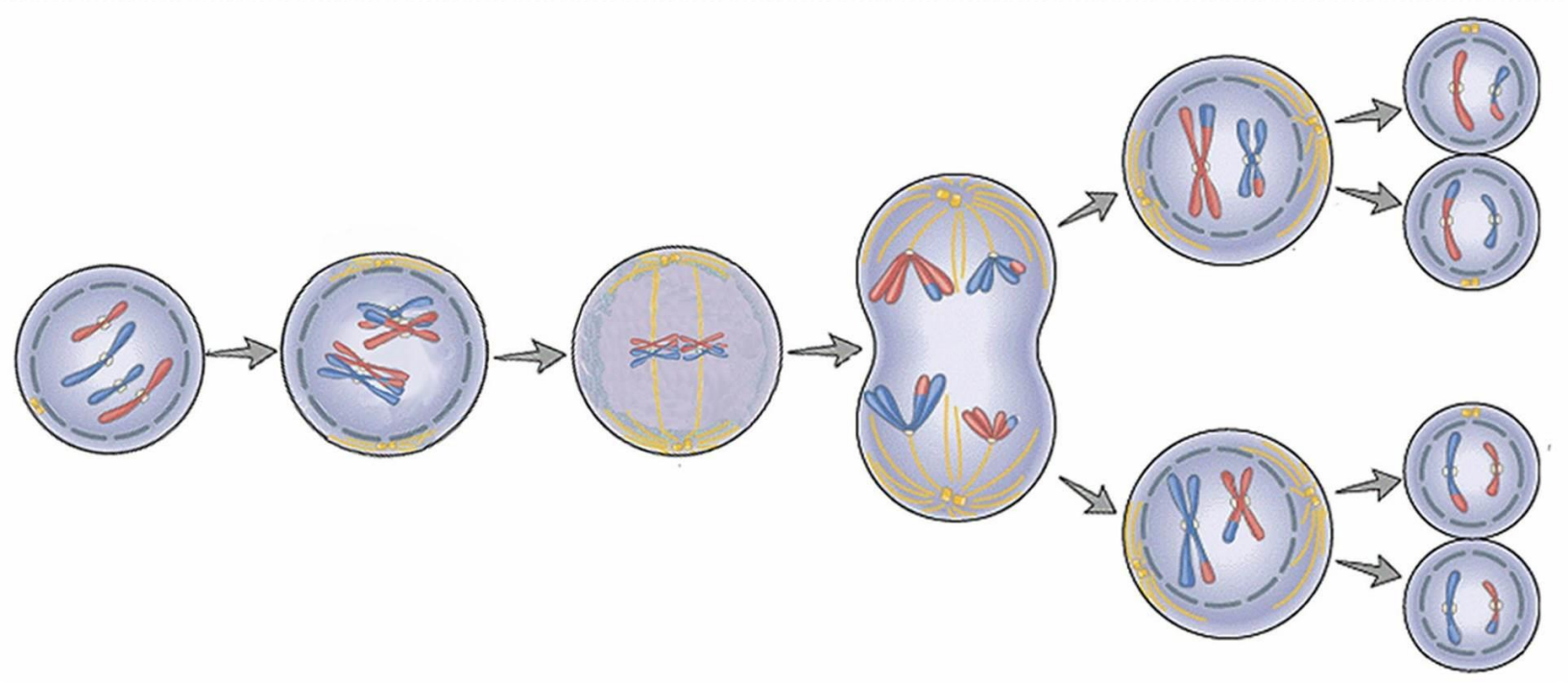
- The definition of meiosis.
- Significance of meiosis.
- The phases of meiotic division.
- The events of each phase during meiosis.
- A comparison between mitotic and meiotic division phases.

Overview of meiosis

- The sexual reproduction process includes two events:
  1. Generating haploid cells presenting gametes.
  2. The fusion of two gametes during fertilization to produce a zygote, a diploid cell.
- Meiosis is a specialized type of cell division which reduces the chromosome number by half to generate the gametes.
- Meiosis occurs in animals and plants.
- Meiosis occurs only in germ cells.

The definition of meiosis :

- Meiosis is a type of cell division that results in four daughter cells each with half the number of chromosomes of the parent cell, as in the production of gametes.

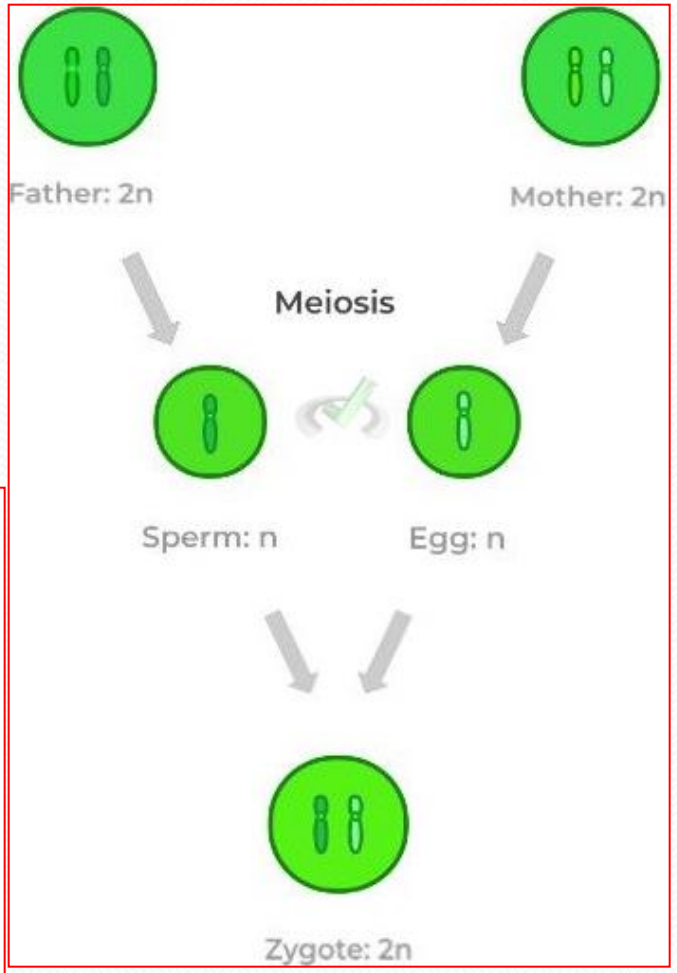


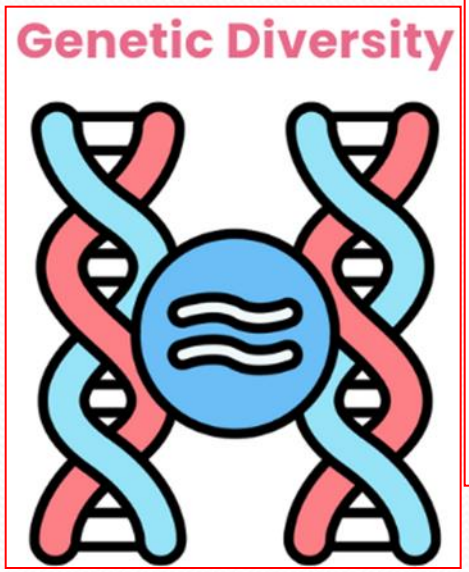
Highlights:

- Mitosis can occur in either haploid or diploid cells, but meiosis is restricted to diploid cells.
- In mammals, meiosis takes place solely in the testes (males) and ovaries (females) to produce haploid sex cells or gametes (sperms and eggs).
- 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).

Significance of meiosis :

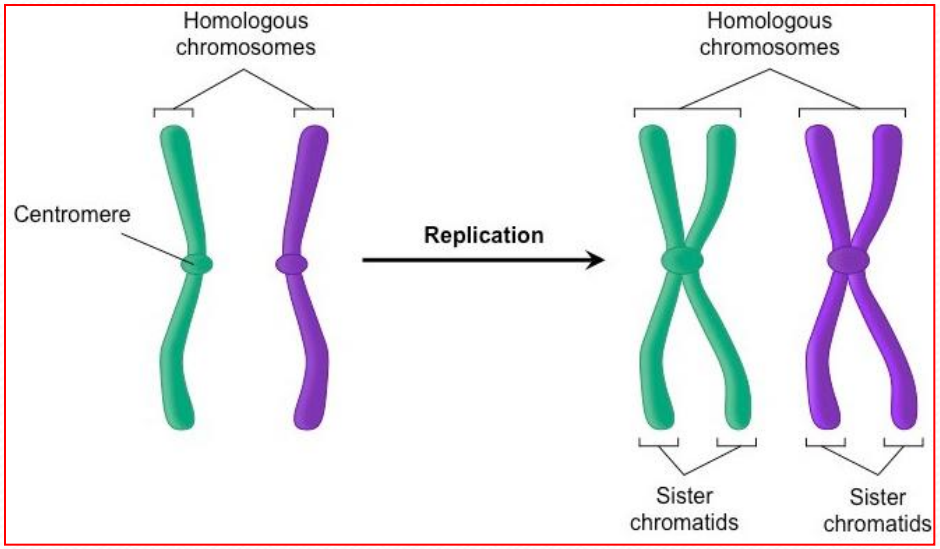
1. Meiosis produces haploid gamete required for sexual reproduction from diploid cells.
2. Meiosis reduces the diploid number of chromosomes by half.
3. Meiosis produces genetic diversity.





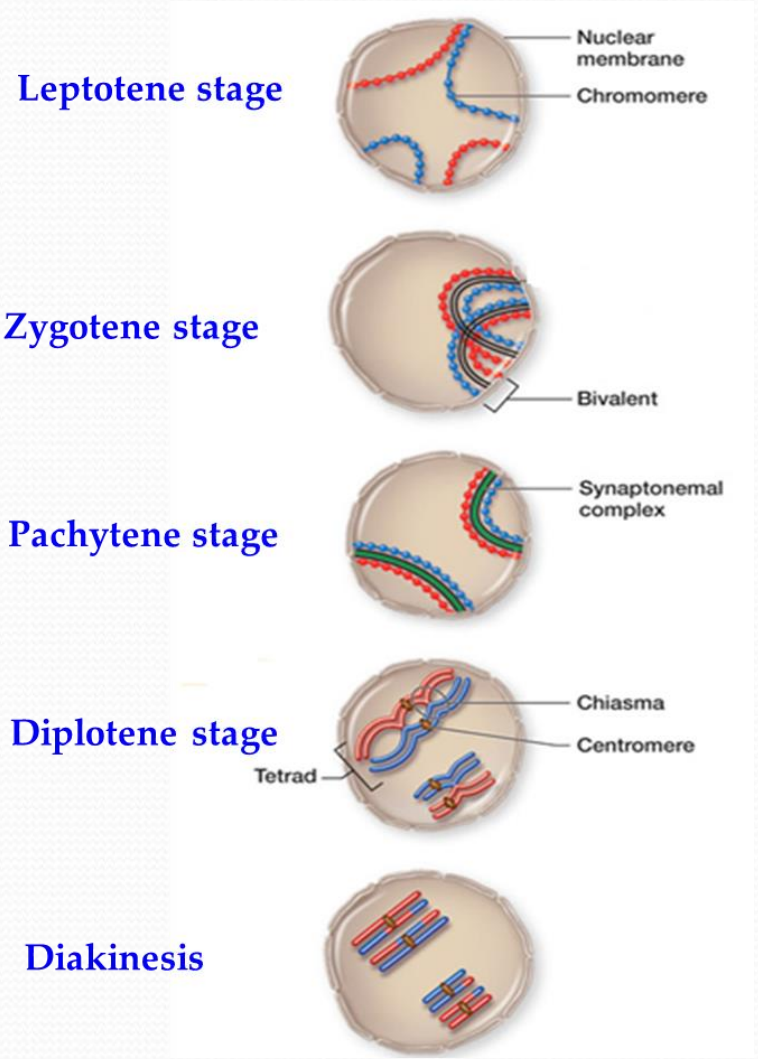
Chromosomes before meiotic division:

- 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.
- A pair of homologous chromosomes has 4 chromatids: each two are siters joint in the centromere.
- Non-sister chromatids in a homologous chromosome are on the opposite side chromosome.



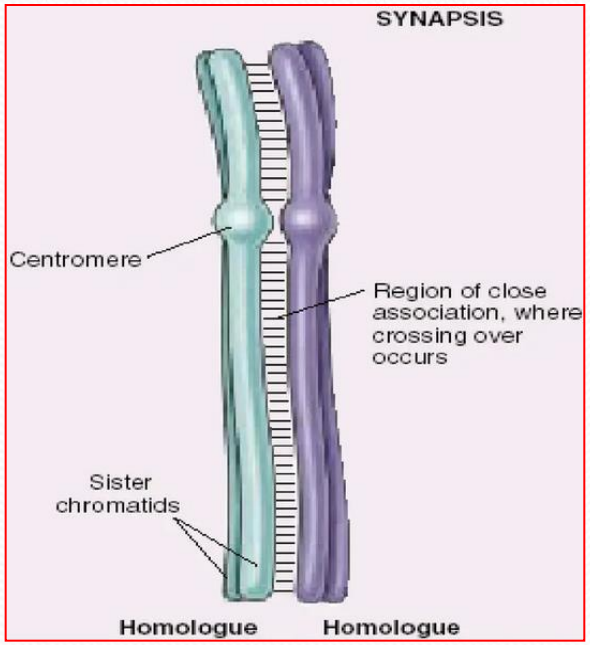
The first meiotic division, meiosis I:

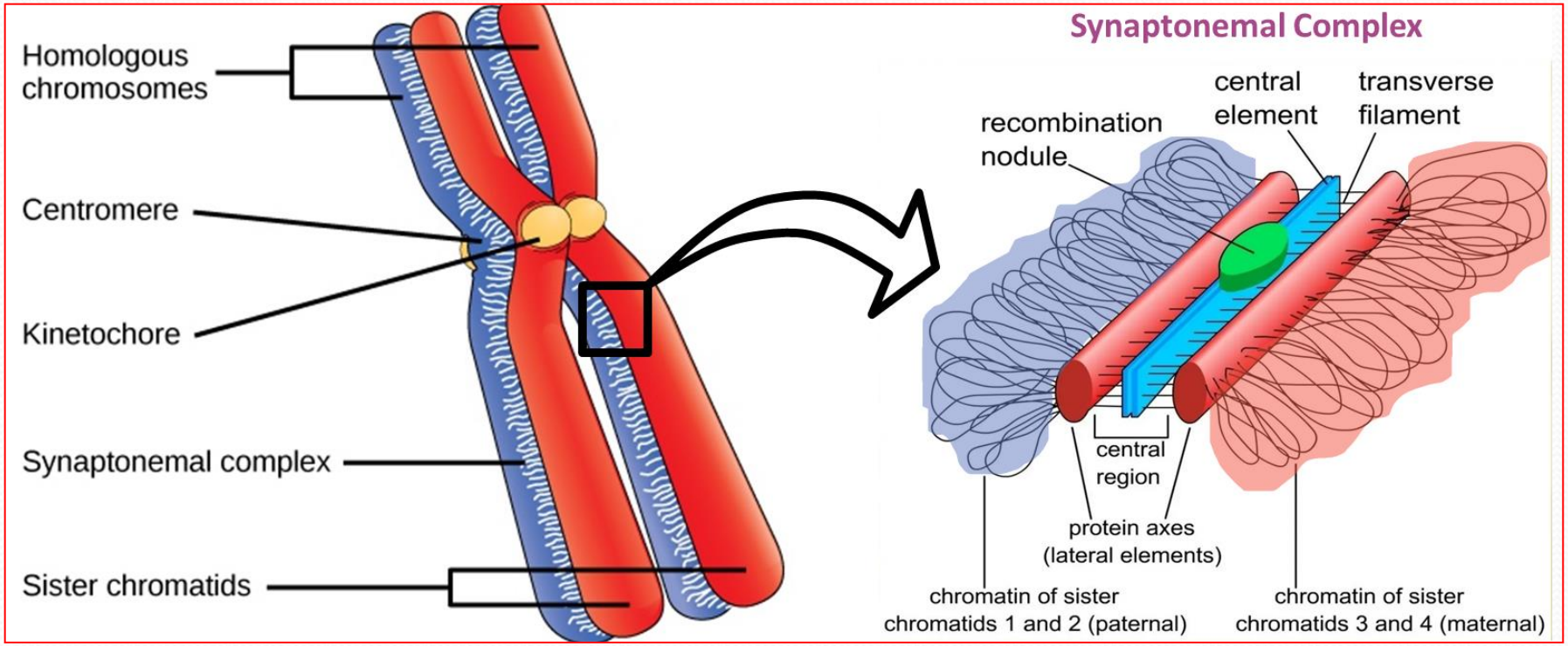
- Meiosis I is divided into four phases:
    1. Prophase I
    2. Metaphase I
    3. Anaphase I
    4. Telophase I
- Prophase I can be sub-classified into five stages:
    1. Leptotene
    2. Zygotene
    3. Pachytene
    4. Diplotene
    5. Diakinesis.



Meiosis I, 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).

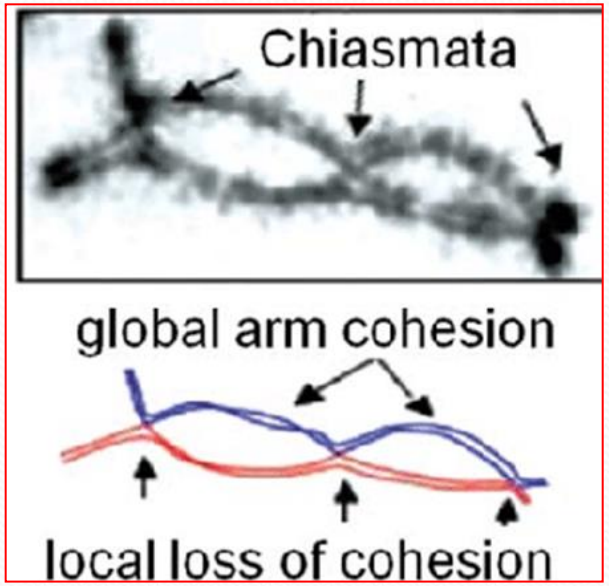


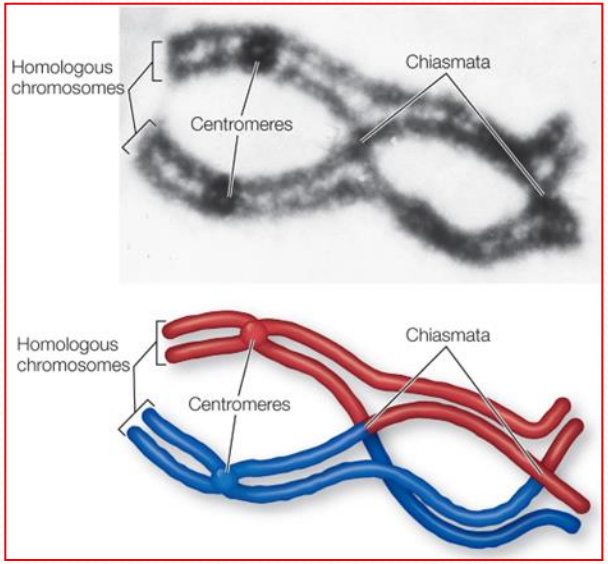


When synapsing occurs, the chromosomes do not lie side by side but rather on top of each other with a protein called the synaptonemal complex holding them together.

3. Pachytene:

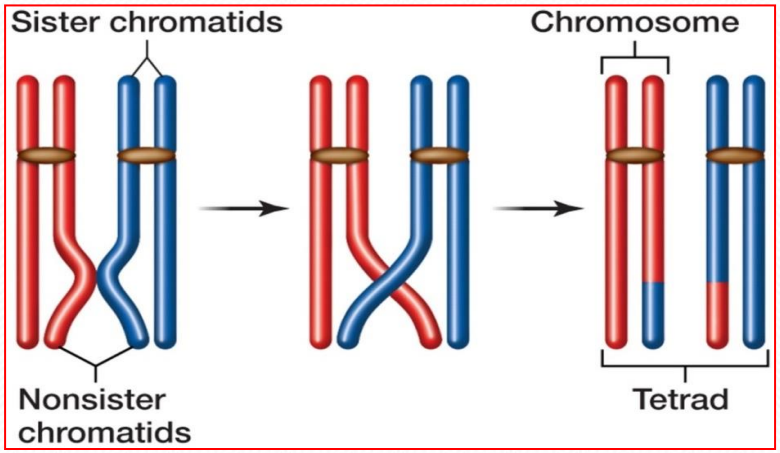
- There are two important events occur here: chiasma formation and crossing over.
- Synapsis is complete and the paired chromosomes are held together tightly with the aid of the synaptonemal complex and structures termed chiasma (plural: chiasmata).
- The chiasma is the physical link between non-sister chromatids.

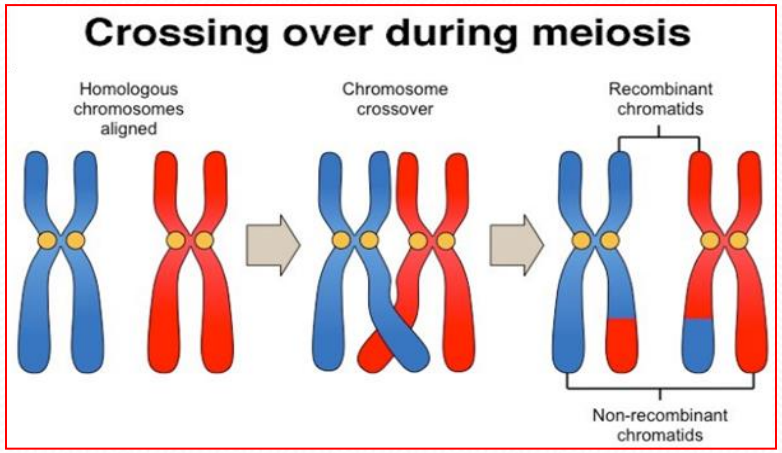




3. Pachytene (continued):

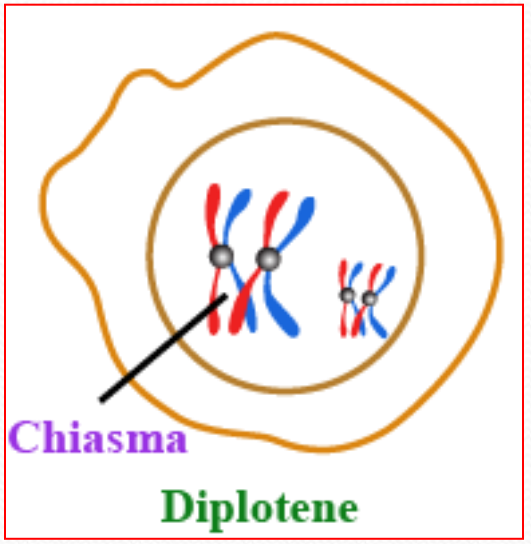
- Crossing over between homologous chromosomes occurs and DNA is exchanged between the bivalents in a process called homologous recombination.
- One consequence of crossing over is the generation of a new combination of genetic material in the gametes.
- The two chromatids in a single chromosome are sister chromatids, but chromatids from each of the homologous chromosomes are called non-sister chromatids.





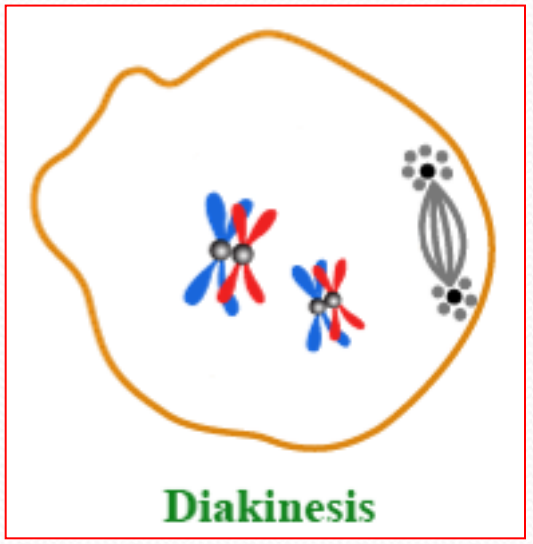
4. Diplotene:

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

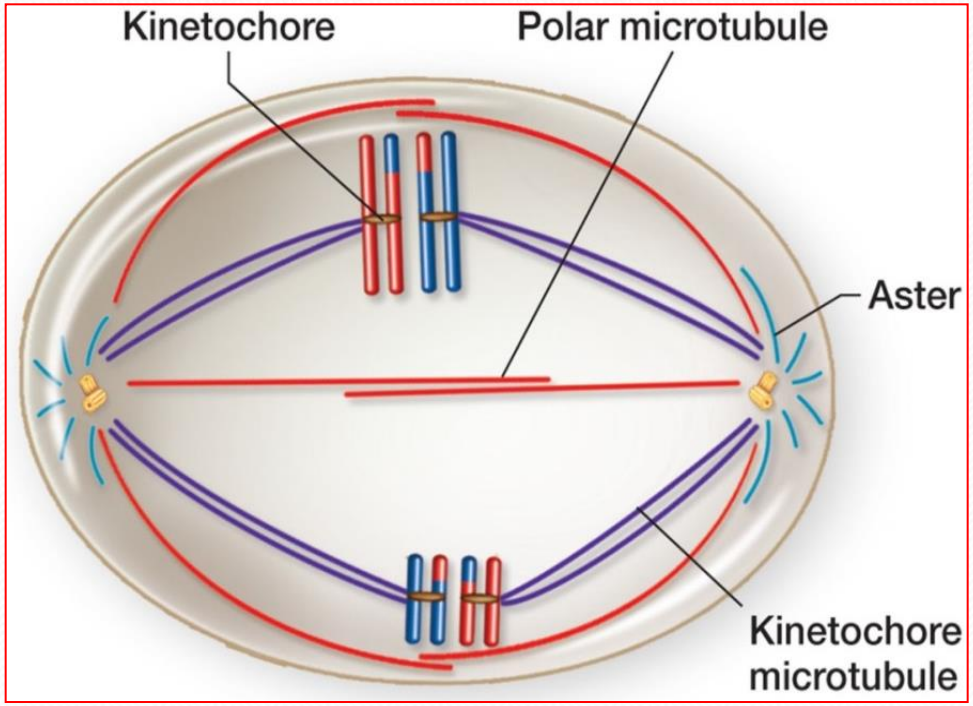


5. Diakinesis:

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

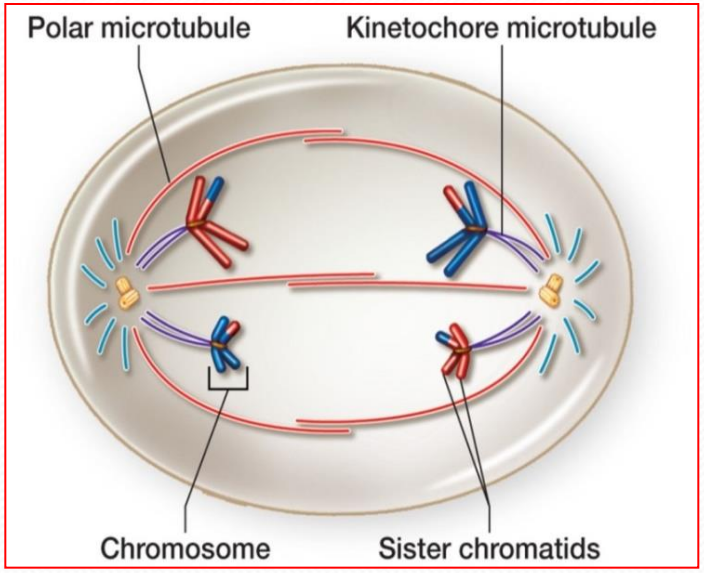


Meiosis I, Metaphase I:



- 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.

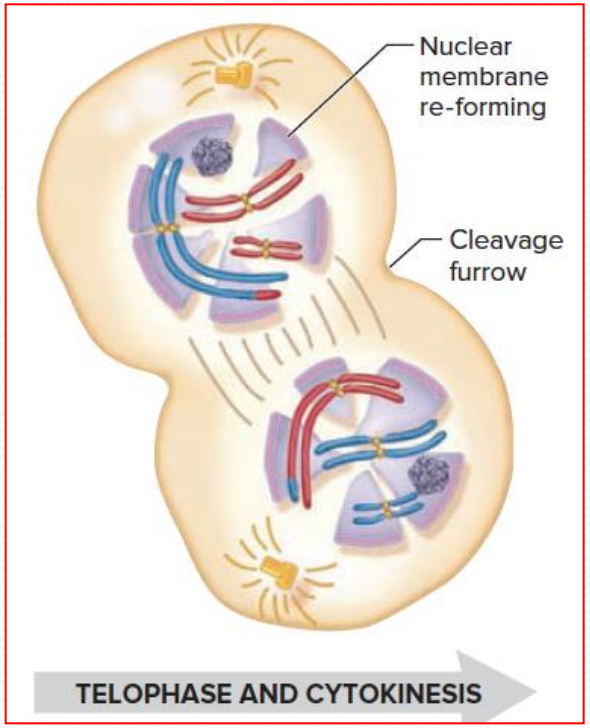
Meiosis I, Anaphase I:



- 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 meiosis I is called a reductional division because it reduces the number of chromosomes (2n) by half in each daughter cell (n).

Meiosis I, Telophase I:

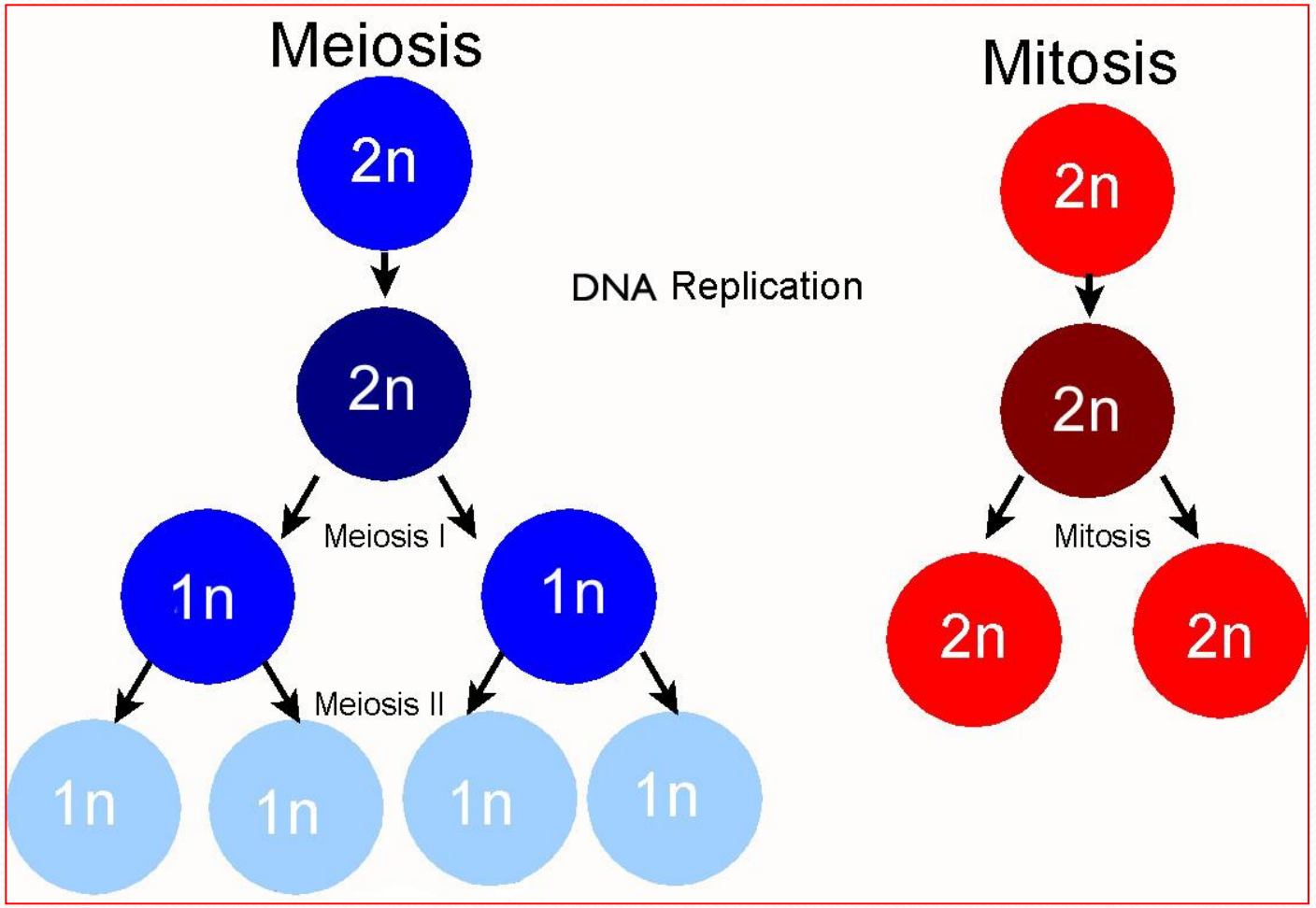
- The nuclear membrane reforms around the chromosomes.
- cytokinesis takes place.



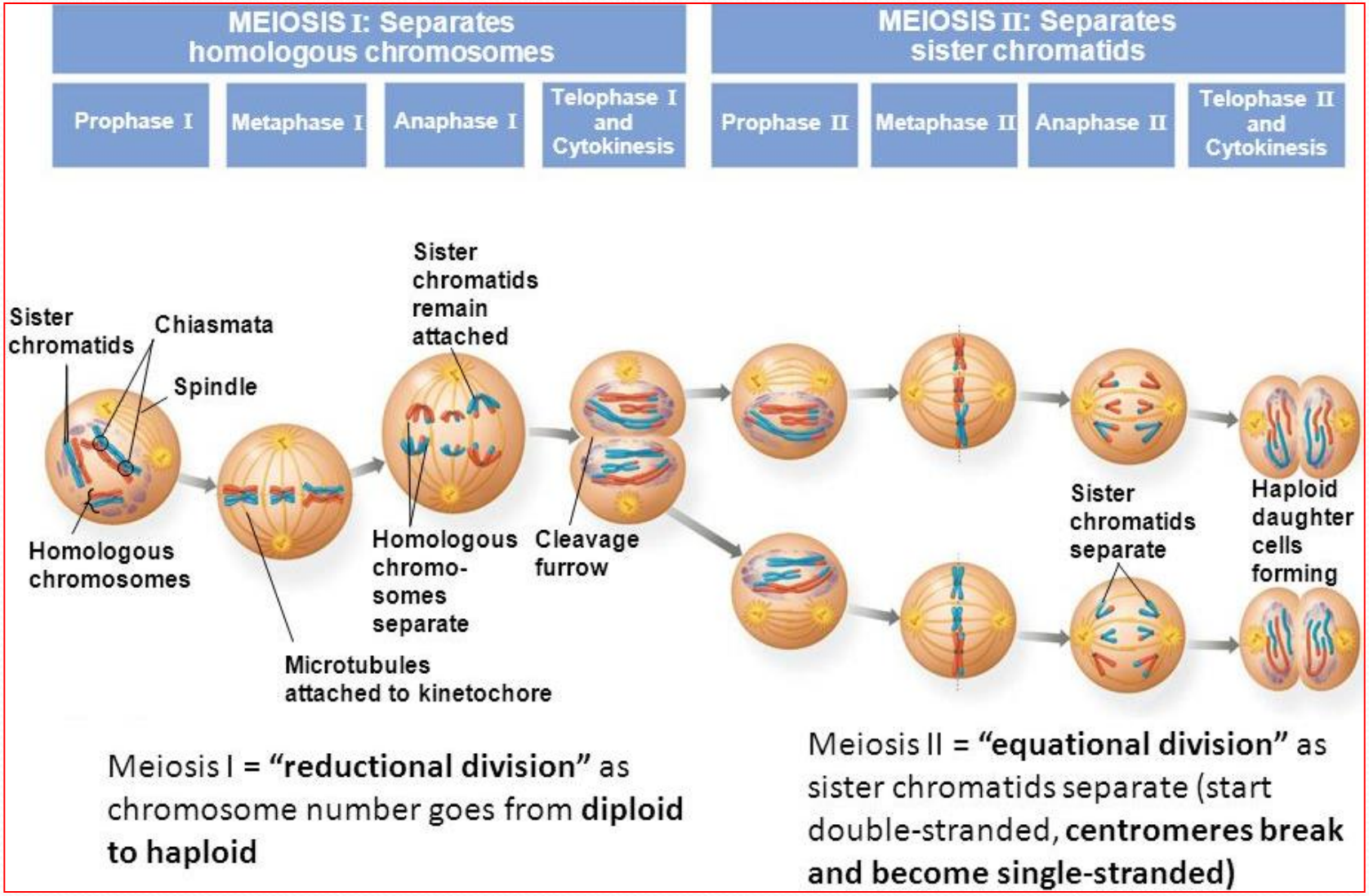
The second meiotic division, Meiosis II:

- 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.

A conclusion for Meiosis vs Mitosis in diploid cells



Summary: An overview of Meiosis

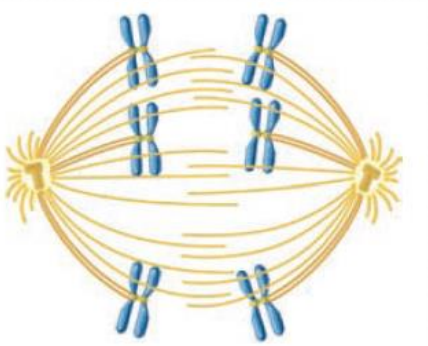


A comparison between Mitosis and Meiosis

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.

Quiz: Meiosis

1. Which phase of meiosis is depicted in the drawing below?



- Metaphase of meiosis I
- Metaphase of meiosis II
- Anaphase of meiosis I
- Anaphase of meiosis II

2. Meiosis I is not followed by cytokinesis.

- True
- False

4. During prophase I, non-sister chromatids are connected by:

- synaptonemal complex
- cohesion
- chiasmata
- centromere