Meiosis I and II division

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Course: Cell biology (MA 219)

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Outline

- Introduction to Meiosis
- Meiosis I and Meiosis II
- Significance of meiosis

Objectives

- To have an overview of the meiosis I and II.

MEIOSIS

Definition : Reductional division

Meiosis is the special type of cell division in which the number of chromosomes in daughter cells is reduced to half, as compared to the parent cell .

Meiosis can take place in

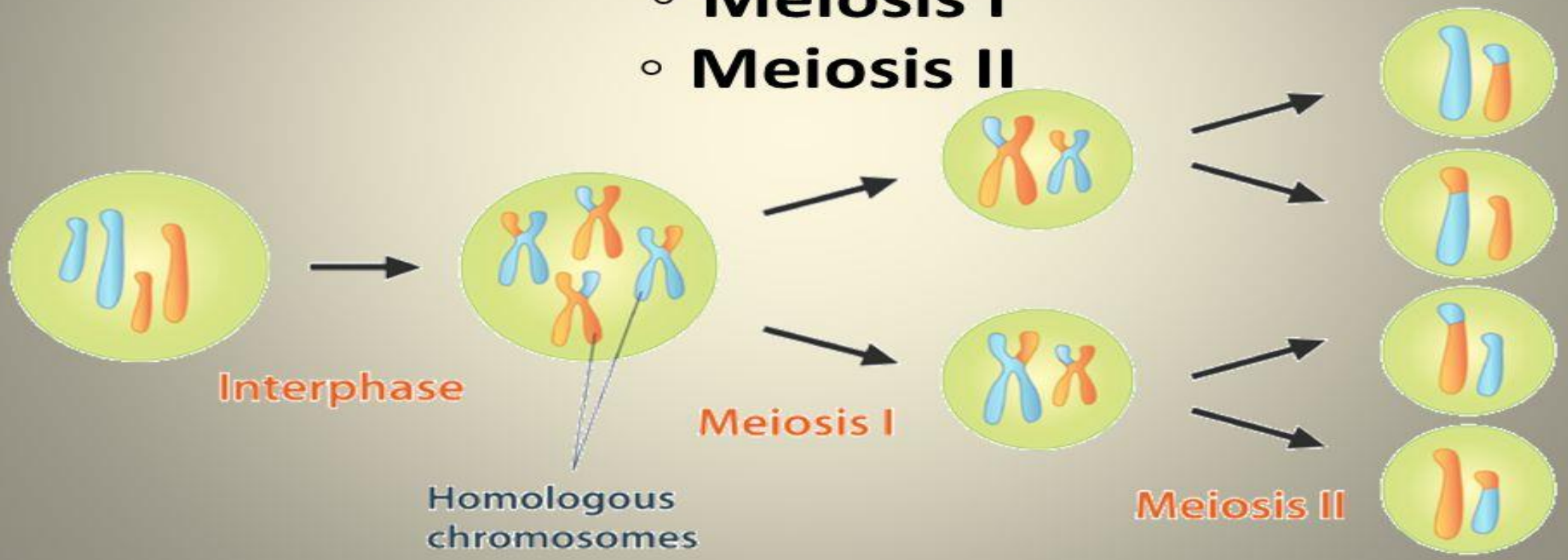
Diploid cells only, in animals at the time of gamete formation, while in plants when spores are produced.

- ***Each diploid cell after meiosis produces four haploid cells, because it involves two consecutive divisions after single replication of DNA.***

What is Meiosis?

Meiosis involves two divisions

- **Meiosis I**
- **Meiosis II**



Meiosis: two stages

Interphase germ cell in gonads

Meiosis I

Prophase I *Synapsis for crossing over*

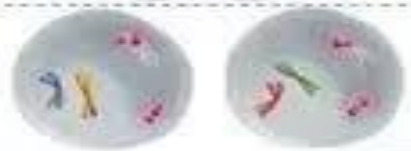
Metaphase I

Segregation
Homologous pairs are separated
reducing chromosome number by half

Anaphase I *Independent assortment*

Telophase I

Meiosis II



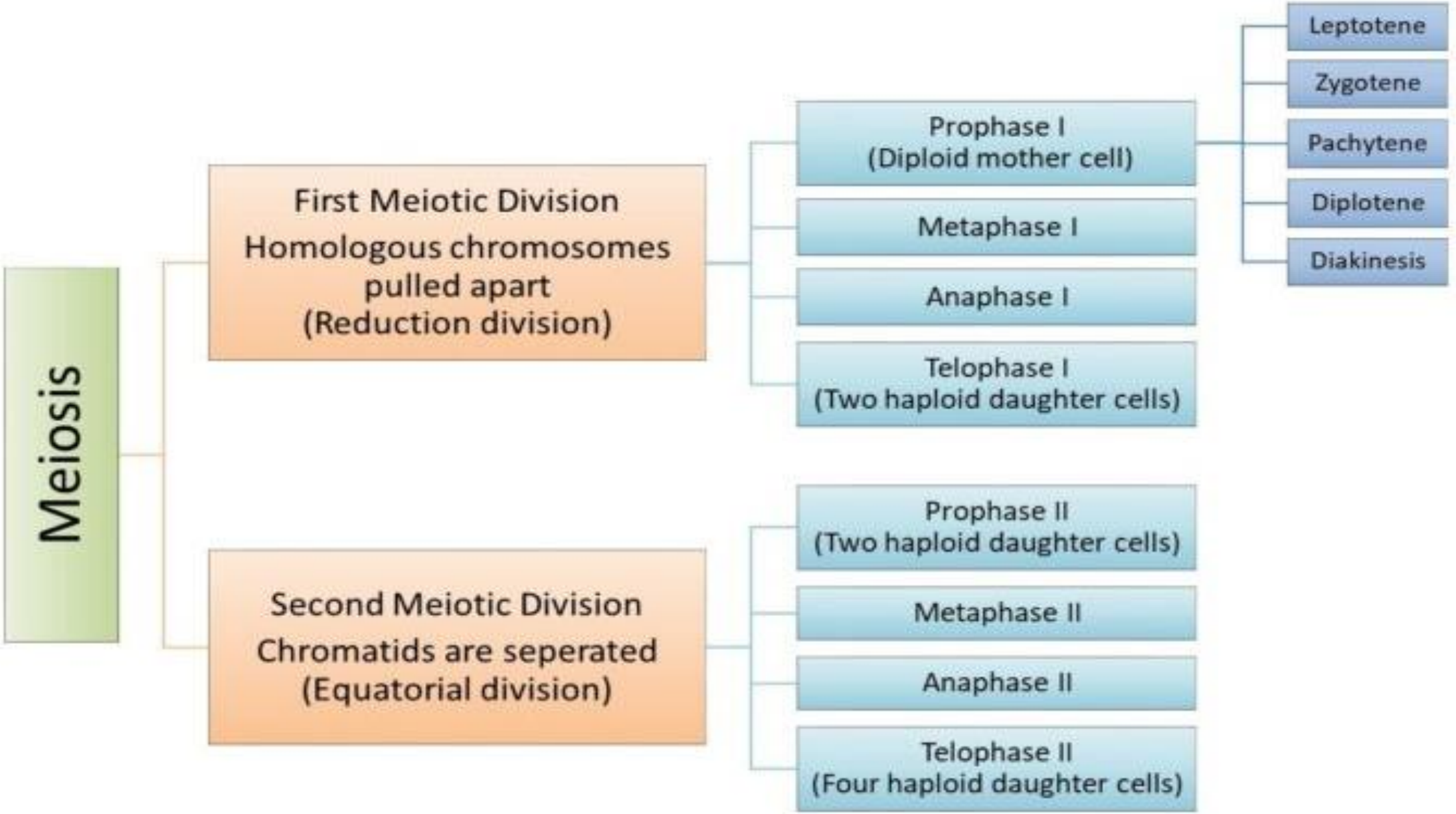
Prophase II

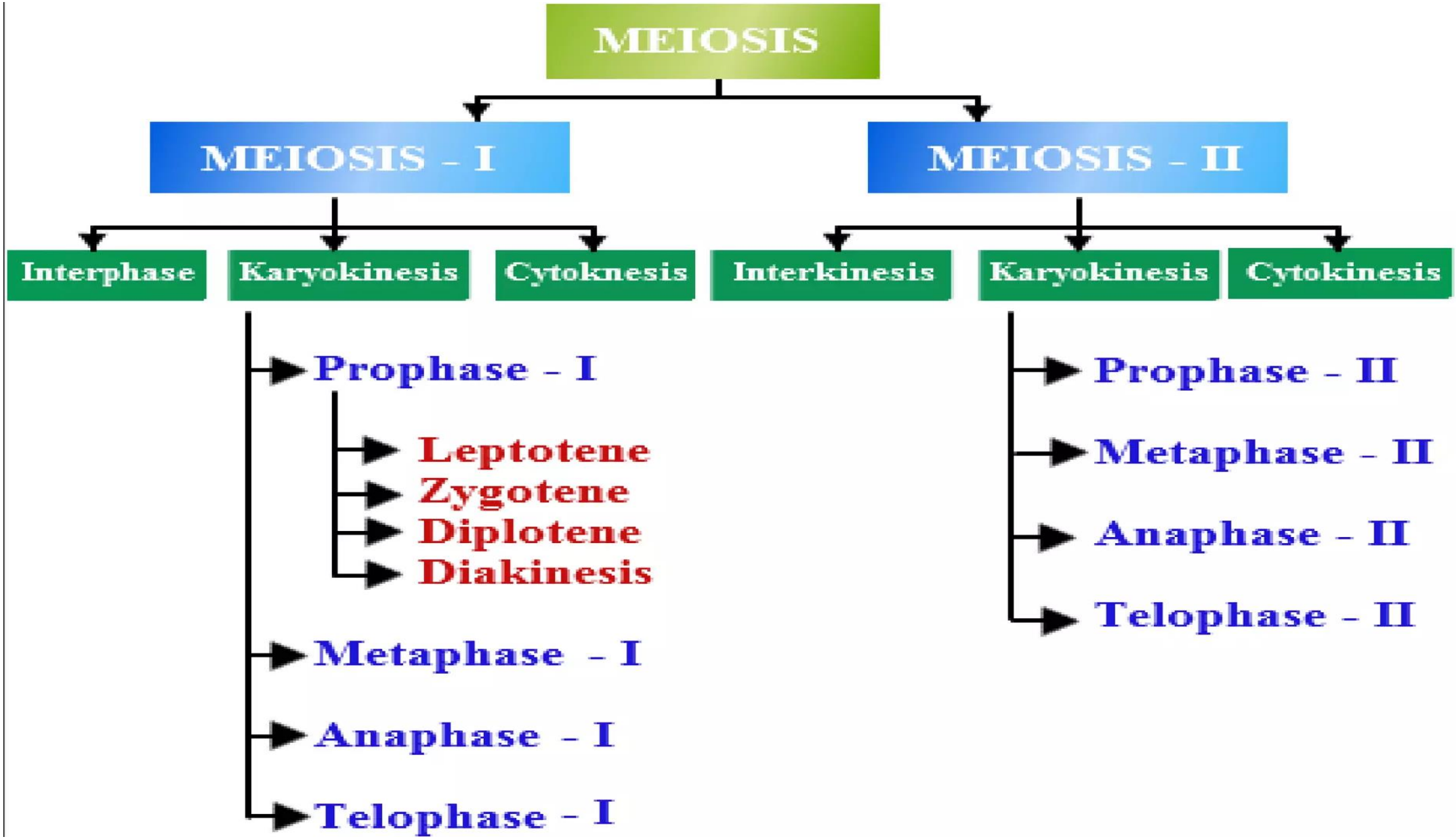
Metaphase II

Sister chromatids are separated
producing four haploid gametes

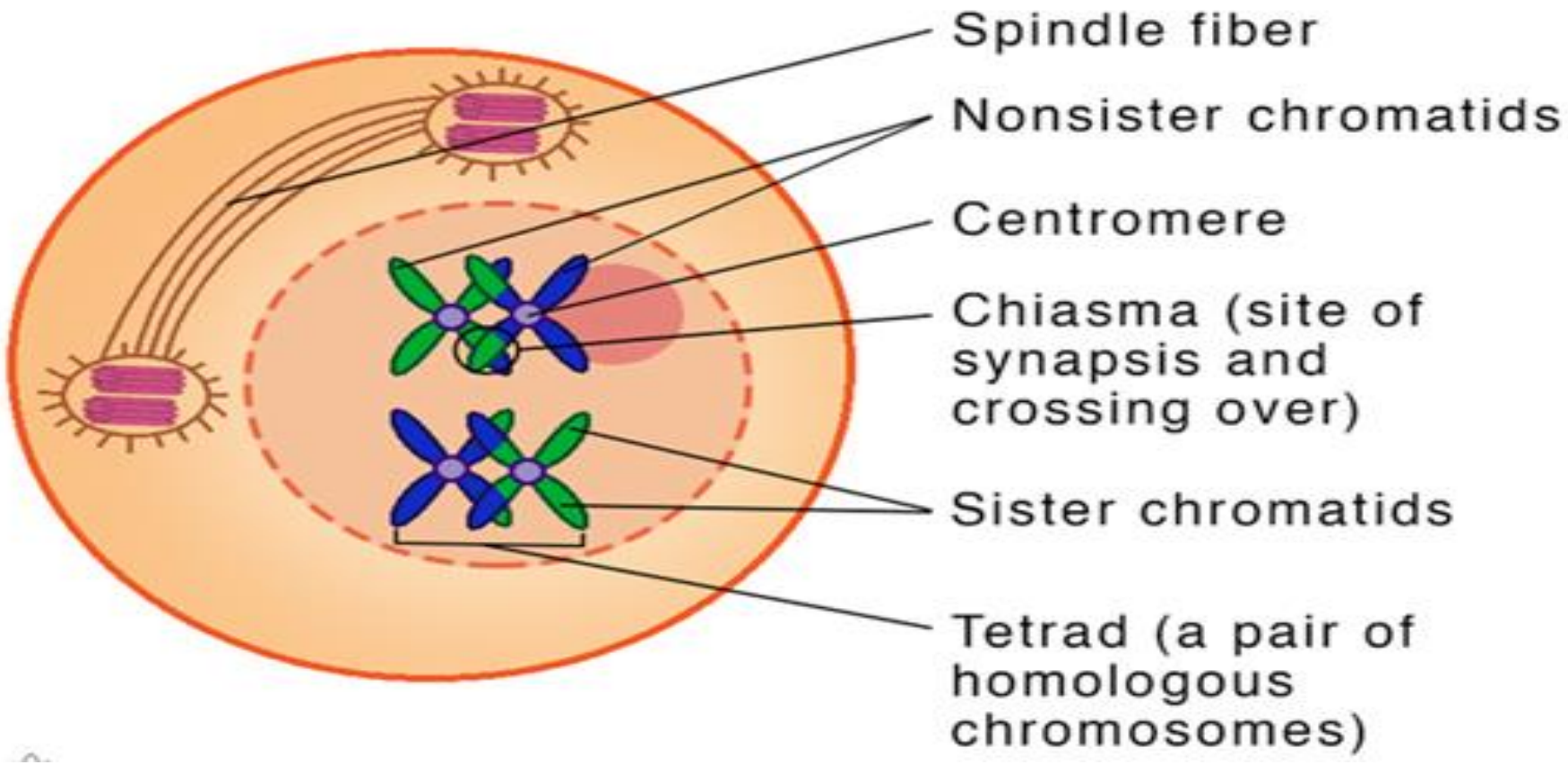
Anaphase II

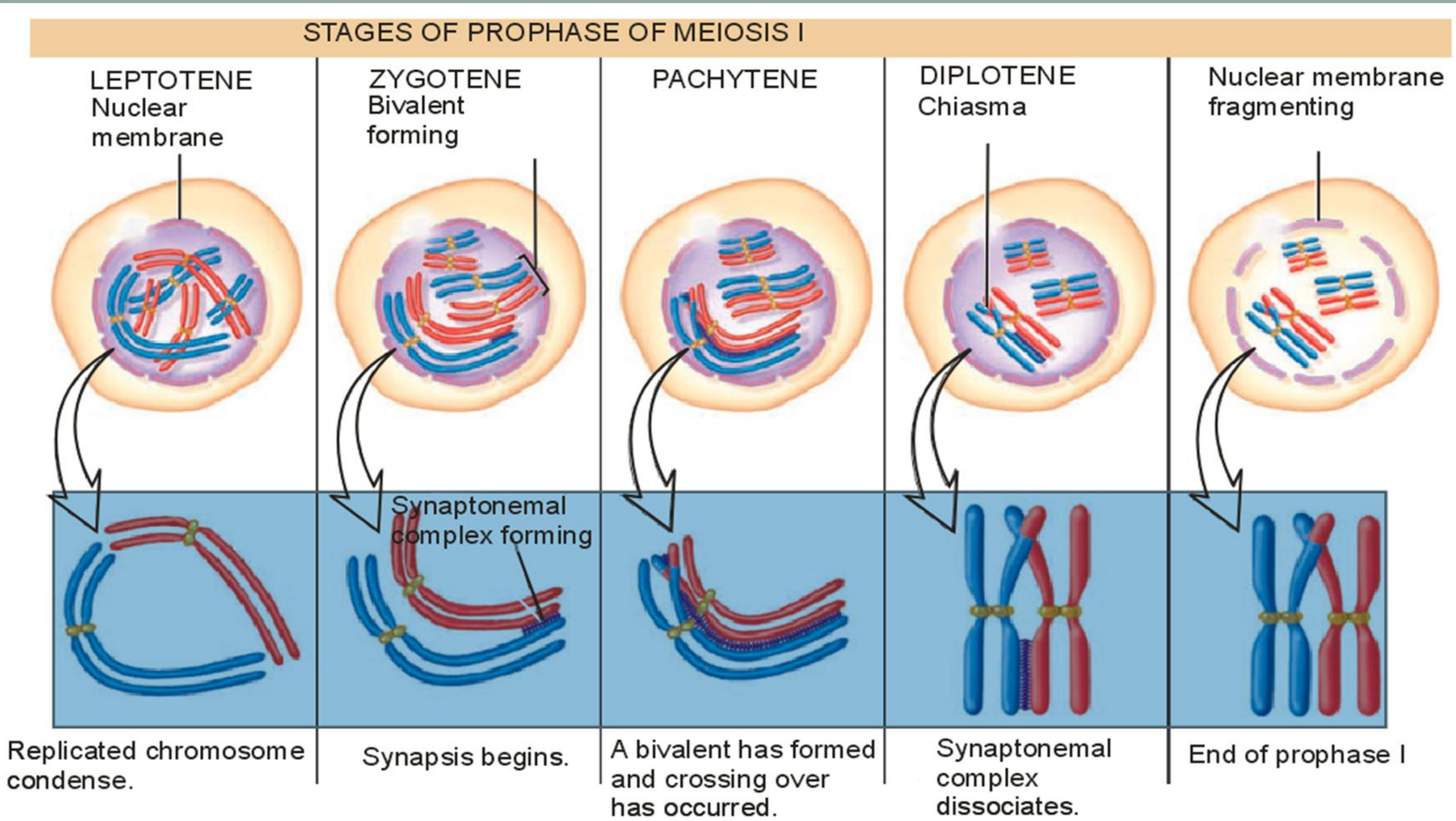
Telophase II


Meiosis
First Meiotic Division
Homologous chromosomes pulled apart
(Reduction division)
Prophase I
(Diploid mother cell)
Leptotene
Zygotene
Pachytene
Diplotene
Diakinesis
Metaphase I
Anaphase I
Telophase I
(Two haploid daughter cells)
Second Meiotic Division
Chromatids are seperated
(Equatorial division)
Prophase II
(Two haploid daughter cells)
Metaphase II
Anaphase II
Telophase II
(Four haploid daughter cells)


MEIOSIS
MEIOSIS - I
MEIOSIS - II
Interphase
Karyokinesis
Cytoknesis
Interkinesis
Karyokinesis
Cytokinesis
Prophase - I
Leptotene
Zygotene
Diplotene
Diakinesis
Metaphase - I
Anaphase - I
Telophase - I
Prophase - II
Metaphase - II
Anaphase - II
Telophase - II

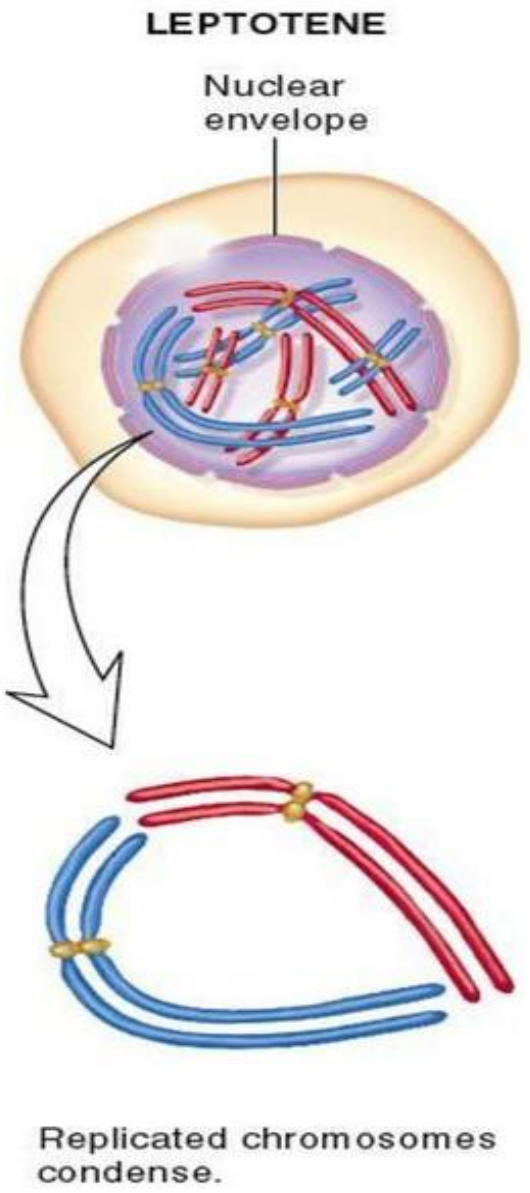
Prophase I of Meiosis




STAGES OF PROPHASE OF MEIOSIS I
LEPTOTENE
Nuclear membrane
ZYGOTENE
Bivalent forming
PACHYTENE
DIPLOTENE
Chiasma
Nuclear membrane fragmenting
Synaptonemal complex forming
Replicated chromosome condense.
Synapsis begins.
A bivalent has formed and crossing over has occurred.
Synaptonemal complex dissociates.
End of prophase I

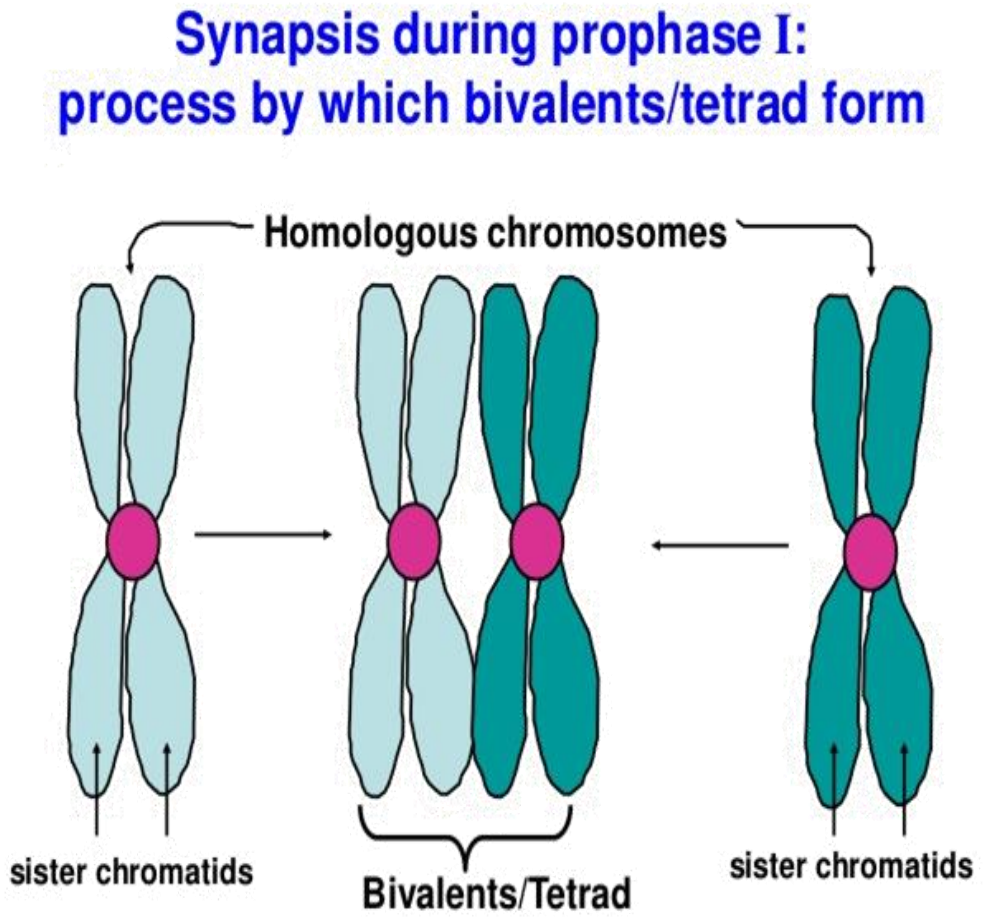
Prophase 1

- **Leptonema:** (from Greek words meaning "**thin threads**“)
  - During the **leptotene stage,** the replicated chromosomes begin to condense and become visible with a light microscope.
  - Each chromosome begins to search its homologue (homology search)



Zygotene:

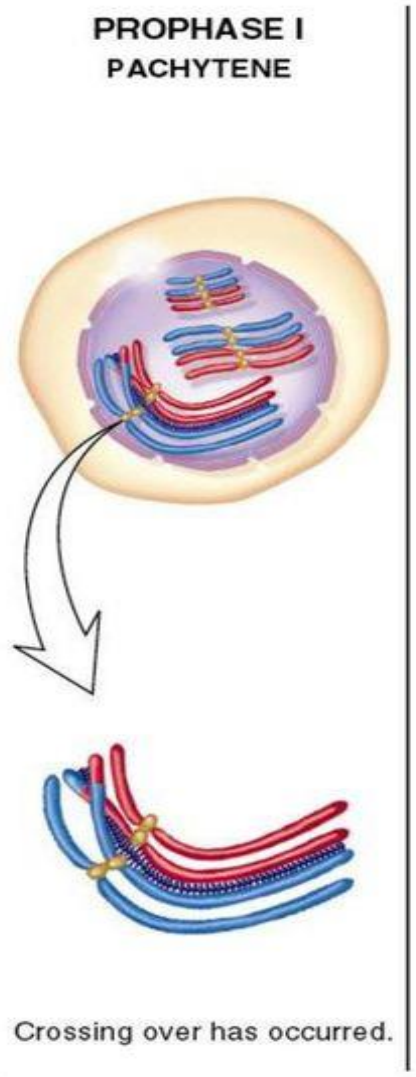
- In the Zygotene sub phase, a process called “synapsis” takes place.
- In synapsis, the homologous chromosomes start paring and each pair is called **bivalent**.
- The Chromosomes become thicker and shorter.



Pachytene

In **pachynema**: "**thick threads**"

- At pachytene, the homologs have become completely aligned.
- The associated chromatids are known as **bivalents**.
- Each bivalent contains two pairs of sister chromatids, or a total of four chromatids.
- The chromosomes continue to condense.
- Crossing-over occurs (Exchange of genetic material between non-sister chromatids of homologous chromosomes) between non-sister chromatids but the result of crossing-over is only visible when the chromosomes begin to separate.

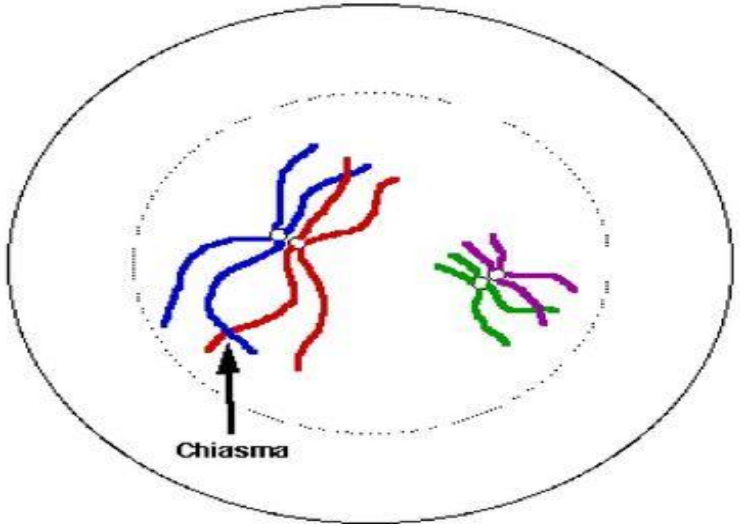


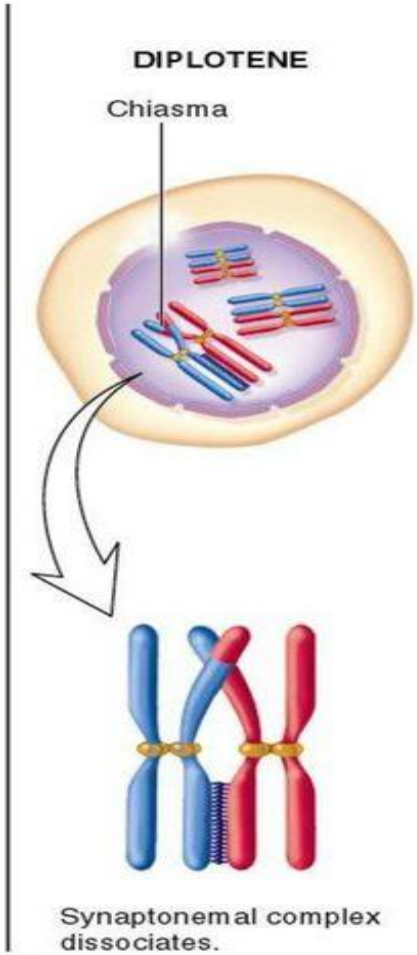
Diplonema: "two threads"

- The homologous chromosomes in each tetrad begin to separate, but they remain connected at points of **crossing over.**

Each point of crossing over is known as a **chiasma** (plural: chiasmata).

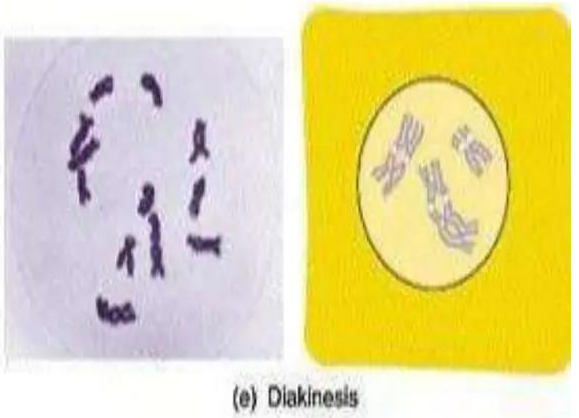
- Also at this stage, the nuclear envelope begins to break down.

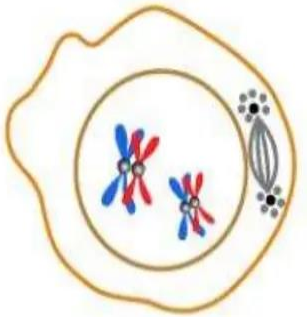




DIAKINESIS

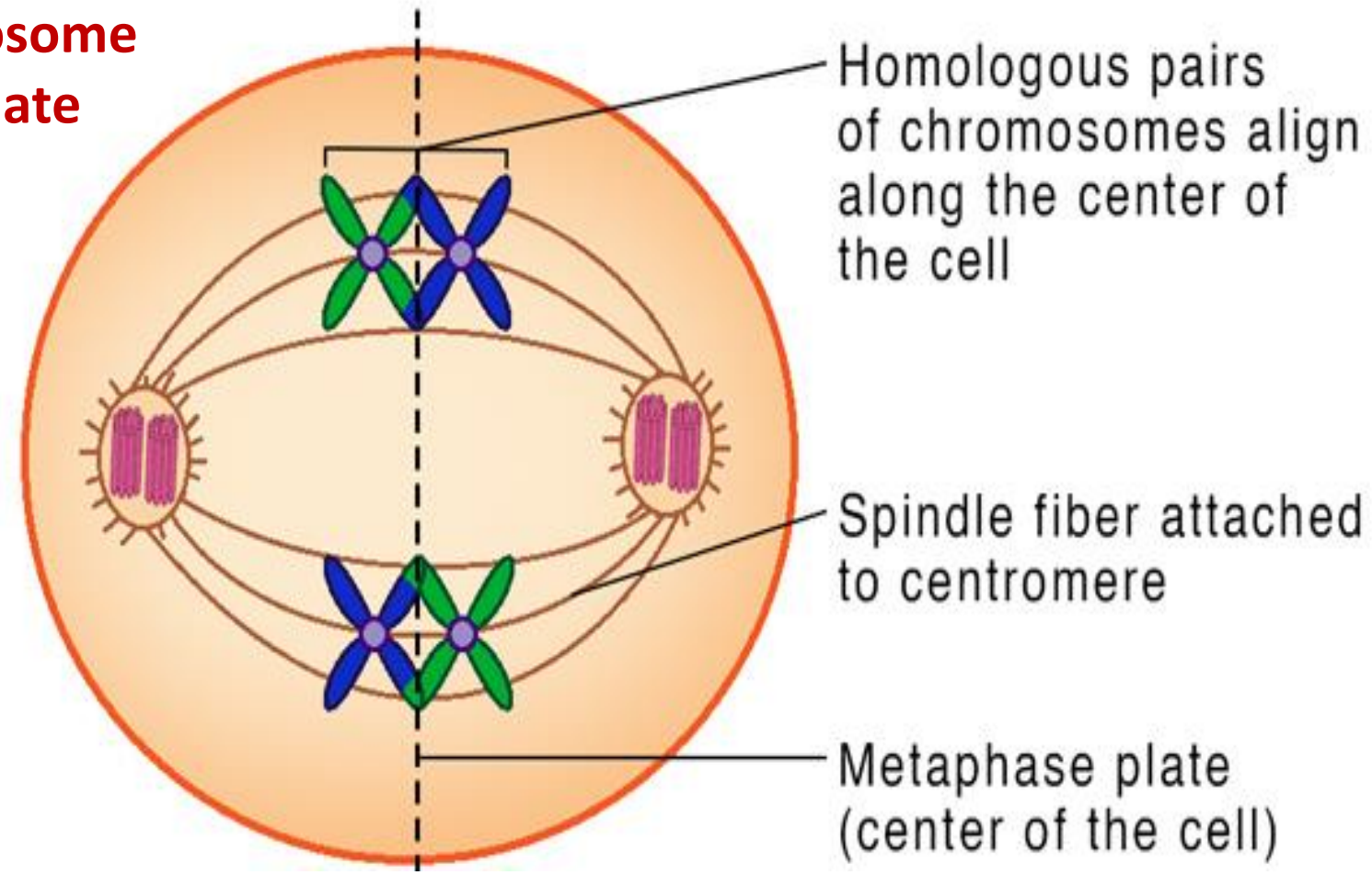
- The chromosomes become more **contracted**.
- The bivalents are more evenly distributed in the nucleus and migrate towards the periphery.
- The homologues remain in contact with each other by their terminal chiasmata.
- The nucleolus is detached from the chromosome, or disappears.
- Remnants of the synaptonemal complexes may still be seen.





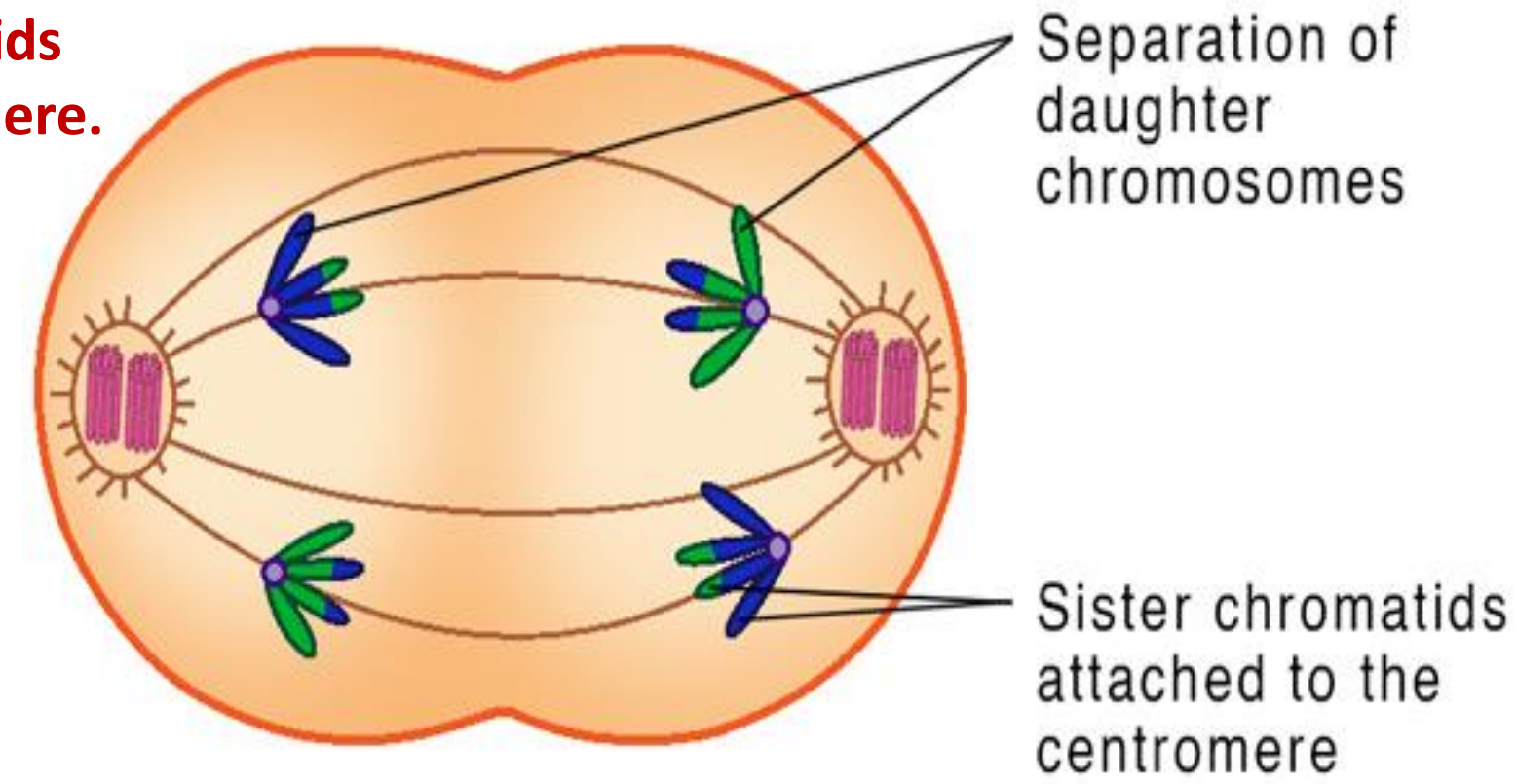
Metaphase I of Meiosis

- ✓ **The bivalent chromosome align at equatorial plate**



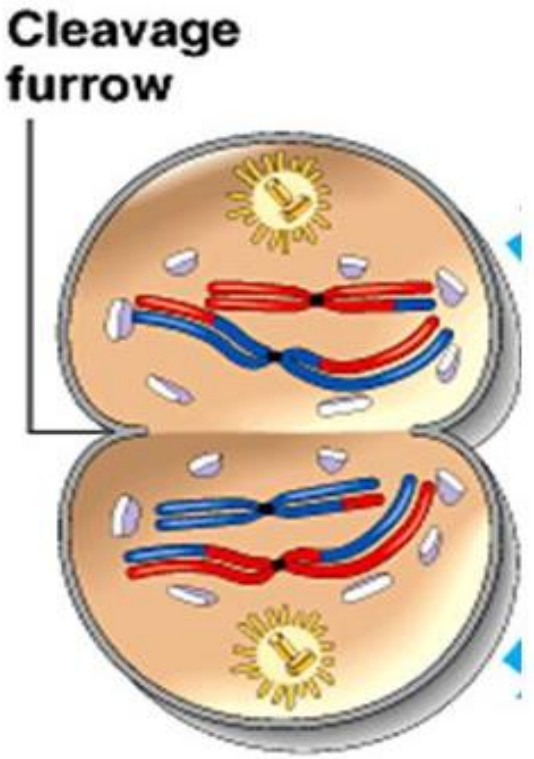
Anaphase I of Meiosis

- **Homologous chromosome separate but sister chromatids remain attached at centromere.**



- **Telophase I,** movement of homologous chromosomes continues until there is a haploid set at each pole.
  - Each chromosome consists of linked sister chromatids.

Cytokinesis follows



Two haploid cells form; chromosom are still double

Meiosis II

- It is initiated immediately after cytokinesis before chromosome gets elongated.
- Prophase II: Nuclear membrane disappears and chromosome becomes compact.
- Metaphase II stage: The chromosomes align at equator.

✓ Anaphase II:

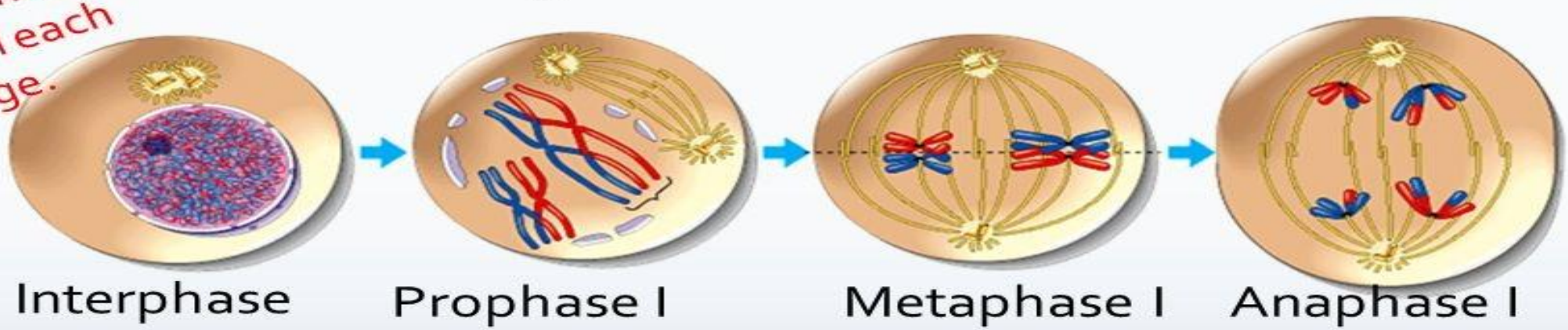
- Start with splitting of centromere of each chromosome to move towards opposite poles.

✓ Telophase II:

- Two groups of chromosomes get enclosed by nuclear membrane followed by cytokinesis to form four haploid daughter cells.

The stages of meiosis I and II

Let's first label each stage.

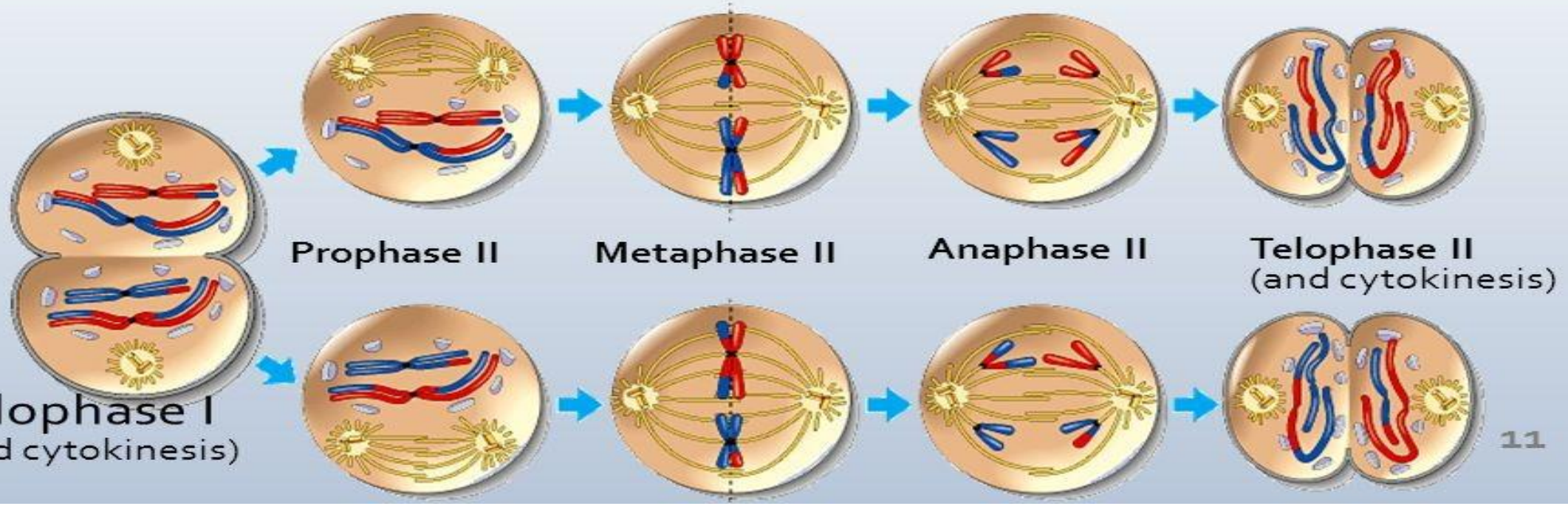


Interphase

Prophase I

Metaphase I

Anaphase I



Telophase I
(and cytokinesis)

Prophase II

Metaphase II

Anaphase II

Telophase II
(and cytokinesis)

Importance of Meiosis

- **Ensure diploid number chromosomes** is **maintained** from one generation to next.
- Provide **genetic variations**.
- Leads to **genetic recombinations**:

a) **Prophase I** – **Crossing over**. Genetic material exchange between non-sister chromatids of a bivalent. Formation of new gene combination on a chromosome.

b) **Metaphase I** – **Random arrangement** or **Independent assortment**. Homologous chromosomes arranged independently, randomly at metaphase plate.

- Gametes have **different gene combinations**. **Random fertilization** of ovum by a sperm results in **genetic variation** in organisms.

Difference between Mitosis and meiosis

Mitosis	Meiosis
1. Takes place in the somatic cells. 2. It is a single division which produces two cells. 3. Haploid and diploid both kind of cells may undergo mitosis. 4. Crossing over absent. 5. Pairing of chromosome does not occur.	1. Takes place in reproductive cells. 2. It is a double division which produces four cells. 3. Only diploid cells undergo meiosis cell division. 4. Crossing over takes place. 5. Pairing of homologous chromosome occurs.

Difference between Mitosis and meiosis

Hereditary material is equally distributed in the daughter cell

No crossing over and genetic information remains unchanged generation after generation

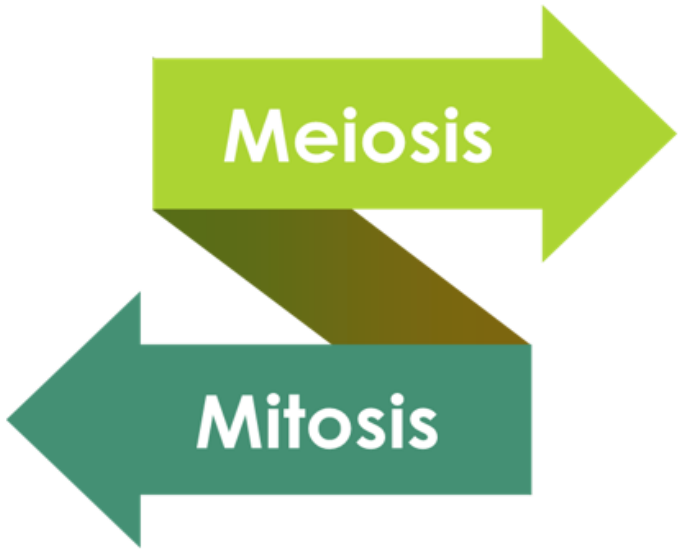
Some organisms undergo asexual reproduction by mitosis

Involved in regeneration, healing of the wound, and replacement of older cells

The development and growth of multicellular organisms require mitosis

Involved in tissue culture and cloning

Malfunction in mitosis leads to unwanted tumors or cancer



Crossing over and a random assortment of chromosomes

New genetic combinations in the next generation

Reduction division to maintain chromosome numbers of species

Involved in gametes formation

Malfunction may lead to genetic disorders