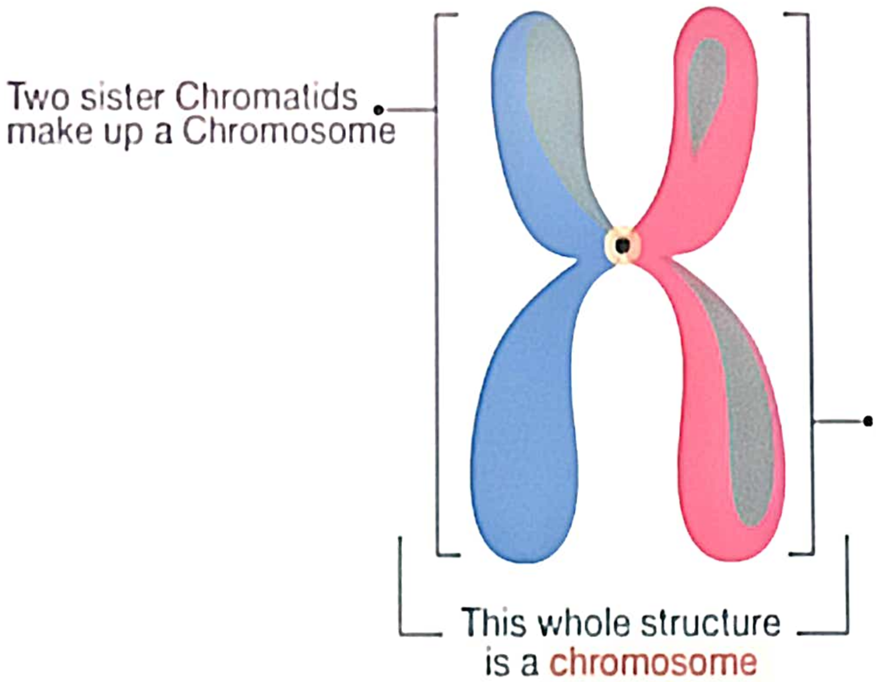
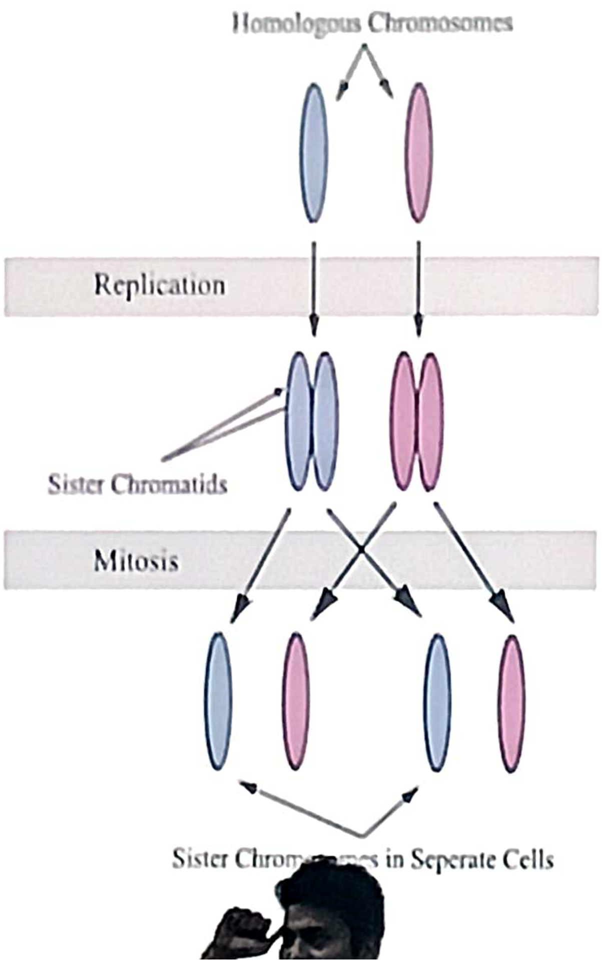
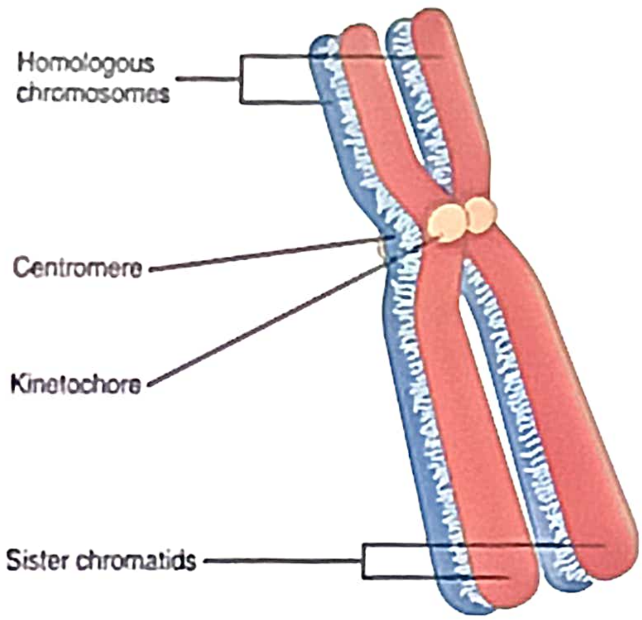

Two sister Chromatids
make up a Chromosome
This whole structure
is a chromosome



Homologous Chromosomes
Replication
Sister Chromatids
Mitosis
Sister Chrom
in Seperate Cells

**Difference between Chromosome and Chromatid**

| **Chromosome** | **Chromatid** |
|---|---|
| Their Function is to carry the genetic material | Their main function is to enable the cells to duplicate |
| A chromosome occurs throughout the cell's life cycle | A chromatid, on the other hand, is created only when the cell passes through mitosis or meiosis stages |
| Chromosomes are not exact copies of each other. One copy of the gene comes from each parent | Sister Chromatids are identical copies of each other |
| Chromosomes have centromeres | The centromere is exclusively present in the sister chromatids. |
| DNA is utilized during macromolecule synthesis<br>(synthesis of complex proteins) | DNA is not utilized during macromolecule synthesis |




A **chromosome** is a thread-like structure present in the nucleus or nuclear region of the cytoplasm that is made up of a single molecule of DNA (Deoxyribonucleic acid) and proteins, carrying some or all genetic materials of an organism.

A **chromatid** is an identical half of a duplicated chromosome. After duplication of a chromosome, two identical halves are formed, each of which is called a chromatid.

[redacted]

# Meiosis

- **Meiosis** involves two sequential nuclear divisions followed by cell divisions that produce gametes (sex cells) containing half the number of chromosomes and half the DNA found in somatic cells.
- The **zygote** (the cell resulting from the fusion of an ovum and a sperm) and all the somatic cells derived from it are **diploid (2n)** in chromosome number (46 chromosomes in human); thus, their cells have two copies of every chromosome and every gene encoded on this chromosome.
- These chromosomes are called **homologous chromosomes** because they are similar but not identical; one set of chromosomes is of maternal origin, the other is from paternal origin.
- The **gametes**, having only one member of each chromosome pair, are described as **haploid (1n)**.
- <u>During gametogenesis, reduction in chromosome number to the haploid state (23 chromosomes in humans) occurs through **meiosis**.</u>

- This reduction is necessary to maintain a constant number of chromosomes in a given species.
- Reduction in chromosome number to **(1n)** in the first meiotic division is followed by reduction in DNA content to the haploid **(1d)** amount in the second meiotic division.
- During meiosis, the chromosome pair may exchange chromosome segments, thus altering the genetic composition of the chromosomes. This genetic exchange, called **crossing-over,** and the random assortment of each member of the chromosome pairs into haploid gametes give rise to infinite genetic diversity.

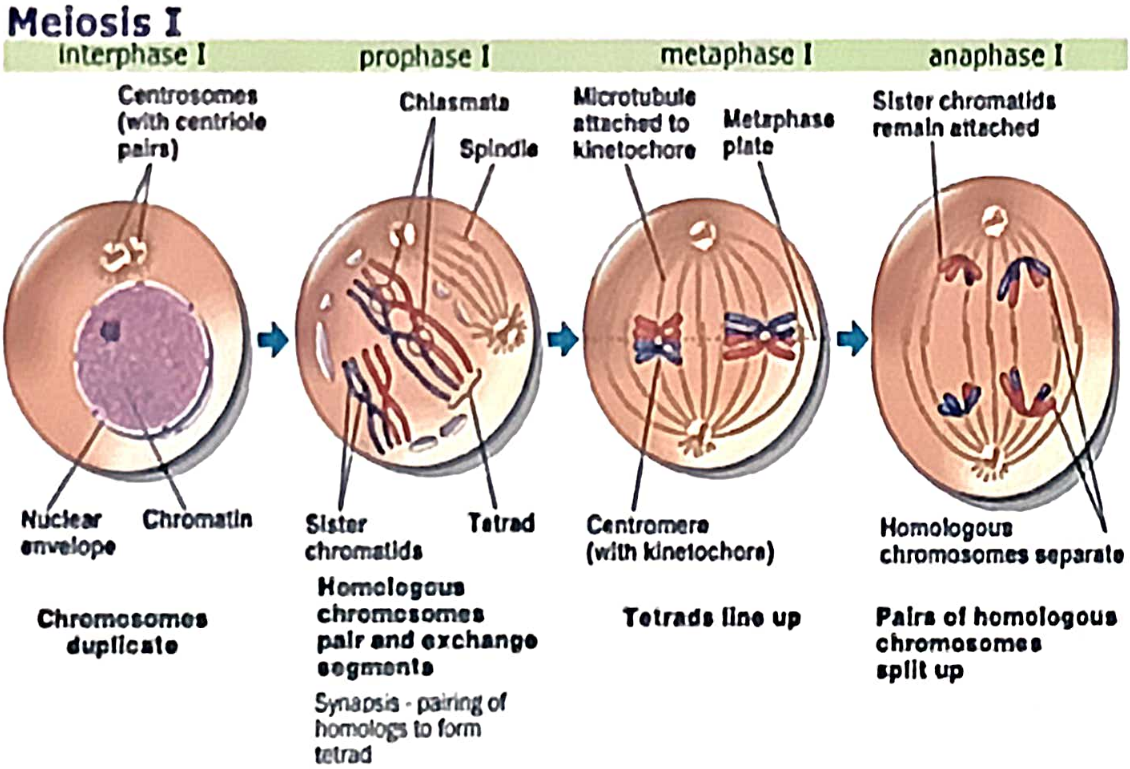
## Differences in Meiosis between Male & Female

- The nuclear events of meiosis are the same in males and females, but the cytoplasmic events are markedly different.
- In males, the two meiotic divisions of a **primary spermatocyte** yield four structurally identical, although genetically unique, haploid **spermatids**. Each spermatid has the capacity to differentiate into a **spermatozoon**.
- In contrast, in females, the two meiotic divisions of a **primary oocyte** yield one haploid **ovum** and three haploid **polar bodies**. The ovum receives most of the cytoplasm and becomes the functional gamete. The polar bodies receive very little cytoplasm and degenerate.

## Divisions & Phases of Meiosis

- **Meiosis** consists of two successive mitotic divisions without the additional **S phase** between the two divisions.
- During the S phase that precedes meiosis, DNA is replicated forming sister chromatids (two parallel strands of DNA) joined together by the centromere. The DNA content becomes **(4d)**, but the chromosome number remains the same **(2n)**.
- The cells then undergo a **reductional division (meiosis I)** and an **equatorial division (meiosis II)**.
- During **meiosis I**, as the name *reductional division* implies, the chromosome number is reduced from diploid **(2n)** to haploid **(1n)**, and the amount of DNA is reduced from the **(4d)** to **(2d)**.
- No DNA replication precedes **meiosis II**.
- The division during meiosis II is always equatorial because the number of chromosomes does not change. It remains at **(1n)**, although the amount of DNA represented by the number of chromatids is reduced to **(1d)**.

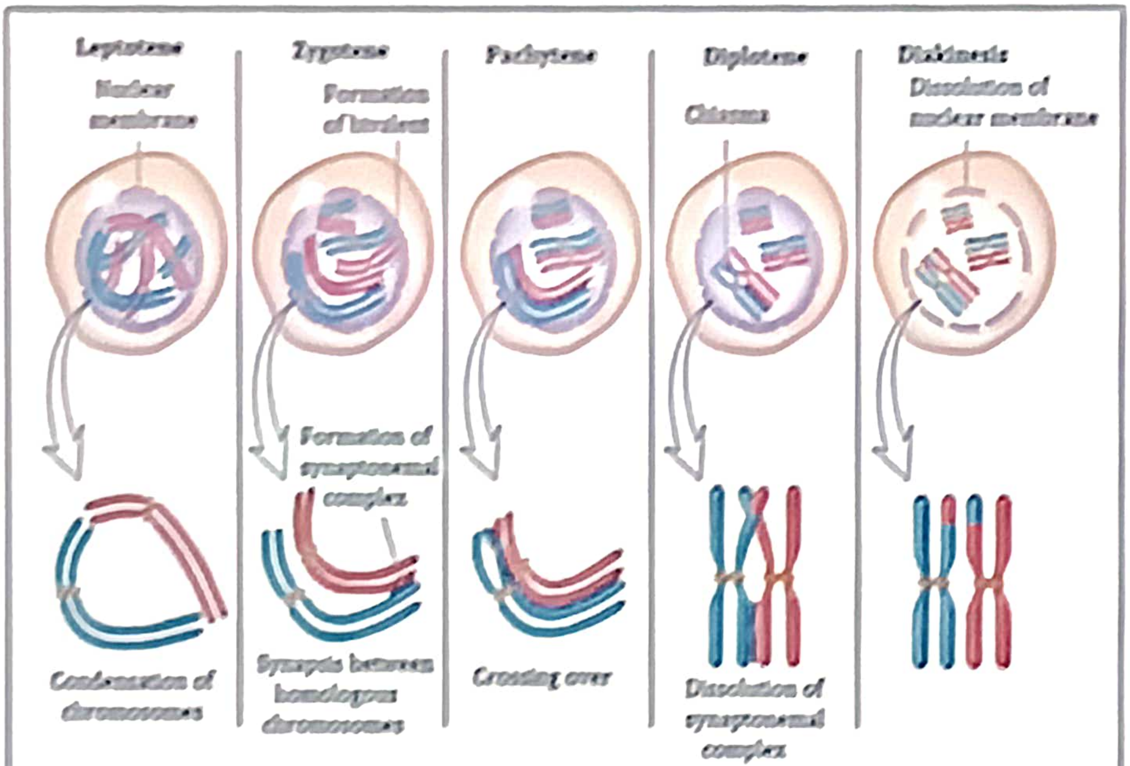
# Meiosis 1



Meiosis I
interphase I
prophase I
metaphase I
anaphase I
Centrosomes (with centriole pairs)
Nuclear envelope
Chromatin
Chromosomes duplicate
Chiasmata
Spindle
Sister chromatids
Tetrad
Homologous chromosomes pair and exchange segments
Synapsis - pairing of homologs to form tetrad
Microtubule attached to kinetochore
Metaphase plate
Centromere (with kinetochore)
Tetrads line up
Sister chromatids remain attached
Homologous chromosomes separate
Pairs of homologous chromosomes split up

## Phases of Meiosis I

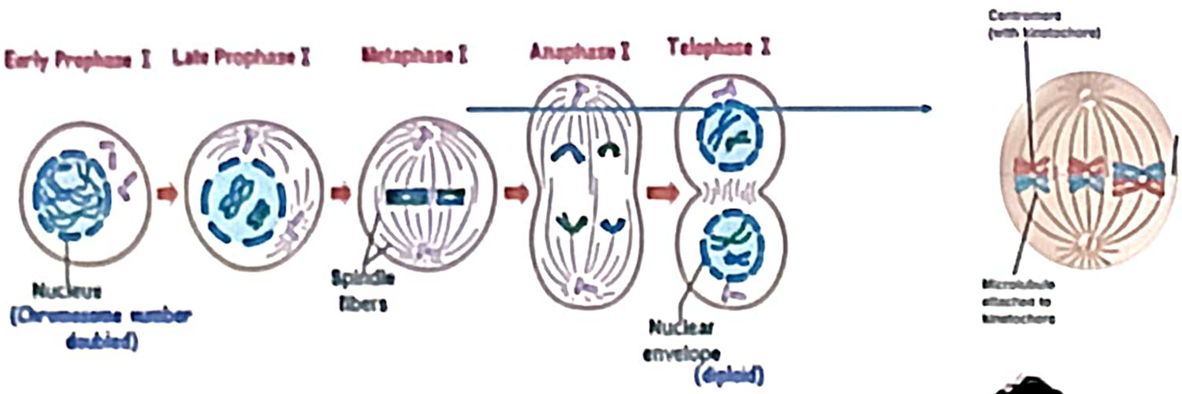
1. **Prophase I:** It is an extended phase that is subdivided into the following five stages:
   **Leptotene:** chromosomes start to condense.
   **Zygotene:** homologous chromosomes become closely associated (synapsis) to form pairs of chromosomes (bivalents) consisting of four chromatids (tetrads).
   **Pachytene:** crossing over between pairs of homologous chromosomes to form chiasmata (sing. chiasma).
   **Diplotene:** homologous chromosomes start to separate but remain attached by chiasmata.
   **Diakinesis:** homologous chromosomes continue to separate, and chiasmata move to the ends of the chromosomes.

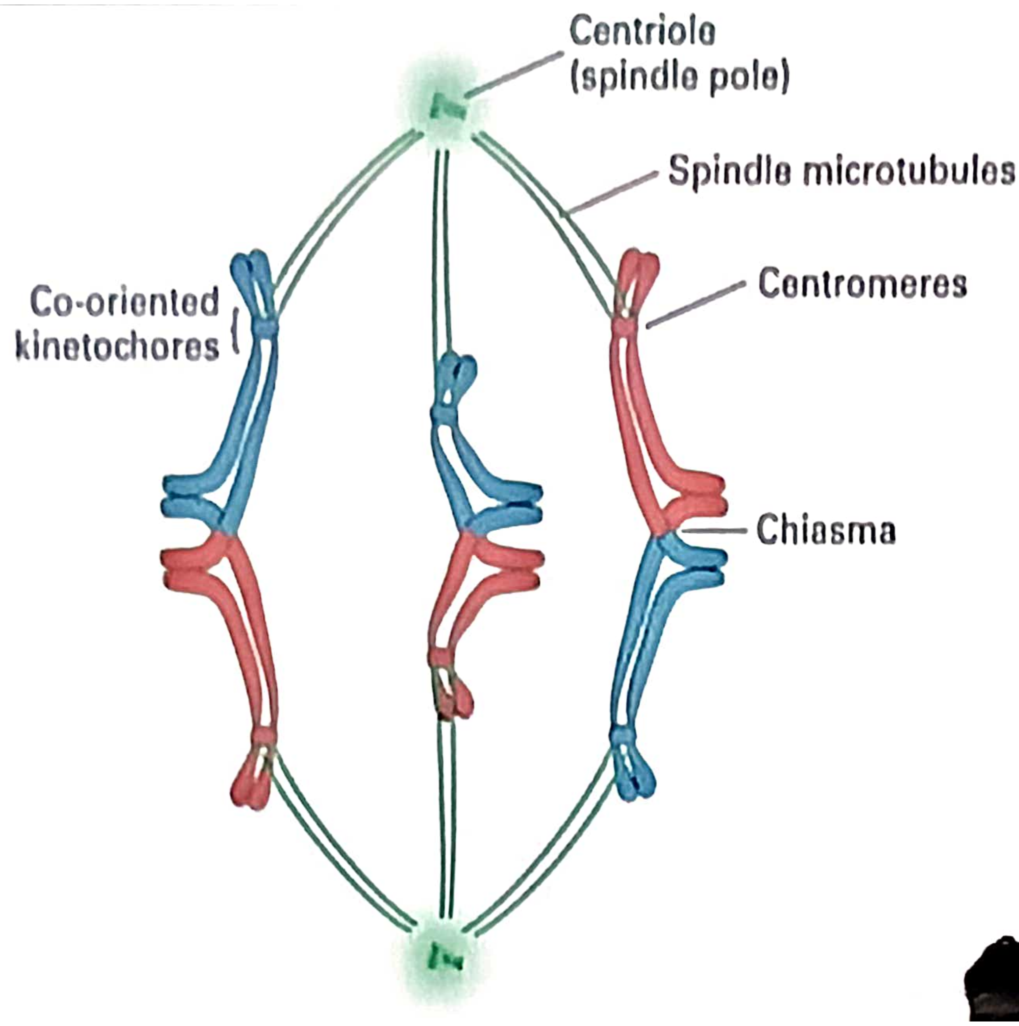



Stages of Prophase I

**Metaphase I:** Metaphase I is similar to the metaphase of mitosis except that the paired chromosomes are aligned at the **equatorial plate** with one member on either side.

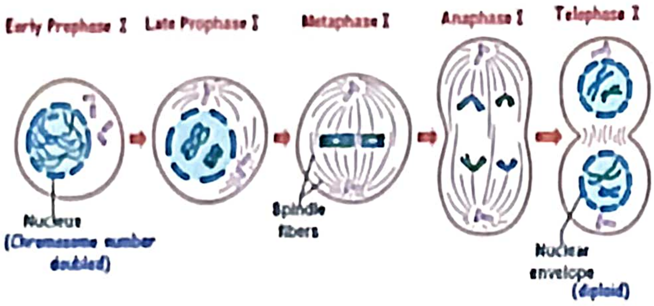
- The chiasmata are cut, and the homologous chromosomes separate completely.
- The spindle microtubules begin to interact with the chromosomes through the **kinetochore** at the centromere.
- The chromosomes undergo movement to ultimately align their centromeres along the equatorial plate with one member of the homologous chromosomes on either side.

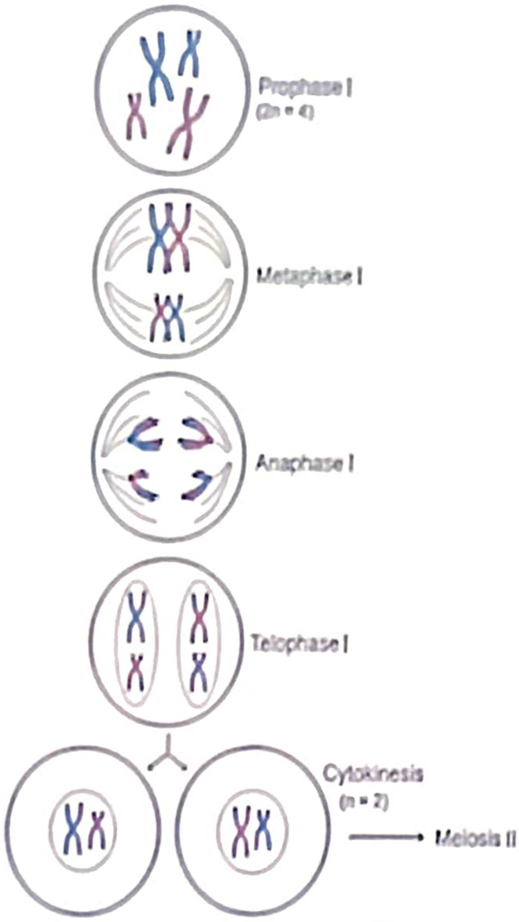



Centriole
(spindle pole)
Spindle microtubules
Co-oriented
kinetochores
Centromeres
Chiasma

## Telophase I:

- Homologous chromosomes, each consisting of two sister chromatids, are at the opposite poles of the cell.
- Reappearance of the nucleolus and nuclear envelope.
- At the completion of meiosis I, the cytoplasm divides. Each resulting daughter cell is haploid in chromosome number **(1n)** and contains one member of each homologous chromosome pair. The cell is still diploid in DNA content **(2d)**.

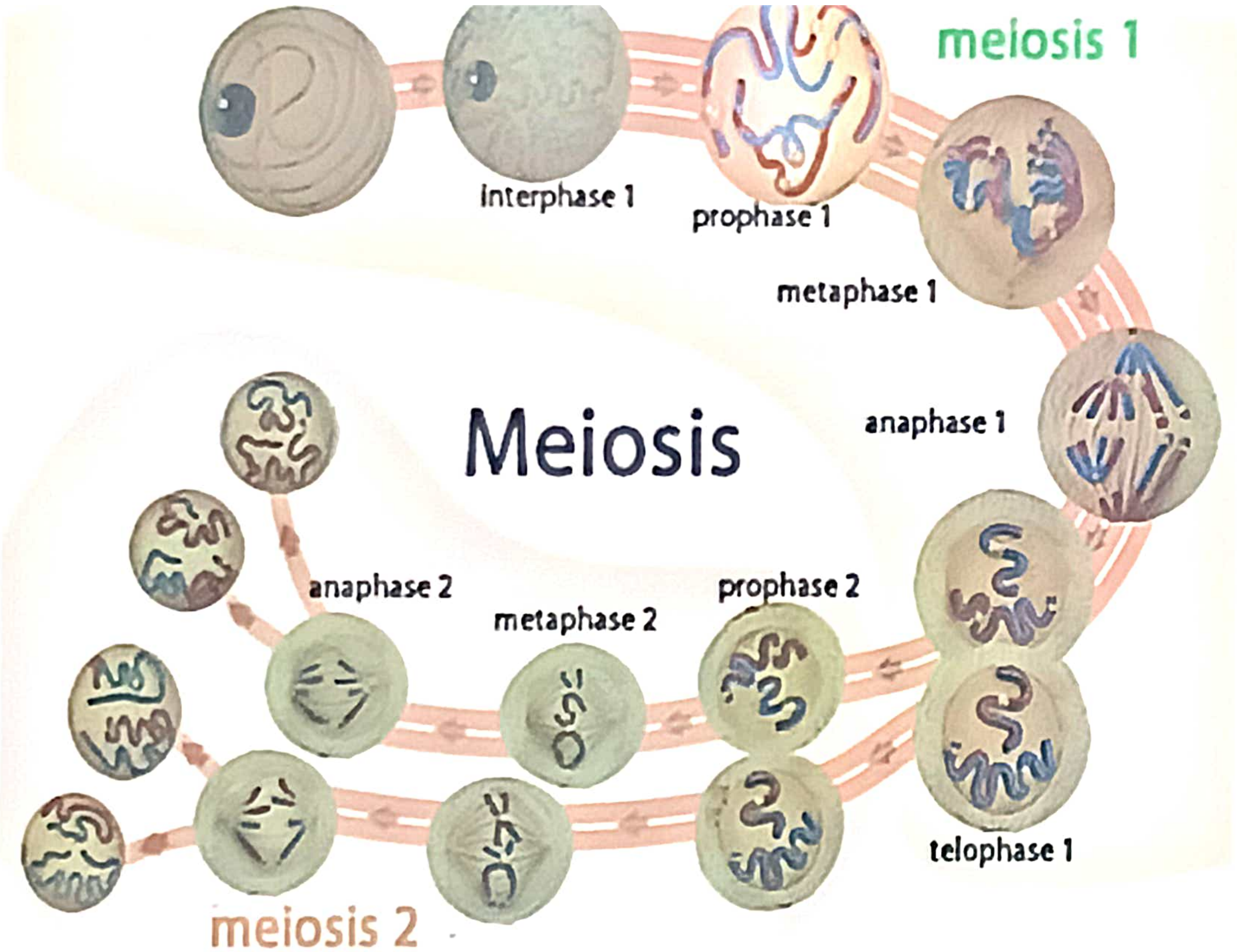



Prophase I
(2n = 4)
Metaphase I
Anaphase I
Telophase I
Cytokinesis
(n = 2)
Meiosis II

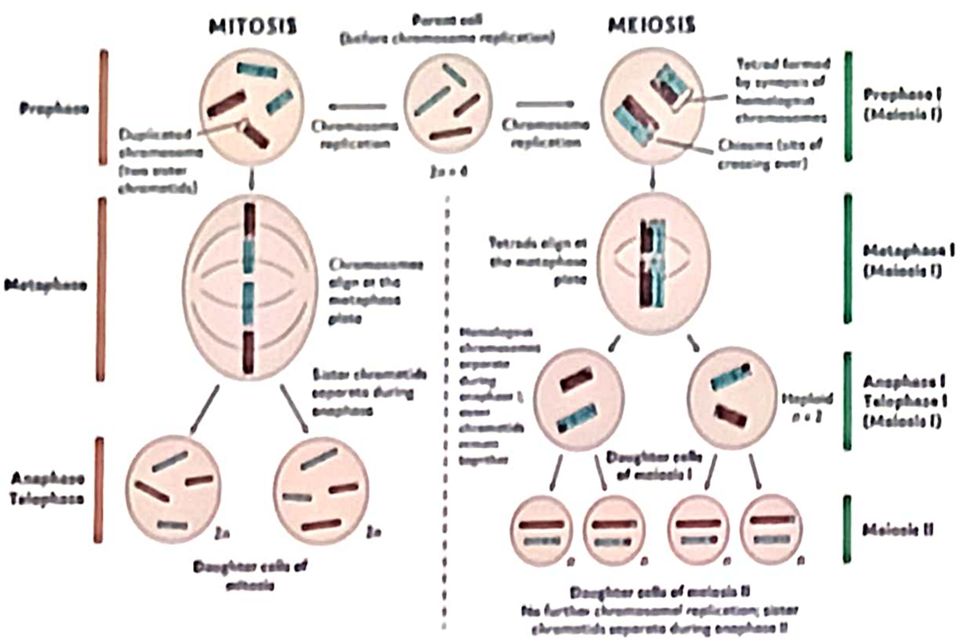
## Phases of Meiosis II:

- After meiosis I, the cells quickly enter meiosis II without passing through an S phase.
- **Meiosis II** is an equatorial division and resembles mitosis.
- During this phase, the sister chromatids will separate at anaphase II and move to opposite poles of the cell.
- During meiosis II, the cells pass through **prophase II, metaphase II, anaphase II,** and **telophase II.**
- These stages are essentially the same as those in mitosis except that they involve a haploid set of chromosomes **(1n)** and produce daughter cells that have only haploid DNA content **(1d)**.
- Unlike the cells produced by mitosis, which are genetically identical to the parent cell, the cells produced by meiosis are genetically unique.

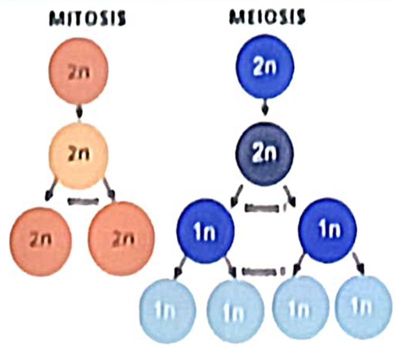
*By the end of meiosis II, each parent cell (2n) give rise to 4 daughter cells with haploid number of chromosomes (1n) and each daughter cell is genetically different from the parent cell.*


meiosis 1
interphase 1
prophase 1
metaphase 1
anaphase 1
Meiosis
telophase 1
prophase 2
metaphase 2
anaphase 2
meiosis 2

## Stages




## DIFFERENCE BETWEEN MITOSIS AND MEIOSIS
### DEFINITION & FUNCTIONS



## SIGNIFICANCE OF MITOSIS

- It is the type of multiplication in unicellular organism.
- It maintains the Kern-Plasma-Relation or karyoplasmic ratio of the cell.
- DNA, Proteins, RNA, etc., are synthesised in this process.
- It is a method for replacing old worn out cells.
- Any type of wound or injury is healed by this process.
- It plays an important role in the regeneration of a part of organism.
- It is responsible for growth of living organism.

**Kern-Plasma-Relation or karyoplasmic ratio:** It states that their is a definite relation between mass of nuclear material and the cytoplasm of the cell.
This theory was put forward by Hertwig in the year 1903.

Farmer and Moore (1905) introduced the term 'Meiosis'.

## SIGNIFICANCE OF MEIOSIS

- It maintains and restores the definite number of chromosomes in sexually reproducing organism.
- It is essential for sexual reproduction by providing haploid chromosomes in the gametes.
- It is the main cause of variation in the progeny which may result in the improvement of the race.
- It leads to induced mutation which may be useful or harmful.

| | Mitosis | Meiosis |
|---|---|---|
| Definition | A process of asexual reproduction in which the cell divides into two, producing a replica with an equal number of chromosomes in each resulting diploid cell. | A type of cellular reproduction in which the number of chromosomes are reduced by half producing two haploid cells. |
| Occurs in | All organisms | Reproductive cells of humans, animals, plants and fungi. |
| Type of reproduction | Asexual | Sexual |
| Genetically | Produces identical organisms or cells | Different cells or organisms. |
| Crossing over | No, crossing over cannot occur. | Yes, mixing of chromo somes can occur. |
| Pairing of Homologous chromosomes | No | Yes |
| Number of divisions | 1 | 2 |
| Number of daughter cells produced | 2 diploid cells | 4 Haploid cells |

# Microbial growth

- Provided with the right conditions (food, correct temperature, etc) microbes can grow very quickly.
- Depending on the situation, this could be a good thing for humans (yeast growing in wort to make beer) or a bad thing (bacteria growing in your body causing infections).
- It's important to have knowledge of their growth, so we can predict or control their growth under particular conditions.
- While growth for muticellular organisms is typically measured in terms of the increase in size of a single organism, microbial growth is measured by the increase in population, either by measuring the increase in cell number or the increase in overall mass.

## Growth Curve

- Since bacteria are easy to grow in the lab, their growth has been studied extensively.
- It has been determined that in a **closed system** or **batch culture** (no food added, no wastes removed) bacteria will grow in a predictable pattern, resulting in a **growth curve** composed of four distinct phases of growth:
  - the *lag phase*,
  - the *exponential or log phase*,
  - the *stationary phase*, and
  - the *death or decline phase*.
- Additionally, this growth curve can yield **generation time** for a particular organism – the amount of time it takes for the population to double.

## Lag phase

- The **lag phase** is an adaptation period, where the bacteria are adjusting to their new conditions.
- The length of the lag phase can vary considerably, based on how different the conditions are from the conditions that the bacteria came from, as well as the condition of the bacterial cells themselves.
- Actively growing cells transferred from one type of media into the same type of media, with the same environmental conditions, will have the shortest lag period. Damaged cells will have a long lag period, since they must repair themselves before they can engage in reproduction.
- Typically, cells in the lag period are synthesizing RNA, enzymes, and essential metabolites that might be missing from their new environment (such as growth factors or macromolecules), as well as adjusting to environmental changes such as changes in temperature, pH, or oxygen availability. They can also be undertaking any necessary repair of injured cells.