

Cell Cycle and Cell Division

Cell cycle

Cell cycle is defined as the series of changes that occur in a cell which leads to division of cells into two daughter cells. Cell cycle is divided into two phases- interphase and mitosis. The average duration of cell cycle in human cells is 24 hours. Of this, mitosis lasts for only 1 hour. Therefore, the majority of cell cycle is spent in interphase.

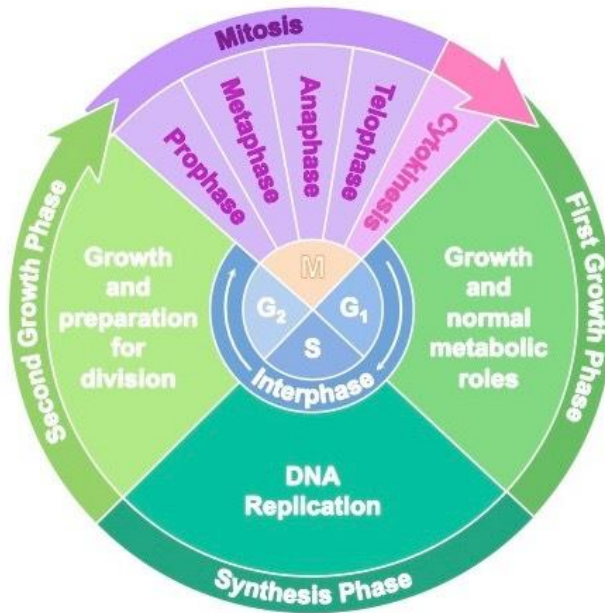


Fig. 1. Cell cycle

Interphase

It is a phase in which different changes occurs to prepare the cell for cell division. It is further divided into following phases-

G₁ phase is also known as first gap phase. During this phase, biosynthetic activities occur at a very fast rate. Cell synthesizes more proteins, increase the number of mitochondria and ribosomes. Cell also prepares itself for DNA replication.

S phase is the phase where DNA is replicated. At the end of DNA replication, each chromosome is with two sister chromatids. Thus, the amount of DNA gets doubled during this phase, but the ploidy remains same.

G₂ phase is the phase where the cell prepare itself for mitosis. It also involves protein synthesis and further growth of the cell.

Mitosis

Called as equational division as the number of chromosomes in the daughter cell and the parent cell remains the same. It begins with nuclear division. This is known as karyokinesis. Chromosomes get distributed equally during mitosis. It takes place only in somatic cells.

It is divided into following phases-

Prophase

During this phase chromatin condenses to form chromosomes. There are two identical copies of each chromosome which are attached to centromere. During the end of the prophase, nucleolus dissolves. Nuclear membrane also disintegrates at the end. The centrosome moves to the opposite poles. Spindle fibers starts to appear.

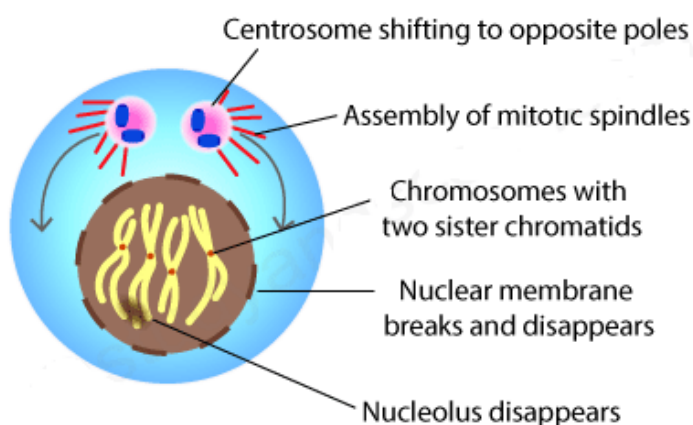


Fig. 2. Prophase of mitosis

Metaphase

During this phase, chromosomes aligned themselves on the equatorial plate. The analysis of the metaphase chromosome is used in cytogenetics and cancer studies.

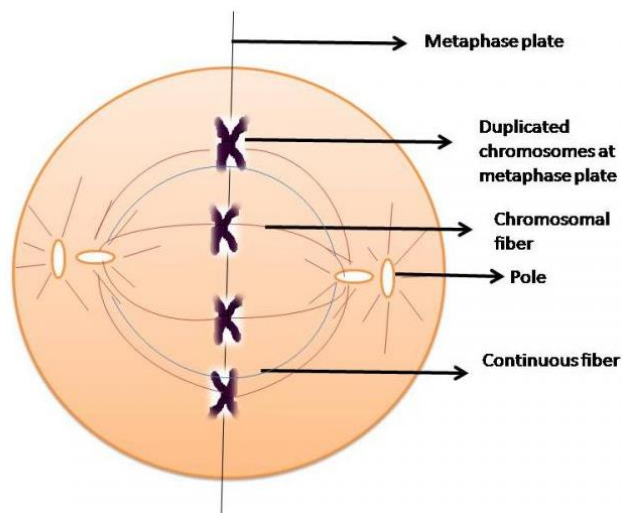


Fig. 3. Metaphase of mitosis

Anaphase

It is the shortest stage of the cell cycle. During this phase, the replicated chromosomes move apart and daughter chromatids move to the opposite poles. Chromosomes are maximally condensed during late anaphase. The chromosomes appear Y- shaped as they move to the opposite poles.

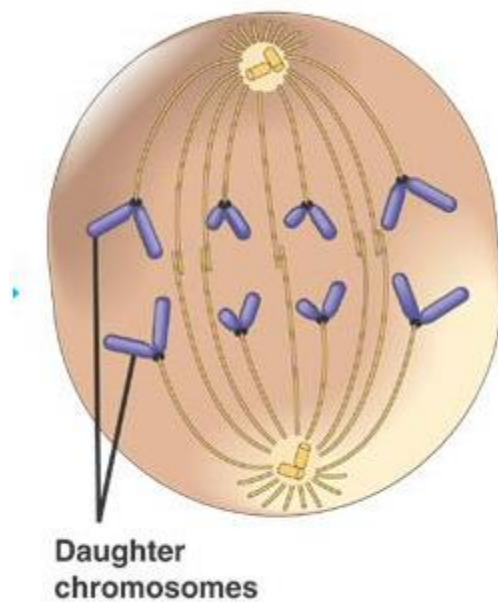


Fig. 4. Anaphase of mitosis

Telophase

This is where two daughter nuclei are formed. Nucleolus and nuclear membrane re-appear. The late telophase is marked by cytokinesis. This is last phase of mitosis. Finally the chromosomes reach the poles.

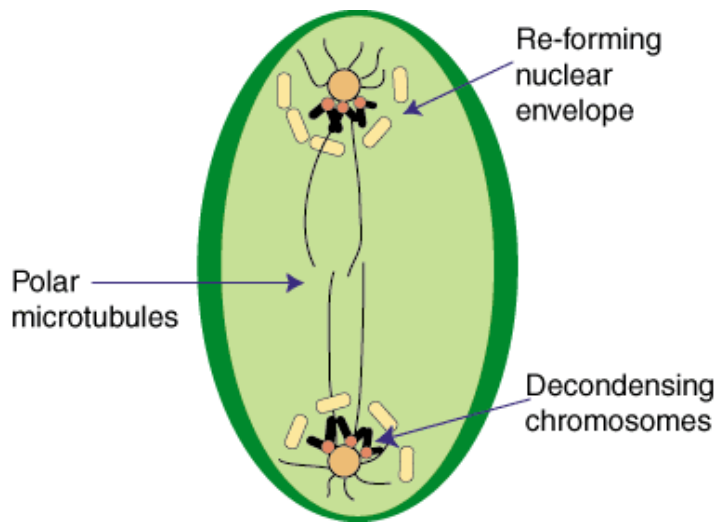


Fig. 5. Telophase of mitosis

Cytokinesis

The division of cytoplasm, organelles, and cell membrane to form two cells is known as cytokinesis. It divides the cell into two daughter cells which are identical to the parent cell.

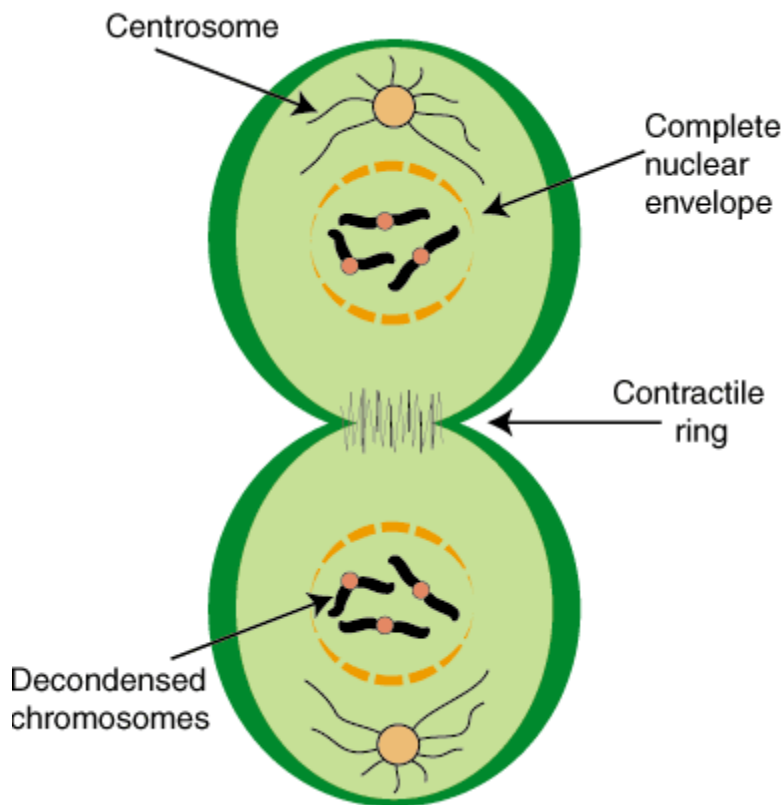


Fig. 6. Cytokinesis

Importance of mitosis

- Produce genetically identical daughter cells.
- Growth of the body occurs via mitosis.
- Cell repair and replacement also occurs via mitosis.
- Maintenance of nucleo-cytoplasmic ratio.

Cell cycle exit

Some cells divide at a fast rate whereas some divide slowly and some even do not divide once they are formed. Those cells which do not divide once formed, enter into a phase known as G₀ phase. For example, neuronal cells once formed will not divide.

Meiosis

Also known as reductional division because it reduces the number of chromosomes to half the parent cell. It is of two types meiosis I and meiosis II. Gametes such as sperm or egg are formed by meiosis.

Meiosis I

It is divided into following phases-

Prophase I

It is the longest phase of meiosis I. During this phase, homologous chromosomes pair and DNA segments are exchanged (known as recombination). It is further divided into following-

Leptotene

- It is the first stage of meiosis.
- Each individual chromosome exists with two sister chromatids.
- Elements of synaptonemal complex assemble.
- Condensation and coiling of chromosomes occur.

Zygotene

- Chromosomes align as homologous pair of chromosomes.
- Synapsis of homologous chromosomes occur.
- The paired chromosomes are known as bivalent or tetrad.



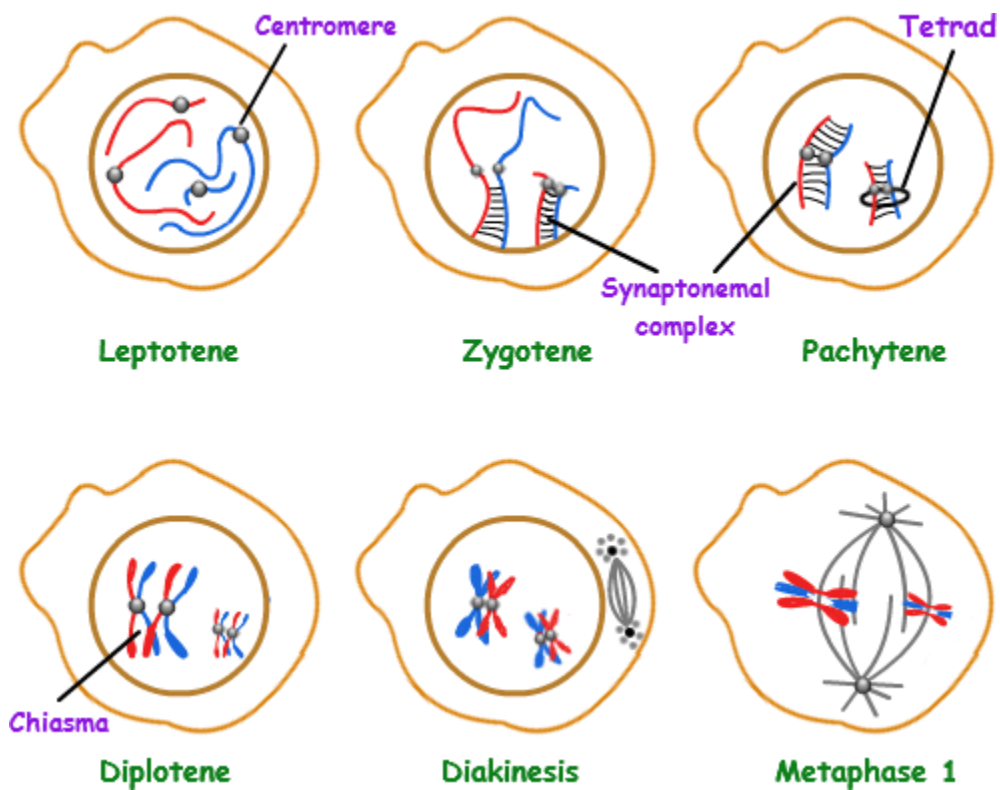


Fig. 7. Different stages of prophase I of meiosis I

Pachytene

- During this stage, crossing over and homologous recombination occurs.
- Chiasmata are formed where homologous chromosomes exchange their segments.

Diplotene

- Homologous chromosomes start to separate.
- Synaptonemal complex disassembles.
- Chromosomes remain bound at the chiasmata.

Diakinesis

- Chromosomes condense further, so that four parts of the tetrads are visible.
- The nucleoli disappear, nuclear membrane disintegrates.
- Mitotic spindle starts to form.

Metaphase I

Homologous chromosomes are aligned on the metaphasic plate. The replicated chromosomes are joined together via protein known as cohesin.

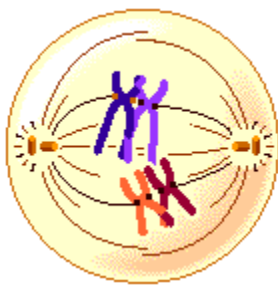


Fig. 8. Metaphase I

Anaphase I

As the kinetochore microtubules shorten, homologous chromosomes are pulled to the opposite poles. The cohesin (protein complex) degrades from the chromosome arms while remaining safe surrounding the centromere. Thus the sister chromatids remain together while homologs segregate.

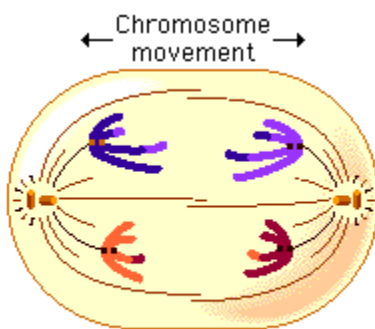


Fig. 9. Metaphase I

Telophase I

Each daughter cell now has half the number of chromosomes as compared to parent cell. The microtubules forming the spindle begin to disappear. The chromosomes form chromatin once again. Sister chromatids remain attached.

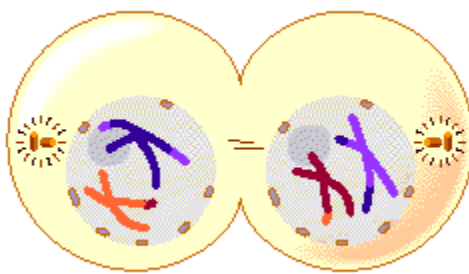


Fig. 10. Telophase I

Meiosis II

Meiosis II is the second meiotic division. It is similar to mitosis, but the genetic results are different. It results in the formation of four haploid cells from the two haploid cells produced in meiosis I.

The four main steps of Meiosis II are as follows- **Prophase II, Metaphase II, Anaphase II, and Telophase II.**

In **prophase II** nucleoli and nuclear membrane disappears. Shortening and thickening of the chromatids also occur during this phase. Centrosomes move to the poles and spindle fibers are formed for the second meiotic division.



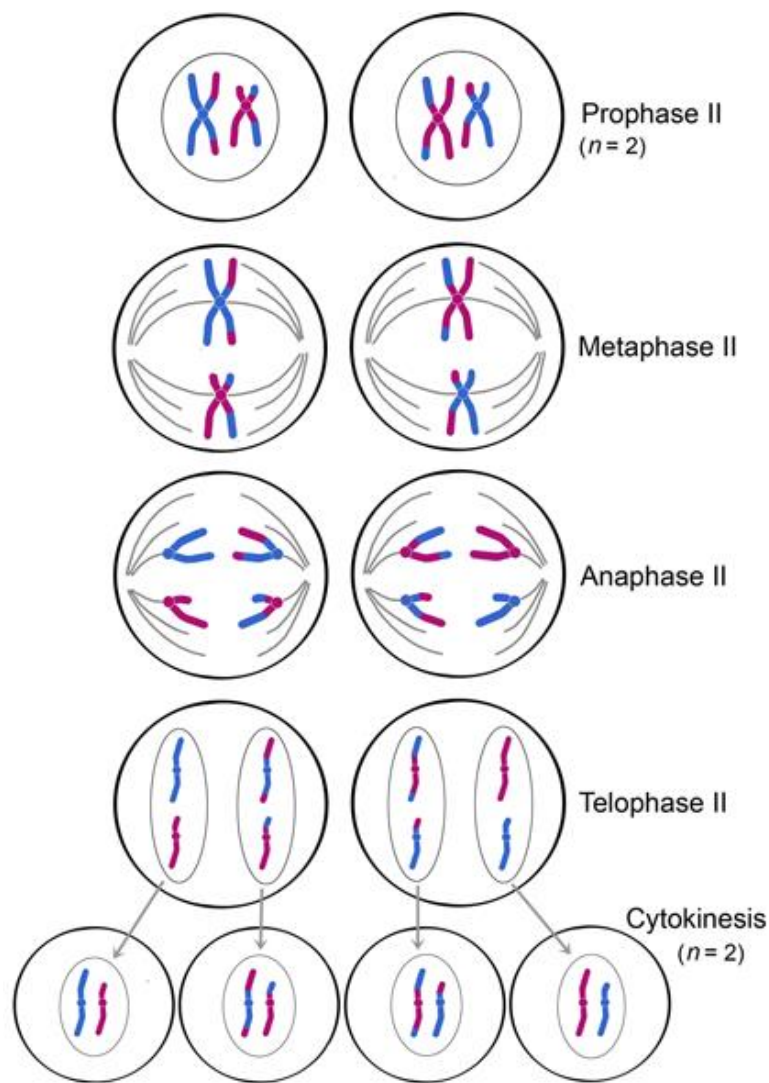


Fig. 11. Different stages of meiosis II

In **metaphase II**, the centromeres are present with two kinetochores that are attached to spindle fibers from the centrosomes at opposite poles. The metaphasic plate is rotated by 90 degrees when compared to meiosis I, perpendicular to the previous plate.

Anaphase II is accompanied by sister chromatid segregation. The remaining cohesin is degraded to allow sister chromatid segregation.

Telophase II, which is like telophase I, de-condensation of chromosomes occurs. Nuclear envelopes reorganize and cleavage or cell plate formation starts to produce four daughter cells, each with a haploid set of chromosomes.

Significance of Meiosis:

- Maintenance of chromosome number generation after generation in case of sexual reproduction.
- Increases variation in population.