

Cell Cycle and Cell Division

- **Cell cycle**

- It is defined as a series of events that takes place in a cell, leading to the formation of two daughter cells.
- The average duration of a cell cycle for a human cell is about 24 hours and for yeast cell, it is about 90 minutes
- Cell cycle is divided into two basic phases: Interphase and M phase

- **Interphase**

- Interphase involves a series of changes that prepares the cell for division. It involves the period of cell growth and DNA replication in an orderly manner.

- It is divided into three phases:

- **G₁ phase** – It involves growth of cell and preparation of DNA replication.
- **S phase** – It involves DNA replication. The amount of DNA doubles, but the chromosome number remains the same.
- **G₂ phase** – It involves protein synthesis and further growth of cell, which prepares it for division.
- **G₀ phase or quiescent phase** – It is the stage when metabolically active cell remains quiescent for long period of time.

- **Significance of Cell Division**

- It is the mean of asexual reproduction in unicellular organisms.
- It is essential for the growth of a single celled zygote into a whole new multicellular organism.
- It helps in the repair of injuries and worn out tissues.
- It replaces dead cells of the body and thus is essential for growth of organism.
- In sexual reproduction, meiosis occurs. This type of cell division not only results in production of gametes, but also brings new combinations of genes, thus resulting in variations among a population. This also leads to evolution of a species.

- **Mitosis**

- It is a process of cell division where chromosomes replicate and get equally distributed into two daughter cells. Hence, it is also called equational division.
 - The process of mitosis keeps the chromosome number equal in daughter as well as parental cell.
 - Mitosis usually takes place in somatic cells.
- Mitosis involves four stages:
- **Prophase**
 - It involves initiation and condensation of chromosomes.
 - Nucleolus and nuclear membrane disappear.
- **Metaphase**
 - Chromosomal material condenses to form compact chromosomes that get aligned in the middle of nucleus at equatorial plate.
- **Anaphase**
 - Centromere splits and chromosomes move apart towards two opposite poles due to shortening of spindle fibres
- **Telophase**
 - Chromosomes finally reach their respective poles.
 - Nuclear envelope assembles around each chromosome cluster.
 - Nucleolus and other organelles reform.
- **Karyokinesis and Cytokinesis**
 - Karyokinesis is the division of nucleus during mitosis or meiosis that is followed by cytokinesis.
 - Cytokinesis involves the division of cytoplasm of a cell.
 - Cytokinesis is achieved in animal cell by cleavage that deepens and divides the cell into two.
 - It is achieved in plant cell by cell plate formation.
 - When karyokinesis is not followed by cytokinesis, a multinucleate condition arises. This is called syncytium.
- **Significance of mitosis**
 - It results in the formation of diploid daughter cells with identical genetic material.
 - Mitosis plays a significant role in cell repair, growth, and healing.
- **Meiosis**
 - It is the process which involves the reduction in the amount of genetic material.
 - It mainly occurs in germ cells.

- At the end of meiosis II, four haploid cells are formed.
 - It is comprised of two successive nuclear and cell division with a single cycle of DNA replication.
- The phases of meiosis are as shown below-
- **Meiosis I**
 1. **Prophase I** – It comprises of 5 stages:
 - **i. Leptotene**
 - Chromosomes start condensing.
 - **ii. Zygotene**
 - Pairing of chromosomes called synapsis occurs.
 - A pair of synapsed homologous chromosomes is called bivalent or tetrad.
 - **iii. Pachytene**
 - Exchange of genetic material (crossing over) between non-sister chromatids occurs.
 - Chiasmata formation
 - **iv. Diplotene**
 - Bivalents formed during pachytene separate from each other (except at chiasmata) due to dissolution of synaptonemal complex
 - **v. Diakinesis**
 - Terminalisation of chiasmata can be observed.
 - By the end of this stage, the nucleolus disappears and the nuclear envelope breaks.
 - **2. Metaphase I**
 - Bivalents (tetrad) get aligned along metaphase plate through spindle fibres.
 - **3. Anaphase I**
 - Homologous chromosomes separate while chromatids remain attached at their centromere.
 - **Telophase I**
 - Nucleolus and nuclear membrane reappear around chromosome cluster at each pole.
 - **Interkinesis** – It is the stage between two meiotic divisions.
- **Meiosis II**
 1. **Prophase II**
 - Chromosomes become compact.
 - Nuclear membrane disappears.
 2. **Metaphase II**
 - Chromosomes align at the equator.
 - Kinetochores of sister chromatids attach to spindle fibres at each pole.

- **3. Anaphase II**
 - Chromatids separate by splitting of centromere.
 - As a result, chromatids move towards their respective poles in the cell.
- **4. Telophase II**
 - Nuclear envelope reforms around the chromosome clusters.
 - After meiosis II, the process of cytokinesis results in the formation of four haploid cells (tetrad of cells).
- **Significance of meiosis:**
 - It brings about variation.
 - It maintains the chromosome number constant from generation to generation.