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:
- **G_1 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.
- **G_2 phase –** It involves protein synthesis and further growth of cell, which prepares it for division.
- **G_0 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.