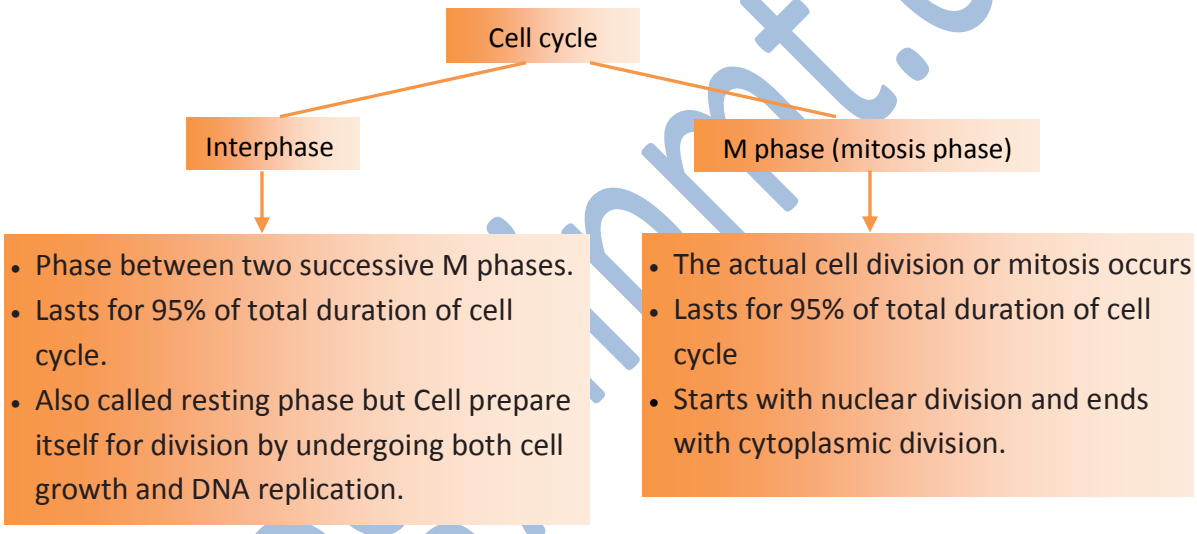
CELL CYCLE AND CELL DIVISION

- Growth and reproduction are characteristics of living cells and organisms.

Cell Cycle –

- The sequence of events by which a cell duplicates its genome, synthesizes the other constituents of the cell and eventually divides into two daughter cells is termed **cell cycle.**
- Cell cycle includes three processes cell division, DNA replication and cell growth in coordinated way.
- Duration of cell cycle can vary from organism to organism and also from cell type to cell type. (e.g., in Yeast cell cycle is of 90 minutes, in human 24 hrs.)



Interphase

- It is divided into 3 further phases G1, S, and G2.

G1 phase (Gap 1 Phase)

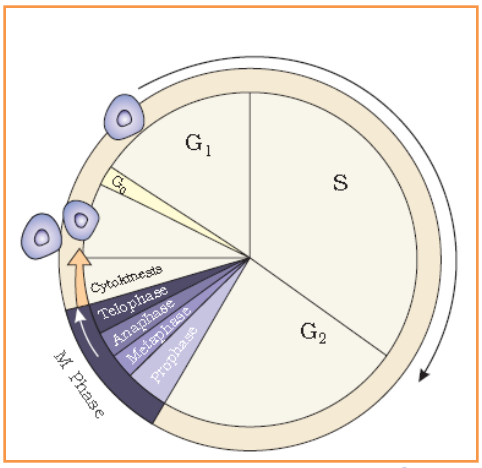
- Corresponds to the interval between mitosis and initiation of DNA replication.
- During G1 phase the cell is metabolically active and continuously grows but does not replicate its DNA.

S phase (synthesis phase)

- period during which DNA synthesis or replication takes place.
- During this time the amount of DNA per cell doubles. (only amount of DNA is doubled, no of chromosomes remain same.)
- In animal cells, during the S phase, DNA replication begins in the nucleus, and the centriole duplicates in the cytoplasm.

G2 phase (Gap 2 Phase)

- Proteins are synthesised in preparation for mitosis while cell growth continues.



- Some cells do not exhibit division like heart cells, nerve cells etc. these cells enter in an inactive phase called G_0 or quiescent phase from G1 phase.
- Cells in this phase are metabolically active but they do not divide unless they are called on to do so.

Mitosis or M phase

- In animals, mitotic cell division is only seen in the diploid somatic cells while in the plants mitotic divisions can be seen in both haploid and diploid cells.
- it is also called as **equational division** as the number of chromosomes in the parent and progeny cells are the same.
- Mitosis is divided into the following four stages:
  - Prophase
  - Metaphase
  - Anaphase
  - Telophase

Prophase

- It follows the S and G2 phases of interphase.
- The centrioles now begin to move towards opposite poles of the cell.
- In prophase Chromosomal material condenses to form compact mitotic chromosomes.
- Initiation of the assembly of mitotic spindle with the help of the microtubules.
- Cell organelles like Golgi complexes, endoplasmic reticulum, nucleolus and the nuclear envelope disappear.

Metaphase

- Start of metaphase is marked by the complete disintegration of the nuclear envelope.
- The chromosomes are spread through the cytoplasm of the cell.
- condensation of chromosomes is completed and they can be observed clearly under the microscope.

- This is the stage at which morphology of chromosomes is most easily studied.
- At this stage, metaphase chromosome is made up of two sister chromatids, which are held together by the centromere.
- centromere serve as the sites of attachment of spindle fibres to the chromosomes.
- chromosomes are moved into position at the centre of the cell.
- the metaphase is characterised by all the chromosomes coming to lie at the equator with one chromatid of each chromosome connected by its kinetochore to spindle fibres from one pole and its sister chromatid connected by its kinetochore to spindle fibres from the opposite pole.
- The plane of alignment of the chromosomes at metaphase is referred to as the **metaphase plate or equatorial plate.**

Anaphase

- At the onset of anaphase, each chromosome arranged at the metaphase plate is **split** simultaneously and the two daughter chromatids begin to **move** towards the two opposite poles.
- As each chromosome moves away from the equatorial plate, the centromere of each chromosome is towards the pole and hence at the leading edge, with the arms of the chromosome trailing behind

Telophase

- At the beginning of telophase, the chromosomes at their respective poles decondense and form chromatin network.
- Nuclear envelope assembles around the chromatin network.
- Nucleolus, Golgi complex and ER etc cell organelles reform.

Cytokinesis

- After karyokinesis the cell itself is divided into two daughter cells by a separate process called cytokinesis.
- In an animal cell, this is achieved by the appearance of a **furrow** in the plasma membrane.
- The furrow gradually deepens and ultimately joins in the centre dividing the cell cytoplasm into two.
- Plant cells undergo cytokinesis by **cell plate method**. In cell plate method wall formation starts in the centre of the cell and grows outward to meet the existing lateral walls.
- The formation of the new cell wall begins with the formation of a simple precursor, called the **cell-plate** that represents the middle lamella between the walls of two adjacent cells.
- At the time of cytoplasmic division, organelles like mitochondria and plastids get distributed between the two daughter cells.
- In some organisms karyokinesis is not followed by cytokinesis as a result of which multinucleate condition arises leading to the formation of **syncytium** (e.g., liquid endosperm in coconut). (should be coenocytic)

Significance of mitosis

(1) Mitosis results in the production of diploid daughter cells with identical genetic complement usually.
(2) The growth of multicellular organisms is due to mitosis.
(3) Cell growth results in disturbing the ratio between the nucleus and the cytoplasm. Therefore, cell divide to restore the nucleo-cytoplasmic ratio.
(4) mitosis is important in cell repair. The cells of the upper layer of the epidermis, cells of the lining of the gut, and blood cells are being constantly replaced.
(5) Mitotic divisions in the meristematic tissues – the apical and the lateral cambium, result in a continuous growth of plants throughout their life.

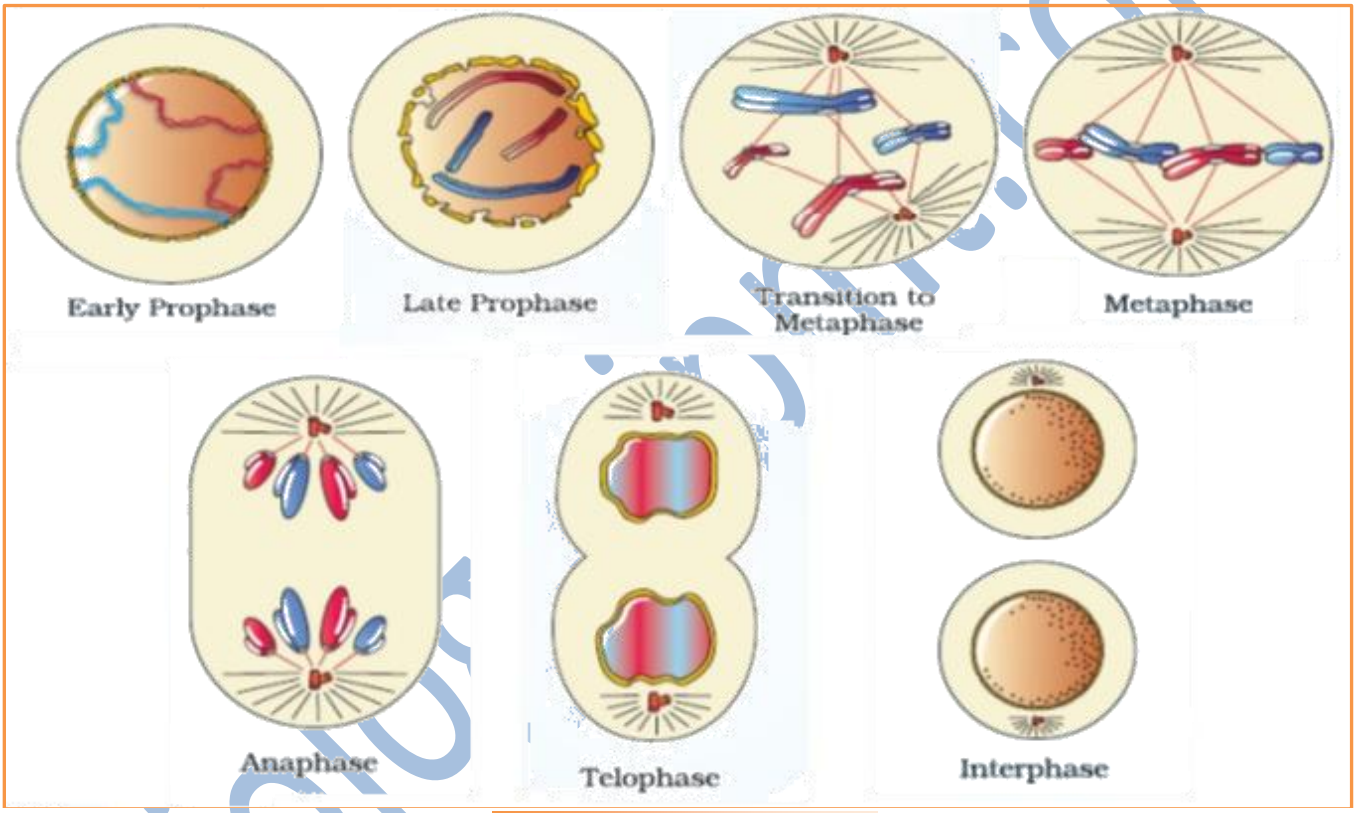


Fig: Different stages of Mitosis

Meiosis

- The specialised kind of cell division that reduces the chromosome number by half results in the production of haploid daughter cells called **meiosis.**
- It is responsible for formation of haploid gametes, which during sexual reproduction form diploid zygote by fusion.
- Meiosis involves two sequential cycles of nuclear and cell division called **meiosis I** and **meiosis II** but only a single cycle of DNA replication.
- Interphase of meiosis is similar to interphase of mitosis.

Meiosis I

Prophase I

- Prophase of the meiosis I division is typically longer and more complex than prophase of mitosis.
- It has been further subdivided into the following five phases based on chromosomal behavior.

Prophase I

- **Leptotene** → Chromosomes become gradually visible under the light microscope. (Bouquet phase)
- **Zygotene** → Homologous chromosomes start pairing together and form **synaptonemal** complex or tetrad by synapsis.
- **Pachytene** → Appearance of **recombination** nodules. **Crossing over** occurs between non-sister chromatids of the homologous chromosomes.
- **Diplotene** → Dissolution of the synaptonemal complex. Recombined chromosomes of the tetrad separate from each other except at the sites of crossovers. These X-shaped structures, are called **chiasmata.**
- **Diakinesis** → terminalisation of chiasmata. Chromosomes are fully condensed. Meiotic spindle is assembled to prepare the homologous chromosomes for separation. By the end of diakinesis, the nucleolus and nuclear envelope disappear.

Metaphase I:

- The bivalent chromosomes align on the equatorial plate.
- The microtubules from the opposite poles of the spindle attach to the pair of homologous chromosomes.

Anaphase I:

- The homologous chromosomes separate, while sister chromatids remain associated at their centromeres.

Telophase I

- The nuclear membrane and nucleolus reappear.
- cytokinesis follows telophase I.

- Although in many cases the chromosomes do undergo some dispersion, they do not reach the extremely extended state of the interphase nucleus. The stage between the two meiotic divisions is called **interkinesis** and is generally short lived.

- Interkinesis is followed by prophase II, a much simpler prophase than prophase I.

Meiosis II

Meiosis II resembles a normal mitosis.

Prophase II:

- Meiosis II is initiated immediately after cytokinesis.
- The nuclear membrane disappears by the end of prophase II.
- The chromosomes again become compact.

Metaphase II:

- At this stage the chromosomes align at the equator and the microtubules from opposite poles of the spindle get attached to the kinetochores of sister chromatids.

Anaphase II:

- splitting of the centromere of each chromosome.
- Chromosomes move toward opposite poles of the cell.

Telophase II:

- the two groups of chromosomes once again get enclosed by a nuclear envelope.
- cytokinesis follows resulting in the formation of four haploid daughter cells).

SIGNIFICANCE OF MEIOSIS

(1) by meiosis conservation of specific chromosome number of each species is achieved across generations in sexually reproducing organisms.

(2) It also increases the genetic variability in the population of organisms from one generation to the next. Variations are very important for the process of evolution.