CELLS

A cell is defined as the smallest, basic unit of life that is responsible for all of life's processes.

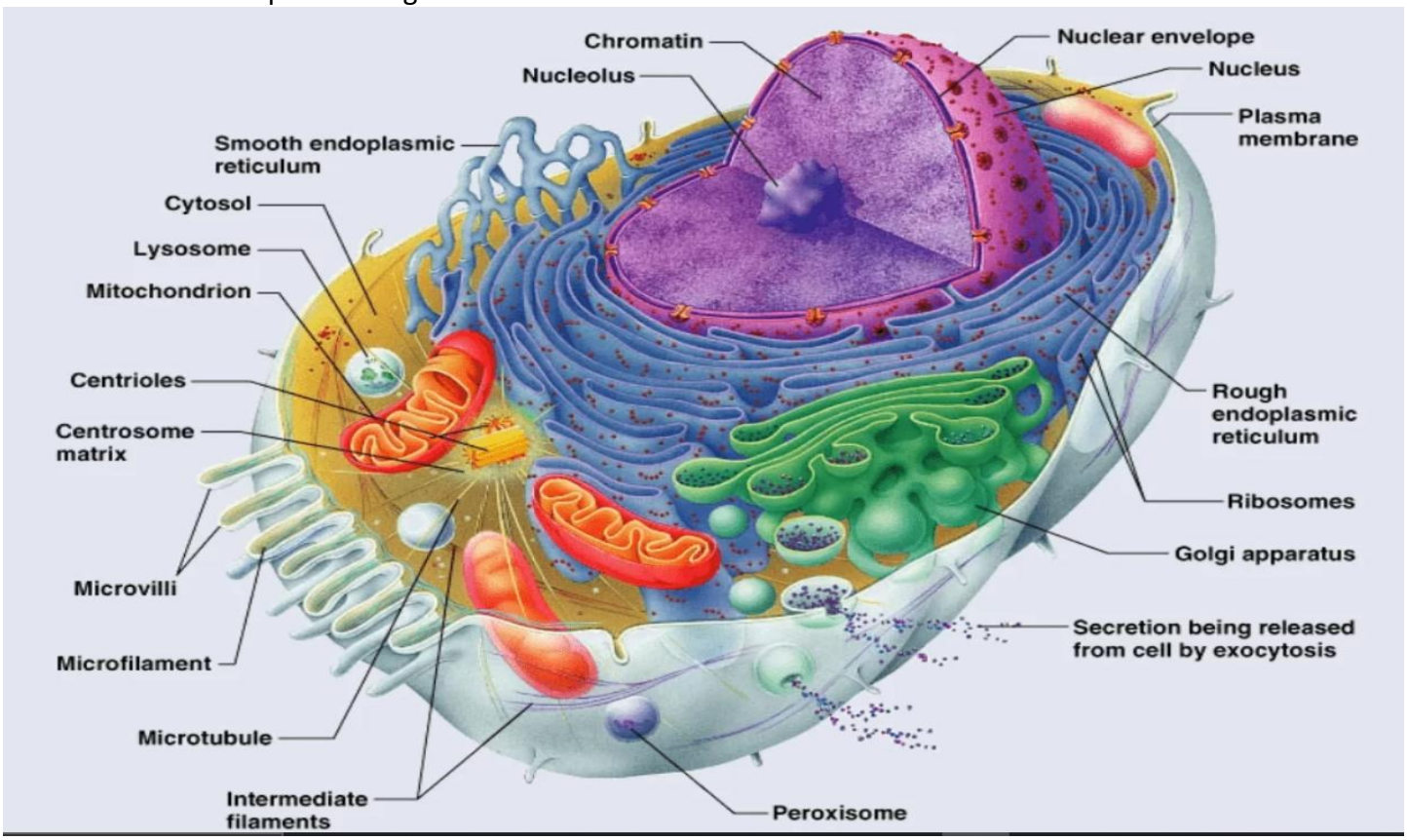
Cells are the structural, functional, and biological units of all living beings. A cell can replicate itself independently. Hence, they are known as the building blocks of life**.** Robert Hooke discovered the cell in 1665. Robert Hooke observed a piece of bottle cork under a compound microscope and noticed minuscule structures that reminded him of small rooms. Consequently, he named these "rooms" as cells.

Characteristics of Cells:

- Cells provide structure and support to the body of an organism.
- The cell interior is organised into different individual organelles surrounded by a separate membrane.
- The nucleus (major organelle) holds genetic information necessary for reproduction and cell growth.
- Every cell has one nucleus and membrane-bound organelles in the cytoplasm.
- Mitochondria, a double membrane-bound organelle is mainly responsible for the energy transactions vital for the survival of the cell.
- Lysosomes digest unwanted materials in the cell.
- Endoplasmic reticulum plays a significant role in the internal organisation of the cell by synthesising selective molecules and processing, directing and sorting them to their appropriate locations.

The Cell Theory:

1. Every living organism is made of one or more cells.
2. The cell is the basic unit of structure and function.
3. All cells arise from pre-existing cells.



Types of Cells

Cells are similar to factories with different labourers and departments that work towards a common objective. Various types of cells perform different functions. Based on cellular structure, there are two types of cells:

Eukaryotic vs. Prokaryotic Cells

Characteristics	Eukaryotic Cells	Prokaryotic Cells
Definition	Any cell that contains a clearly defined nucleus and membrane bound organelles	Any unicellular organism that does not contain a membrane bound nucleus or organelles
Examples	Animal, plant, fungi, and protist cells	Bacteria and Archaea
Nucleus	Present (membrane bound)	Absent (nucleoid region)
Cell Size	Large (10-100 micrometers)	Small (less than a micrometer to 5 micrometers)
DNA Replication	Highly regulated with selective origins and sequences	Replicates entire genome at once
Organism Type	Usually multicellular	Unicellular
Chromosomes	More than one	One long single loop of DNA and plasmids
Ribosomes	Large	Small
Growth Rate/Generation Time	Slower	Faster
Organelles	Present	Absent
Ability to Store Hereditary Information	All eukaryotes have this ability	All prokaryotes have this ability
Cell Wall	Simple: Present in plants and fungi	Complex: Present in all prokaryotes
Plasma Membrane	Present	Present
Cytoplasm	Present	Present

Cell Structure:

The cell structure comprises individual components with specific functions essential to carry out life's processes. These components include- cell wall, cell membrane, cytoplasm, nucleus, and cell organelles.

Cell Membrane

- The cell membrane supports and protects the cell. It controls the movement of substances in and out of the cells. It separates the cell from the external environment. The cell membrane is present in all the cells.
- The cell membrane is the outer covering of a cell within which all other organelles, such as the cytoplasm and nucleus, are enclosed. It is also referred to as the plasma membrane.
- By structure, it is a porous membrane (with pores) which permit the movement of selective substances in and out of the cell. Besides this, the cell membrane also protects the cellular component from damage and leakage.
- It forms the wall-like structure between two cells as well as between the cell and its surroundings.

- Plants are immobile, so their cell structures are well-adapted to protect them from external factors. The cell wall helps to reinforce this function.

Cell Wall

- The cell wall is the most prominent part of the plant's cell structure. It is made up of cellulose, hemicellulose and pectin.
- The cell wall is present exclusively in plant cells. It protects the plasma membrane and other cellular components. The cell wall is also the outermost layer of plant cells.
- It is a rigid and stiff structure surrounding the cell membrane.
- It provides shape and support to the cells and protects them from mechanical shocks and injuries.

Cytoplasm

- The cytoplasm is a thick, clear, jelly-like substance present inside the cell membrane.
- Most of the chemical reactions within a cell take place in this cytoplasm.
- The cell organelles such as endoplasmic reticulum, vacuoles, mitochondria, ribosomes, are suspended in this cytoplasm.

Nucleus

- The nucleus contains the hereditary material of the cell, the DNA.
- It sends signals to the cells to grow, mature, divide and die.
- The nucleus is surrounded by the nuclear envelope that separates the DNA from the rest of the cell.
- The nucleus protects the DNA and is an integral component of a plant's cell structure.

Cell Organelles

Cells are composed of various cell organelles that perform certain specific functions to carry out life's processes. The different cell organelles, along with its principal functions, are as follows:

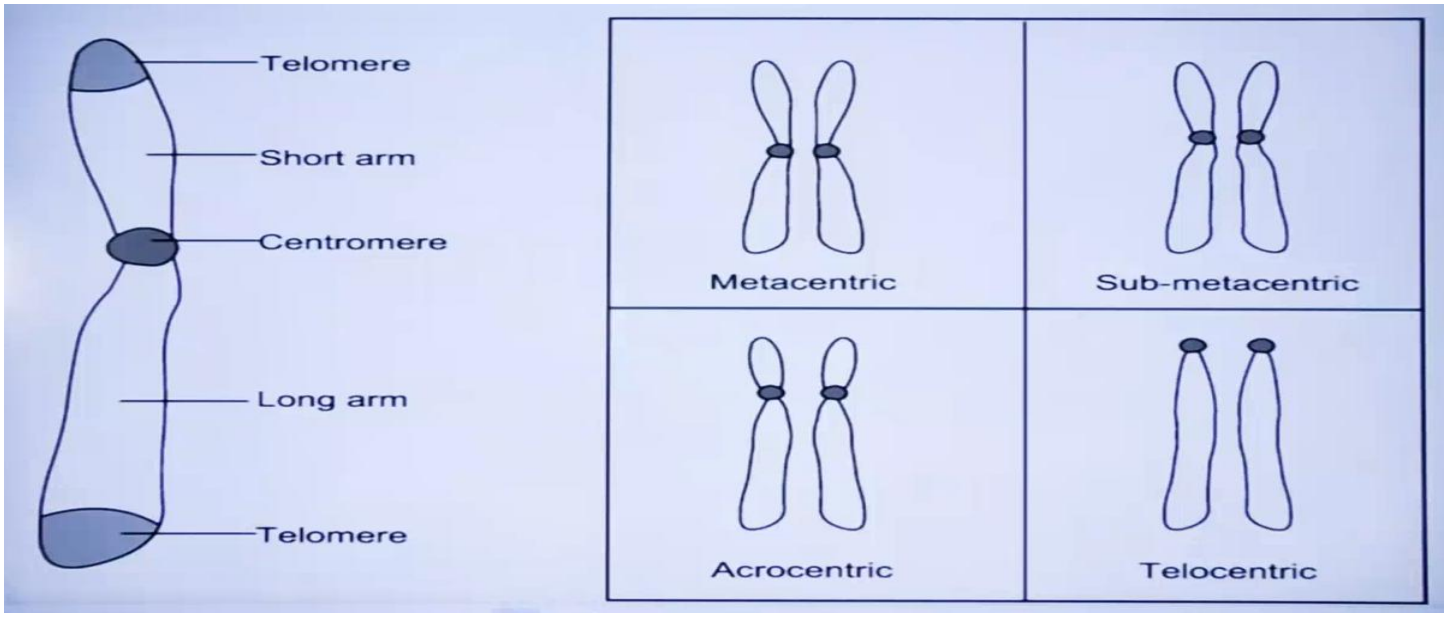
- **Nucleolus**
  The nucleolus is the site of ribosome synthesis. Also, it is involved in controlling cellular activities and cellular reproduction
- **Nuclear membrane**
  The nuclear membrane protects the nucleus by forming a boundary between the nucleus and other cell organelles.
- **Chromosomes**
  Chromosomes play a crucial role in determining the sex of an individual. Each human cells contain 23 pairs of chromosomes
- **Endoplasmic reticulum**
  The endoplasmic reticulum is involved in the transportation of substances throughout the cell. It plays a primary role in the metabolism of carbohydrates, synthesis of lipids, steroids and proteins.
- **Golgi Bodies**
  Golgi bodies are called the cell's post office as it is involved in the transportation of materials within the cell
- **Ribosome**

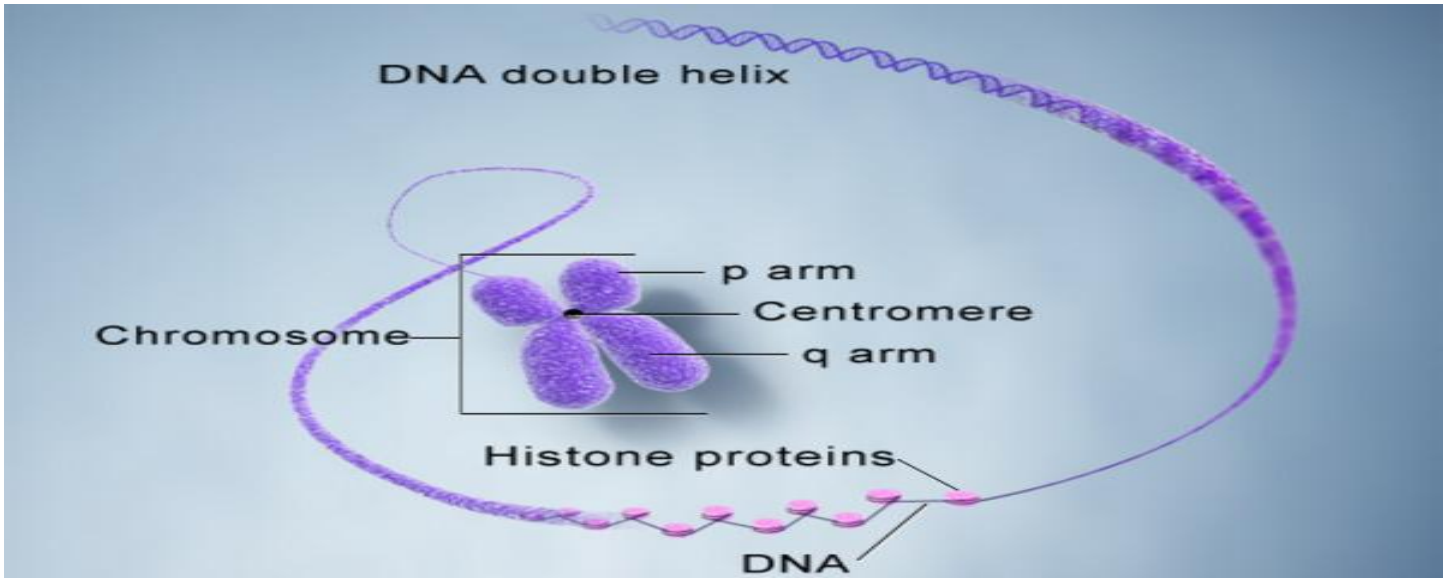
Ribosomes are the protein synthesisers of the cell

- **Mitochondria**
  The mitochondrion is called “the powerhouse of the cell.” It is called so because it produces ATP – the cell’s energy currency
- **Lysosomes**
  Lysosomes protect the cell by engulfing the foreign bodies entering the cell and helps in cell renewal. Therefore, it is known as the cell’s suicide bags
- **Chloroplast**
  Chloroplasts are the primary organelles for photosynthesis. It contains the pigment chlorophyll
- **Vacuoles**
  Vacuoles stores food, water, and other waste materials in the cell.

Chromosome

In the nucleus of each cell, the DNA molecule is packaged into thread-like structures called chromosomes. Each chromosome is made up of DNA tightly coiled many times around proteins called histones that support it’s Structure.



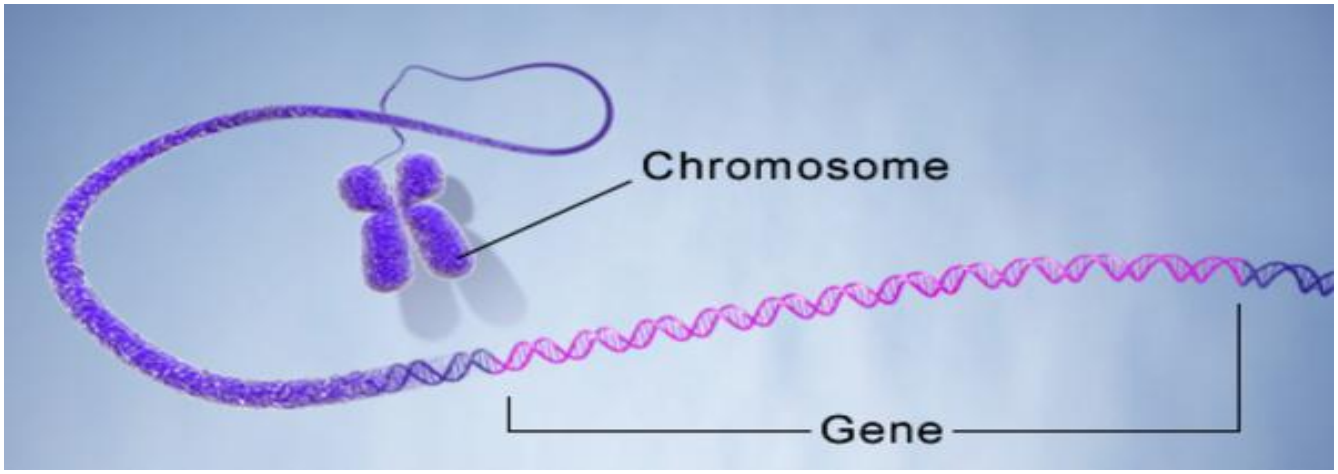


Difference between Chromosome and Chromatin

	Chromosomes	Chromatin
Composition	It is composed of DNA and protein.	It is composed of DNA, histones and non-historic proteins.
Aniline	It does not contain aniline.	It contains aniline.
Function	They are responsible for transporting DNA.	They are responsible for shaping the chromosomes.
Quantities	There are 23 pairs of chromosomes for a total of 46.	There are only 2 types of chromatins: euchromatin and heterochromatin.

GENE

A **gene** is the basic physical and functional unit of heredity. Genes are made up of DNA. Some genes act as instructions to make molecules called proteins.



Cell Division

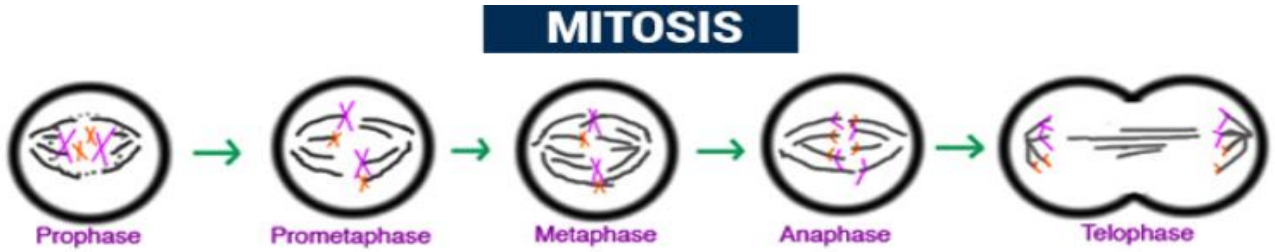
A single cell divides many times and forms a multicelled organism. Unicellular bacteria and protozoa divide and increase in number. The injured tissues are replaced by new cells through cell division.

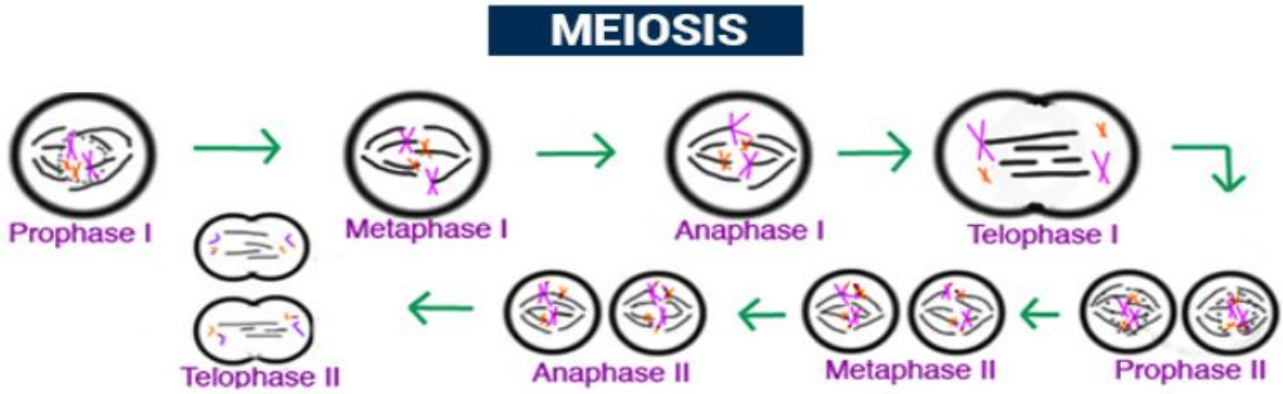
Cell division happens when a parent cell divides into two or more cells called daughter cells. Cell division usually occurs as part of a larger cell cycle. All cells reproduce by splitting into two, where each parental cell gives rise to two daughter cells.

There are two kinds of cell division- mitotic cell division and meiotic cell division :

1. Mitotic : Cell division is for growth and replacement of older cells by new cells wherein the two daugher cells are identical and similar to mother cell in all respects. Mitotic cell division occurs in haploid as well as diploid cells.

2. Meiotic : Cell division occurs in the gonads for sexual reproduction to produce gametes. The resultant cells, egg (in female) and sperms (in male), possess half the chromosome number of that present in the parent cell. Meiotic cell division takes place only in diploid cells responsible for production of haploid spores or gametes.





Phases of the Cell Cycle

There are two primary phases in the cell cycle:

1. **Interphase**: This phase was thought to represent the resting stage between subsequent cell divisions, but new research has shown that it is a very active phase.
2. **M Phase (Mitosis phase)**: This is where the actual cell division occurs. There are two key steps in this phase, namely cytokinesis and karyokinesis.

The interphase further comprises three phases:

1. **G0 Phase (Resting Phase):** The cell neither divides nor prepares itself for the division.
2. **G1 Phase (Gap 1)**: The cell is metabolically active and grows continuously during this phase.
3. **S phase (Synthesis)**: The DNA replication or synthesis occurs during this stage.
4. **G2 phase (Gap 2):** Protein synthesis happens in this phase.
5. **Quiescent Stage (G0)**: The cells that do not undergo further division exits the G1 phase and enters an inactive stage. This stage is known as the quiescent stage (G0) of the cell cycle.

There are four stages in the **M Phase,** namely:

1. Prophase
2. Metaphase
3. Anaphase
4. Telophase

Mitosis:

- **The nucleus and its content divide**
- **Cells divide to increase their numbers**

Phases of Mitosis

1. Prophase:

• Copied DNA condenses into chromosomes
• The nucleolus disappears, and the nuclear membrane breaks down.
• Spindle fibers begin to form. Phases of Mitosis

2. Metaphase:

• Chromosomes line up in a single file at the center of the cell. Phases of Mitosis

3. Anaphase:

• Sister chromatids separate
• Spindle fibers begin to shorten, pulling chromatids toward opposite sides of the cell.
• The cell begins to lengthen. Phases of Mitosis

4. Telophase

• A nuclear membrane forms around the chromatin.
• Chromosomes begin to unwind.
• Spindle fibers begin to break down.
• Two identical cells form.

MEIOSIS

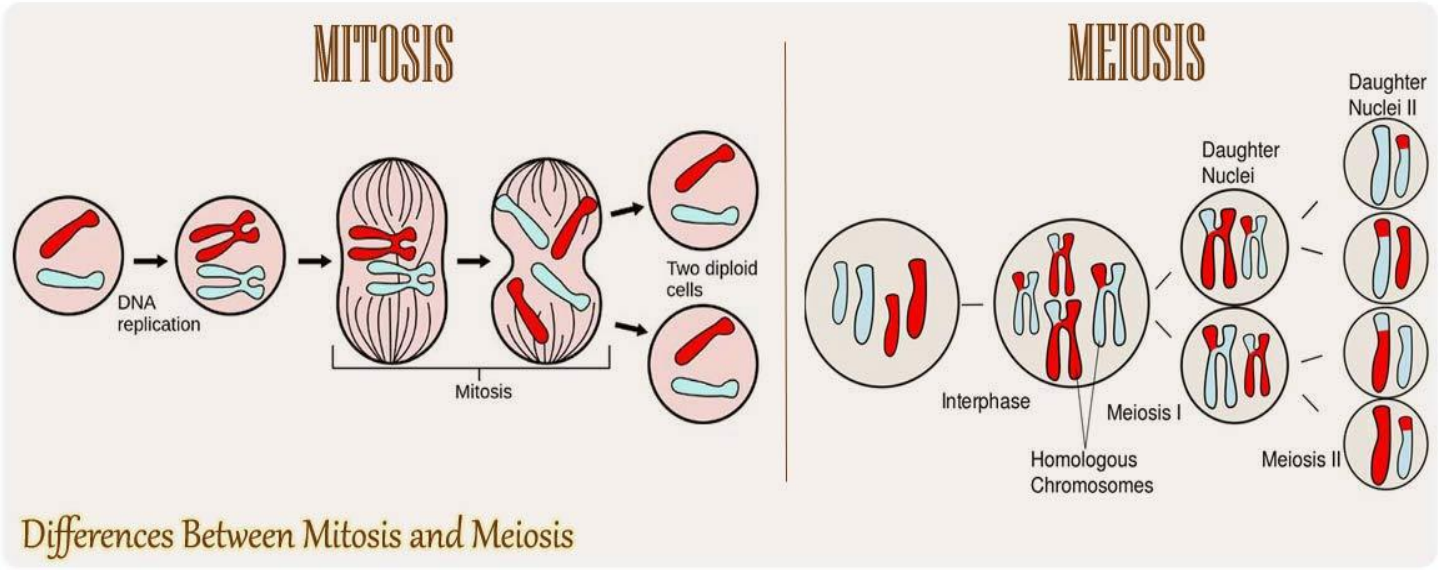
Meiosis I

Prophase I: Prophase of the first meiotic division is typically longer and more complex when compared to prophase of mitosis.

Metaphase I: The bivalent chromosomes align on the equatorial plate (Figure 10.3). The microtubules from the opposite poles of the spindle attach to the kinetochore 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 and this is called as dyad of cells



Meiosis II

Prophase II: Meiosis II is initiated immediately after cytokinesis, usually before the chromosomes have fully elongated. In contrast to meiosis I, meiosis II resembles a normal mitosis. 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: It begins with the simultaneous splitting of the centromere of each chromosome (which was holding the sister chromatids together), allowing them to move toward opposite poles of the cell

Telophase II: Meiosis ends with telophase II, in which the two groups of chromosomes once again get enclosed by a nuclear envelope