# CELL DIVISION

In multicellular organisms, growth is caused due to the cumulative effect of cell division cell elongation and cell differentiation

Cell division is essential for growth and reproduction of organisms

**Rudolf Virchow** proposed that New cells arise from pre-existing cells by division.

**Phases of the Cell cycle:**

A) Interphase

B) Mitosis Phase (M Phase)

Interphase:

Non division phase between successive mitotic divisions is called - **interphase.**

During interphase, nucleus appears to be resting physically but physiologically or bichemically it is very active. Interphas takes 15-20 Hrs.The cell prepares for division in interphase.

On the basis of biochemical studies, interphase is divided into $G_1$, S and $G_2$ Phases (G = Gap periods, S = synthetic period).

$G_1$ peroid – Increase in size of the cell and Lot of RNA and proteins are synthesised.

S Phase: this phase marks period of DNA replication and so the DNA of the cell doubles. How ever the number of chromosomes remains the same

$G_2$ peroid - Synthesis of RNA and proteins is continued. New organelles are synthesized. Proteins and energy pools associated with structure and movement of chromosomes are established in $G_2$ - phase.

M Phase represents actual cell division

Types of cell divisions - **Mitosis** and **Meiosis**

## MITOSIS or Equational Division

Mitosis was first discovered in animal cells by **Walter Fleming** (1878).

**Strasburger** (1879) identified mitosis in plant cells

The term **Mitosis** was coined by **Walter Fleming.**

Mitosis occurs in all kinds of cells regardless of their ploidy. Mitosis is called **somatic cell division** since it occurs most commonly in vegetative cells or somatic cells.

In plants, active centres of mitosis are **Root apex & stem apex.**

Best region to observe mitosis in plants is **Root apex.**

**During mitosis both the nucleus and cytoplasm divide.**

Division of nucleus is **Karyokinesis.** It results in the formation of **two identical daughter nuclei.**

During mitosis chromosomes replicate **once** and nucleus divides **once.**

Phases in karyokinesis are - **Prophase, Metaphase, Anaphase** and **Telophase.**

The first phase and lengthy phase in mitosis is **prophase.**

In early prophase chromosomes are long slender and are spread extensively in the nucleoplasm

In mid prophase each chromosome (arms only) splits longitudinally and forms two chromatids that are united at the centromere.

In late prophase Chromatin randomly scattered in the cytoplasm. Nuclear envelope and nucleolus disappear by the end of **prophase.**

Bipolar spindle is organized and individual chromosomes are oriented at equitorial plane during **Metaphase.**

Spindle in plant cells is **Bipolar** and **Anastral.** Spindle fibres are formed from **microtubules** (the material is **tubulin).**

**Continuous spindle fibres** extend from pole to pole and

**chromosomal spindle fibres** extend from pole to equitorial plane and attach to chromosomes at centromere region.

**Interzonal fibers** are found suspended nearer to the equator on its either side.

Plate like structure formed by orientation of chromosomes at the equitorial plane is called **equitorial** or **metaphase plate.**

Centromeres lie on equitorial plane and arms float freely during metaphase.

Centromeres divide and daughter chromosomes separate and move to opposite poles during **anaphase.**

Sister chromatids transform into daughter chromosomes

The shortest phase in mitosis is **Anaphase.**

Movement of chromosomes depends upon the association of spindle fibres with their centromeres.

During anaphasic movement of chromosomes, centromeres lead the arms.

Chromosomes acquire V, L, J, I shapes based on the position of centromere.

Changes in telophase are reverse to those of **Prophase.**

Nuclear envelope and nucleolus are formed in **Telophase.**

Nuclear envelope is re-organised from RER by a process called **nucleogenesis.**

Chromosomes uncoil and form chromatin which together appear as reticulum

Daughter nuclei formed in telophase are **identical** both **quantitatively** and **qualitatively.**

The number of chromosomes in daughter cells is same as in the parent cell. Hence mitosis is **equational division.**

Division of cytoplasm is **cytokinesis.** In plant cells it takes place by **cell plate method.**

A barrel-shaped structure organized in the inter zonal region by remaining spindle fibres at the end of telophase is called -**phragmoplast.**

Cell plate material is secreted by **Golgi vacuoles.**

Fluid plate formed by fusion of Golgi vaculose is called **cell plate.**

Cell plate expands **centrifugally** and transforms into **middle lamellum.**

New primary walls are deposited on either side of the middle lamellum

**Significance of** mitosis.

Growth of the organism is caused and restores the surface to volume ratio of the cell

Genetic continuity and equality are maintained by **mitosis.**

Helps for grafting in vegetative propagations,

wound healing and regeneration are by **mitosis.**

In unicellular organisms cell division helps in reproduction.

**Meiosis**

Cell division which reduces the chromosomal, number to exactly half is **Meiosis.**

**August Weisman** (1887) discovered that chromosomal number is reduced to half in, reproductive cells after meiosis.

Meiosis was discovered in plant cells by **Strasburger.**

The term **'Meiosis'** was coined by - J.B., **Farmer** & J.E. **Moore.**

Meiosis is a must in all sexually reproducing organisms to maintain the constant chromosome number of the species.

Meiosis is an **antithetical process** to **fertilization.** In haploid cells, meiosis does not take place.

Normal meiosis occurs in diploid cells. Cells which undergo meiosis are called **meiocytes.**

Key features of meiosis:

1. The meiotic division takes place at the end of $G_2$ phase of the interphase as in the case of mitotic cell division.
2. It involves sequential cycle of two nuclear division called Meiosis-I and Meiosis-II but only a single cycle of DNA replication takes place
3. Meiosis-I intiates after the parental chromosomes replicates to produce identical sister chromatids at the S-Phase of Interphase
4. Pairing of chromosomes and recombinations
5. Four haploid cells are formed at the end of Meoisis-II

Meiosis I has 4 phases

Prophase I,

Metaphase I,

Anaphase I &

Telophase I.

Prophase I is very lengthy phase (12-24 Hrs.) having 5 sub phases Leptotene, zygotene, pachytene, diplotene and diakinesis.

In Leptotene, nucleus enlarges, chromosomes are very thin and long showing bead-like structures called chromomeres.

Homologous chromosomes pair to form bivalents occurs during Zygotene.

Pairing of homologous maternal and paternal chromosomes forming bivalents is called synapsis.

Synapsis takes place during zygotene.

Synapsis may be proterminal or procentric or random.

Nucleolus enlarges in zygotene.

During pachytene, each chromosome shows two chromatids so that bivalent shows 4 chromatids. Hence they are called pachytene tetrads.

Crossing over takes place at 4 stand stage during pachytene.

Exchange of segments between non-sister chromatids is called crossing over.

Crossing over results in recombinations of linked genes, which ultimately lead to evolution.

Enzymes helping in crossing over are Endonuclease & Ligase.

indicators of points of crossing over are chiasmata.

Chromosomes of bivalents condense by spiralization and Chiasmata are best seen in -Diplotene due to repulsion between homologous chromosomes.

The process of terminalization of chiasmata occurs during diakinesis.

Movement of intermediary chiasmata to ends of chromosomes due to repulsion between homologous chromosomes is called terminalization.

Nuclear envelope and nucleolus disappear during diakinesis.

Bivalents become very thick and short and migrate to the periphery of the nucleus.

Best phase to count chromosomes is diakinesis.

**During metaphase 1**, bipolar spindle is organised and bivalents are arranged at equitorial plane.

Centromeres bivalents are away from equitorial plane, and arms are on equitorial plane.

The homologous chromosomes remain attached by the chiasmata at the telomeric ends.

Homologous chromosomes of each bivalent segregate and move to opposite poles during anaphase -I.

Segregation of homologous chromosomes during anaphase I is called disjunction.

Random segregation of chromosomes during anaphase I is a cause for recombinations of non linked genes.

Two genomes of the parent cell separate due to disjunction.

The number of chromosomes is reduced to half by the end of anaphase - I.

Nuclear membrane and nucleolus reappear in Telophase-I

Two haploid nuclei are formed by the end of telophase - I.

Time gap between meiosis - I & meiosis - II is called interkinesis.

Chromosomes become short and thick, nuclear envelope and nucleolus disappear by the end of prophase - II.

During metaphase - II, two spindles are formed at right angle to the metaphase - I spindle.

Individual chromosomes are arranged at the equitorial plane during metaphase - II.

In meiosis, centromeres divide and daughter' chromosomes move to opposite poles during anaphaseII.

Cytokinesis takes place at tig:,end of meiosis - II and 4 daughter cells are formed.

It is known as simultaneous type of cytokinesis.

In successive type, cytokinesis occurs twice following meiosis -1 and meiosis - II. (Pollen mother cell of maize)

Meiosis results in the formation of 4 haploid cells from one diploid cell.

**Significance:**

Main significance of meiosis is maintainance of constant chromosomal number of the species.

Recombinations of genes caused by crossing over in pachytene lead to evolution.