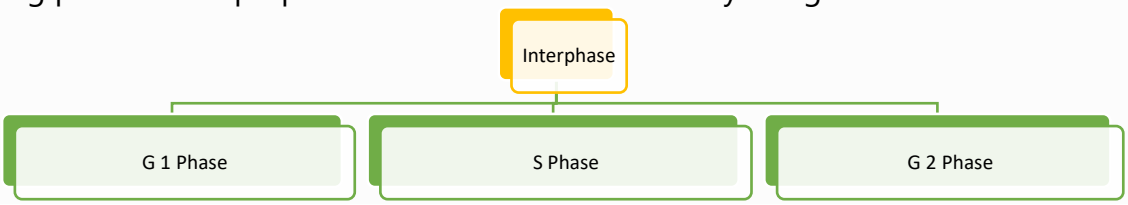
CHAPTER-10
CELL CYCLE AND CELL DIVISION

- The sequence of events by which a cell duplicates its genetic material, synthesizes the other constituents and eventually divides into two daughter cells is called **cell cycle.**
- Cell growth (in terms of cytoplasmic increase) is a continuous process.
- Human cell divides once in approximately 24 hours.
- Vary in different organisms. **Yeasts-90 minutes**

Phases of Cell cycle
Cell cycle is divided into two basic phases-

1. **Interphase**– Phase between two successive M phases.
   Constitute 95% of a cell cycle.
   Resting phase- Cells prepare itself for nuclear division by cell growth.



Gap Phase 1	Synthesis Phase	Gap Phase 2
Cell increases in size (Cytoplasmic growth)	DNA Replication takes place in nucleus	Cell Growth (Cytoplasmic growth) continues.
Duplication of Organelles like ER, Golgi bodies, lysosomes etc.	Centrosomes Duplicates in Cytoplasm (Animal Cell)	Duplication of Organelles like Mitochondria and Plastids
Length of this Phase Vary-Longest Phase	DNA doubles per cell and chromosomes no. remain same.	Protein synthesis in preparation for mitosis.
Cell remains metabolically Active		Increased metabolic rate.
RNA, Protein and Enzyme (Used during M phase) synthesise (in same sequence).		Spindle fibres and asters are formed

Some cells in adult animals cell exit G1 phase and enter inactive G_0 phase. Ex: Heart cell.
Quiescent Stage (G_0)- Cell do not proliferate (divide) but remain metabolically.
Cell can exit G_0 and resume G1 phase whenever required (in case of injury or cell death) so.

M Phase–Mitosis (actual cell division) termed as **Equational division** ***(Chromosomes number same in parental & progeny cells.)***
Karyokinesis (nuclear division) generally followed by cytokinesis (cytoplasm division).

In animals mitosis is present in only somatic diploid cells (exception few insects like male honey bee-drone) but in plants it is seen in both haploid and diploid cells.

Prophase -first & longest phase followed by G2 phase.
1. Initiation of condensation of chromosomal materials.
2. Chromosomes composed of two chromatids.

3. Centrioles move towards opposite poles & radiates out microtubules called asters.
4. Endoplasmic reticulum, Golgi complex & nuclear membrane disappears.

Metaphase

1. Nuclear membrane completely disappears.
2. Condensation complete chromosomes clearly visible (Best stage for morphology of chromosomes)
3. Two sister chromatids attached with spindle fibres with kinetochores (disc-shaped structures at the surface of centromeres of chromosomes)
4. Chromosomes moves & gets aligned to metaphase plate/spindle equator through spindle fibres from both the poles.

Anaphase

1. Two sister chromatids splitting off from each chromosome & now referred as daughter chromosomes.
2. Two chromatids start moving towards opposite poles.
3. Centromere leads towards poles and arms tailing behind

Telophase - last stage

1. Chromosomes reach at opposite poles and loose its identity as discrete unit.
2. Nuclear membrane reappears around the chromosomes.
3. Nucleolus, Golgi complex and ER reappear.

Cytokinesis -division of cytoplasm after karyokinesis (division of nucleus) into two daughter cells.

- In some organisms karyokinesis is not followed by cytokinesis results in multinucleate condition- forms syncytium (e.g. liquid endosperm in coconut).
- **In animal cells**- appearance of furrows in plasma membrane that deepens gradually and joins to divide cytoplasm into two parts.
- **In plant cells**- Wall formation starts at the centre and grows outwards to meet lateral walls. The formation of cell wall begins with formation of **cell plate** that represent middle lamella.

Significance of Mitosis

1. Mitosis occur in diploid cells & produces diploid daughter cells with identical genetic complement.
2. Some lower plants and some social insects' (like male honey bee-drone) haploid cells also divide by mitosis.
3. Helps in repair of cells, especially in lining of gut and blood cells.
4. Meristematic division in apical and lateral cambium results in continuous growth of plants.

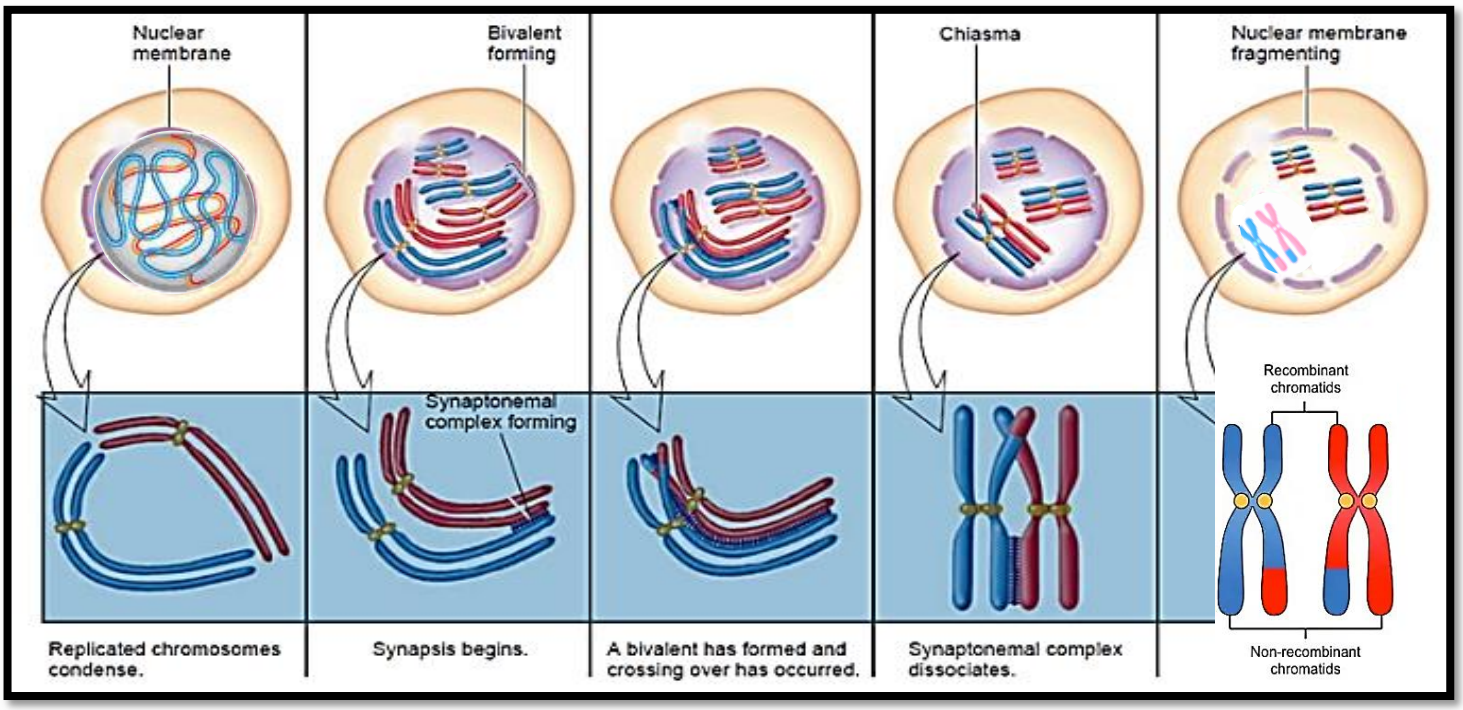
Meiosis- Reductional Division

- Chromosomes no. reduce to half- form haploid daughter cells.
- Occur in diploid germ cell to form haploid gametes in sexually reproducing organisms, diploid phase is restored by fertilization.
- Two sequential cycles of nuclear and cell division called meiosis I and meiosis II but single cycle of DNA replication.
- It involves pairing of homologous chromosome and recombination between non-sister chromatids.
- Four haploid cells are formed at the end of meiosis II.
- Initiate after parental chromosomes have replicated to produce identical sister chromatids at the S phase.

Meiosis I	Meiosis II
• Prophase I	• Prophase II
• Metaphase I	• Metaphase II
• Anaphase I	• Anaphase II
• Telophase I	• Telophase II

Meiosis I

Prophase I



Leptotene	Zygotene	Pachytene	Diplotene	Diakinesis
Chromosomes gradually visible Under light microscope.	Homologous chromosomes start pairing- synapsis	Chromosomes becomes distinct & clearly appears as tetrads	Dissolution of the Synaptonemal complex	Terminalisation of chiasmata
Compaction of chromosomes continues	Accompanied by synaptonemal complex.	Crossing over (exchange of genetic Materia) occurs between non-sister chromatids of the homologous chromosomes.	Bivalents to separate from each other Except at the sites of crossovers- x-shaped structures, called Chiasmata.	Chromosomes are Fully condensed
Short lived stage	Complex formed called Bivalent/Tetrad	Enzyme-mediated process- recombinase	In oocytes of some vertebrates, diplotene can last for Months or years.	Meiotic spindle is prepare for separating homologous chromosomes
	Short lived stage	Recombination completed leaving the chromosomes linked at the sites of crossing over.		Nucleolus and cell organelles disappears and the nuclear envelope also breaks. Transition to Metaphase

Metaphase I

- Bivalent chromosome align at equatorial plate,
- Microtubules from the opposite poles of the spindle get attached to kinetochore of homologous chromosomes.

Anaphase I

- Homologous chromosome separate but sister chromatids remain attached at centromere.
- Homologous chromosomes moves to opposite pole.

Telophase I

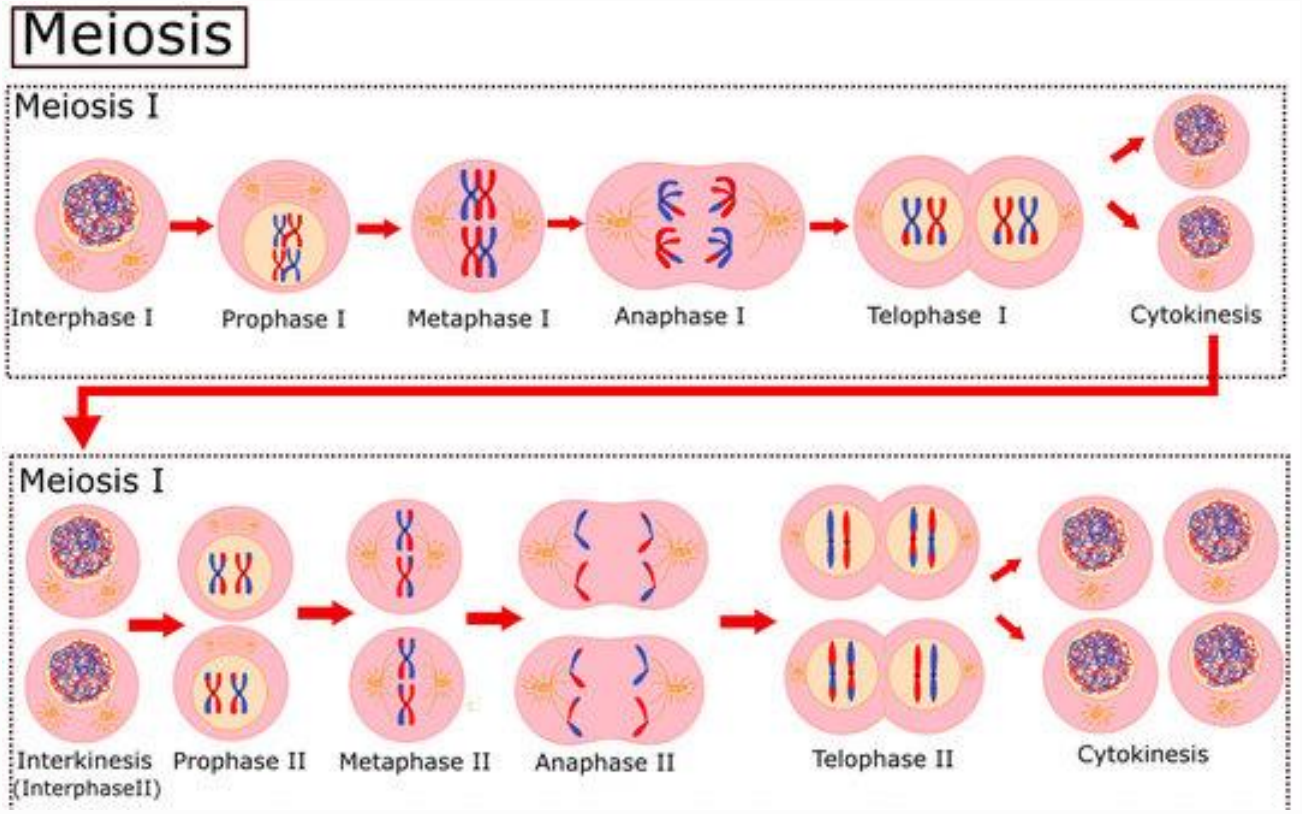
- Nuclear membrane and nucleolus and cell oragnelles reappear.
- Chromosomes starts losing their individual identity.

Cytokinesis

- Furrow divides the cytoplasm forming a dyad of cells
- In many cases the chromosomes do undergo some dispersion, they do not reach the extremely extended state of the interphase nucleus.

Interkinesis

- Stage between two meiotic divisions, generally short lived.
- No replication of DNA.
- Followed by prophase II.



Meiosis II

Prophase II

- Starts before chromosome gets fully elongated.
- Nuclear membrane disappears and chromosome becomes compact.

Metaphase II

- Chromosomes align at equator.
- Microtubules attach with kinetochores of sister chromatids.

Anaphase II

- Splitting of chromosome from centromere.
- Sister chromatin (now referred as Chromosomes) to move towards opposite poles by shortening of microtubules.

Telophase II

- Two groups of chromosomes get enclosed by nuclear membrane.
- Nucleolus and cell organelles reappear.
- Chromosomes starts losing their individual identity.

Cytokinesis

- Furrow divides the cytoplasm of forming a tetrad of cells (four haploid daughter cells).

Significance of meiosis–

1. Forms the haploid gametes by reduction of chromosomes no. to half that are essential for sexual reproduction.
2. Crossing over introduces new recombination of traits leading to genetic variability hence leads to Evolution.
3. Helps in maintenance of chromosome number of sexually reproducing organism.
4. Provides evidence of basic relationship of organisms.