Course- B.Sc. Part-II Botany Subsidiary

PAPER–II

Topic- Cell cycle and Different stages of Mitosis and Meiosis(CYTOLOGY)

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Topic -1

Cell cycle

The cell cycle is an ordered series of events involving cell growth and cell division.The cell cycle has two major phases

1 The interphase and

2. the Mitotic phase.

During interphase the cell prepares itself by accumulating nutrient and raw material for mitotic phase, During this stage which is divided into G1, s and G2

G1 Phase

During this phase little change is visible although the cell is biochemically very active. The cell during this stage remains busy accumulating building blocks for new DNA molecule besides conserving the existence of native parental DNA. Associated proteins for such action are also synthesized. Enough energy sources is required for DNA replication for the cell conserves during this phase.

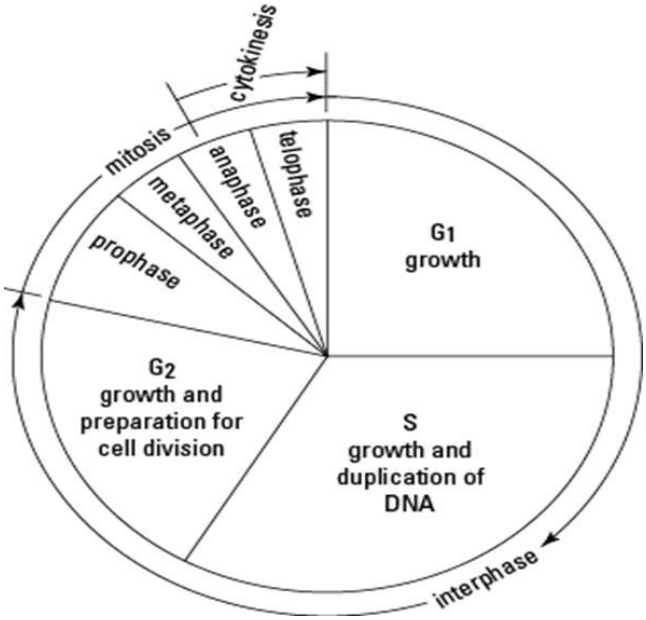
S phase

S phase is the period of wholesale DNA synthesis during which the cell replicates its genetic content; a normal diploid somatic cell with a 2N complement of DNA at the beginning of S phase acquires a 4N complement of DNA at its end. (Recall that N = 1 copy of each chromosome per cell [haploid]; 2N = 2 copies [diploid].) The duration of S phase may vary from only a few minutes in rapidly dividing, early embryo cells to a few hours in most somatic cells. Early embryo cells generally “live off” the accumulated stores of maternal RNA and proteins present in the egg and are transcriptionally silent, whereas cells in later development and mature organisms must actively transcribe subsets of their genes to survive and maintain specialized functions. The longer time required for the latter to complete S phase probably allows these cells to coordinate DNA replication with transcription and to preserve higher-order gene and chromatin structural information that influences gene expression for transmission to progeny cells.

G2 phase

During this stage the cell stores energy and synthesizes proteins required for manipulation of Chromosomes. G2 phase and the beginning of mitosis are denoted by a 4-N DNA content. Following

DNA replication and prior to cell division (cytokinesis), cells must maintain the integrity and proximity of the recently duplicated chromosomes (sister chromatids).



Different stages of Cell cycle

Topic -2

Mitosis

Interphase occurs prior to the beginning of mitosis and encompasses what's called stage G1, or first gap, stage S, or synthesis, and stage G2, or second gap. Stages G1, S, and G2 must always occur in this order. The cell cycle begins with stage G1, which is a part of interphase.

During interphase, the cell is busy growing. It's producing proteins and cytoplasmic organelles during the G1 phase, duplicating its chromosomes during the S phase, and then continuing to grow in preparation for mitosis in the G2 phase.

Prophase

Prophase is the first step of mitosis. This is when the genetic fibers within the cell's nucleus, known as chromatin, begin to condense and become tightly compacted together.

During interphase, the parent cell's chromosomes are replicated, but they aren't yet visible. They're just floating around in the form of loosely collected chromatin. During prophase, that loose chromatin condenses and forms into visible, individual chromosomes.

Since each of the parent cell's chromosomes was replicated during interphase, there are two copies of each chromosome in the cell during prophase. Once the chromatin has condensed into individual chromosomes, the genetically-identical chromosomes come together to form an "X" shape, called sister

chromatids.

These sister chromatids carry identical DNA and are joined at the center (in the middle of the "X" shape) at a point called the centromere. The centromeres will serve as anchors that'll be used to pull the sister chromatids apart during a later phase of mitosis.

After the sister chromatids form, two structures called centrosomes move away from each other outside of the nucleus. As they move to opposite sides of the cell, the centrosomes form something called the mitotic spindle. The mitotic spindle will eventually be responsible for separating the identical sister chromatids into two new cells and is made up of long protein strands, called microtubules.

Late Prophase: Prometaphase

Prometaphase is often referred to as "late prophase." (Though it's also sometimes called "early metaphase" or referred to as a distinct phase entirely!) Regardless, some really important things occur during prometaphase that propel cell division along and that help explain what happens in metaphase.

Prometaphase is the phase of mitosis following prophase and preceding metaphase. The short version of what happens during prometaphase is that the nuclear membrane breaks down.

During Late Prometaphase , the nuclear membrane or nuclear envelope (i.e. the lipid bilayer surrounding the nucleus and encasing the genetic material in the nucleus) breaks apart into a bunch of membrane vesicles. Once the nuclear envelope breaks apart, the sister chromatids that were stuck inside the nucleus break free.

Now, the kinetochore microtubules move near the sister chromatids and attach to them at the centromere (that spot at the center of the "X"). Now these kinetochore microtubules are anchored at opposite poles on either end of the cell, so they're extending themselves toward the sister chromatids and connecting them to one of the edges of the cell.

Metaphase

Metaphase is the phase of mitosis that follows prophase and prometaphase and precedes anaphase. Metaphase begins once all the kinetochore microtubules get attached to the sister chromatids' centromeres during prometaphase. The force generated during prometaphase causes the microtubules to start pulling back and forth on the sister chromatids. Since the microtubules are anchored at opposite ends of the cell, their back-and-forth pulling on different sides of the sister chromatids gradually shifts the sister chromatids to the middle of the cell. This equal and opposite tension causes the sister chromatids to align along the equator.

Anaphase

The third phase of mitosis, following metaphase and preceding telophase, is anaphase. Since the sister chromatids began attaching to centrosomes on opposite ends of the cell in metaphase, they're prepped and ready to start separating and forming genetically-identical daughter chromosomes during anaphase.

During anaphase, the centromeres at the center of the sister chromatids are severed. (It sounds worse than it is!) Remember how the sister chromatids are attached to the mitotic spindle? The spindle is made up of microtubules, which start shrinking during this phase of mitosis. They gradually pull the severed sister chromatids toward opposite poles of the cell. Finally, during the second half of anaphase,

the cell begins to elongate as polar microtubules push against each other.. At the end of anaphase, chromosomes reach their maximum condensation level. This helps the newly separated chromosomes stay separated and prepares the nucleus to re-form which occurs in the final phase of mitosis.

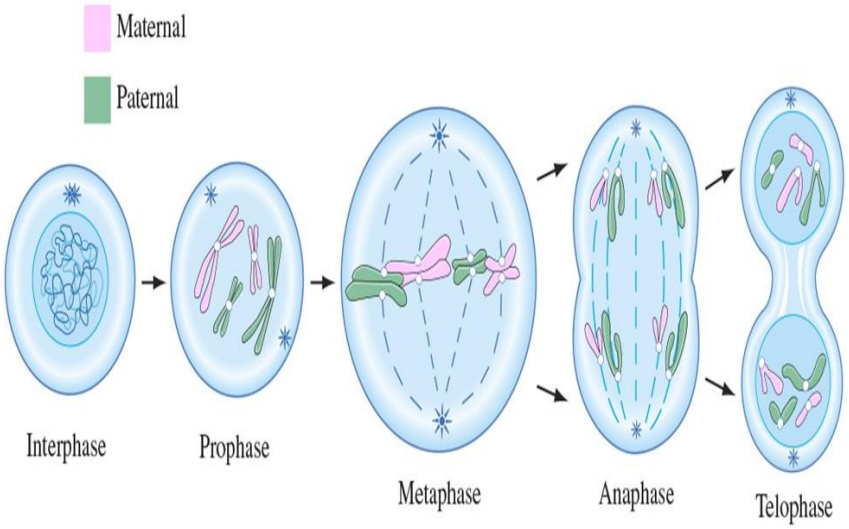
Telophase

Telophase is the last phase of mitosis. Telophase is when the newly separated daughter chromosomes get their own individual nuclear membranes and identical sets of chromosomes.

Toward the end of anaphase, the microtubules began pushing against each other and causing the cell to elongate. Those polar microtubules keep elongating the cell during telophase. In the meantime, the separated daughter chromosomes that are being pulled to opposite ends of the cell finally arrive at the mitotic spindle.

Cytokinesis

Cytokinesis is the actual division of the cell membrane into two discrete cells. At the end of mitosis, there are two new nuclei contained within the existing parent cell, which has stretched out into an oblong shape. So at this point, there's actually two complete nuclei hanging out in one cell! Cytokinesis is responsible for completing the process of cell division by taking those new nuclei, separating the old cell in half, and ensuring that each of the new daughter cells contains one of the new nuclei.



Meiosis

Sexual reproduction in organisms takes place through the fusion of male and female gametes, the sperm and the egg respectively. Gametes are haploid in nature, i.e., they contain only half the number of chromosomes. This genetic content makes them different from other body cells. Meiosis leads to the formation of haploid cells.

Meiosis 1

Mitotic cell division is equational in nature while meiosis is a reduction division. The salient features of meiotic division that make it different from mitosis are as follows:-

It occurs in two stages of the nuclear and cellular division as Meiosis I and Meiosis II. DNA replication occurs, however, only once. It involves the pairing of homologous chromosomes and recombination between them. Four haploid daughter cells are produced at the end, unlike two diploid daughter cells in mitosis.Meiosis 1 separates the pair of homologous chromosomes and reduces the diploid cell to haploid. It is divided into several stages that include, prophase, metaphase, anaphase and telophase.

Meiosis

Meiosis 1 Stages

The different stages of meiosis 1 can be explained by the following phases :

Prophase 1

Metaphase 1

Anaphase 1

Telophase

Prophase I is longer than the mitotic prophase and is further subdivided into 5 substages,

leptotene

zygotene

pachytene

diplotene

diakinesis

The chromosomes begin to condense and attain a compact structure during leptotene.

In zygotene, the pairing of homologous chromosomes starts a process known as chromosomal synapsis, accompanied by the formation of a complex structure called synaptonemal complex. A pair of synapsed homologous chromosome forms a complex known as bivalent or tetrad.

At pachytene stage, crossing over of non-sister chromatids of homologous chromosomes occurs at the recombination nodules. The chromosomes remain linked at the sites of crossing over.

Diplotene marks the dissolution of the synaptonemal complex and separation of the homologous chromosomes of the bivalents except at the sites of cross-over. The X-shaped structures formed during separation are known as chiasmata.

Diakinesis is marked by the termination of chiasmata and assembly of the meiotic spindle to separate the homologous chromosomes. The nucleolus disappears and the nuclear envelope breaks down.

Meiosis 1 Metaphase 1

The bivalents align at the equatorial plate and microtubules from the opposite poles attach to the pairs of homologous chromosomes.

Meiosis 1 Anaphase 1

The two chromosomes of each bivalent separate and move to the opposite ends of the cells. The sister chromatids are attached to each other.

Meiosis 1 Telophase 1

The nuclear membrane reappears and is followed by cytokinesis. This gives rise to a dyad of cells.

Phases of Meiosis II

During prophase II, chromosomes condense and the nuclear envelope breaks down, if needed. The centrosomes move apart, the spindle forms between them, and the spindle microtubules begin to capture chromosomes. The two sister chromatids of each chromosome are captured by microtubules from opposite spindle poles.

In metaphase II, the chromosomes line up individually along the metaphase plate.

In anaphase II, the sister chromatids separate and are pulled towards opposite poles of the cell.

In telophase II, nuclear membranes form around each set of chromosomes, and the chromosomes decondense.

Cytokinesis splits the chromosome sets into new cells, forming the final products of meiosis: four haploid cells in which each chromosome has just one chromatid. In humans, the products of meiosis are sperm or egg cells.