Cell cycle and cell division

Cell cycle : a series of events that controls cell growth and cell division. That aim to produce two daughter cells, each containing chromosomes identical to those of the parent cell. The cell cycle incorporates two principal phases: the interphase, and the M phase (mitosis).

1. Interphase:

It representscontinuous growth of the cell and is subdivided into three phases, G1 (gap1) phase, S (synthesis) phase, and G2 (gap 2) phase.

A. The G1 phase

1.It is usually the longest and the most variable phase of the cell cycle

2. G1 Phase begins at the end of M phase until s phase .

3. During the G1 phase:

- The cell attains its full size and gathers nutrients
- synthesizes RNA and proteins which are necessary for DNA synthesis and chromosome replication.
- *At the end of this phase Duplication of centrosomes are start*ed

B. The S phase (DNA replication)

During this phase

- The DNA of the cell is doubled and new chromatids are formed. Now two sister chromatid attached by centromere

C. The G2 phase (cell preparation for cell division)

It starts by the end of DNA replication and last until the beginning of mitosis

At this phase

- Proteins and energy essential to mitosis (cell division) are stored.
- *Duplication of centrosome is completed* .

Remember: Chromosomes during interphase: At G1phase:46 single chromosome (chromatid) while At S phase and G2 phase 46 double chromosome (sister chromatid)

G0 Phase (G-zero Phase)

The G0 phase is a resting stage in the cell cycle where Cells in G0 are not preparing to divide. They may have left the cell cycle either temporarily or permanently, depending on the type of cell and its conditions.

- Some cells can return to the cell cycle from G0 when triggered by signals (like growth factors), while others, like fully specialized cells, may stay in G0 forever.
- Cells in G0 perform their specific functions, maintain their metabolism, and can respond to their environment. They may also differentiate during this time.
- Such as neurons and muscle cells, often remain in G0 because they don't divide often.

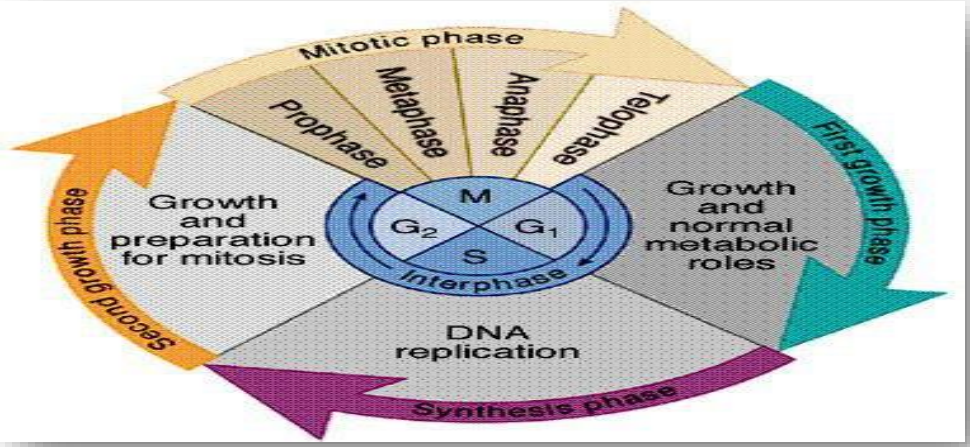

Figure (1) cell cycle

Cell Cycle Checkpoints are internal regulatory mechanisms within the cell cycle that ensure proper progression through different stages of cell division. They are biochemical pathways that monitor various conditions, such as cell size and DNA integrity, and determine whether a cell can advance to the next phase of the cell cycle.

- Checkpoints monitor and modulate the progression of cells through the cell cycle in response to intracellular or environmental signals.'

The restriction checkpoint which is the most critical Checkpoints in the cell cycle. At this checkpoint, the cell evaluates whether it can enter the S phase and continue dividing or if it should exit the cycle.

- If a cell does not meet the required criteria at these checkpoints, cell may stop its cycle, enter a resting state (G0 phase), or undergo apoptosis (programmed cell death) if it has damage.

The mitotic catastrophe : It is defined as the failure to stop the cell cycle before or during mitosis, leading to improper separation of chromosomes. Can occur if there is a malfunction in any of the checkpoints during the G1, S, G2, or M phases of the cell cycle.

Normally, cells that encounter such issues will die through a process called apoptosis (programmed cell death). However, if these cells do not undergo apoptosis, they may divide unevenly in the next cell division. This results in the formation of aneuploidy cells, which have an abnormal number of chromosomes. Therefore, mitotic catastrophe can be considered a mechanism that contributes to the development of tumors (oncogenesis).

2. Mitosis (M) phase

Mitosis is a process of chromosome segregation and nuclear division followed by cell division that produces two daughter cells with the same chromosome number and DNA content as the parent cell.

- Cell division is a crucial process that increases the number of cells, permits renewal of cell populations, and allows wound repair.

  Cell division (mitosis) involve :

  - nucleus division (karyokinesis) which involves four stages: Prophase , Metaphase , Anaphase and Telophase
  - Cytoplasm division (cytokinesis) which results in distribution of nonnuclear organelles into two daughter cells.

❖ Phases of Mitosis

A. Prophase:

1. Condensation of chromatin gives rise to 46 rod-shaped short chromosomes.
2. Each centrosome migrates to the opposite pole of the cell, forming the mitotic spindles
3. The nucleolus disappears.
4. The nuclear envelope breaks up.

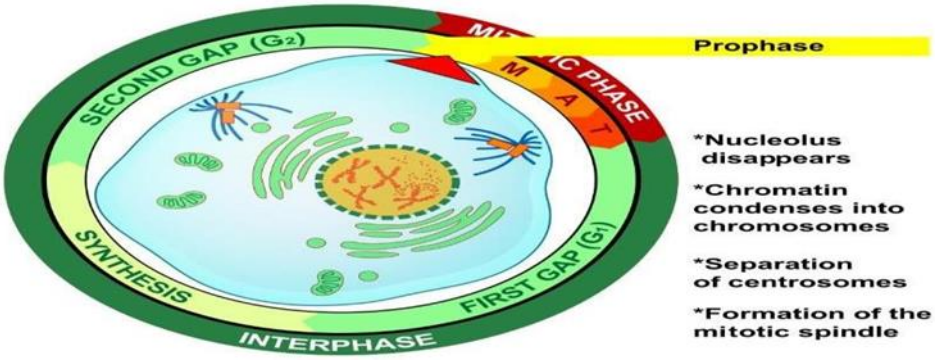

Figure (2) mitotic prophase

B. Metaphase:

1. The 46 d-chromosomes become maximally condensed.
2. The chromosomes align at the equatorial plate (metaphase plate) of the cell.

Each pair of sister chromatids is attached to the mitotic spindles at the kinetochore on each chromatid.

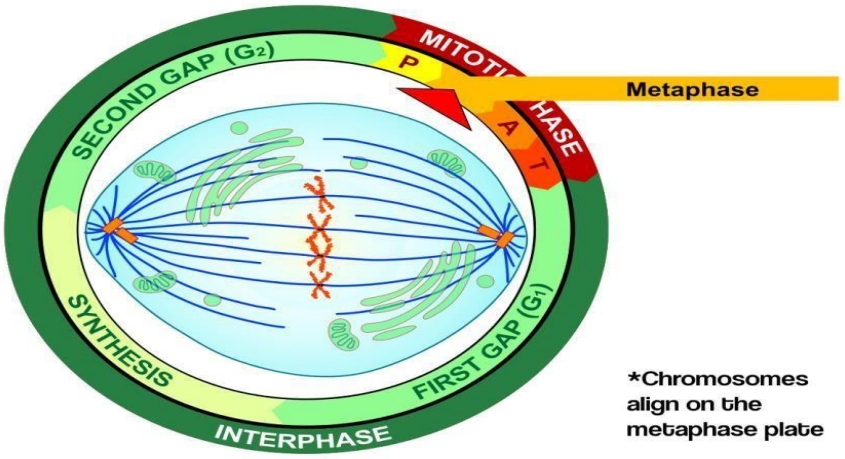

Figure (3) mitotic metaphase

Kinetochores are specialized protein complexes located on the centromere of each chromatid, at which spindle fibers of centrosome are attach.

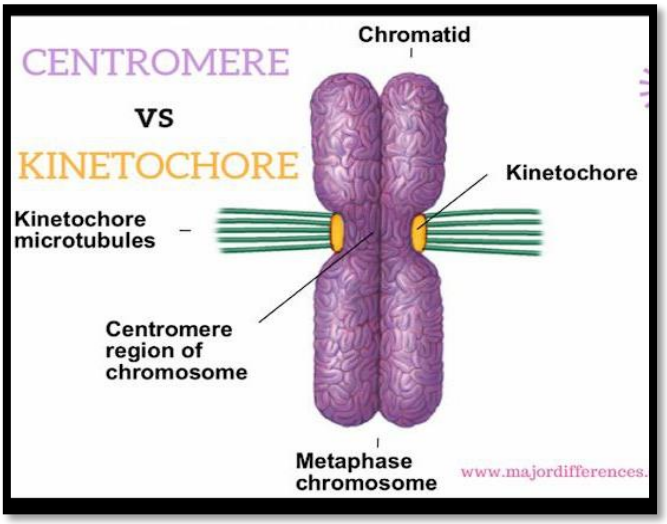

Figure (4) kinetochore at metaphase chromosome

Note : karyotyping done at metaphase

Anaphase:

1. Sister chromatids are Separate at this phase and they migrate to opposite poles of the cell as spindle fibers shortening, pulling the chromatids apart

2. In late anaphase, a groove called the cleavage furrow forms at the cell's equator that mean the start of cytokinesis (cytoplasm division).

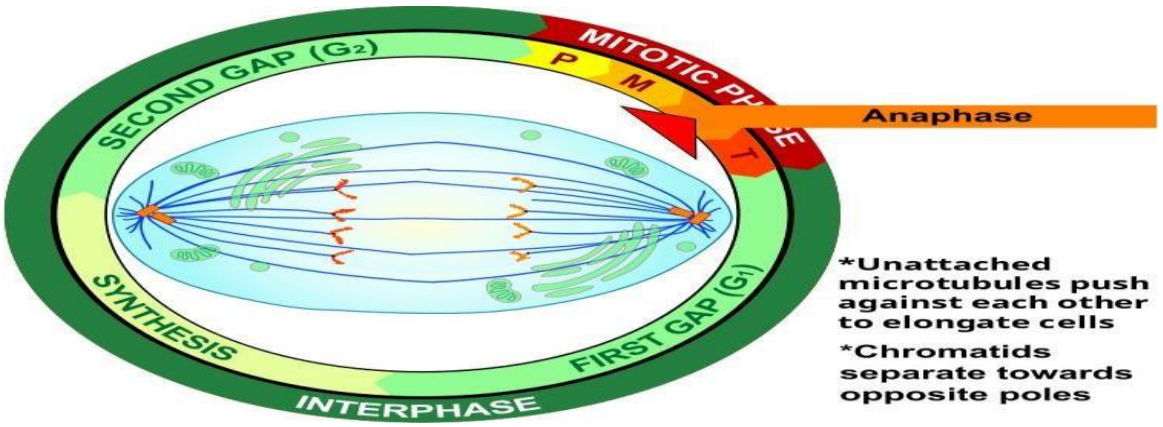

Figure (5) mitotic anaphase

C. Telophase:

1. The separated chromatids (now individual chromosomes) begin to uncoil and decondense back into chromatin, making them less visible.
2. Mitotic spindle fibers disappears
3. Nuclear envelopes reappears around each set of chromosomes creating two distinct nuclei.
4. Nucleolus Reappears
5. Completion of Cytokinesis: The cleavage furrow deepens, and the cytoplasm divides, resulting in two separate daughter cells, each with a complete set of chromosomes and organelles.

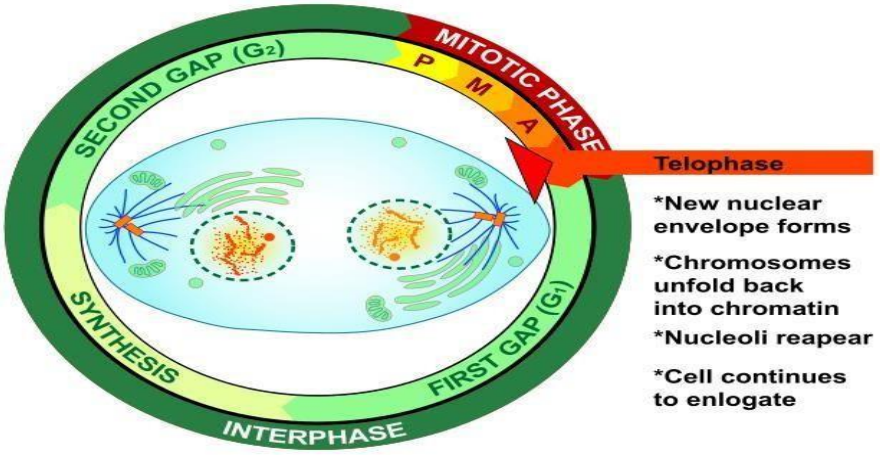

Figure (6): Mitotic Telophase.

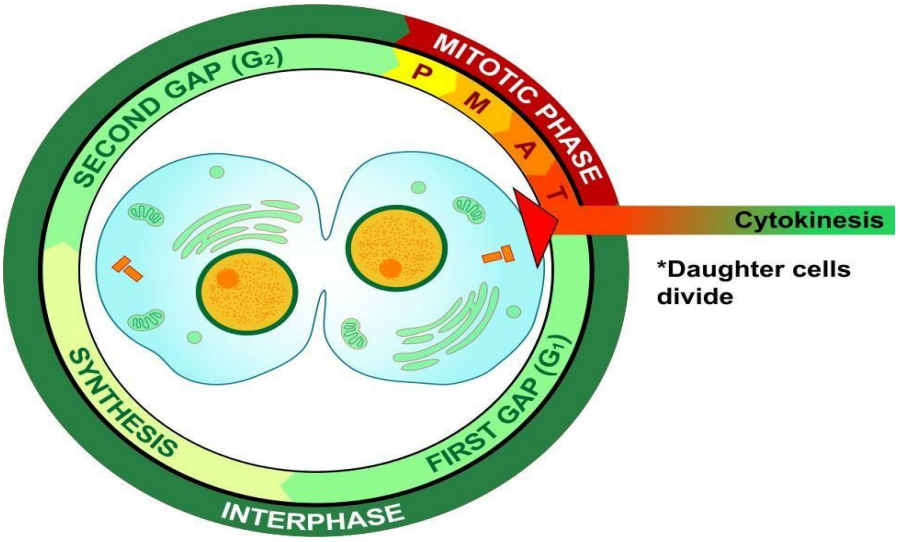

Figure (7) cytokinesis

Comparison between mitotic prophase and mitotic telophase

Mitotic prophase	Mitotic telophase
1. The first stage of mitosis.	1. The final stage of mitosis.
2. Chromosomes condense and become visible as distinct structures, each consisting of two sister chromatids.	2. Chromosomes begin to de-condense back into chromatin, making them less visible.
3. The nuclear envelope starts to break down. .	3.The nuclear envelope re-forms around each set of chromosomes at opposite poles
4. The mitotic spindle begins to form and attach to the kinetochores of chromosomes.	4.The spindle disappears
5. Chromosomes are not yet aligned; they begin to move towards the center of the cell.	5. Chromosomes are at opposite ends of the cell and are no longer aligned
6. Cytokinesis has not yet begun.	6. Telophase is often followed by cytokinesis, where the cell divides into two daughter cells.