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CELL DIVISION

BY

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❖ CELL CYCLE

Cell division is a very important process in all living organisms. During the division of a cell, DNA replication and cell growth also take place. All these processes, i.e., cell division, DNA replication, and cell growth, hence, have to take place in a coordinated way to ensure correct division and formation of progeny cells containing intact genomes. The sequence of events by which a cell duplicates its genome, synthesises the other constituents of the cell and eventually divides into two daughter cells is termed cell cycle. Although cell growth (in terms of cytoplasmic increase) is a continuous process, DNA synthesis occurs only during one specific stage in the cell cycle. The replicated chromosomes (DNA) are then distributed to daughter nuclei by a complex series of events during cell division. These events are themselves under genetic control.

❖ Phases of Cell Cycle

A typical eukaryotic cell cycle is illustrated by human cells in culture. These cells divide once in approximately every 24 hours (Figure 1).

However, this duration of cell cycle can vary from organism to organism and also from cell type to cell type. Yeast for example, can progress through the cell cycle in only about 90 minutes.

The cell cycle is divided into two basic phases:

- Interphase
- M Phase (Mitosis phase)

The M Phase represents the phase when the actual cell division or mitosis occurs, and the interphase represents the phase between two successive M phases. It is significant to note that in the 24-hour average duration of cell cycle of a human cell, cell division proper lasts for only about an hour. The interphase lasts more than 95% of the duration of cell cycle.

The M Phase starts with the nuclear division, corresponding to the separation of daughter chromosomes (karyokinesis) and usually ends with division of cytoplasm (cytokinesis). The interphase, though called the resting phase, is the time during which the cell is preparing for division by undergoing both cell growth and DNA replication in an orderly manner.

The interphase is divided into three further phases:

- G1 phase (Gap 1)
- S phase (Synthesis)
- G2 phase (Gap 2)

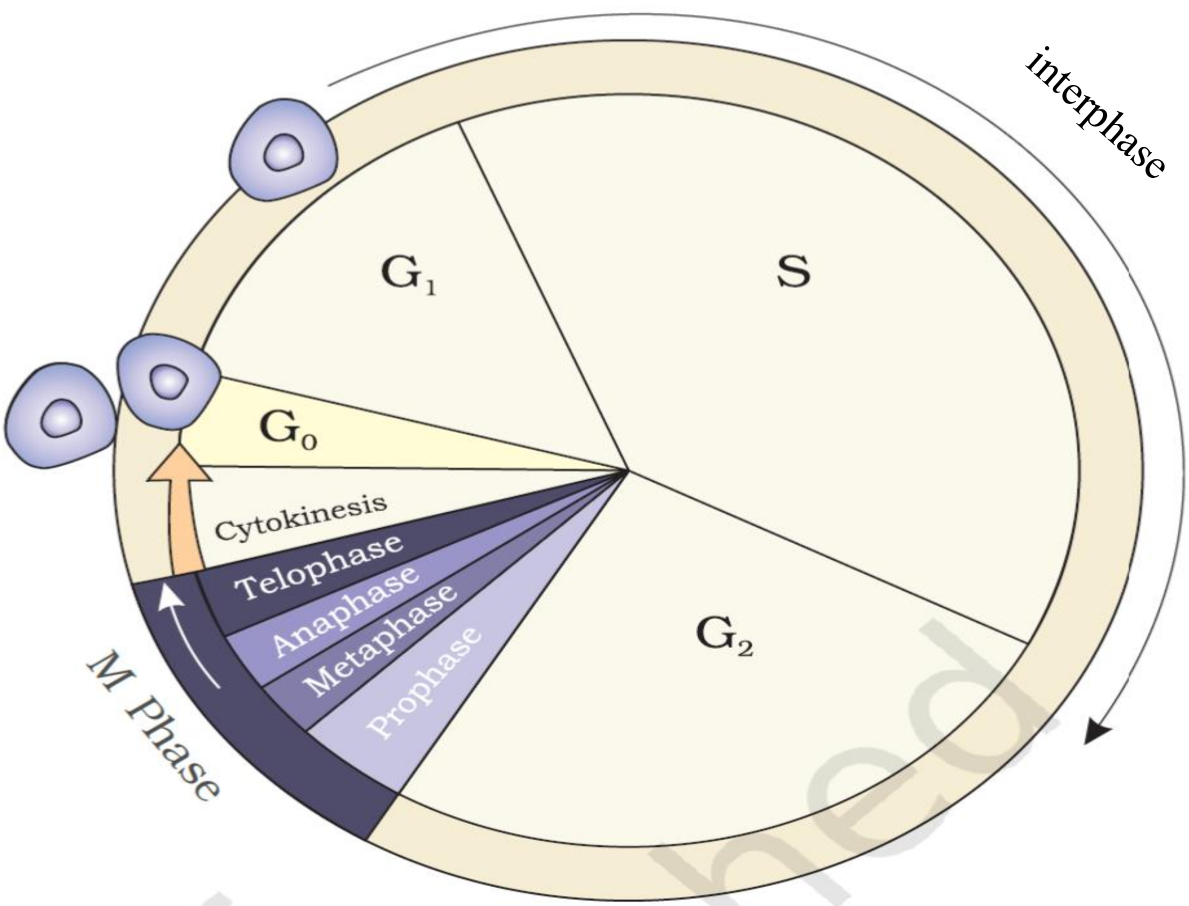

Figure 1 A diagrammatic view of cell cycle indicating formation of two cells from one cell

https://www.youtube.com/watch?v=dI6gaF_iQcs

G1 phase corresponds to the interval between mitosis and initiation of DNA replication. During G1 phase the cell is metabolically active and continuously grows but does not replicate its DNA. S or synthesis phase marks the period during which DNA synthesis or replication takes place.

During this time the amount of DNA per cell doubles. If the initial amount of DNA is denoted as 2C then it increases to 4C. However, there is no increase in the chromosome number; if the cell had diploid or 2n number of chromosomes at G1, even after S phase the number of chromosomes remains the same, i.e., 2n.

In animal cells, during the S phase, DNA replication begins in the nucleus, and the centriole duplicates in the cytoplasm. During the G2 phase, proteins are synthesized in preparation for mitosis while cell growth continues.

Some cells in the adult animals do not appear to exhibit division (e.g., heart cells) and many other cells divide only occasionally, as needed to replace cells that have been lost because of injury or cell death. These cells that do not divide further exit G1 phase to enter an inactive stage called quiescent stage (G0) of the cell cycle. Cells in this stage remain metabolically active but no longer proliferate unless called on to do so depending on the requirement of the organism.

In animals, mitotic cell division is only seen in the diploid somatic cells. Against this, the plants can show mitotic divisions in both haploid and diploid cells.

❖ MITOSIS (M phase)

This is the most dramatic period of the cell cycle, involving a major reorganization of virtually all components of the cell. Since the number of chromosomes in the parent and progeny cells is the same, it is also called as equational division. Though for convenience mitosis has been divided into four stages of nuclear division:

- Prophase, Metaphase, Anaphase and Telophase

Prophase

Prophase which is the first stage of mitosis follows the S and G2 phases of interphase. In the S and G2 phases the new DNA molecules formed are not distinct but intertwined. Prophase is marked by the initiation of condensation of chromosomal material. The chromosomal material becomes untangled during the process of chromatin condensation (Figure 2 a). The centriole, which had undergone duplication during S phase of interphase, now begins to move towards opposite poles of the cell. The completion of prophase can thus be marked by the following characteristic events:

- Chromosomal material condenses to form compact mitotic chromosomes.
- Initiation of mitotic spindle microtubules.

- Cells at the end of prophase, when viewed under the microscope, do not show Golgi complexes, endoplasmic reticulum, nucleolus and the nuclear envelope.

Metaphase

The second phase of mitosis the chromosomes are spread through the cytoplasm of the cell. by this stage, condensation of chromosomes is completed, and they can be observed clearly under the microscope. This then, is the stage at which morphology of chromosomes is most easily studied. At this stage, metaphase chromosome is made up of two sister chromatids, which are held together by the centromere (Figure 2 b). Small disc-shaped structures at the surface of the centromeres are called kinetochores. These structures serve as the sites of attachment of spindle fibers. The key features of metaphase are:

- Spindle fibers attach to kinetochores of chromosomes.
- Chromosomes are moved to spindle equator and get aligned along metaphase plate through spindle fibers to both poles.

Anaphase

At the onset of anaphase, each chromosome arranged at the metaphase plate is split simultaneously and the two daughter chromatids and begin their migration towards the two opposite poles. As each chromosome moves away from the equatorial plate, the centromere of each chromosome is towards the

(Figure 2 c). Thus, anaphase stage is characterized by the following key events:

- Centromeres split and chromatids separate.
- Chromatids move to opposite poles.

Telophase

At the beginning of the final stage of mitosis, i.e., telophase, the chromosomes that have reached their respective poles decondense and lose their individuality. (Figure 2 d). This is the stage which shows key events:

- Chromosomes cluster at opposite spindle poles and their identity is lost as discrete elements.
- Nuclear envelope assembles around the chromosome clusters.
- Nucleolus, Golgi complex and ER reform.

Cytokinesis

Mitosis accomplishes not only the segregation of duplicated chromosomes into daughter nuclei (karyokinesis), but the cell itself is divided into two daughter cells by a separate process called cytokinesis at the end of which cell division is complete (Figure 2 e). In an animal cell, this is achieved by the appearance of a furrow in the plasma membrane.

The furrow gradually deepens and ultimately joins in the center dividing the cell cytoplasm into two, organelles like mitochondria get distributed between the two daughter cells. https://www.youtube.com/watch?v=DwAFZb8juMQ

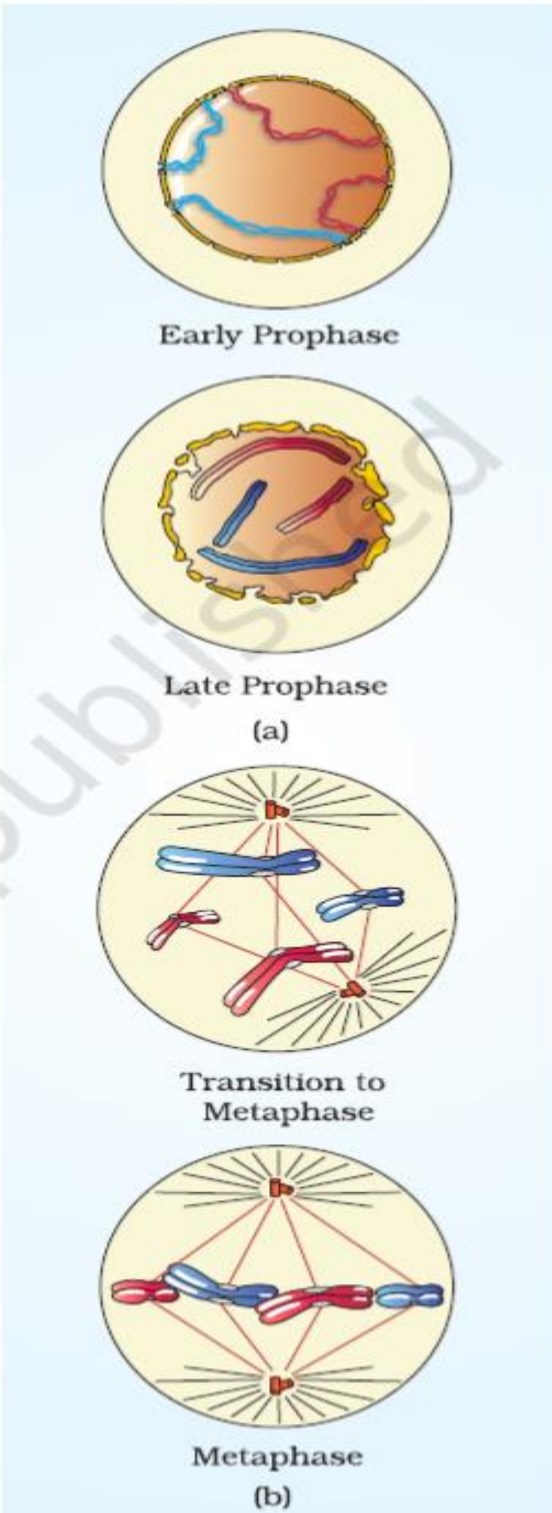

Figure 2 a and b : A diagrammatic view of stages in mitosis

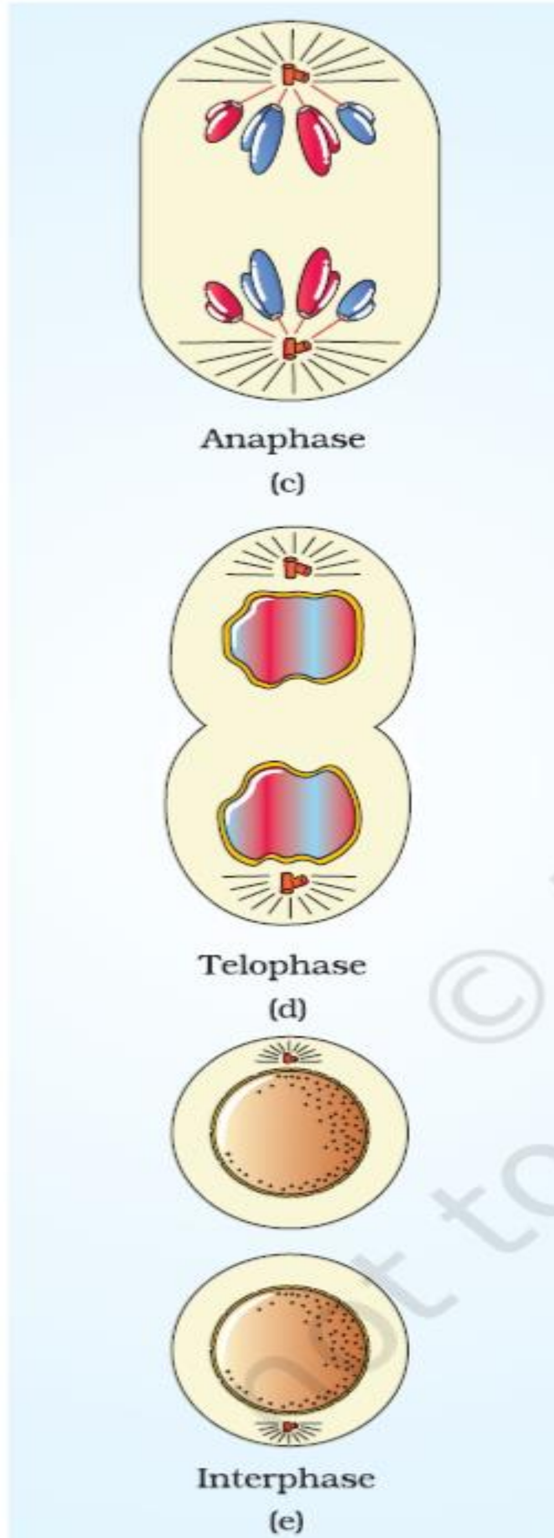

Figure 2 c to e : A diagrammatic view of stages in Mitosis