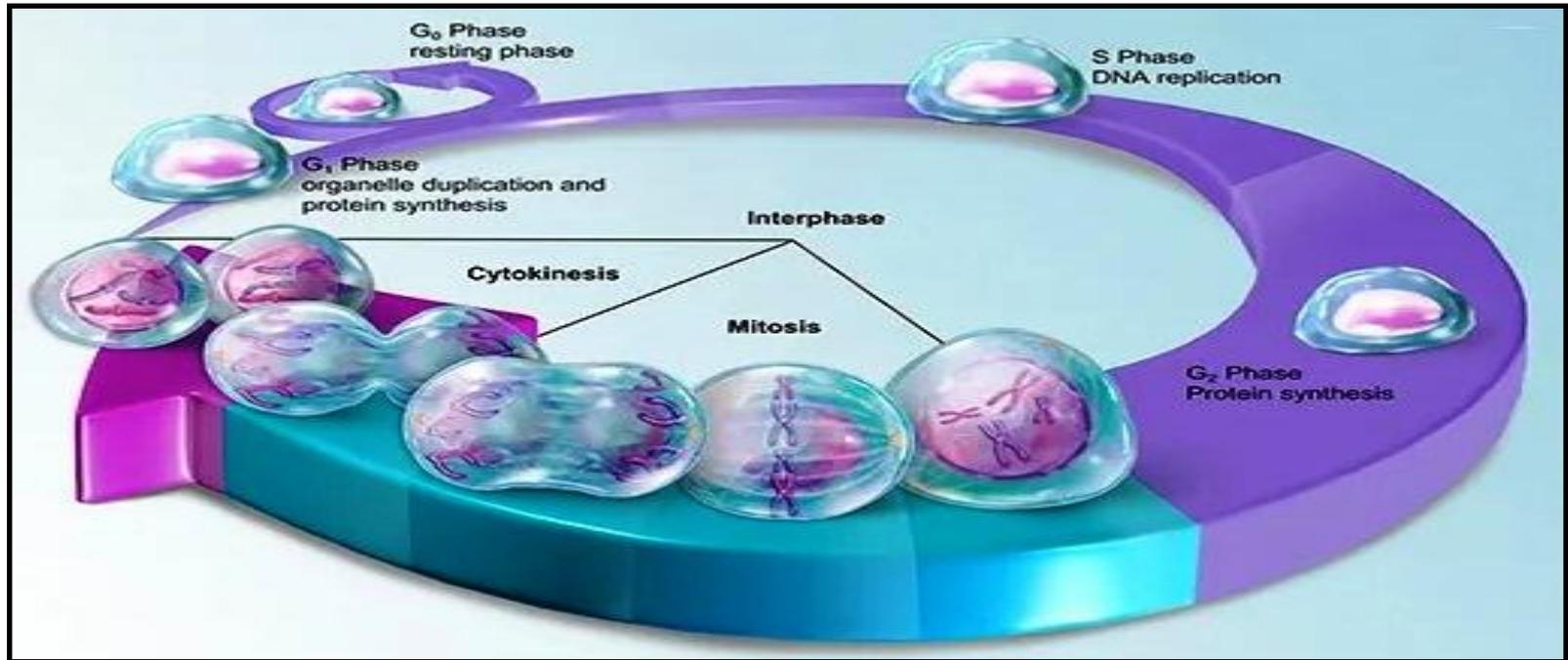


CELL CYCLE



By

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OBJECTIVES

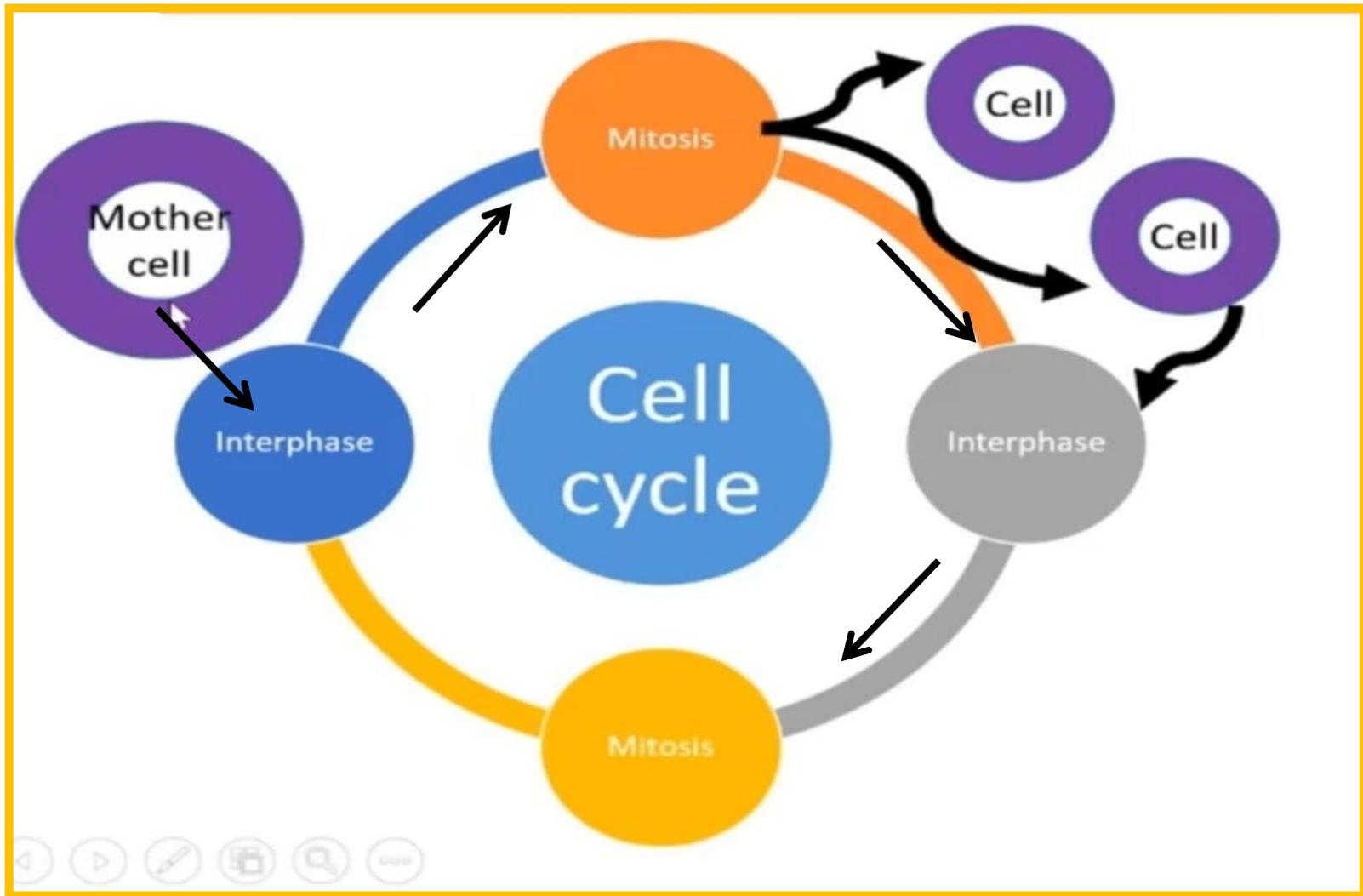
- ✓ Identify various stages of cell cycle.
- ✓ Describe the events that occur in every stage of the cell cycle including; interphase and mitosis.
- ✓ Know the checkpoints along the cell cycle.

Cell cycle

Is divided into two major events:

1-Mitosis: the **short** period of time during which **the cell** divides its nucleus and cytoplasm giving rise to **two daughter cells** each containing the same number of chromosomes (identical to the parent cell).

2-Interphase: a **longer** period of time **between two successive divisions**, during which the cell **increases** its size and content and replicates its genetic material.



Triggers for cell to enter the cell cycle

- Mechanical force
- Injury
- Cell death.

Interphase

is subdivided into three phases:

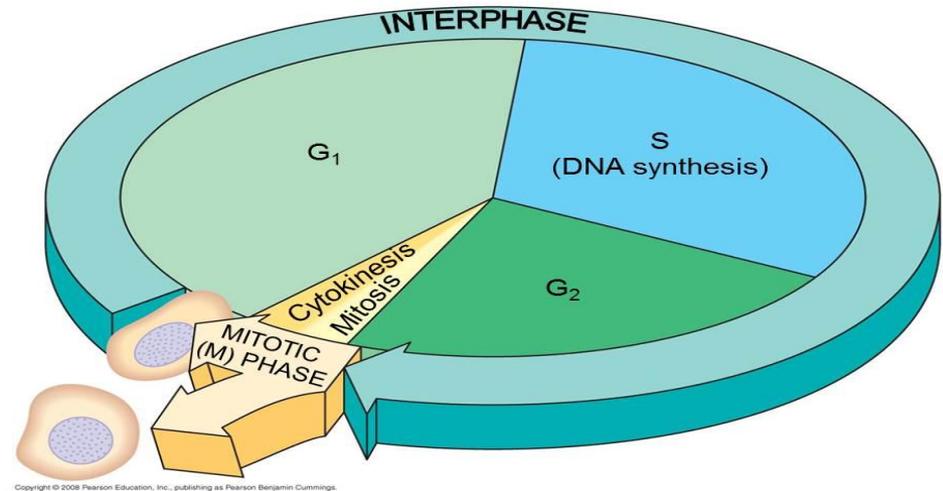
G1 (gap 1) phase

For **synthesis** of **macromolecules** essential for DNA duplication.

S [synthetic] phase

DNA is duplicated.

G2 (gap 2) phase



The cell undergoes **preparations** for mitosis.

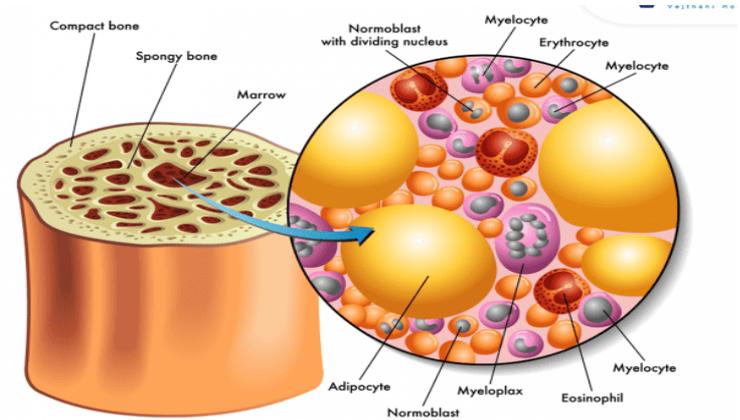
The cell **grows** during the 3 phases

G1 (gap 1) phase (pre-duplication)

- **Definition:** it is the period between the end of mitosis and the beginning of S phase.
- **Duration:** the longest period.
- **During this phase:** The daughter cells formed during previous mitosis **start to:**
 - Synthesize **RNA** and proteins.
 - Synthesize essential **proteins for DNA replication**
 - **Restore** their normal size.

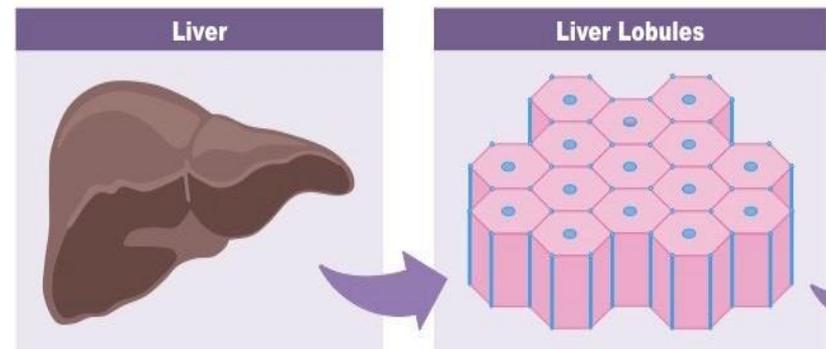
❑ In highly proliferating cells :

- **G1 phase is short**
- e.g. stem cells of bone marrow



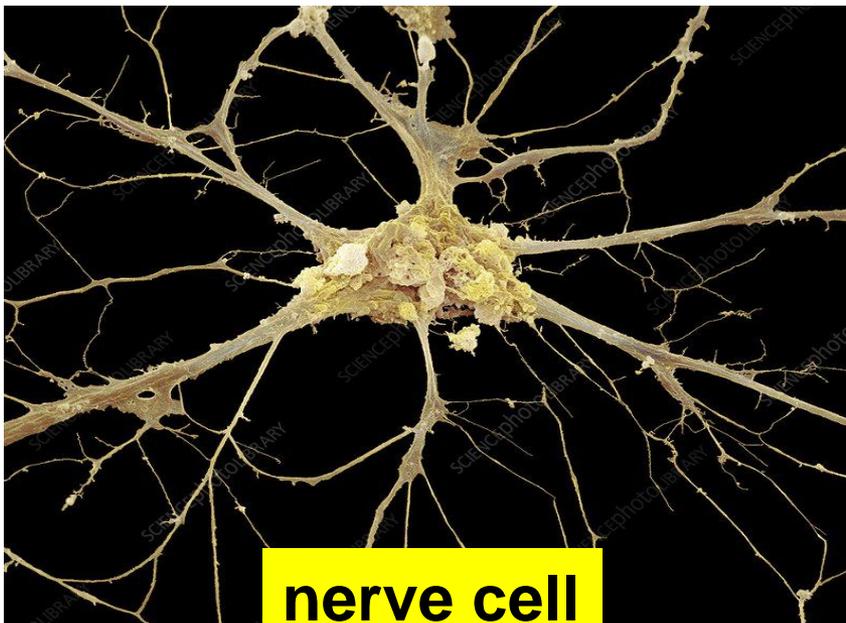
❑ Highly differentiated cells : may leave the cell cycle at **G1** phase either:

- Temporarily (e.g. hepatocyte) may enter the cycle again to repair and regenerate damaged cells (**Prolonged G1 phase**).

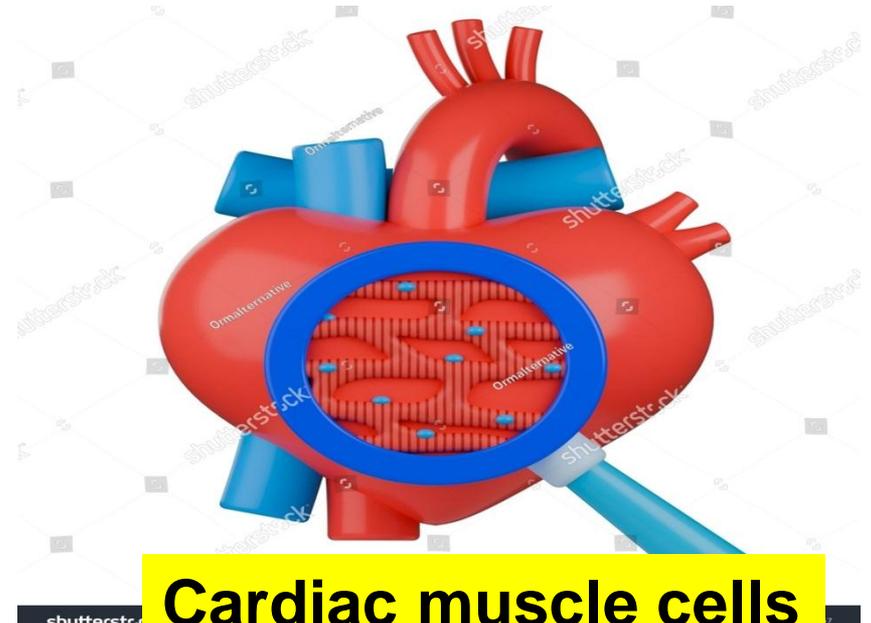


➤ **Permanently**

- e.g. nerve cells and cardiac muscle
- There is **no repair** if the cells are damaged.
- These cells are said to be in resting stage, **the *G0 (outside) phase.***



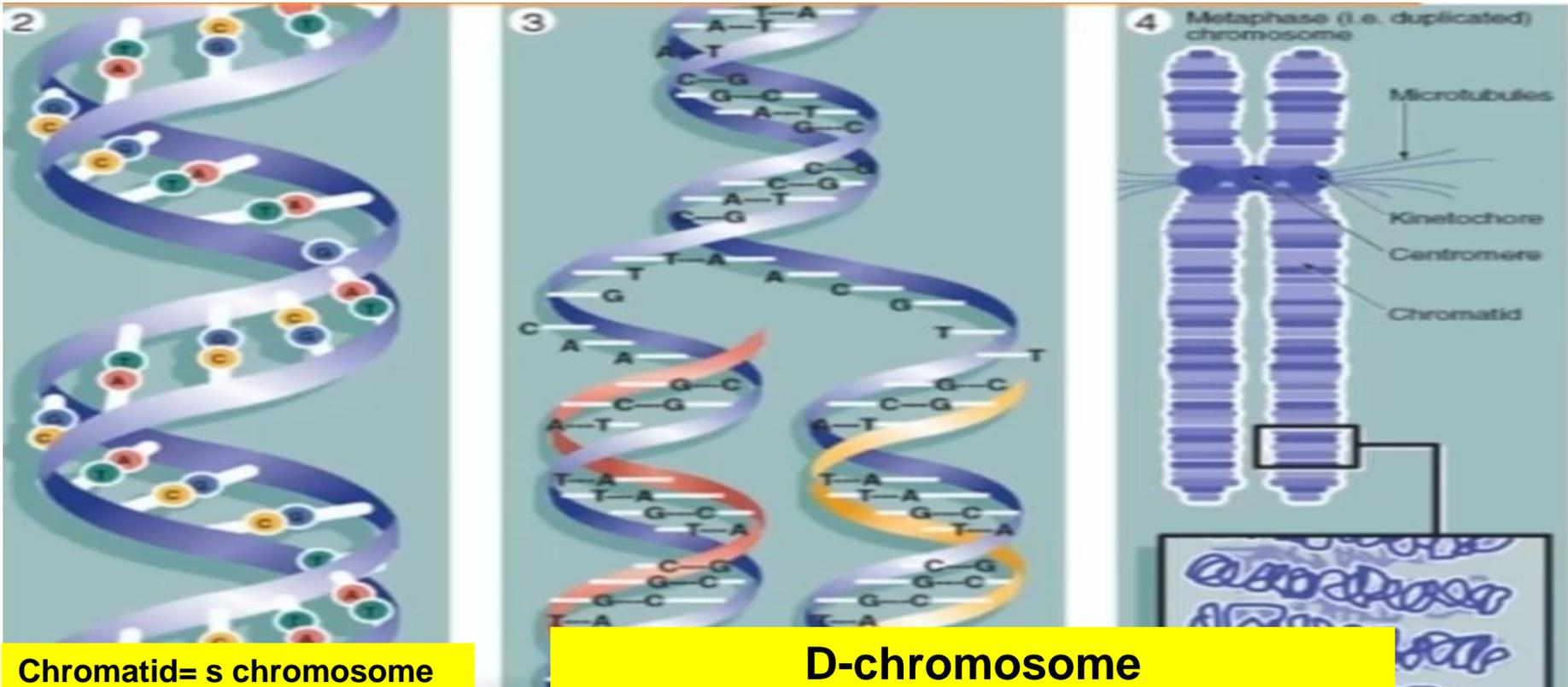
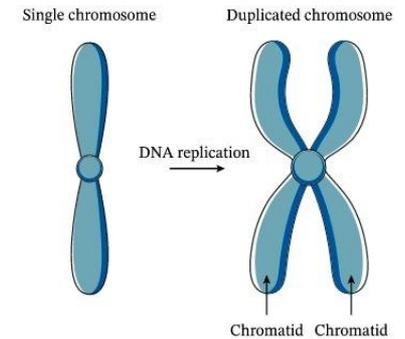
nerve cell



Cardiac muscle cells

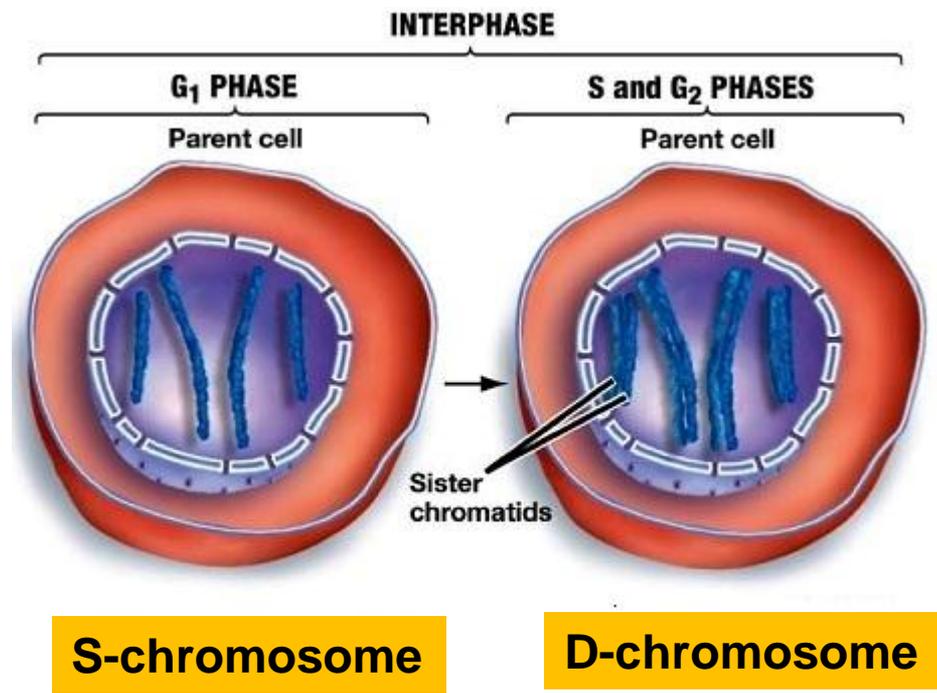
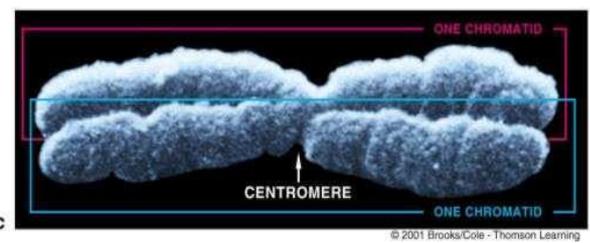
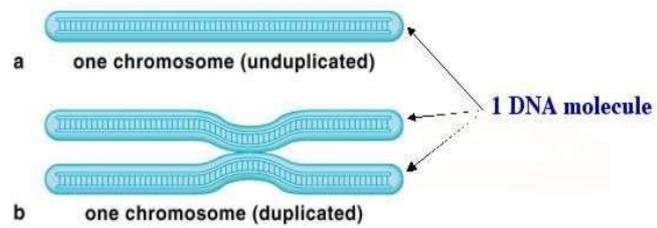
S-Phase (DNA synthesis)

- DNA is duplicated (DNA replication).
- The cell contains 46 d-chromosomes.
- Duplication of the 2 centrioles into 2 pairs.



- in G₁ phase: Single chromosome=**S-chromosome**=one DNA molecule=chromatid. The nucleus contains 46 s-chromosomes.
- in S-phase: Duplicated chromosome=**D-chromosome** =2 DNA molecules=mitotic chromosome. The nucleus contains 46 d-chromosomes. **Each duplicated chromosome has two sister chromatids**

Chromosomes are made of DNA molecules

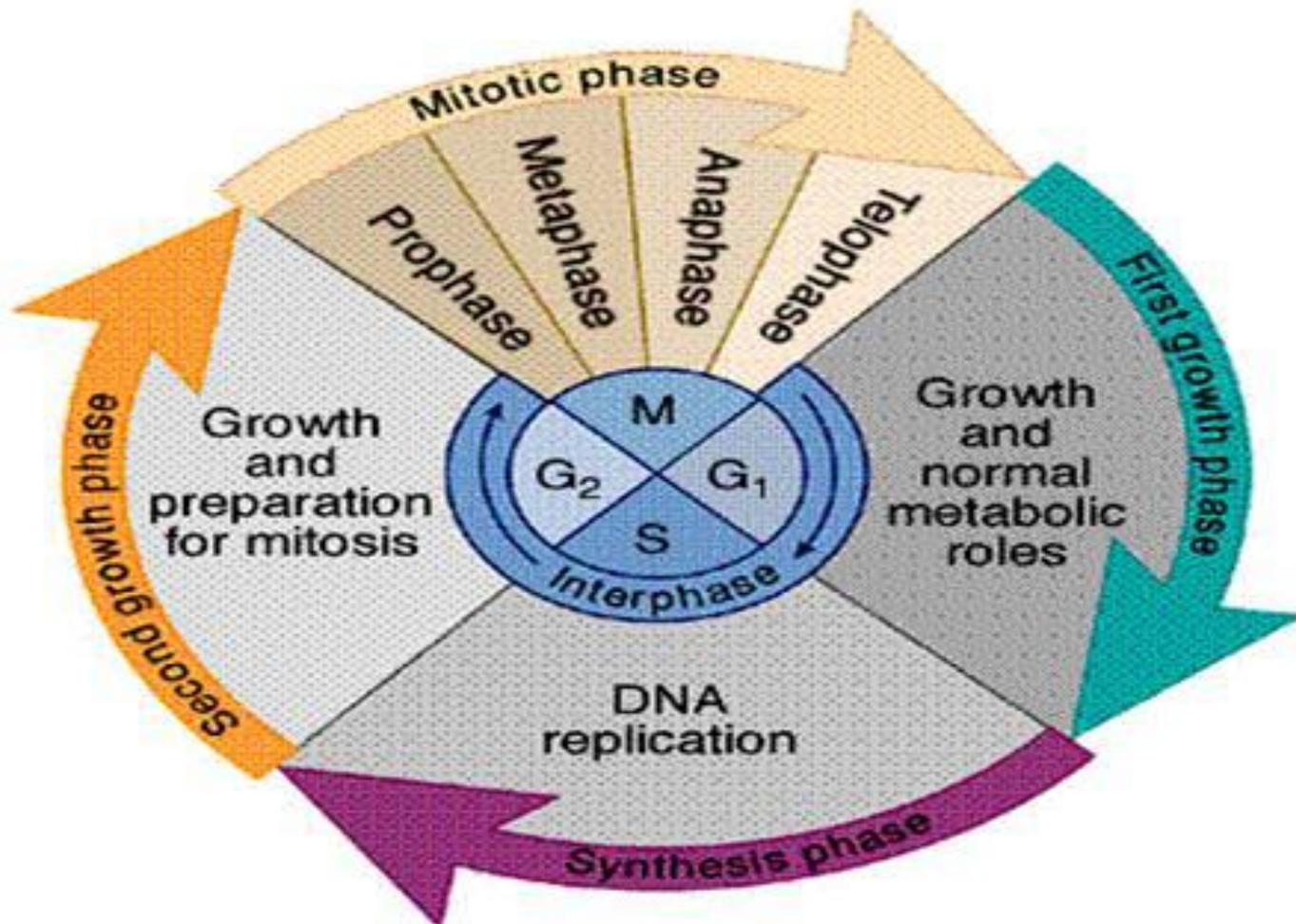


G2 Phase (post-DNA duplication)

Cell prepares it self for mitosis by:

- Synthesis of RNA and proteins essential to cell division.
- Storage of energy.
- Synthesis of **tubulin** for formation of microtubules required for the mitotic spindle.

Interphase



MITOSIS

- **Definition:** It is the process by which the cytoplasm and nucleus of a **somatic cell** are **divided equally** into two identical daughter cells each having the same number of chromosomes as the parent cell.
- **Importance:**
 - 1-Growth & development of the organism.
 - 2-Renewal & repair of cells.
- **Phases:**
 - **Karyokinesis:** division of nuclear material
 - **Cytokinesis:** division of the cytoplasm

Karyokinesis

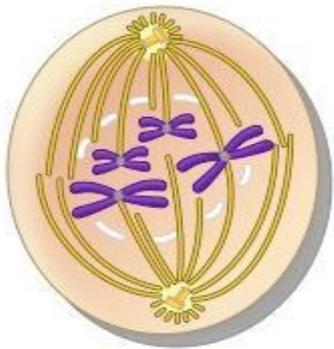
4 stages:

1) Prophase

2) Metaphase

3) Anaphase

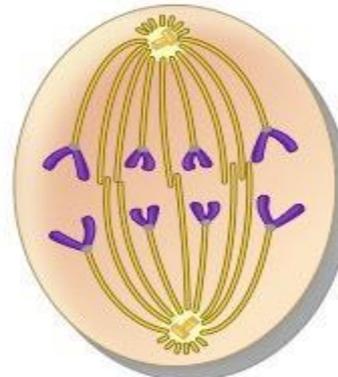
4) Telophase



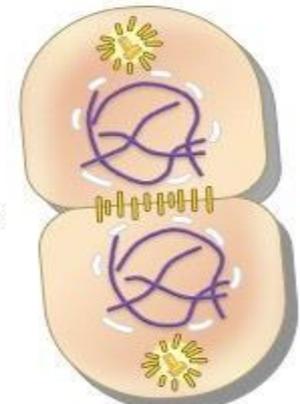
Prophase



Metaphase



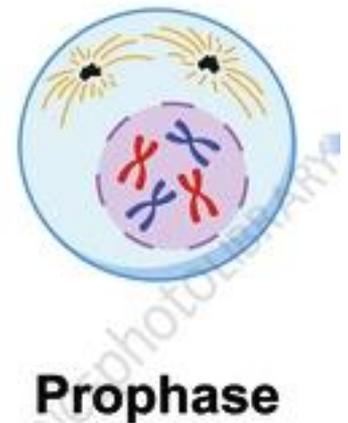
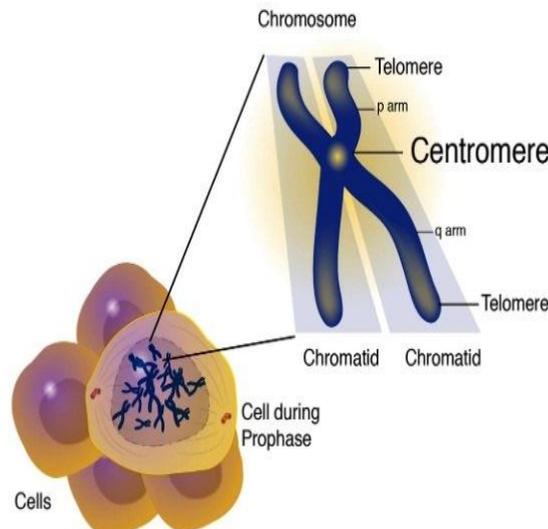
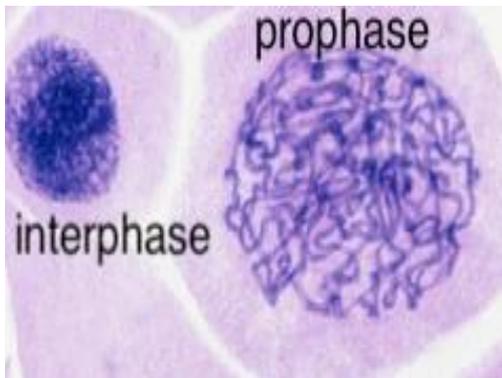
Anaphase



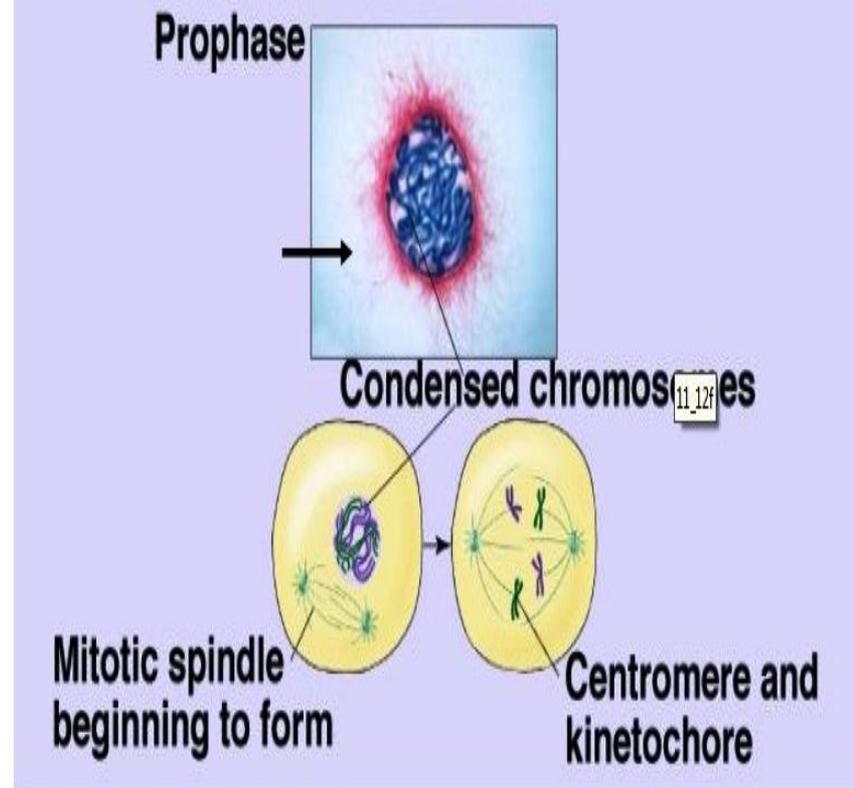
Telophase

1- Prophase: *relatively long*

- **Nucleolus** disappears
- The replicated chromatin **condenses** into thread like **chromosomes** with become visible with L/M.
- Each chromosome consists of two parallel sister chromatids joined together at one point by **centromere**.



- Each pair of **centrioles** moves towards one pole of the cell to form **mitotic spindle**.
- At the centromere region of each chromatid the **kinetochore** develops which serves as a site for attachment to microtubules.
- So each chromosome has one centromere and two kinetochores.
- The **nuclear envelope** remains intact until late in this phase then become to disintegrate.



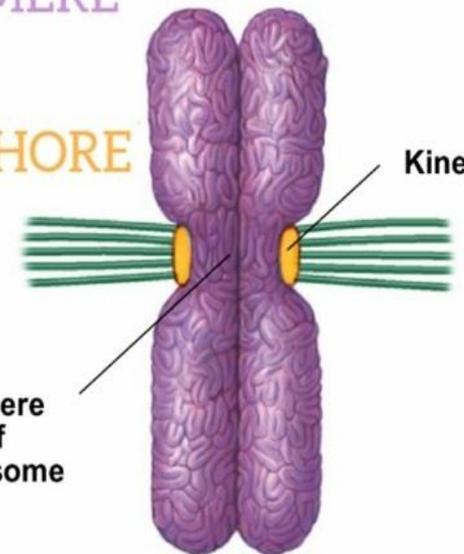
CENTROMERE

VS

KINETOCHORE

Kinetochore microtubules

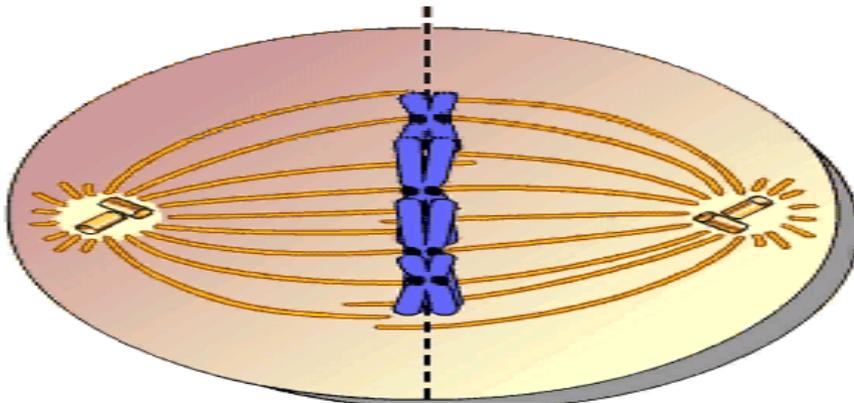
Centromere region of chromosome



Kinetochore

2- Metaphase:

- Disappearance of nuclear envelope.
- Further condensation of chromosomes.
- Chromosomes attach to the mitotic spindle at kinetochores.
- Migration of chromosomes to equatorial plane of the cell.
- It is the best stage at which the chromosomes could be counted.



Mitotic spindle:

❖ Chromosomal microtubules

- Attached to kinetochores.
- They assist in migration of each set of chromatids to one pole of the cell.

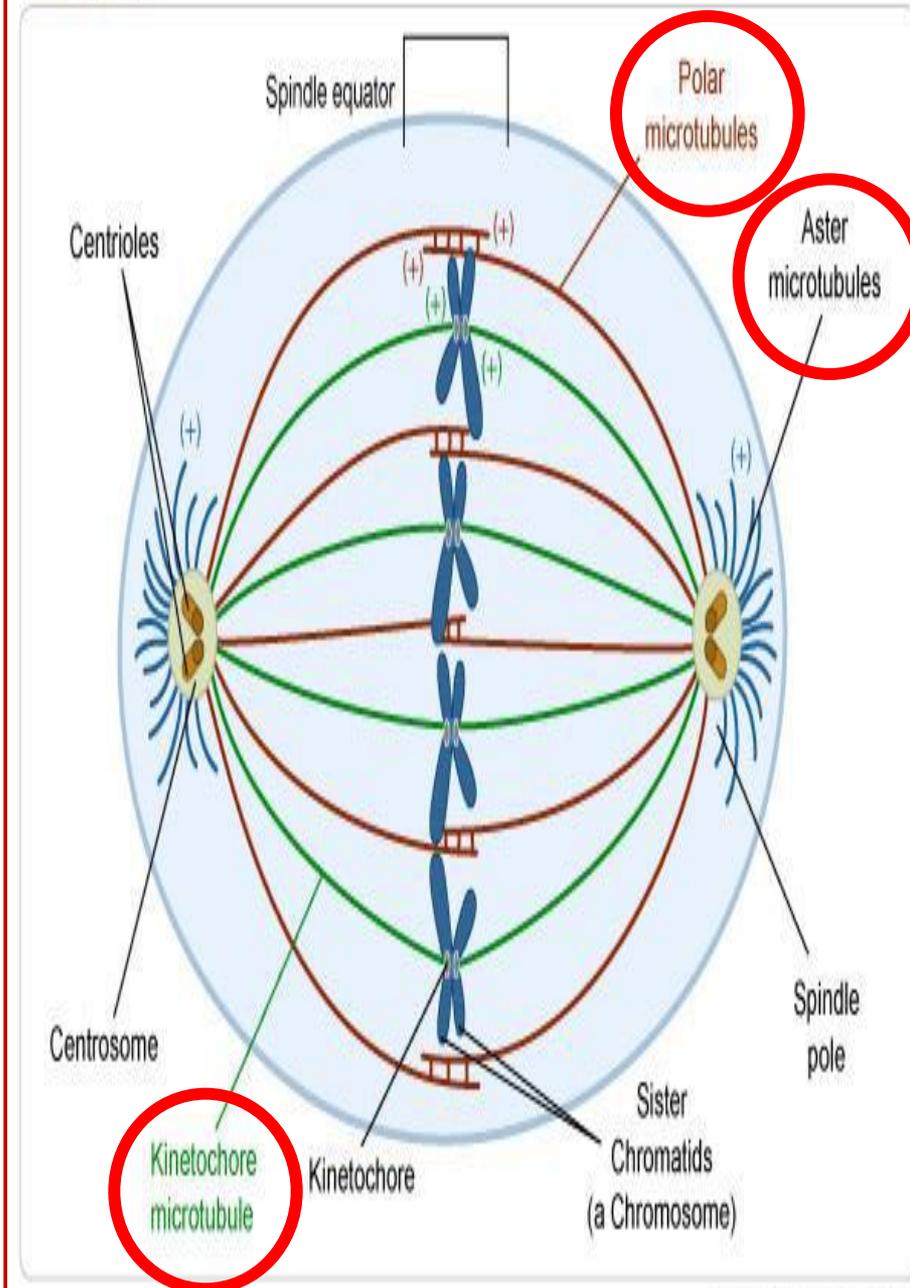
❖ Polar microtubules

- Extend between the two pairs of centrioles.
- Responsible for maintaining the spacing between the two poles during mitotic events.

❖ Astral microtubules

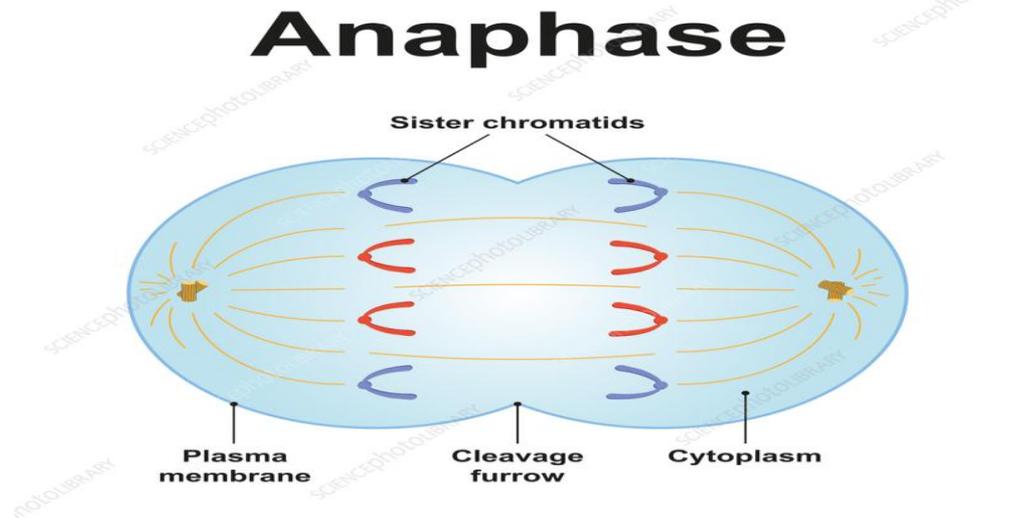
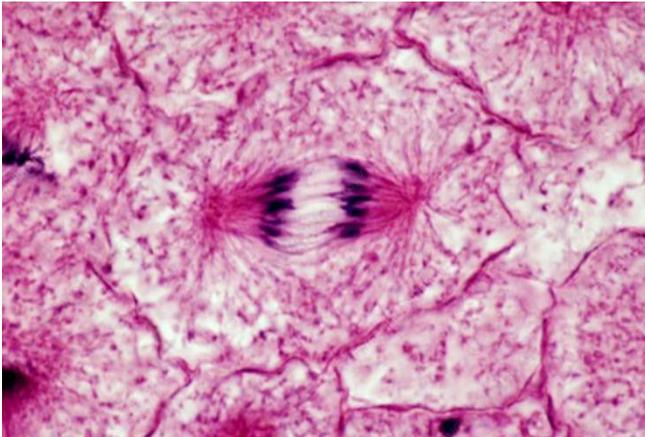
- Short and radiating from centrioles.

Metaphase



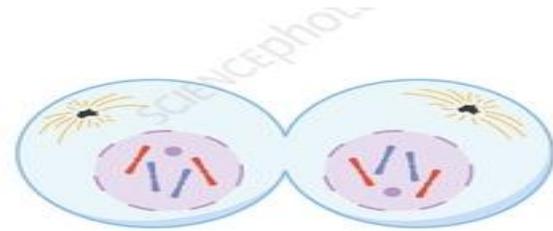
3- Anaphase

- Division of the centromere results in the **separation of the 2 sister chromatids** (which now called **chromosomes**).
- Each group of chromosomes **migrate** to one pole of the cell by the dynamic changes in the lengths of the microtubules forming the mitotic spindles.



4- Telophase

- Each set of chromosomes has reached its respective pole.
- Chromosomes **uncoil** and become **organized** into heterochromatin and euchromatin.



Telophase

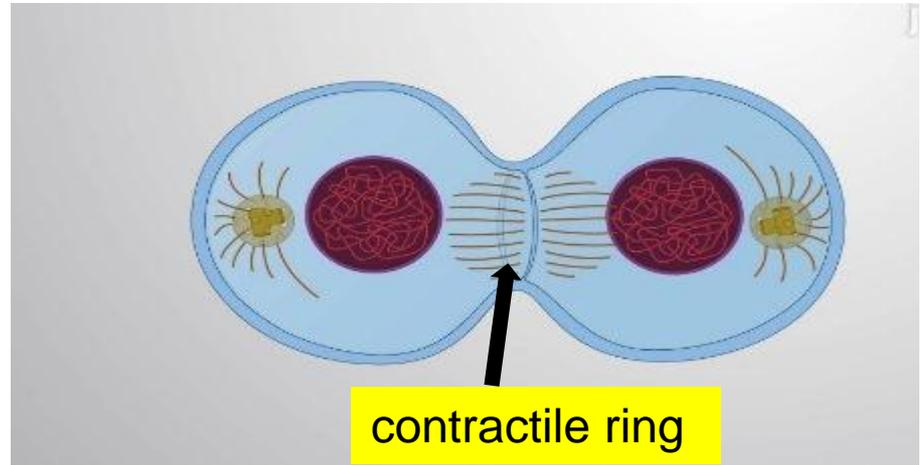
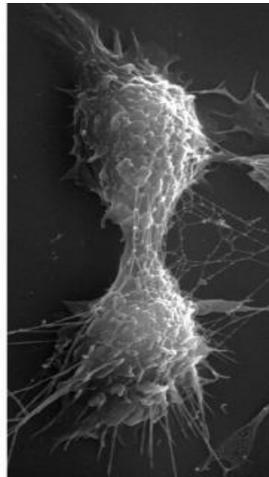
- The mitotic spindles **depolymerizes** (disappear).
- Nuclear envelope is **reformed** around each cell chromosomes.
- Chromosomes spread out into **chromatin** with **reappearance of** nucleoli in the daughter cells.
- A belt-like **contractile ring** of actin filaments and myosin develops in the peripheral cytoplasm at the cell's equator.

Cytokinesis

- At the end of telophase, **constriction** of the contractile ring produces a **cleavage furrow**.
- The cleavage furrow *continues* to deepen until a small bridge of cytoplasm and remaining polar microtubules connect the two daughter cells.
- Then progresses until the cytoplasm is divided into two daughter cells, each with one nucleus.

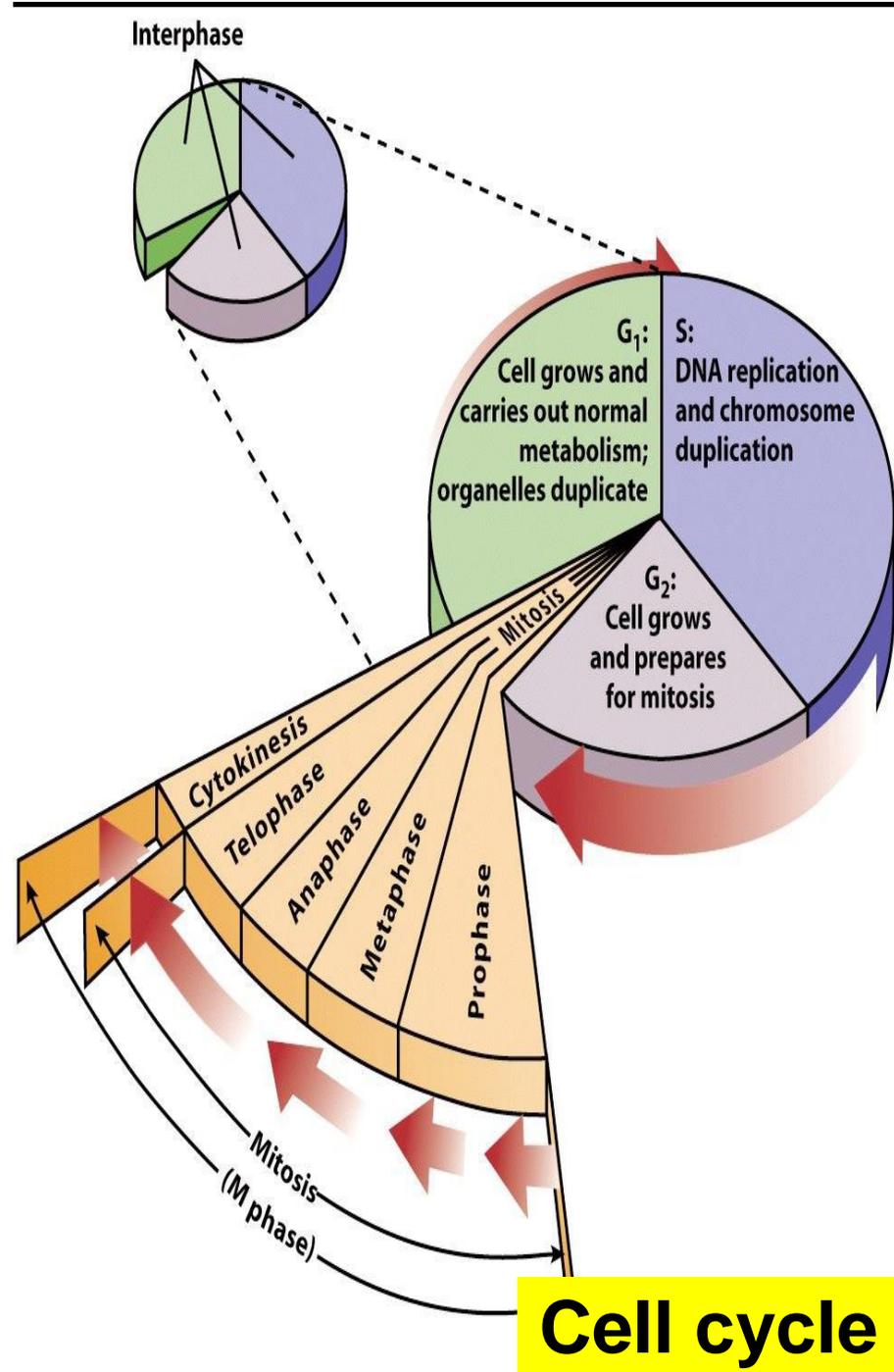
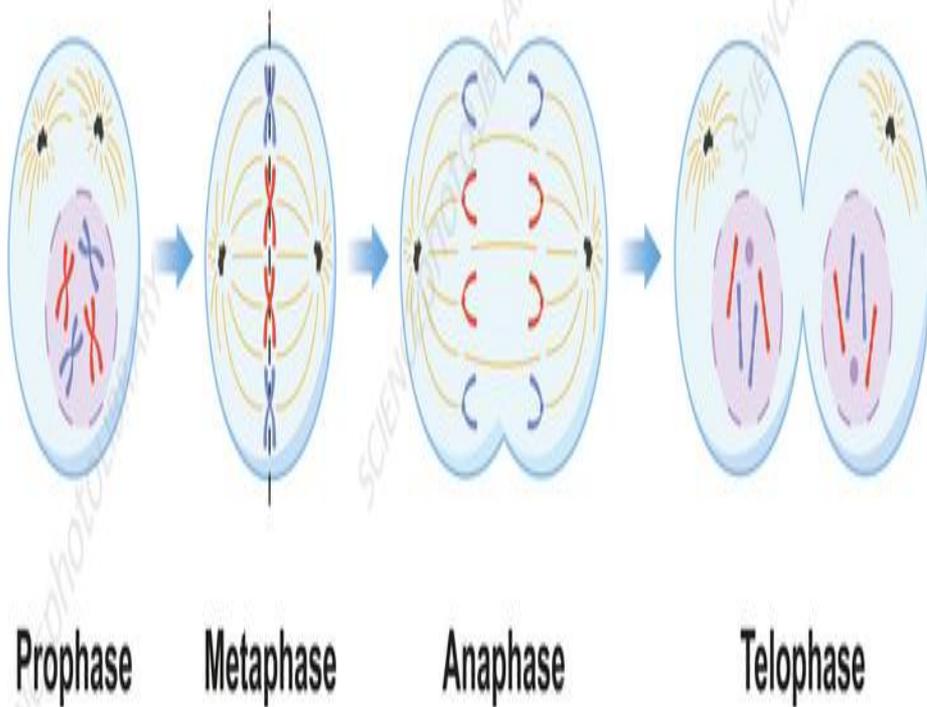


cleavage furrow.



contractile ring

Mitosis Phases



Checkpoints of the cell cycle

- Each phase of the cell cycle has one or more checkpoints.
- Where the **quality of specific cell activities is checked**.
- **Progression** to the next phase of the cycle does not occur until all activities of the preceding phase are **completed satisfactorily**.
- The cell cycle is stopped until the problem is **solved** or the cell undergo **apoptosis** (programmed cell death).



Check points

1-The start or Restriction ckeckpoint : At G1phase

The most important checkpoint

- for
- Cell size
 - Intact DNA.
 - Receiving appropriate growth stimuli

2-DNA damage checkpoint

At G1,S,G2 phases

3- Unduplicated DNA

At G2 phases

4-The metaphase spindle checkpoint :

ensures that all chromosomes are attached to the mitotic spindles.



- ANIMATION FOR CELL CYCLE
- https://www.youtube.com/watch?v=e6N9_RhD10Q
- https://www.youtube.com/watch?v=5bq1To_RKEo

MCQ

Q.1 Which one connected with the cell division

- (a) ER (b) Peroxisomes
(c) Ribosomes (d) Microtubules

Q.5 The replication of nuclear DNA occurs in

- (a) G₁ phase (b) G₂ phase
(c) S phase (d) M phase

Q.10 Mitosis results in

- (a) Reduction in chromosome number
(b) Doubling of chromosome number
(c) Constant chromosome number
(d) Increase in cell volume

Q- Which of the following is true regarding G₁?

- It is the period between end of division and the start of S-phase.
- The amount of DNA is duplicated.
- The centrioles are duplicated.
- Formation of microtubules.

