

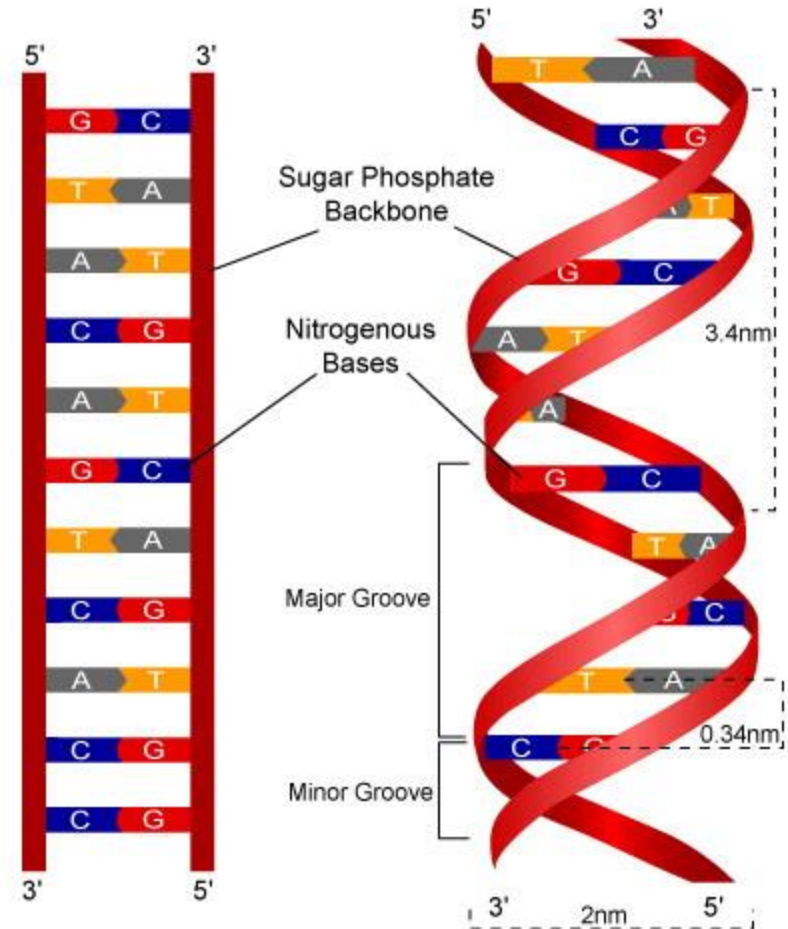
Cell cycle

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Chemical (Molecular) structure of chromatin

- Chromatin is composed mainly of **DNA** (2nm) combined with basic proteins known as **histones**. There are five types of histones which are H₁, H₂A, H₂B, H₃ and H₄. They are packaged together in special manner named order of condensation.



Packaging of DNA into chromatin & chromosome

(Order of condensation)

1-Nucleosome is the basic structural unit of chromatin. DNA filament is wrapped twice around a core of eight histones (octamer). The octamer is formed of two molecules of the 4 histones ; H₂A, H₂B, H₃ and H₄. The segment of DNA between two successive nucleosomes is known as linker DNA which is attached to histones H₁.

2-Nucleosomes and linker DNA constitute what is known as **Beads-on-a string form** of chromatin, which is 10-11 nm in diameter .

Core of 8 histone molecules:
H2A, H2B, H3, and H4

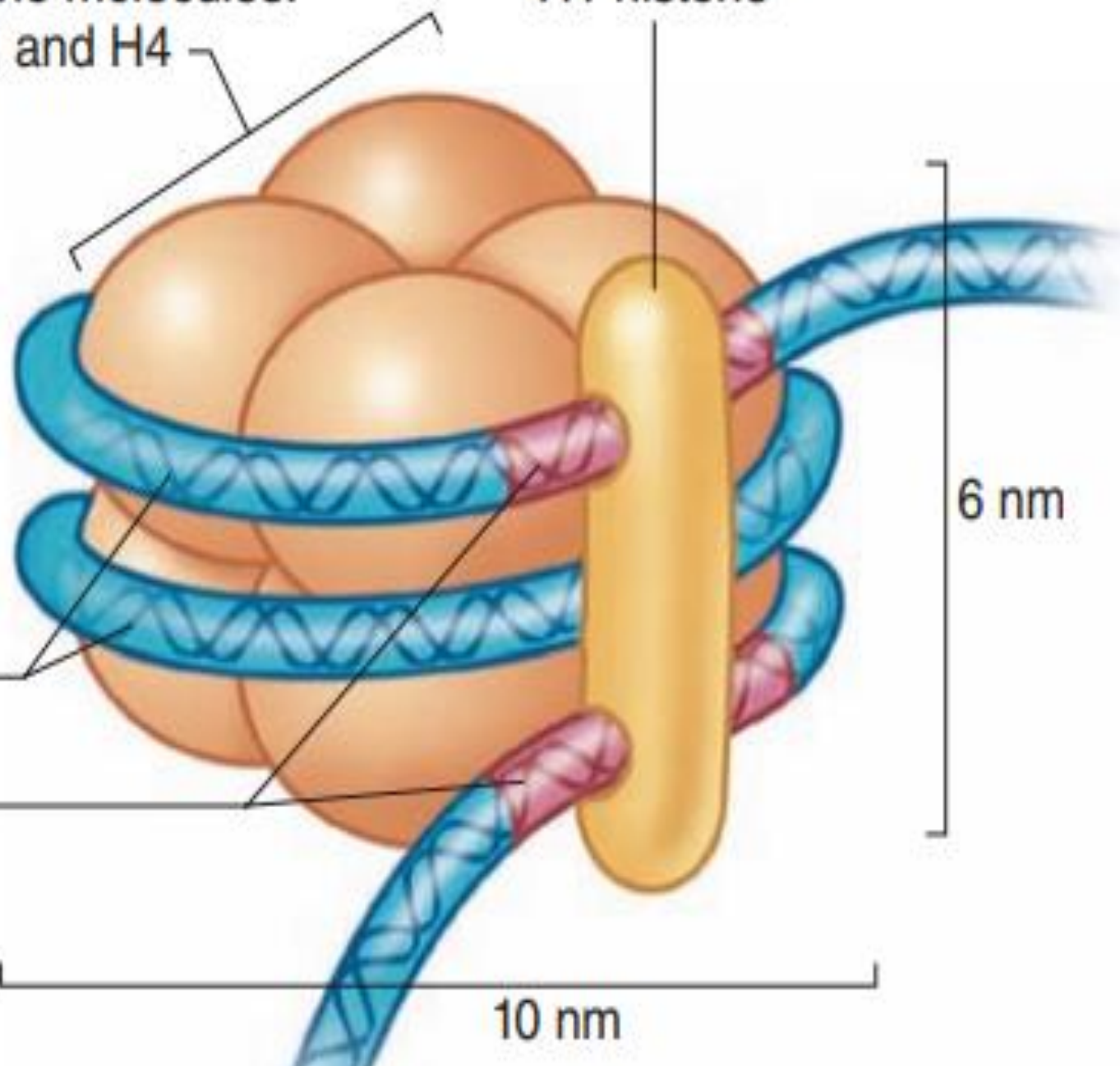
H1 histone

Central DNA

Link DNA

6 nm

10 nm



DNA



2 nm

Nucleosomes (DNA and core histones)



11 nm

Packed nucleosomes in 30-nm chromatin fiber



30 nm

Extended loops of transcriptionally active chromatin, tethered to protein scaffold



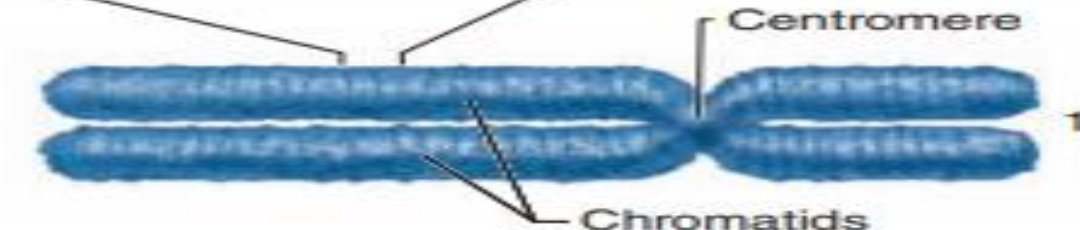
300 nm

Condensed heterochromatin and dispersed euchromatin



700 nm

Entire chromosome at metaphase



1400 nm

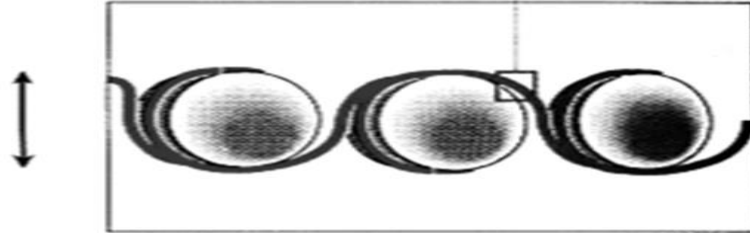
3-Solenoid or 30 nm fibers: It is the next higher order of organization of chromatin. In this structure, nucleosomes become coiled around an axis, with six nucleosomes per turn .

4- Looped domain of chromatin (300nm) is formed due to further coiling of the 30 nm fiber forming series of loops.

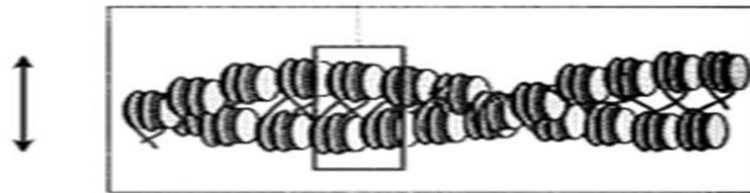
5- Heterochromatin (700nm) and metaphase chromosomes (1400) are formed during mitosis due to further coiling and condensation of the looped domains.



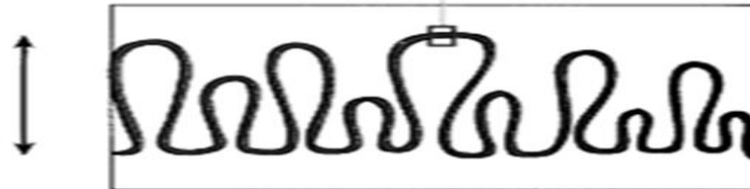
DNA Double Helix 2 nm



Beads-on-a-string form of chromatin 11nm (nucleosome)



30nm chromatin fiber of packed nucleosomes (Solenoid)



Looped domain (300nm)



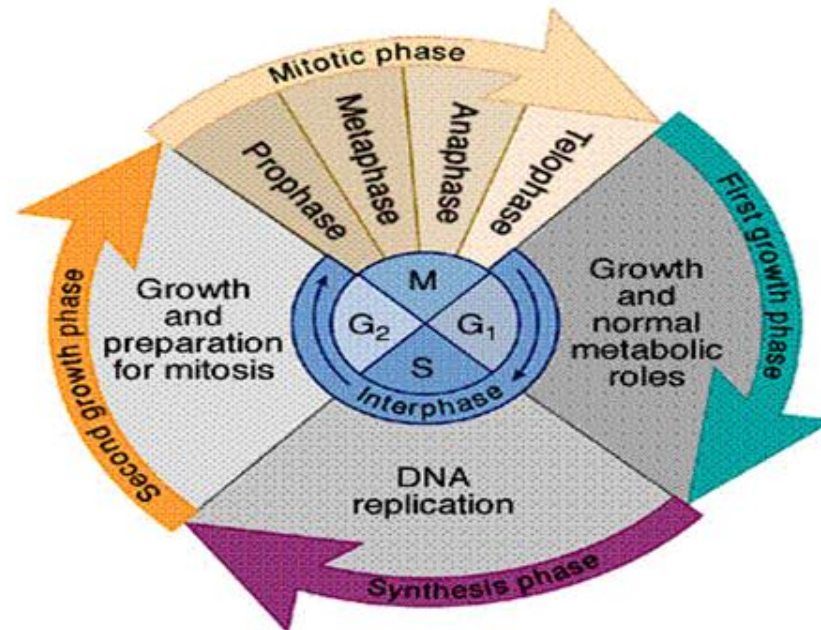
Prophase chromosome 700nm



Metaphase chromosome 1400nm

CELL CYCLE

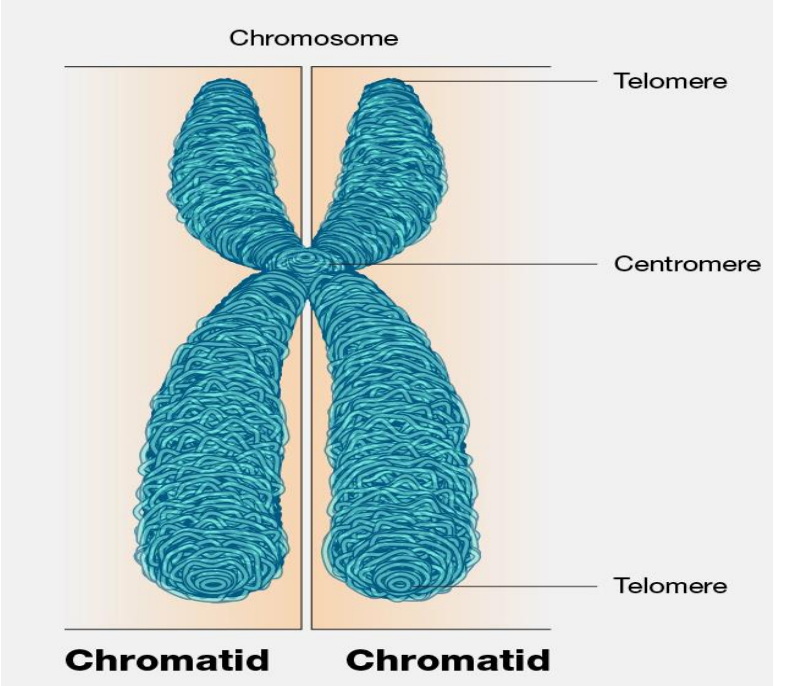
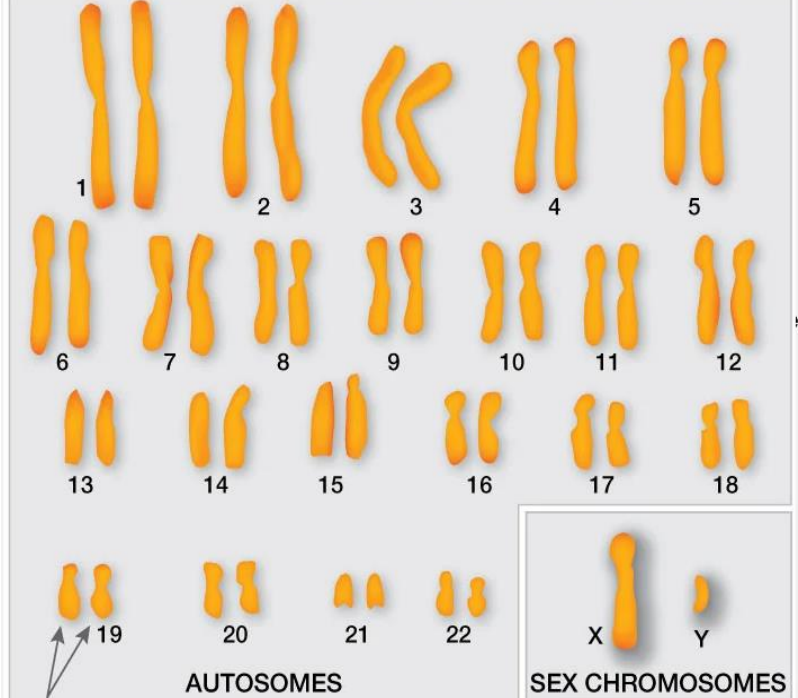
- 1- Mitosis: is the short period of time (1- 2 1 /2 hour) during which the cell divides its nucleus and cytoplasm giving rise to two daughter cells.
- 2- Interphase, a longer+ period of time (20 hours) between two successive divisions, during which the cell increases its size and content and replicates its genetic material.



- **Haploid number:**
 - 23 s-chromosomes = 23 chromatids (ovum & sperm)

- **Diploid number:**
 - 46 s-chromosomes = 46 chromatids
 - 46 d-chromosomes = 92 chromatids

- **Amount of DNA=n**
 - 1n: in germ cells (ovum & sperm)
 - 2n: in somatic cells (46s)
 - 4n: in S-phase (46 d)



INTERPHASE

- is subdivided into three phases:
- **G1 (gap1):** cell prepare for DNA duplication.
- **S (synthetic):** DNA duplicatation.
- **G2 (gap2):** cell prepare for mitosis.

G1 phase (pre-duplication)

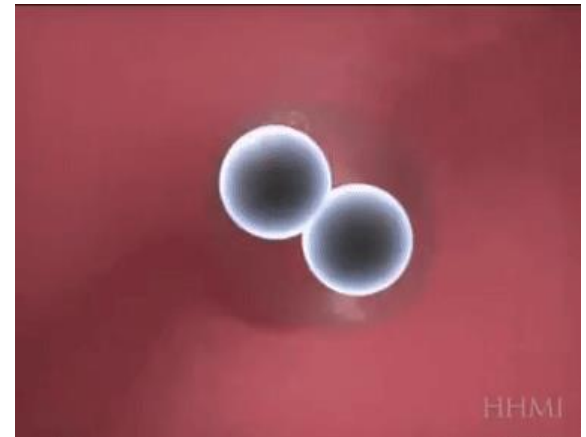
- It is the period between the end of mitosis and the beginning of S- phase. It takes 8 hours.
- **During this phase:**
 - The cell increases in size.
 - Starts to synthesize RNA and protein to build themselves
 - The cell contains 46 s-chromosomes (diploid number) = $2n$ (amount of DNA).

G1 phase (pre-duplication)

The duration of G1 phase may vary from one cell to another according to the main function of the cell :

Highly proliferated cells:

have short G₁ phase e.g. stem cells of bone marrow and germinal epithelium

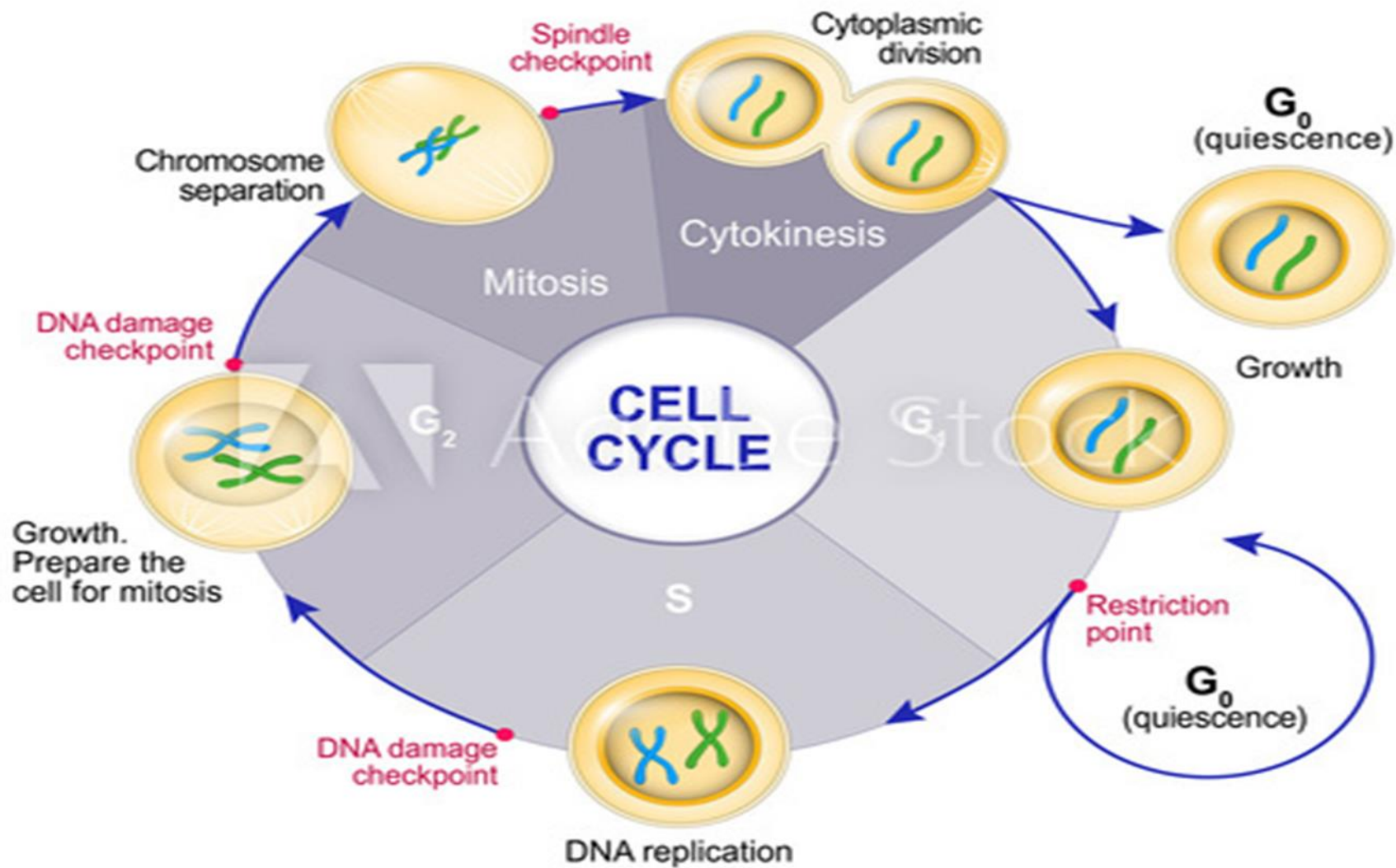


G1 phase (pre-duplication)

Highly differentiated cells:

after the last mitosis may leave the cell cycle at G₁ phase either:

1. **Temporarily** (e.g. hepatocyte and intestinal epithelium): The cells perform their specific functions and some of them may enter the cycle again to repair and regenerate damaged cells (Prolonged G₁ phase).
2. **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 phase.



S-Phase (DNA synthesis)

- **Definition:** The period that follows G1 phase
- **Duration:** It takes 8 hours.
- -During this phase:
 - a. DNA is duplicated (DNA replication). Thus, each somatic cell having 46 s-chromosome and $2n$ DNA after duplication will contain 46 d-chromosomes and double the amount of DNA ($4n$).
 - b. Duplication of the 2 centrioles into 2 pairs

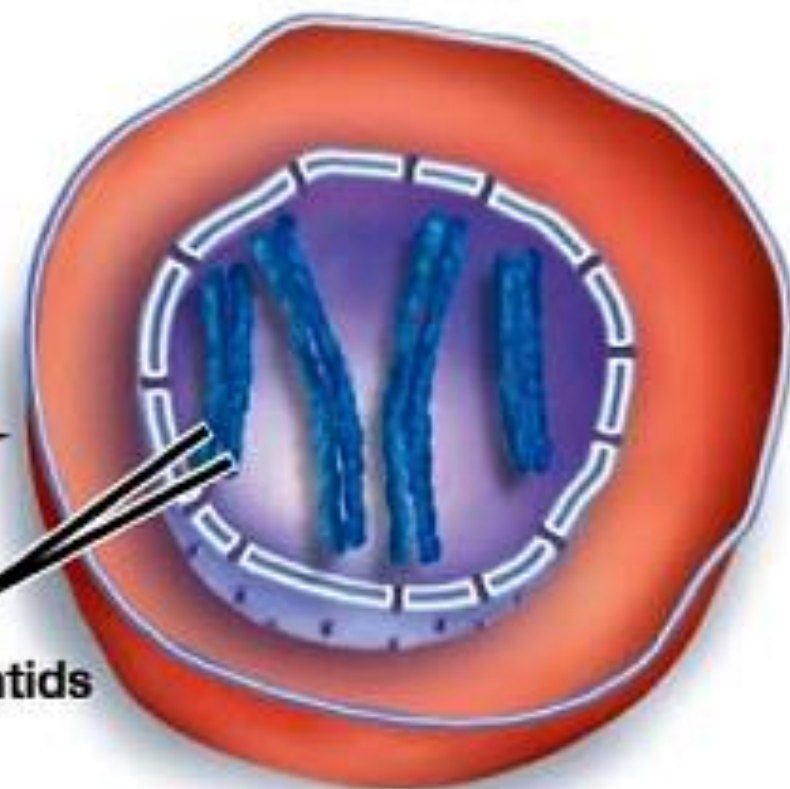
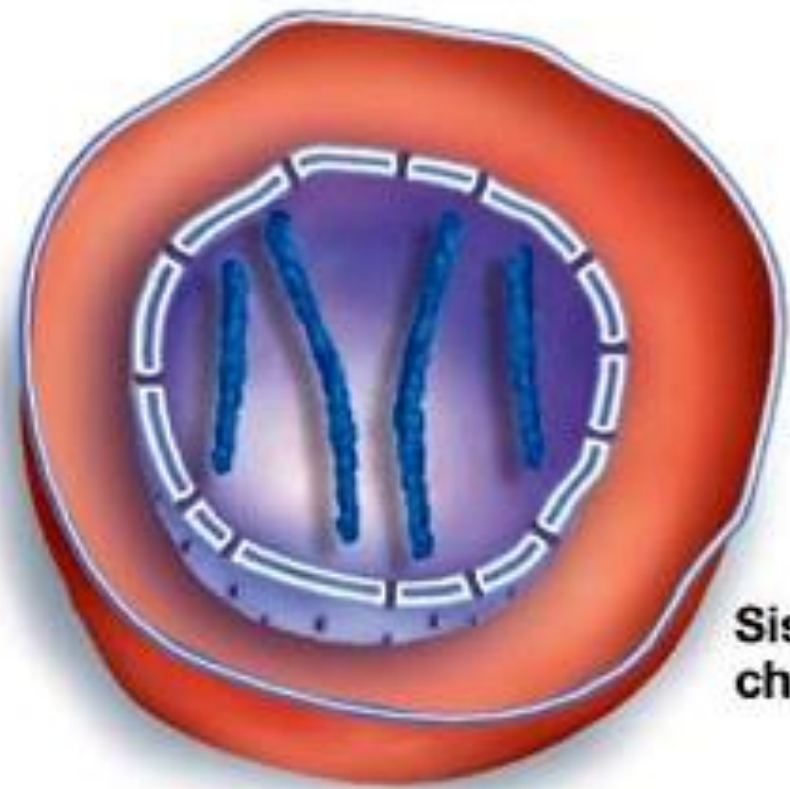
INTERPHASE

G₁ PHASE

S and G₂ PHASES

Parent cell

Parent cell



Sister chromatids

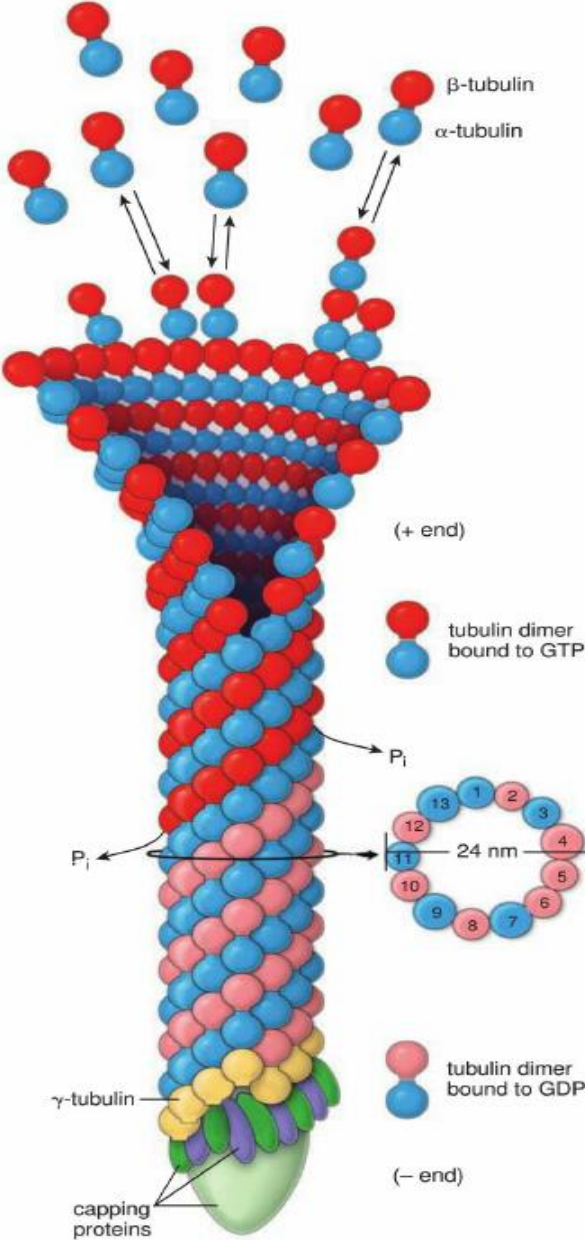
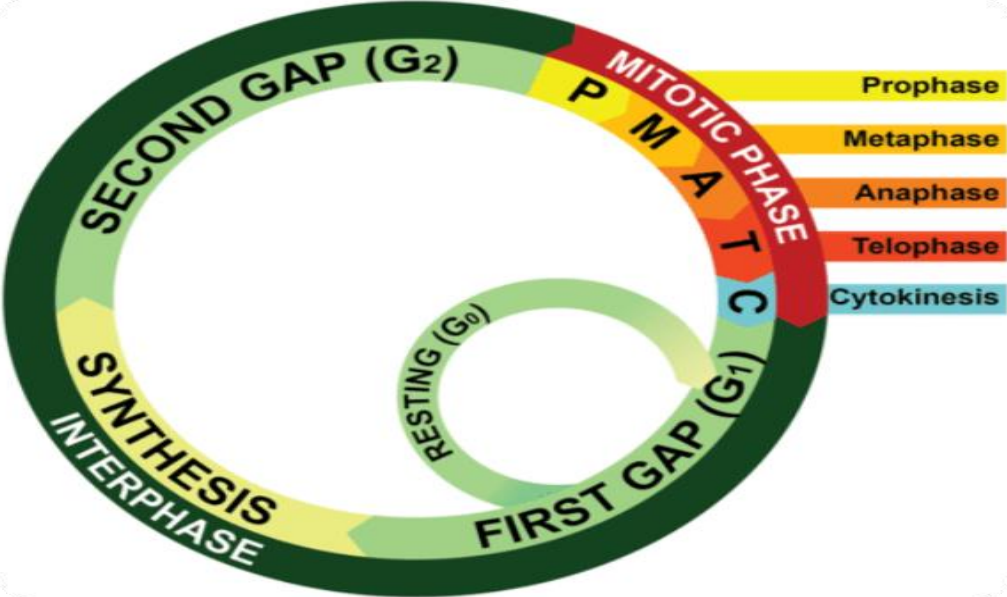
4 unreplicated chromosomes (chromosomes are shown partially condensed to make them visible)

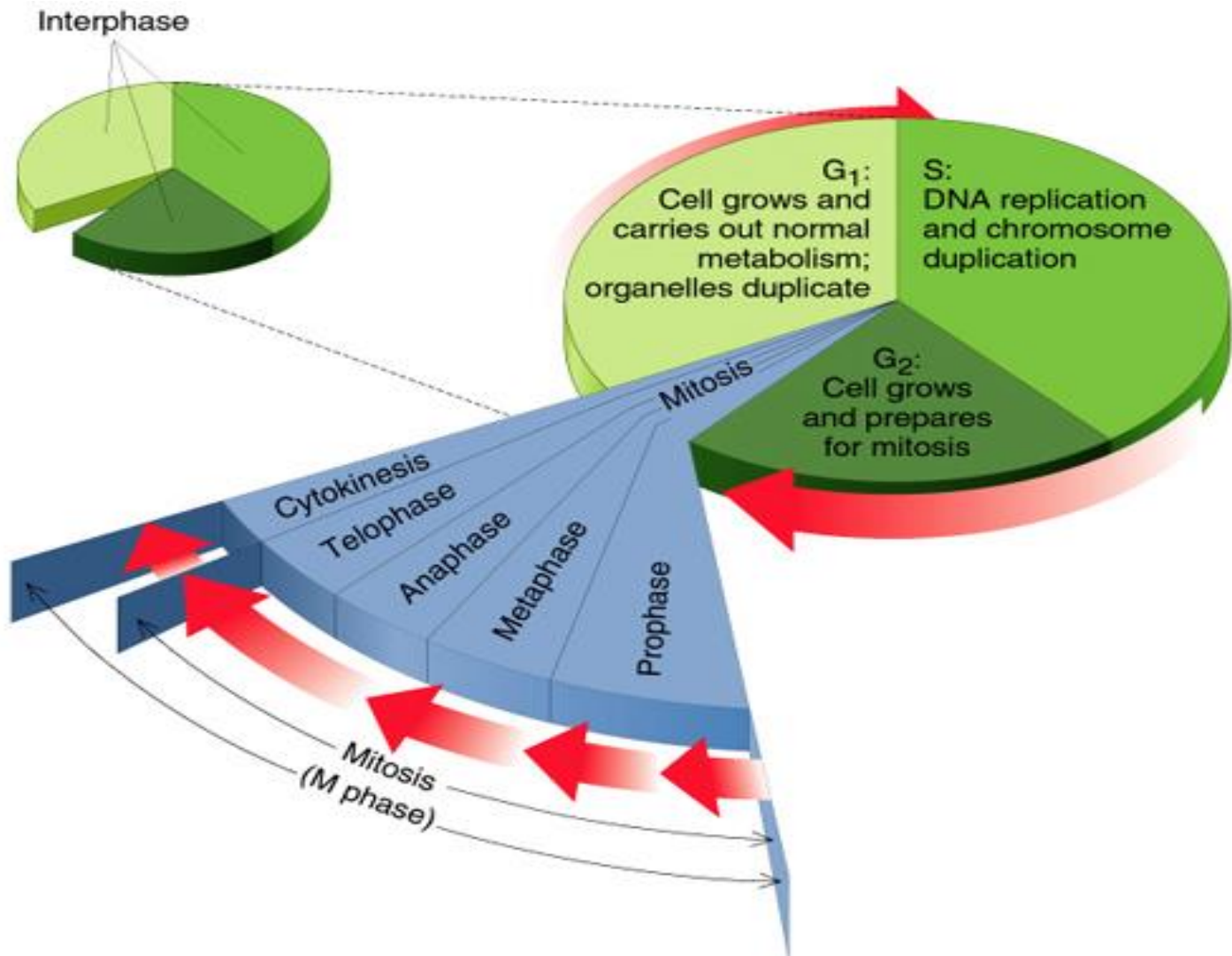
4 replicated chromosomes, each consisting of two sister chromatids

G2 Phase (post-DNA duplication)

- **Definition:** It is the period between S-phase and the beginning of the next mitosis.
- **Duration:** It takes 4 hours.
- **During this phase:** the cell prepares itself for mitosis by:
 - a. Synthesis of RNA and proteins essential to cell.
 - b. Storage of energy for mitosis.
 - c. Synthesis of tubulin that is essential for formation of microtubules required for the mitotic spindle.

G2 Phase (post-DNA duplication)





MITOSIS

Definition: It is the process by which the cytoplasm & nucleus of somatic cell are divided **equally** into two **identical** daughter cells, each cell having the **same** number of chromosomes (46 = 23 pairs) as chromosome as the parent cell.

Duration: 1- 2¹/₂ hours.



PHASES

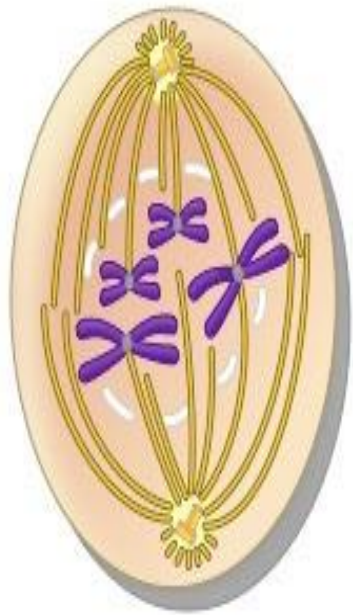
Karyokinesis

- Division of the nuclear material

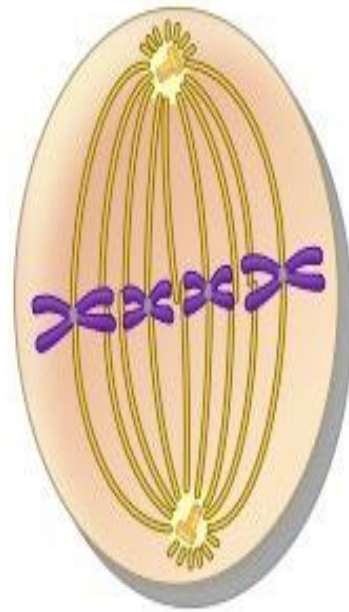
Cytokinesis

- Division of the cytoplasm

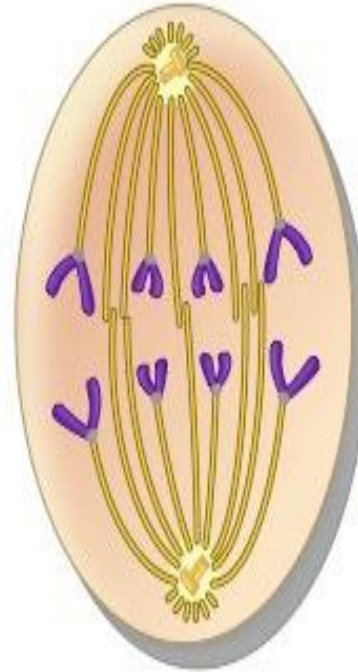
Karyokinesis



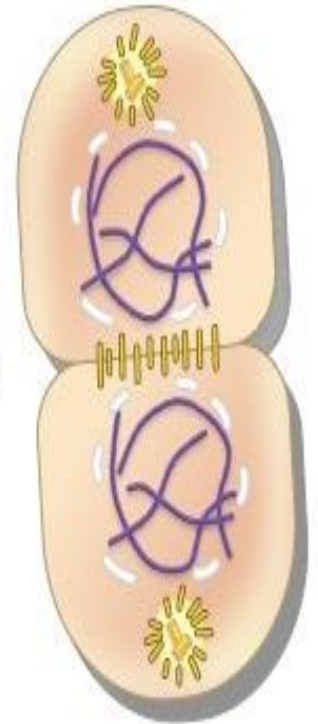
Prophase



Metaphase

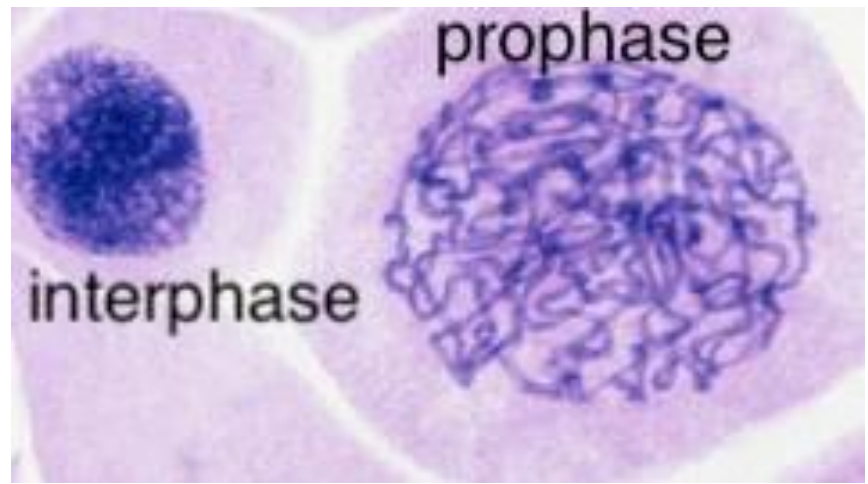


Anaphase



Telophase

PROPHASE

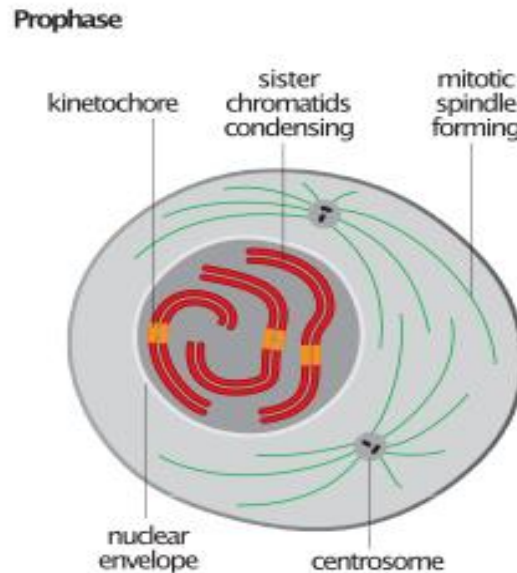


• It is characterized by:-

1. Disappearance of the nucleolus.

2. The chromosomes are condensed and become visible with L/M.

3. The nuclear envelope remains intact until late in this phase, and then starts to disappear.



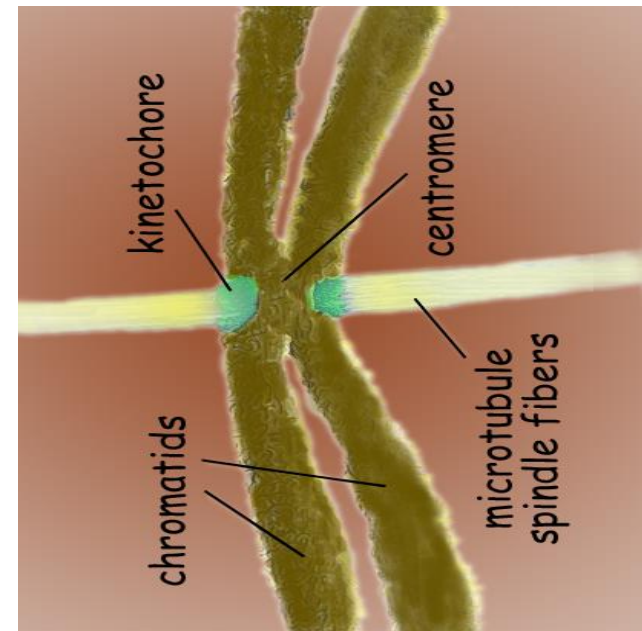
PROPHASE

- It is characterized by:-

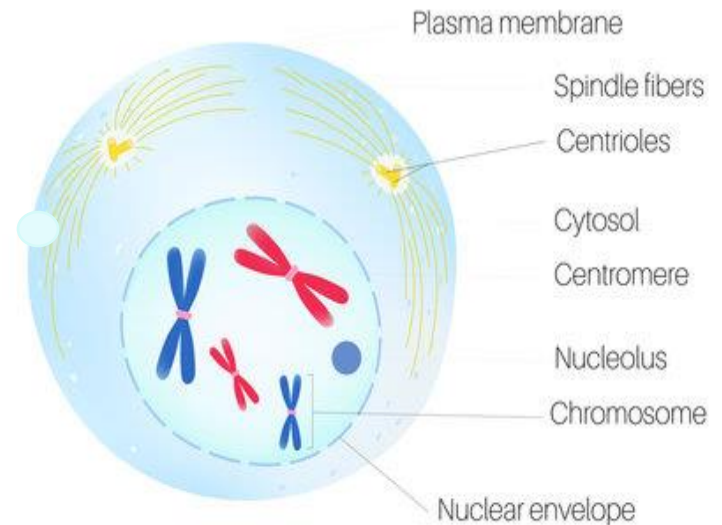
4. Each chromosome consists of two sister chromatids joined together by centromere.

5. At the centromere region of each chromatid the kinetochore develops which is a microtubule-organizing center (MTOC).

6. Each pair of centrioles moves towards one pole of the cell to form mitotic spindle.



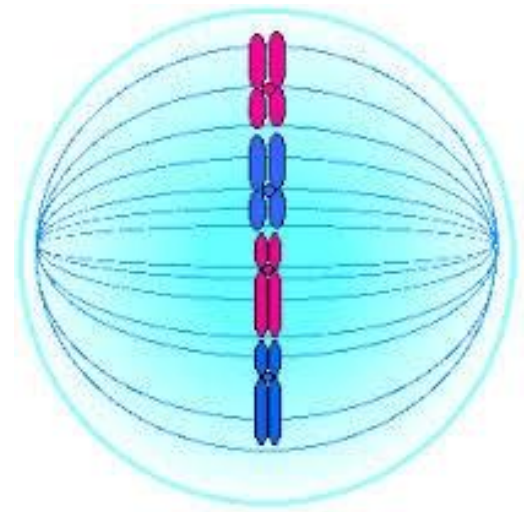
PROPHASE



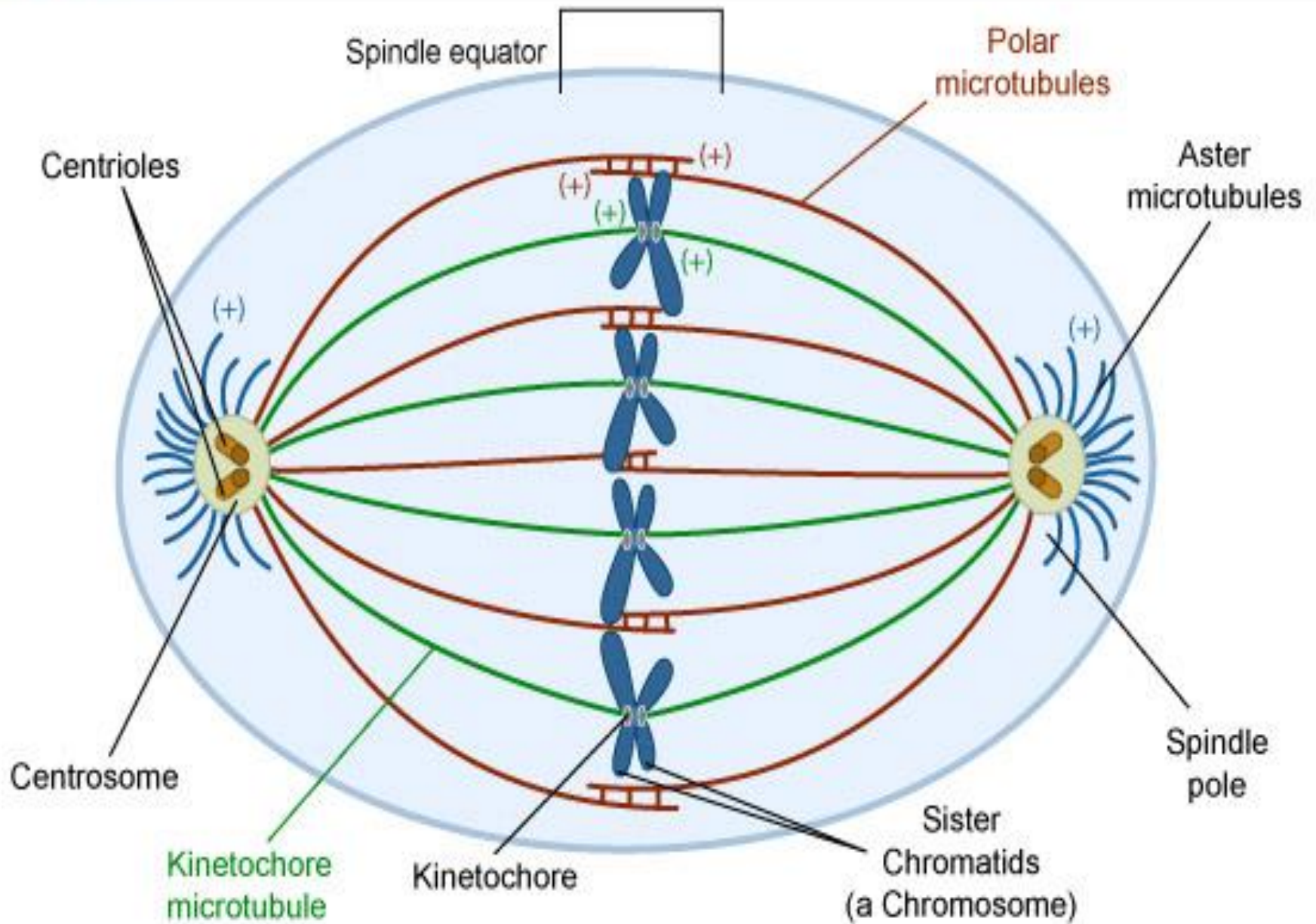
METAPHASE

- It is characterized by:-

1. Complete disappearance of nuclear envelope.
2. Migration of chromosomes to equatorial plane of the cell.



Metaphase



METAPHASE

1. Mitotic spindle at this stage consists of :

a. Chromosomal microtubules that become attached to kinetochores. They assist in migration of each set of chromatids to one pole of the cell.

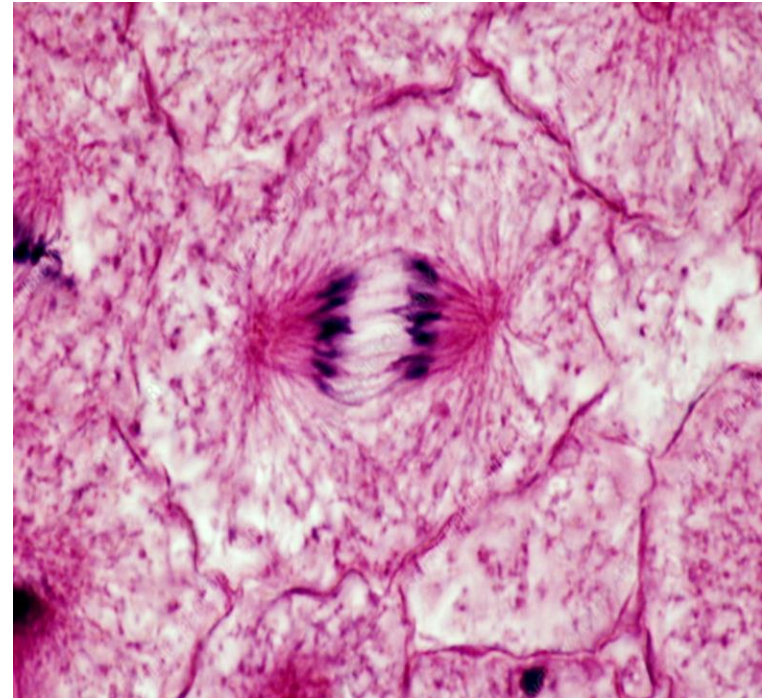
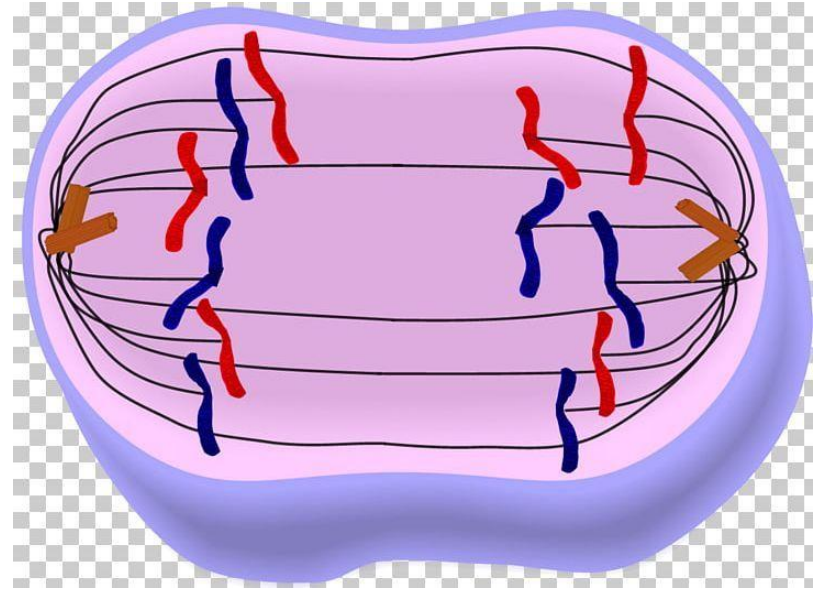
b. Polar microtubules are not attached to kinetochores and extend between the two pairs of centrioles. They are responsible for maintaining the spacing between the two poles during mitotic events.

c. Astral microtubules are originating from the centrosome and organized into radial arrays around it and are not connected to a kinetochores

ANAPHASE

1. It begins when sister chromatids separate from each other. Now the cell contains 92 chromatids (s-chromosomes). They begin to migrate, so that 46 chromatids move to one pole of the cell and the other 46 chromatids move to the other pole.

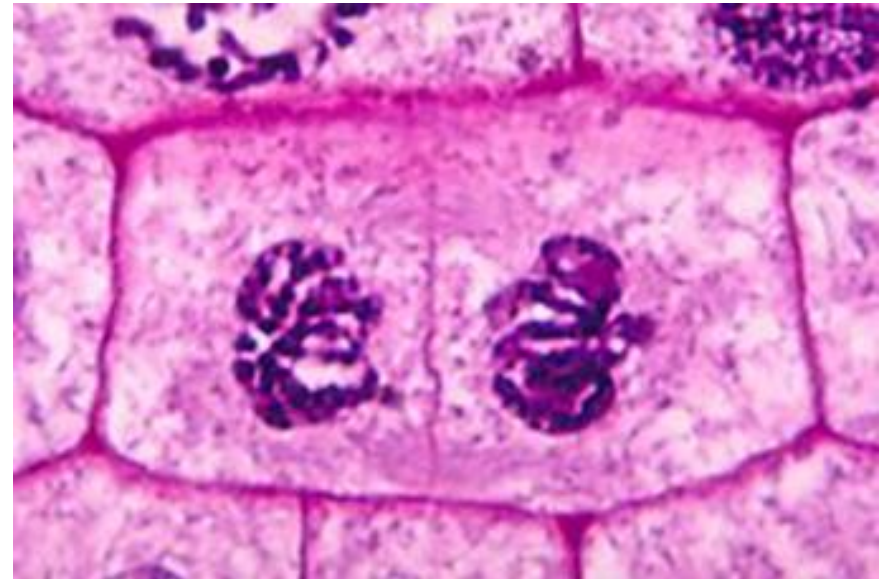
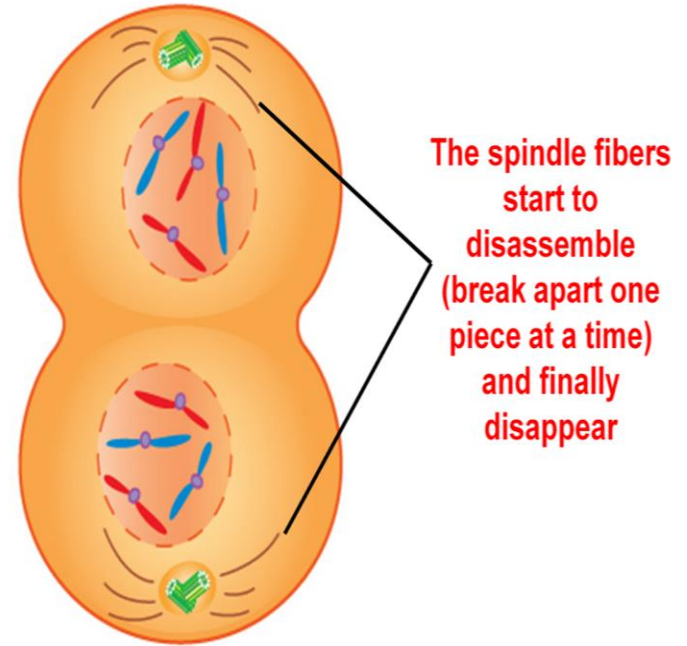
2. In late anaphase a cleavage furrow begins to form at cell membrane.



TELOPHASE

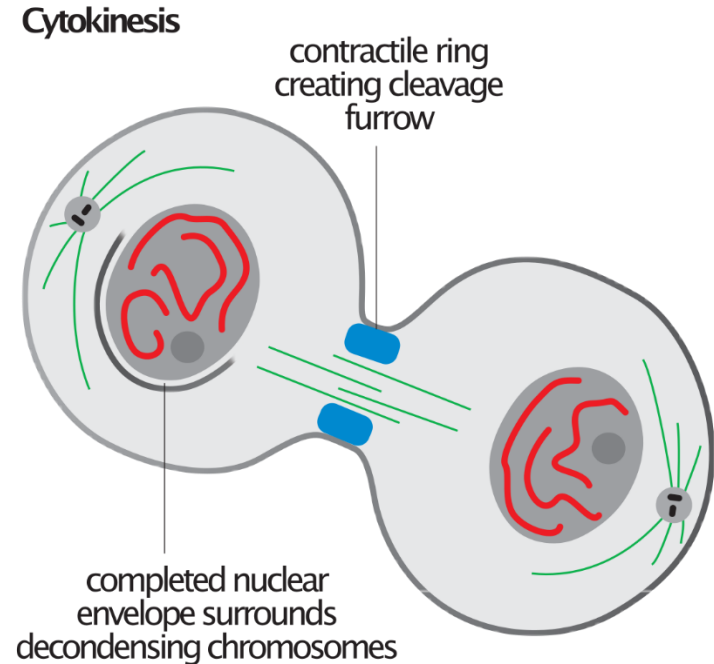
1. Each set of chromosomes has **reached** its respective pole.
2. Reappearance of **nuclei** in the daughter cells.
3. The chromosomes **uncoil** and become organized into heterochromatin and euchromatin of the interphase cell.
4. Nuclear **envelope** is reconstituted.

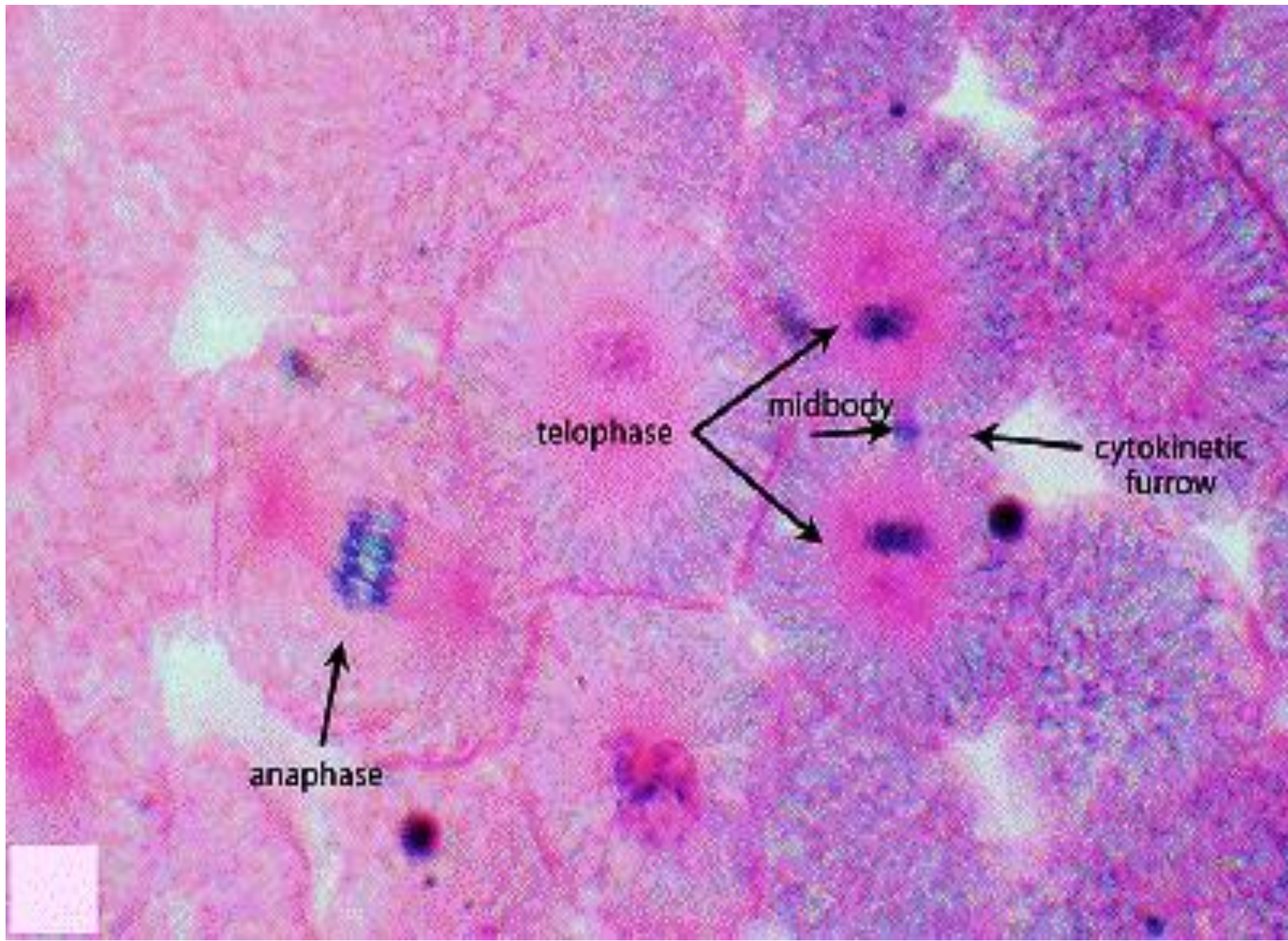
Telophase



Cytokinesis

1. The cleavage furrow continues to deepen until the mid body.
2. Mid body is a small bridge of cytoplasm connecting the two daughter cells together. It is formed of polar microtubules and surrounded by contractile ring.
3. Contractile ring is composed of actin and myosin filaments.
4. Constriction of the ring is followed by separation of the two daughter cells. Each cell contains 46 s-chromosomes.



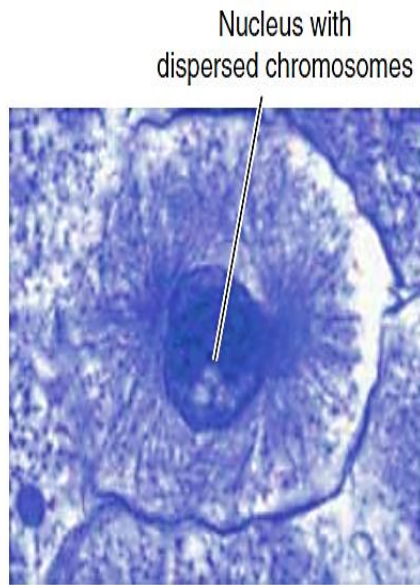
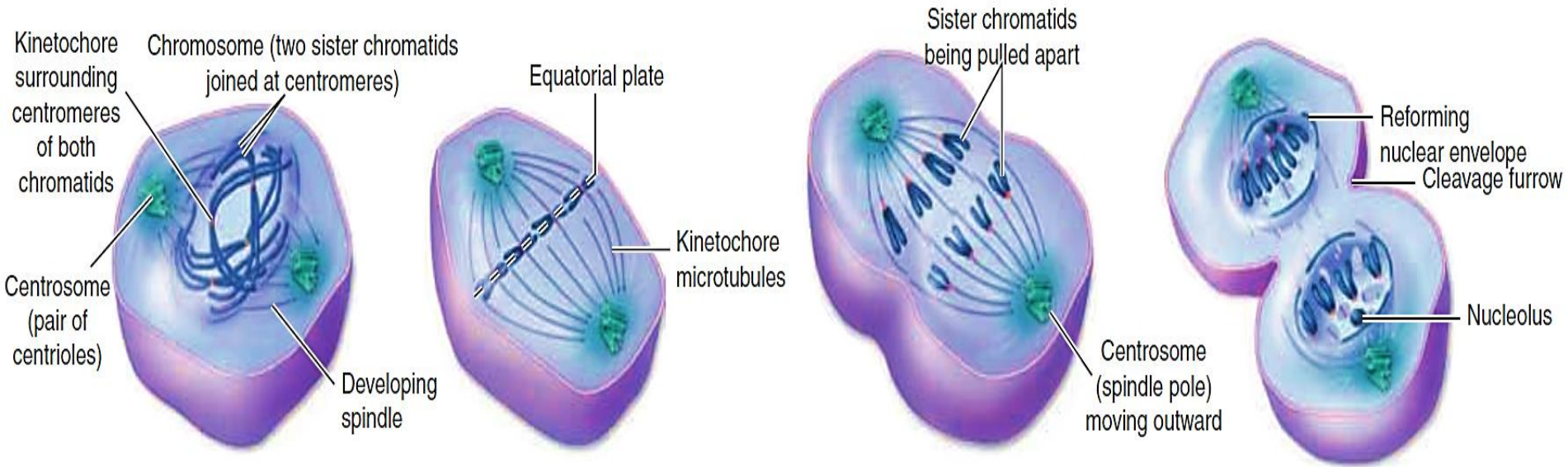


anaphase

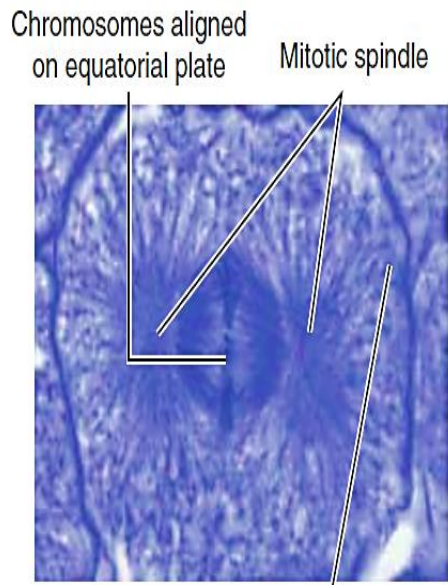
telophase

midbody

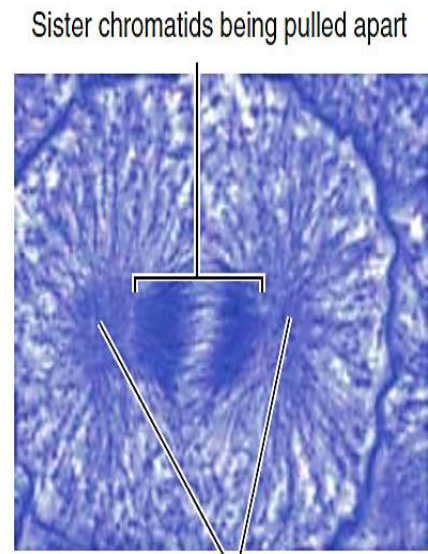
cytokinetic
furrow



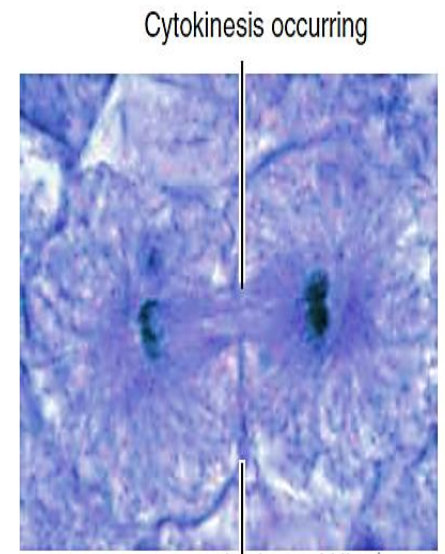
a Prophase



b Metaphase

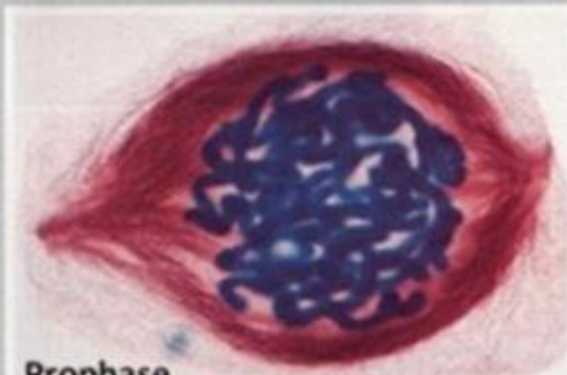


c Anaphase

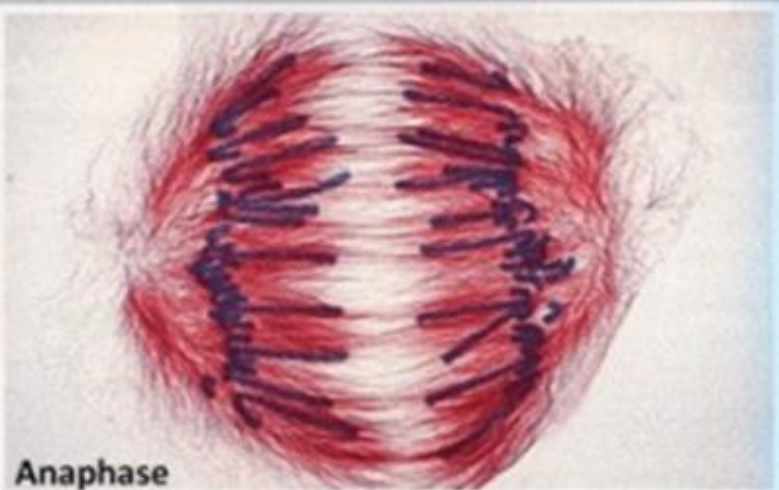


d Telophase

Activate Windows
Go to Settings to activate Windows



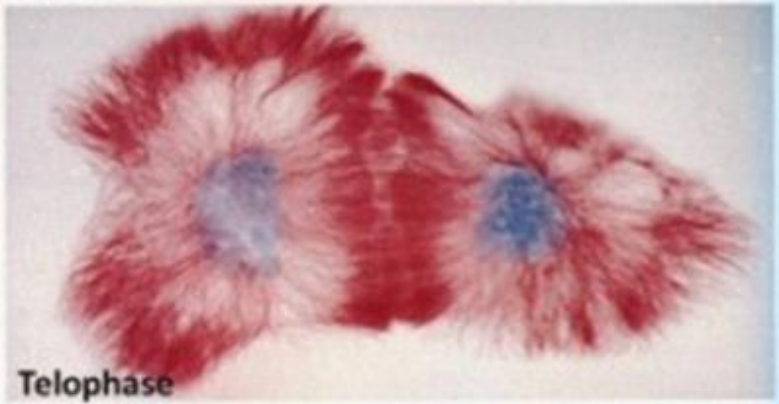
Prophase



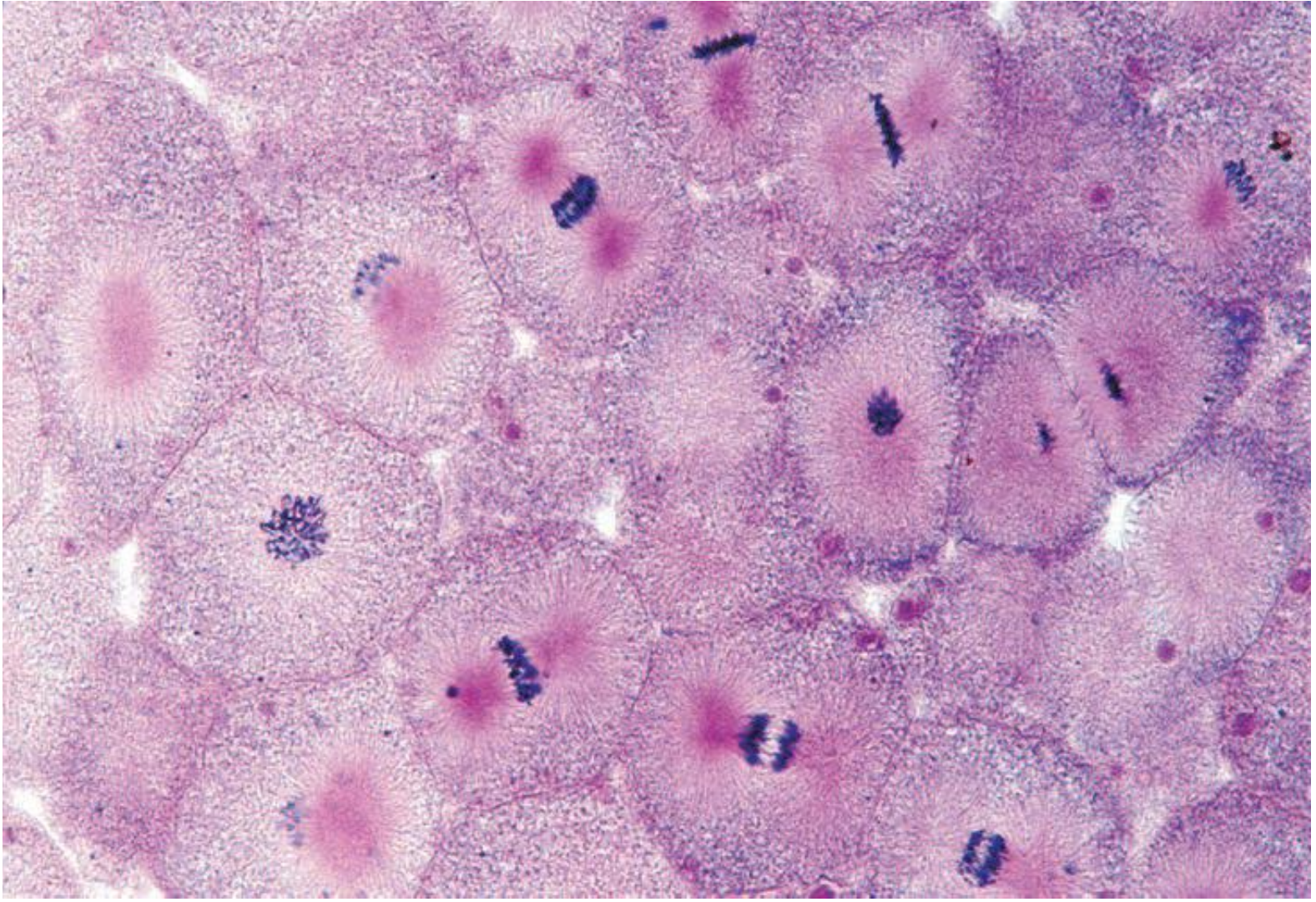
Anaphase



Metaphase



Telophase



A genome is the complete set of genetic information in an organism. It provides all of the information the organism requires to function.

Gene: Segment of chromosomal DNA which controls the production of a particular polypeptide chain.

Mitotic figures

- Cells in mitosis
- Appear in rapidly growing tissues (eg. Intestinal epithelium)



**Clinical
application**

-Increased number of mitotic figures & abnormal mitosis **in tumors** is important to distinguish malignant from benign tumors

-Mitotic figures are important also in prognosis of tumors.

