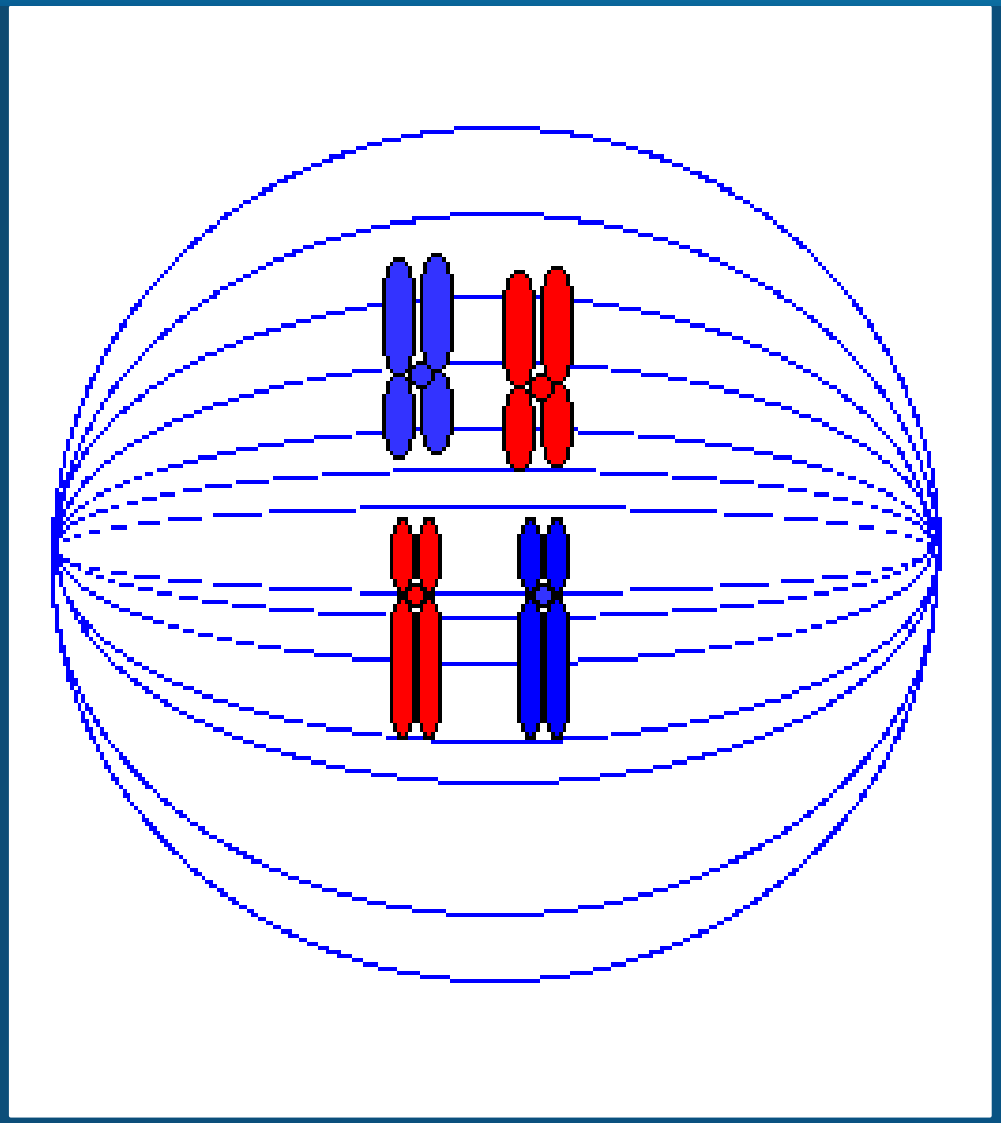
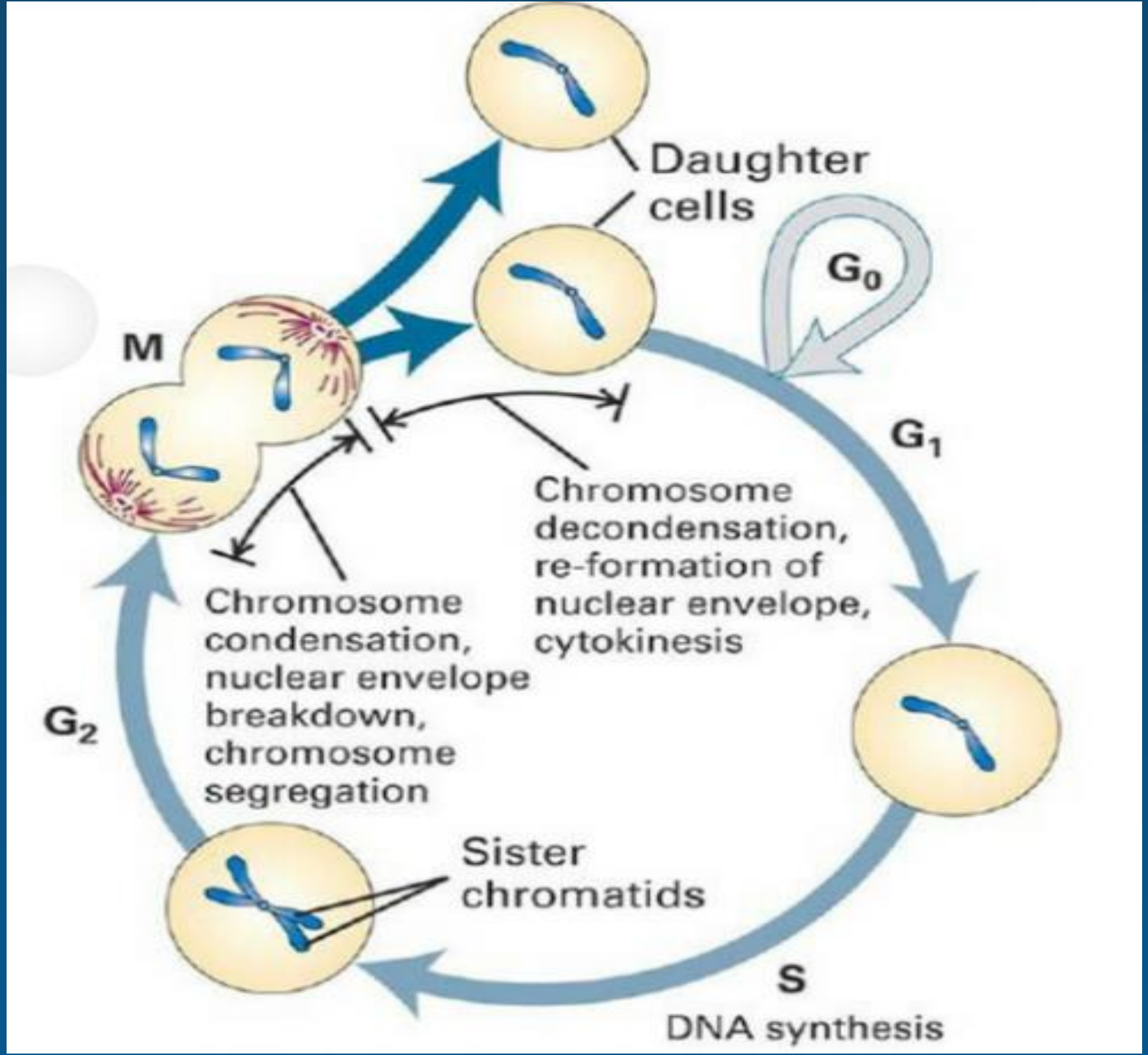
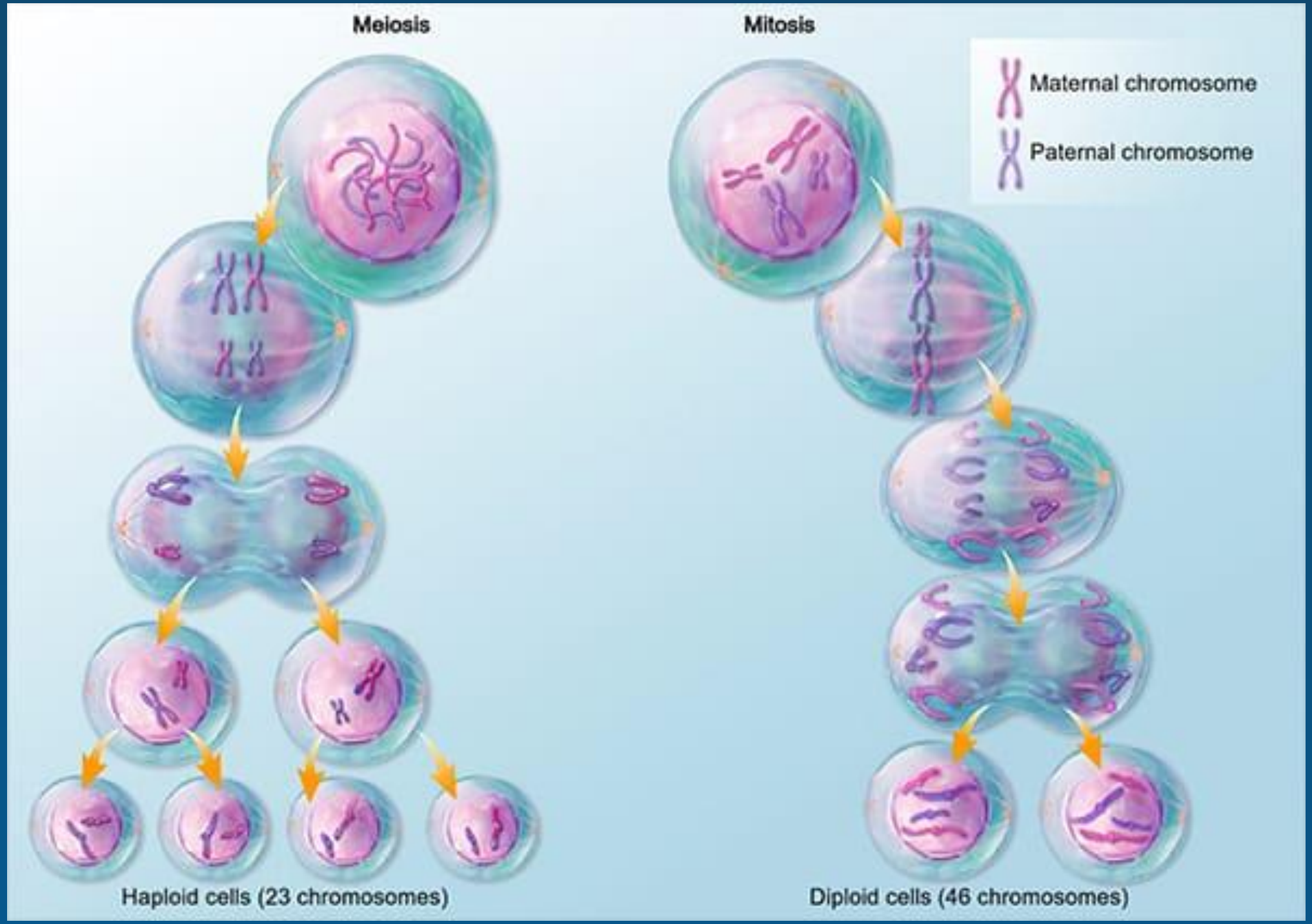
MITOSIS



INTRODUCTION

- The cell undergoes a sequence of changes, which involves period of growth, replication of DNA, followed by cell division. This sequence of changes is called cell cycle.
- It comprises two phases.
- 1. **Interphase**:
- It is the period of non-apparent division.
- 2. **Mitotic Phase**:
- It is the period of division.
- Each phase is further subdivided into different sub-phases.


Daughter cells
G_0
M
G_1
Chromosome decondensation, re-formation of nuclear envelope, cytokinesis
Chromosome condensation, nuclear envelope breakdown, chromosome segregation
G_2
Sister chromatids
S
DNA synthesis


Meiosis
Mitosis
Maternal chromosome
Paternal chromosome
Haploid cells (23 chromosomes)
Diploid cells (46 chromosomes)

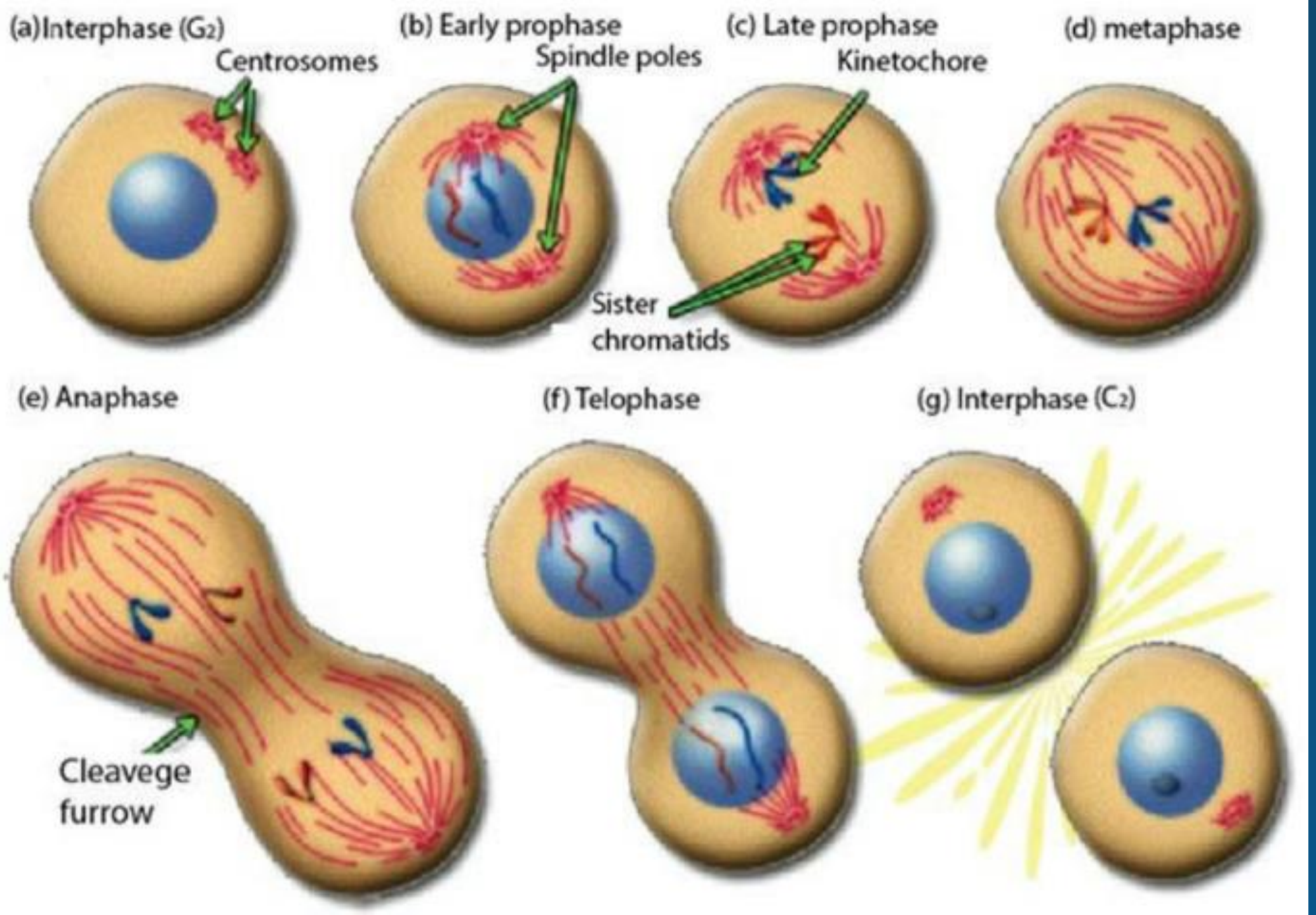
INTERPHASE

- The period of life cycle of cell (cell cycle) between two consecutive divisions is termed as the interphase or misleadingly called resting phase.
- It is the period of great biochemical activity and can further be divided into G_1-phase, S-phase and G_2-phase.
- **G_1 (Gap 1)** is the period of extensive metabolic activity, in which cell normally grows in size, specific enzymes, are synthesized and DNA base units are accumulated for the DNA synthesis.
- Post-mitotic cell can exit the cell cycle during G_1 entering a phase called **G_0**, and remain for days, weeks, or in some cases (e.g., nerve cells and cells of the eye lens) even the life time of the organism without proliferating further.

- Following the G_1 is the **S-phase** (synthesis phase) during which the DNA is synthesized and (chromosome are replicated).
- **G_2 phase (pre-mitotic phase),** prepares the cell for division e.g., energy storage for chromosome movements, mitosis specific proteins, RNA and microtubule subunits (for spindle fibers) synthesize.
- Cells then proceed to next phase which is the period of division. At each stage, there are specific check points, which determine the fate of new phase according to cell's internal make up.
- Length of each phase is variable. In the case of human cell, average cell cycle is about **24 hours**, mitosis takes **30 minutes**, G_1 **9 hours**, the S-phase **10 hours**, and G_2 **4.5 hours** whereas full cycle in yeast cells is only **90 minutes**.

MITOSIS

- It is the type of cell division, which ensures the same number of chromosomes in the daughter cells as that in the parent cells.
- In spite of slight differences, major steps of mitosis are similar in plants as well as in animals.
- It can take place in haploid as well as in diploid cells in nearly all parts of the body if and when required.
- Mitosis is a continuous process, but conventionally it may be divided into two phases.
- 1. **Karyokinesis** involves the division of nucleus
- 2. **Cytokinesis** refers to the division of the whole cell.


(a) Interphase (G_2)
Centrosomes
(b) Early prophase
Spindle poles
(c) Late prophase
Kinetochore
(d) metaphase
Sister chromatids
(e) Anaphase
Cleavege furrow
(f) Telophase
(g) Interphase (C_2)

KARYOKINESIS

- At the beginning of the process in an animal cell, the partition of the centriole takes place, which have been duplicated during interphase but present in the same centrosome. Early in the mitosis the two pair of centrioles separate and migrate to opposite sides of the nucleus, establishing the bipolarity of the dividing cells.
- Three sets of microtubules (fibers) originate from each pair of centrioles. One set the astral microtubules, radiate outward and form aster, other two sets of microtubules compose the spindle.
- The kinetochore microtubules attach to chromosomes at kinetochores and polar microtubules do not interact the chromosomes but instead interdigitate with polar microtubules from the opposite pole. These microtubules are composed of a protein tubulin and traces of RNA.

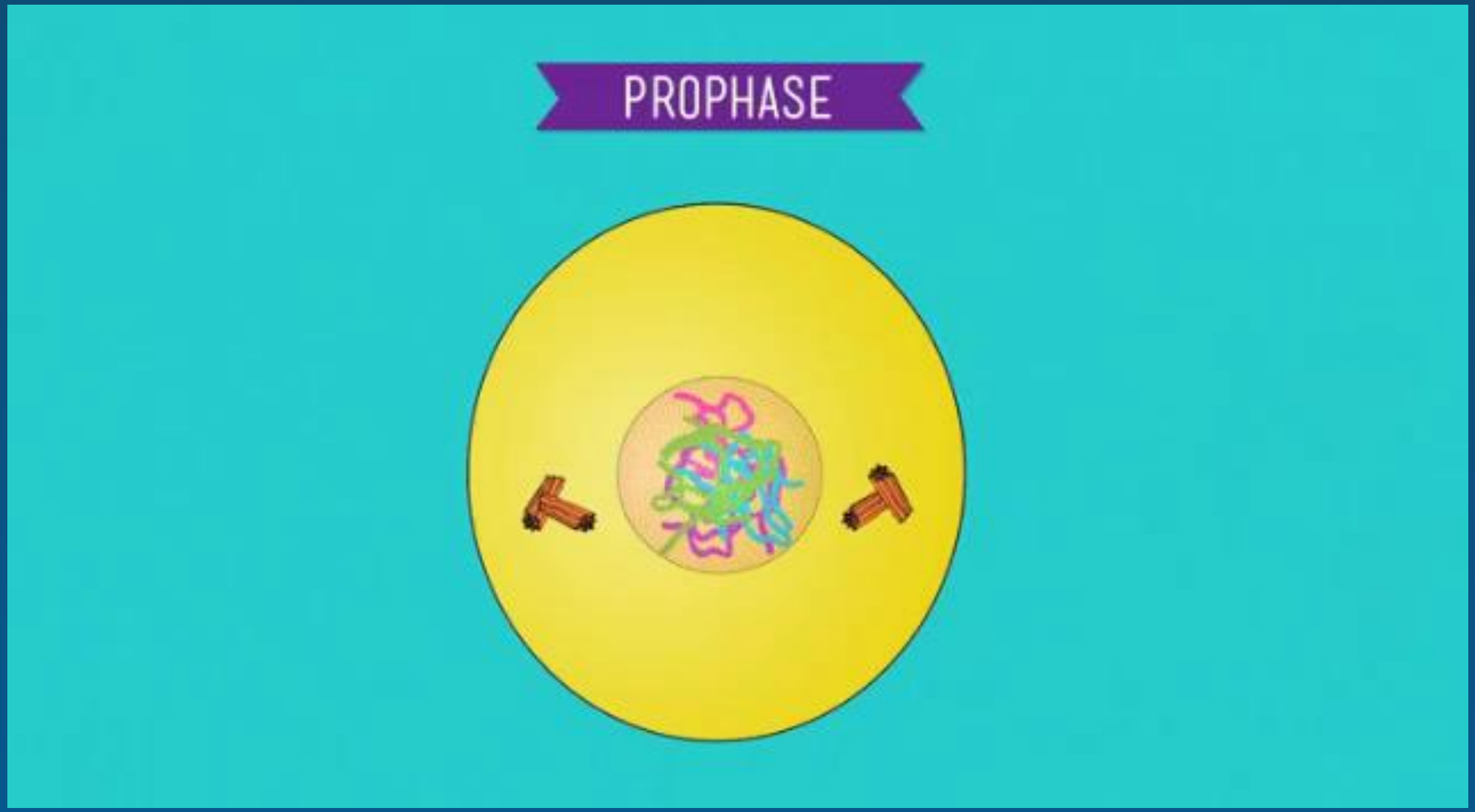
KARYOKINESIS

- This specialized microtubule structure including aster and spindle is called **mitotic apparatus**. This is larger than the nucleus, and is designed to attach and capture chromosomes, aligning them and finally separating them so that equal distribution of chromosomes is ensured.
- Karyokinesis can further be divided into prophase, metaphase, anaphase and telophase for thorough understanding, though it is a continuous process.

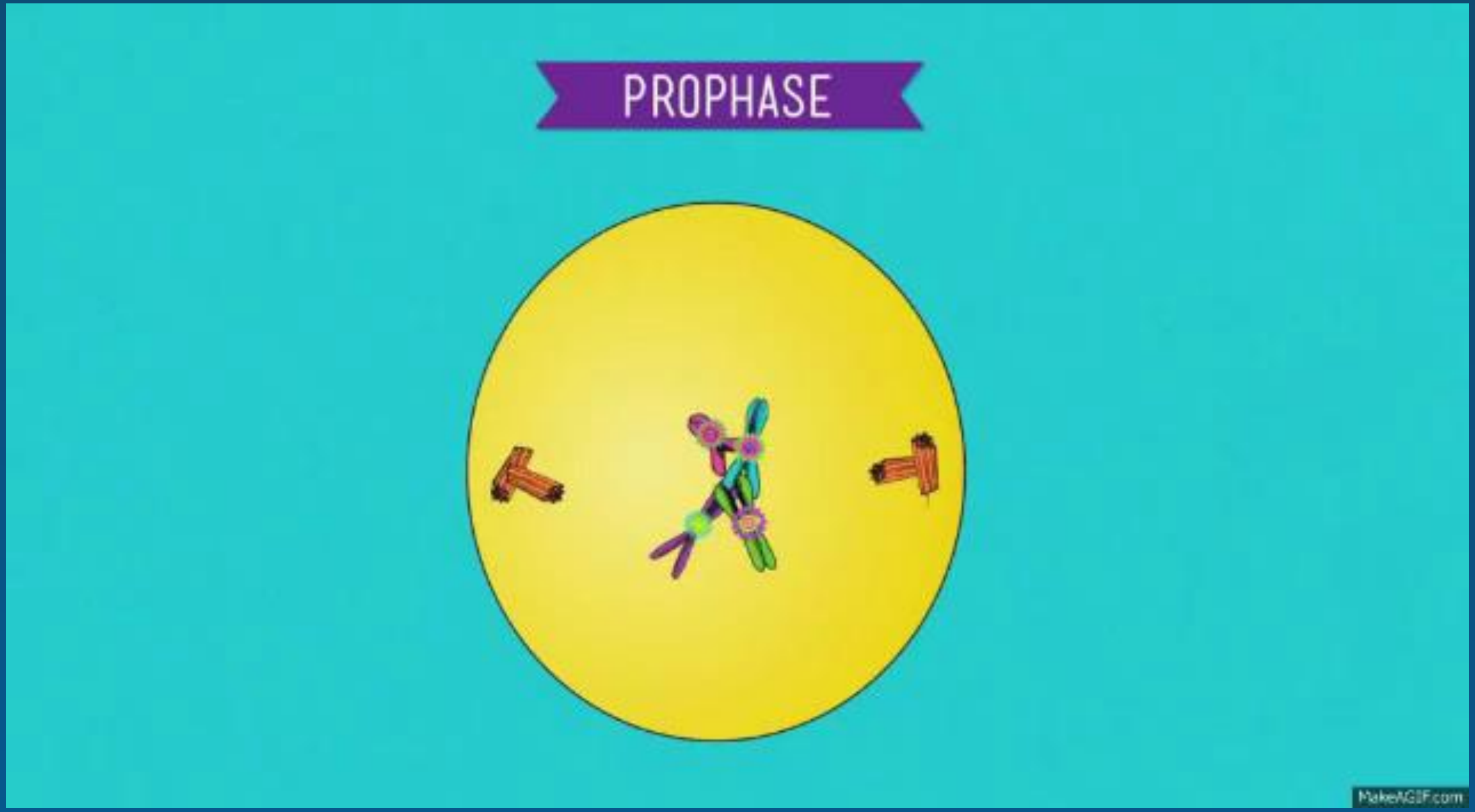
Prophase

- During interphase (non-dividing phase) of the cell cycle the chromosomes are not visible even with electron microscope, but using histologic stains for DNA, a network of very fine threads can be visualized. This network is called as chromatin.
- The chromatin material gets condensed by folding and the chromosomes appear as thin threads (0.25um – 50um in length) at the beginning of prophase.
- Chromosomes become more and more thick ultimately each chromosome is visible having two sister chromatids, attached at centromere. Towards the end of prophase, nuclear envelope disappears and nuclear material is released in the cytoplasm, nucleoli disappear. Mitotic apparatus is organized (as described above). Cytoplasm becomes more viscous.

Early Prophase



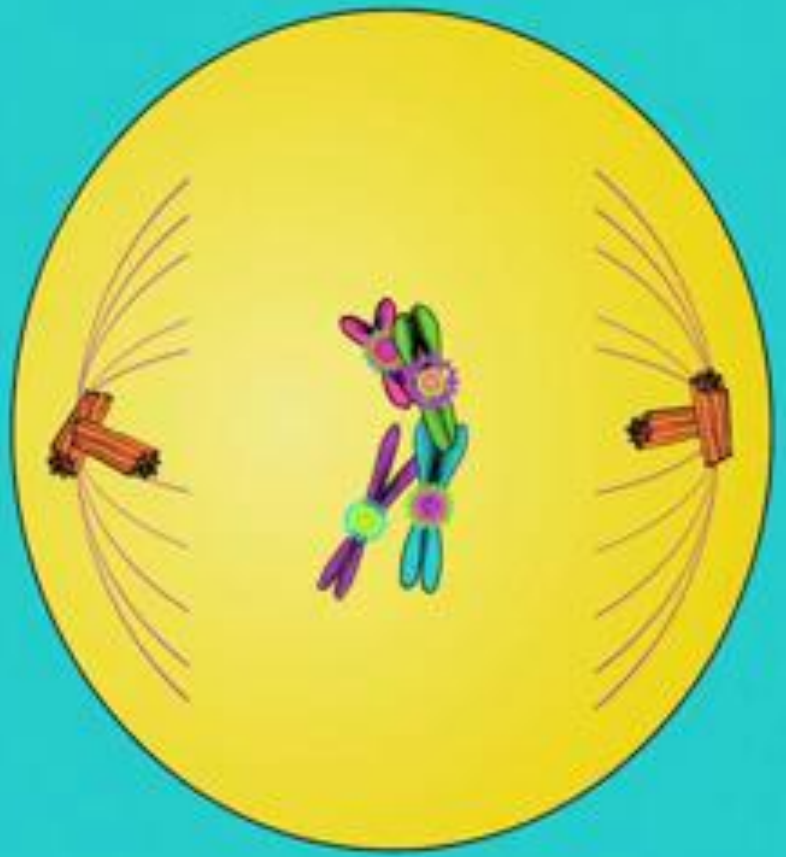
Late Prophase



Metaphase

- Each metaphase chromosome is a duplicated structure which consists of two sister chromatids, attached at a point called centromere or primary constriction. The centromere has special area, the **kinetochore**, with specific base arrangement and special proteins where kinetochore fibers of mitotic apparatus attach.
- The kinetochore fibers of spindle attach to the kinetochore region (specialized area in centromere) of chromosome, and align them at the equator of the spindle forming equatorial plate or metaphase plate. Each kinetochore gets two fibers one from each pole.

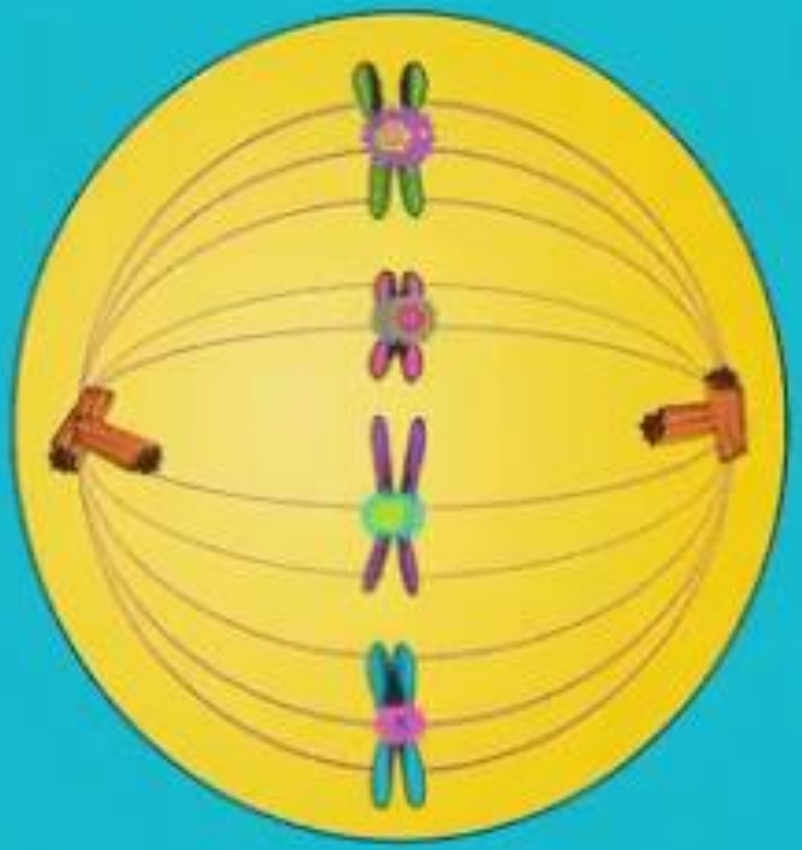
METAPHASE



Anaphase

- It is the most critical phase of the mitosis, which ensures equal distribution of chromatids in the daughter cells.
- The kinetochore fibers of spindle contract towards their respective poles, at the same time polar microtubules elongates exert force and sister chromatids are separated from centromere.
- As a result, half sister chromatids travel towards each pole.

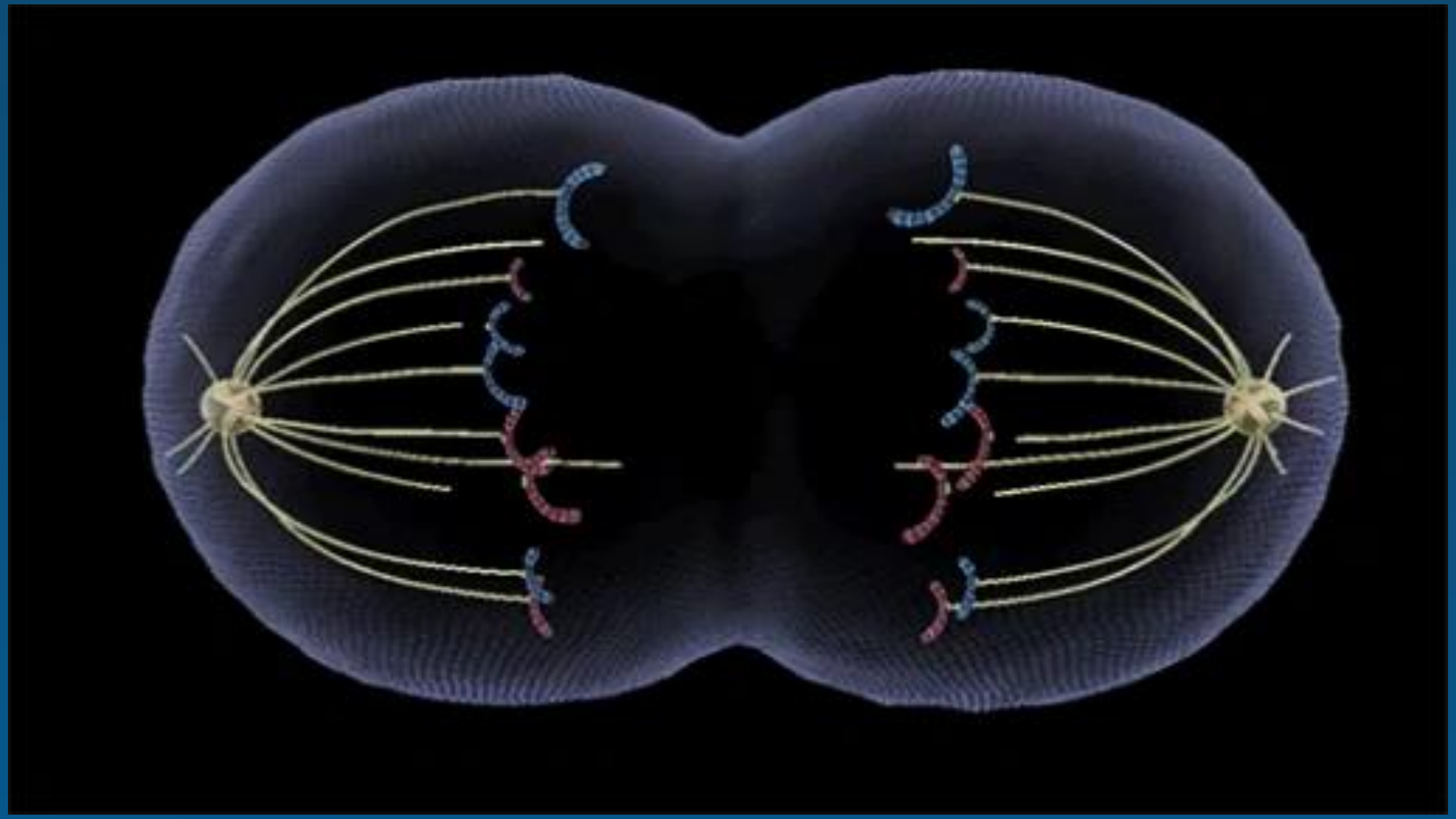
ANAPHASE



Telophase

- Reaching of the chromosomes at opposite poles terminates anaphase and start telophase. The chromosomes decondense due to unfolding, ultimately disappear as chromatin.
- Mitotic apparatus disorganizes nuclear membrane and nucleoli reorganize, resulting two nuclei at two poles of the cell.

Telophase

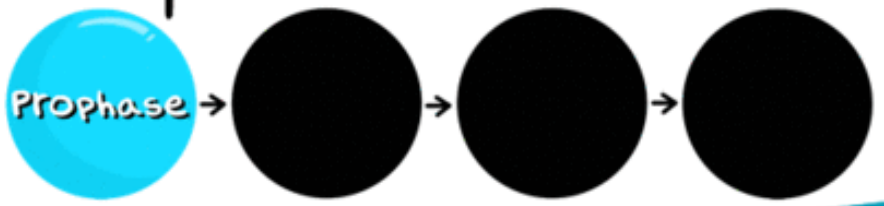


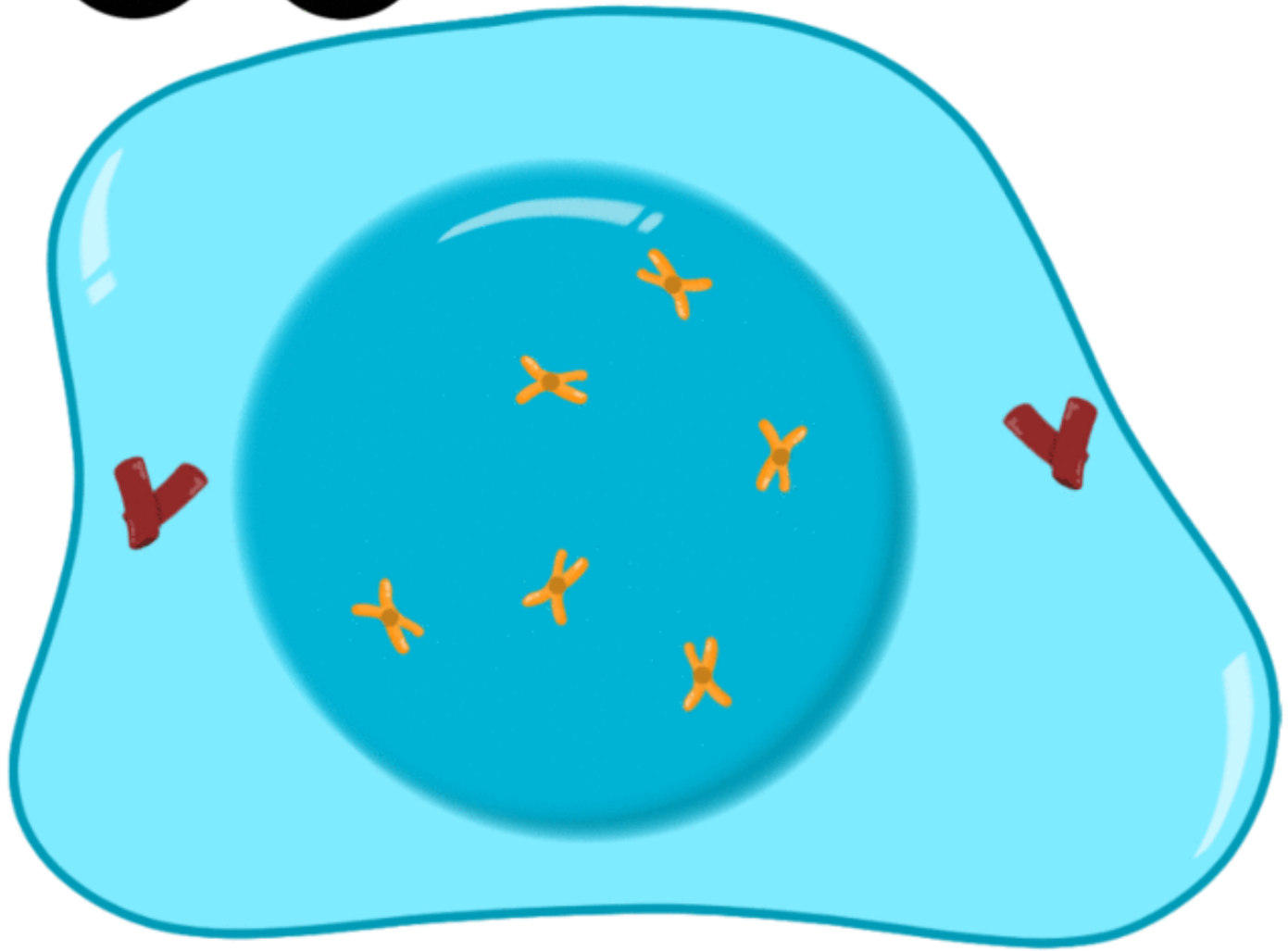
#AmoebaGIFs

Stages of Mitosis

@AmoebaSisters

Prophase

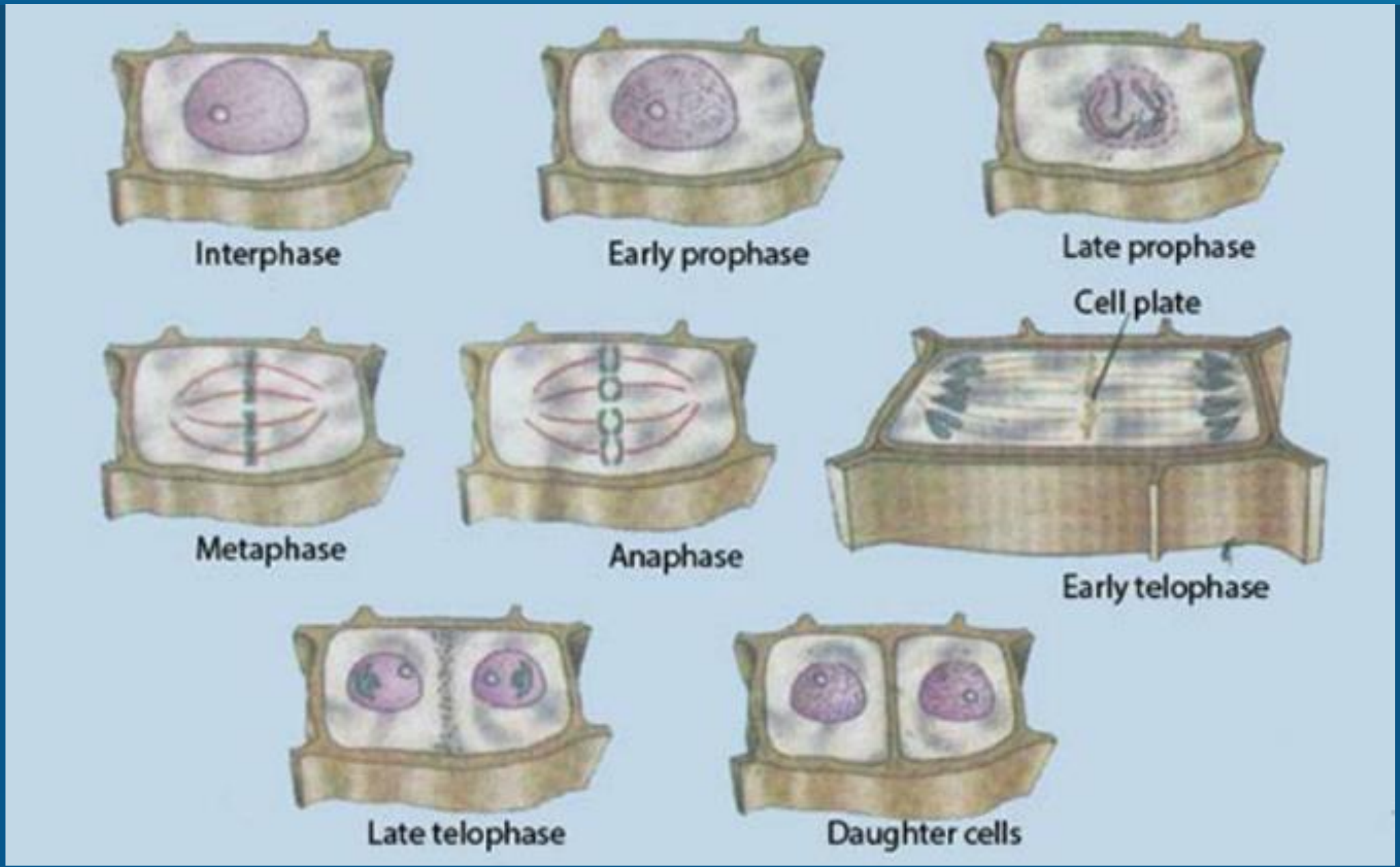




CYTOKINESIS

- During late telophase the astral microtubules send signals to the equatorial region of the cell, where actin and myosin are activated which form contractile ring, followed by cleavage furrow, which deepens towards the center of the cell, dividing the parent cell into two daughter cells.
- Mitotic events in plant cells are generally similar to the events observed in animal cells but there are some major differences. Most higher plants lack visible centrioles, instead they have its analogous region from which the spindle microtubules radiate. Moreover, shape of the plant cell does not change greatly compared with an animal cell- because it is surrounded by a rigid cell wall. At cytokinesis, in place of contractile ring a membrane structure, phragmoplast is formed from vesicle which originate from Golgi complex.
- These vesicles originate actually during metaphase, line up in the center of the dividing cell, where they fuse to form phragmoplast at the end of telophase. The membrane of vesicles becomes the plasma membrane of daughter cells. These vesicles also contain materials for future cell wall such as precursors of cellulose and pectin.

CYTOKINESIS



Importance of Mitosis

- In mitosis the hereditary material is equally distributed in the daughter cell. As there is no crossing over or recombination, the genetic information remains unchanged generation after generation, thus continuity of similar information is ensured from parent to daughter cell. Some organisms, both plants and animals, undergo asexual reproduction.
- Regeneration, healing of wounds and replacement of older cells all are the gifts of mitosis. Development and growth of multicellular organisms depends upon orderly, controlled mitosis. Tissue culture and cloning seek help through mitosis.
- For all this an organism requires managed, controlled and properly organized process of mitosis, which otherwise may result malfunction, unwanted tumors and lethal diseases like cancer.

THE END