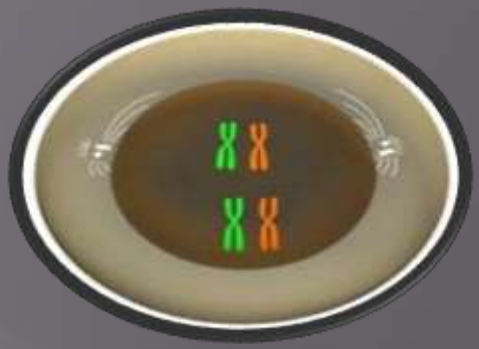
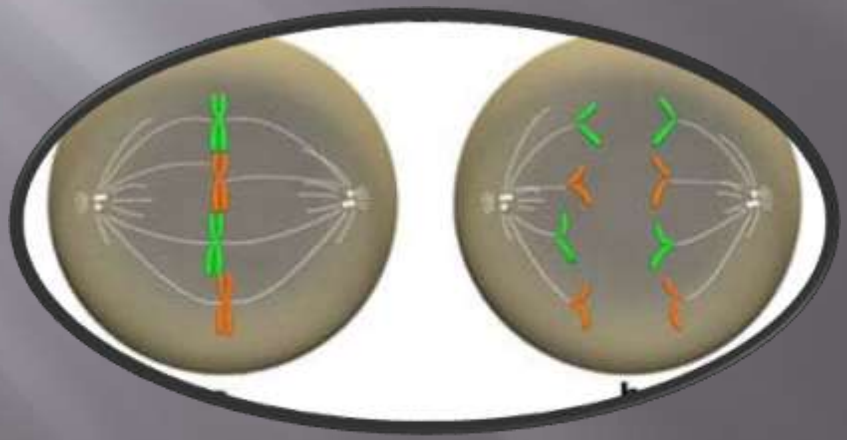


CELLULAR DIVISION



Most cells grow, perform the activities needed to survive, and divide to create new cells. These basic processes, known collectively as **the cell cycle**, are repeated throughout the life of a cell.

In many situations, division also ensures that new cells are available to replace the older cells within an organism whenever those cells die.

- **Prokaryotic cells**, which include bacteria, undergo a type of cell division known as **binary fission**. This process involves replication of the cell's chromosomes, segregation of the copied DNA, and splitting of the parent cell's cytoplasm. The outcome of binary fission **is two new cells that are identical to the original cell**.

- In contrast to prokaryotic cells, **eukaryotic cells** may divide via either **mitosis or meiosis**. Of these two processes, **mitosis is more common**.
- In fact, whereas only **sexually** reproducing eukaryotes can engage in meiosis, all eukaryotes — regardless of size or number of cells — can engage in **mitosis**. **But how does this process proceed, and what sorts of cells does it produce?**

What happens during mitosis?

- **During mitosis**, a eukaryotic cell undergoes a carefully coordinated nuclear division that results in the formation of two genetically identical daughter cells.
- **Mitosis** itself **consists of five active steps**, or phases:

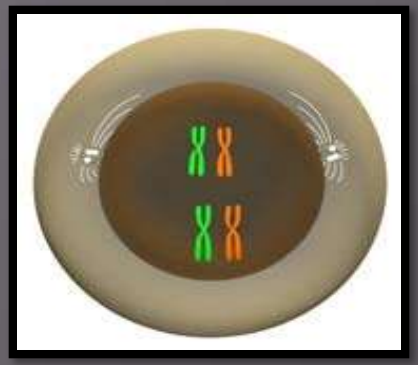
prophase, prometaphase, metaphase, anaphase, and telophase.

- Before a cell can enter the active phases of mitosis, however, it must go through a period known as **interphase**, during which **it grows and produces the various proteins necessary for division.**

- Then, at a critical point during interphase (called the **S phase**), the **cell duplicates its chromosomes and ensures its systems are ready for cell division.**
- If all conditions are ideal, the cell is now ready to move into the first phase of mitosis.

Prophase

- **Prophase** is the first phase of mitosis. During this phase, the chromosomes inside the cell's nucleus condense and form tight structures.
- In fact, the chromosomes become so dense that they appear as **curvy, dark lines** when viewed under a microscope (Figure 1).
- Because each chromosome was duplicated during S phase, it now consists of two identical copies called **sister chromatids** that are attached at a common center point called the **centromere**.



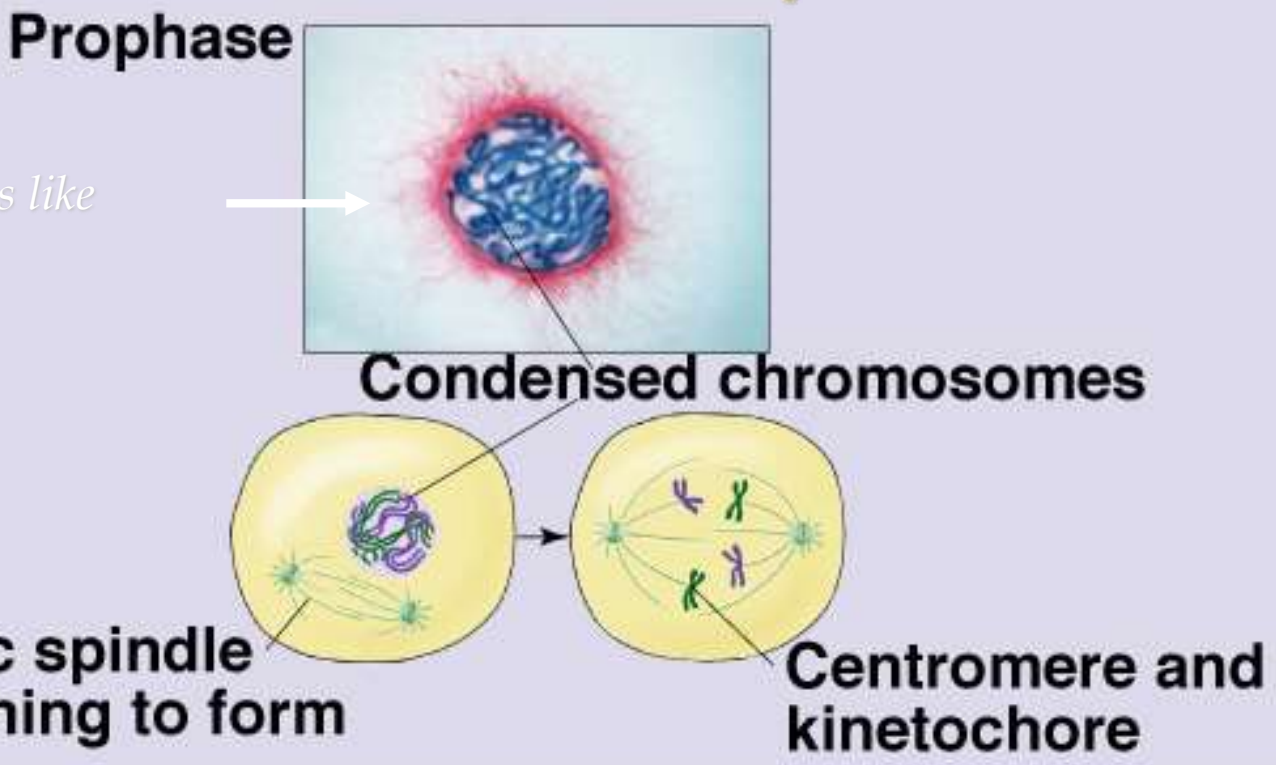
Important changes also take place outside of the nucleus during prophase:

- In particular, two structures called **centrosomes**

move to opposite sides of the cell during this phase and begin building the **mitotic spindle**. The mitotic spindle plays acritical role during the later phases of mitosis as **it orchestrates the movement of sister chromatids to opposite poles of the cell** (Figure 2).

Review of Prophase

What the cell looks like

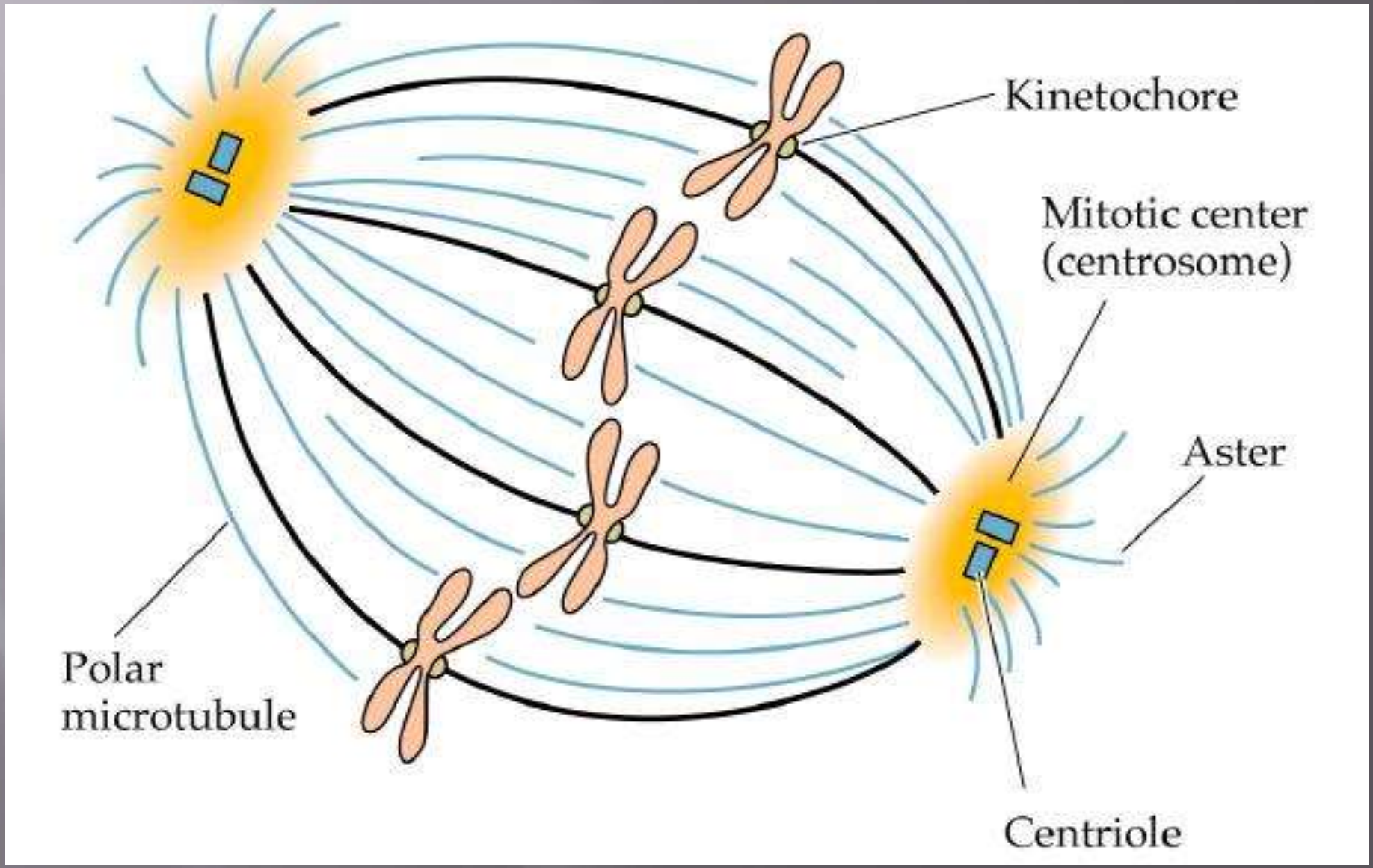


- Nuclear membrane disintegrates, and nucleolus disappears
- Chromosomes condense
- Mitotic spindle begins to form and is complete at the end of prophase
- Kinetochores begin to mature and attach to spindle

Spindle Fibers

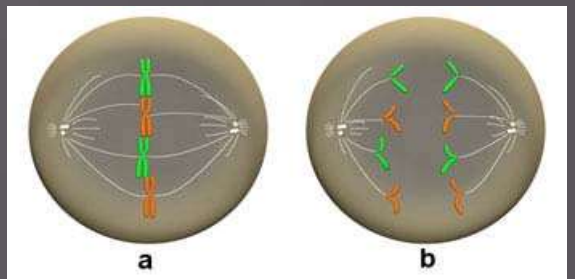
- The mitotic **spindle** form from the **microtubules in plants** and **centrioles in animal cells**
- **Polar fibers** extend from one pole of the cell to the opposite pole
- **Kinetochore fibers** extend from the pole to the centromere of the chromosome to which they attach
- **Asters** are short fibers radiating from centrioles

Sketch The Spindle



Prometaphase

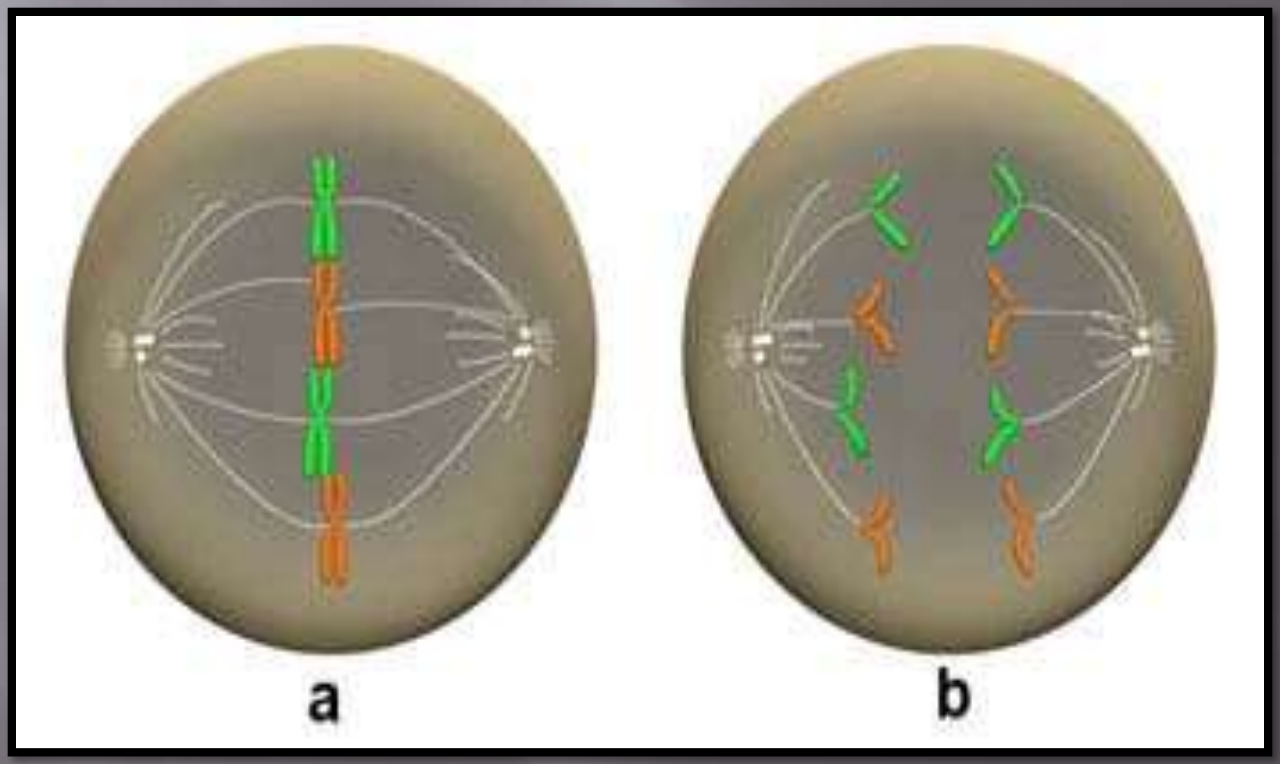
- After prophase is complete, the cell enters **prometaphase**.
- During prometaphase, the nuclear membrane disintegrates and the mitotic spindle gains access to the chromosomes.
- During this phase, a protein structure called the **kinetochore** is associated with the centromere on each sister **chromatid. Stringlike structures called microtubules grow out from the spindle and connect to the sister chromatids at their kinetochores;** one microtubule from one side of the spindle attaches to one sister chromatid in each chromosome, and one microtubule from the other side of the spindle attaches to the other sister chromatid (Figure 3a).



Metaphase

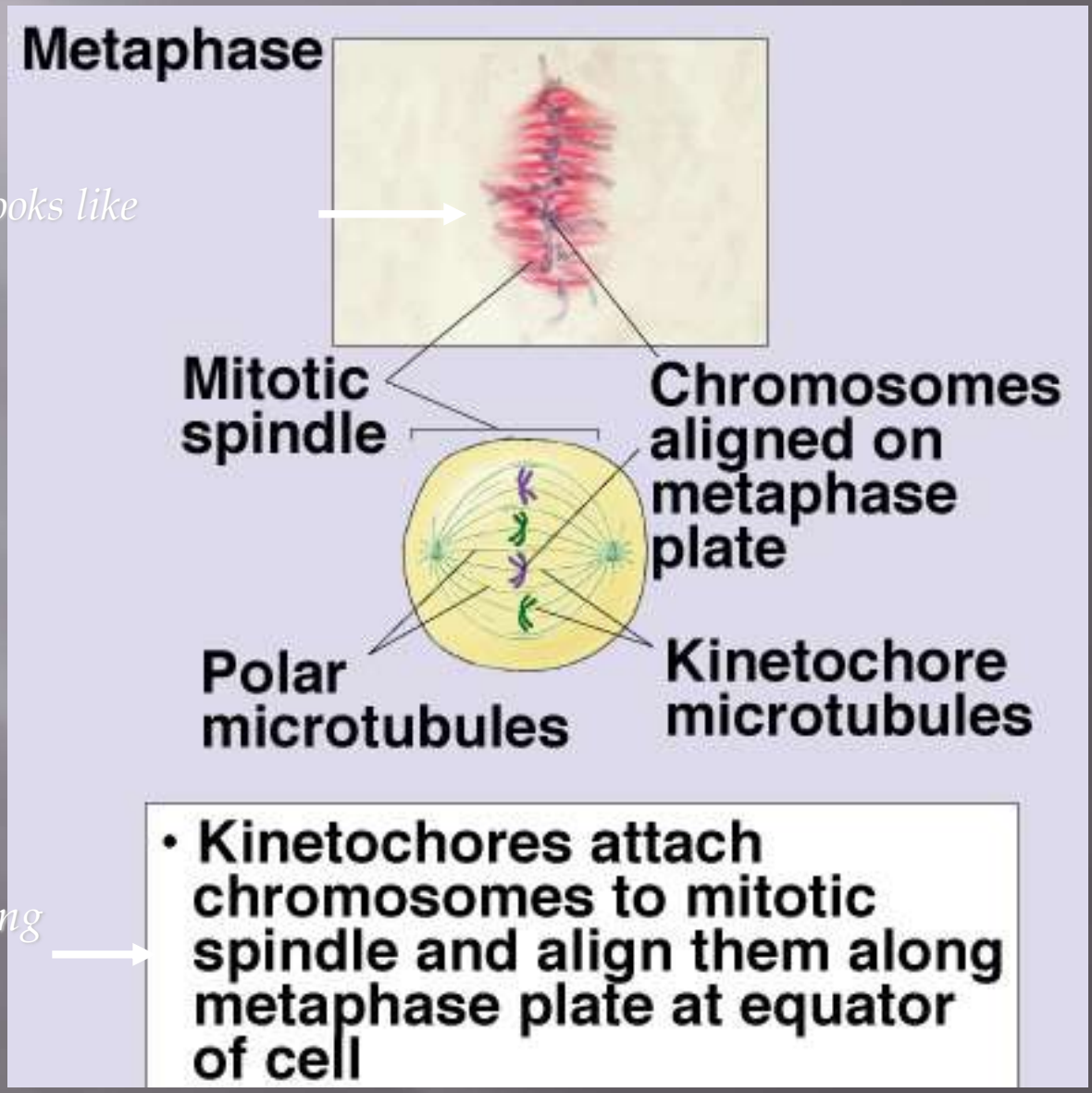
- Following prometaphase, **metaphase** begins. At the start of metaphase, the microtubules arrange the chromosomes in a line along the equator of the cell, known as the **metaphase plate** (Figure 3b).
- The centrosomes, on opposite poles of the cell, then prepare to separate the sister chromatid

Figure 3: In metaphase (a), the microtubules of the spindle (white) have attached and the chromosomes have lined up on the metaphase plate. During anaphase (b), the sister chromatids are pulled apart and move toward opposite poles of the cell.



Review of Metaphase

What the cell looks like



What's occurring

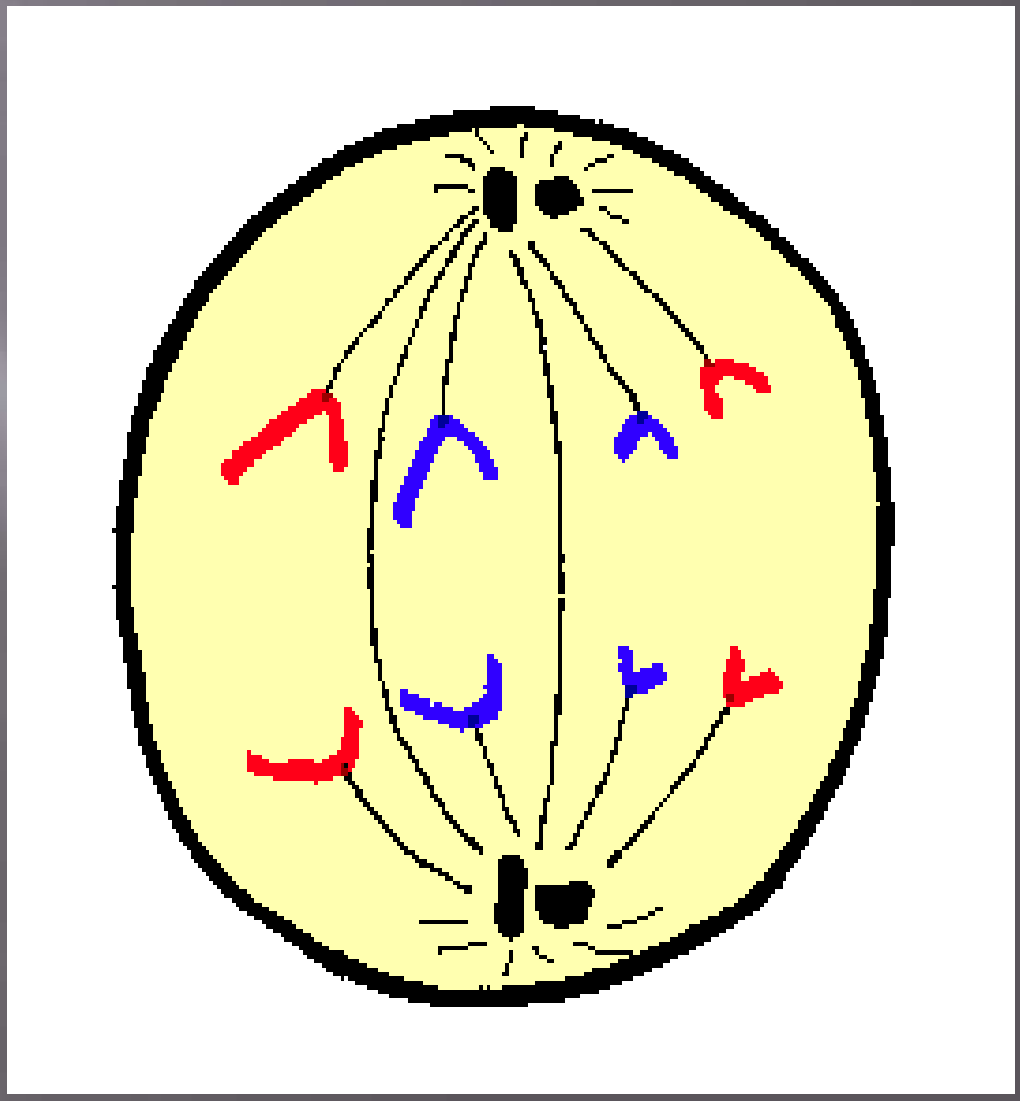
- Kinetochores attach chromosomes to mitotic spindle and align them along metaphase plate at equator of cell

Anaphase

After metaphase is complete, the cell enters anaphase. During anaphase, the microtubules attached to the kinetochores contract, which pulls the sister chromatids apart and toward opposite poles of the cell (Figure 3c). At this point, each chromatid is considered a separate chromosome. .

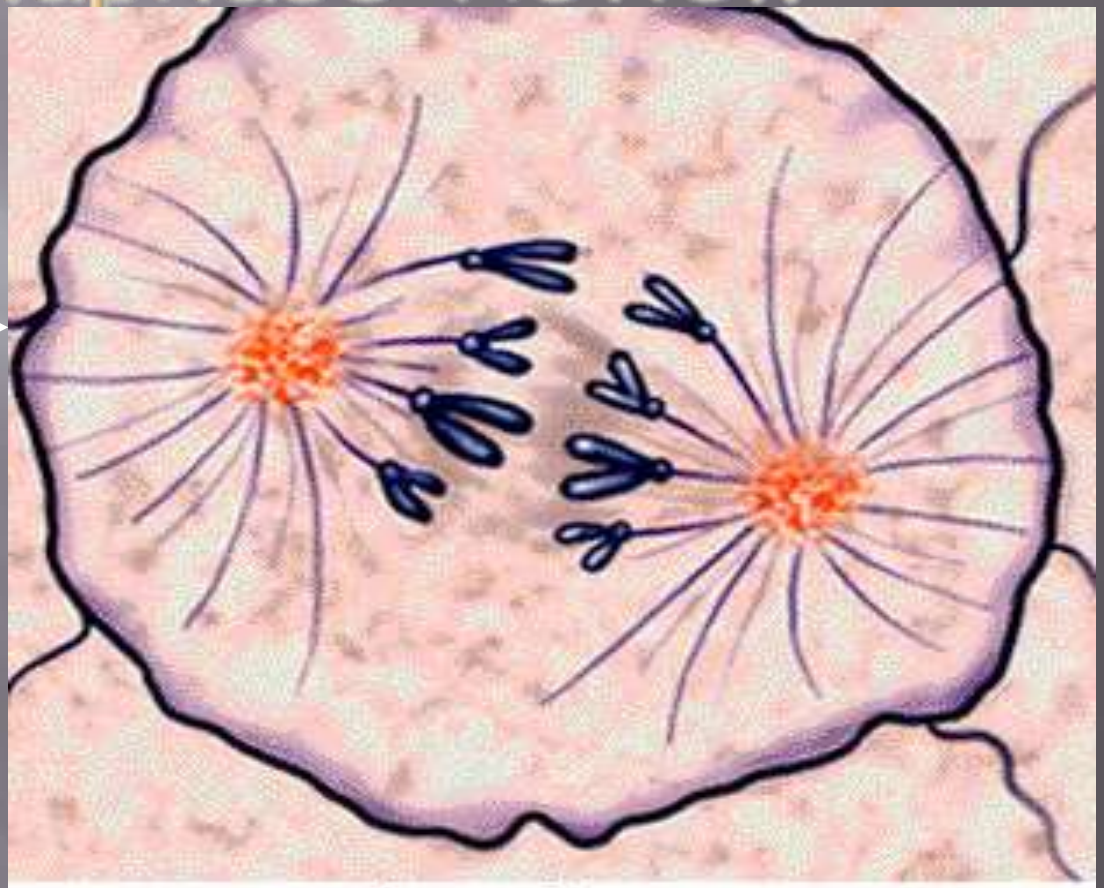
Anaphase

- Occurs rapidly
- Sister chromatids are pulled apart to opposite poles of the cell by kinetochore fibers



Anaphase Review

What the cell looks like



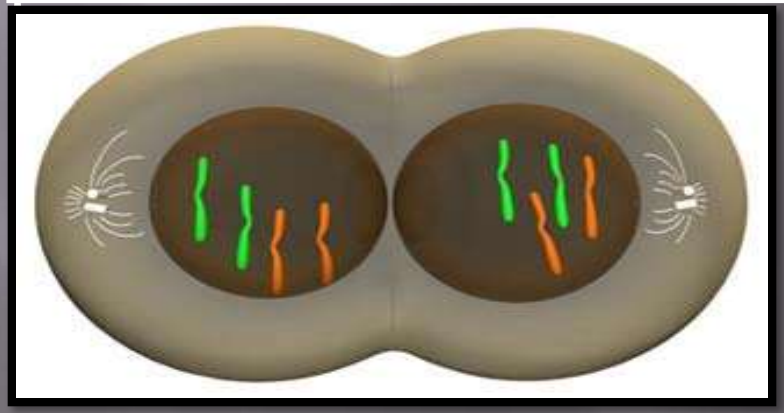
What's occurring

Anaphase

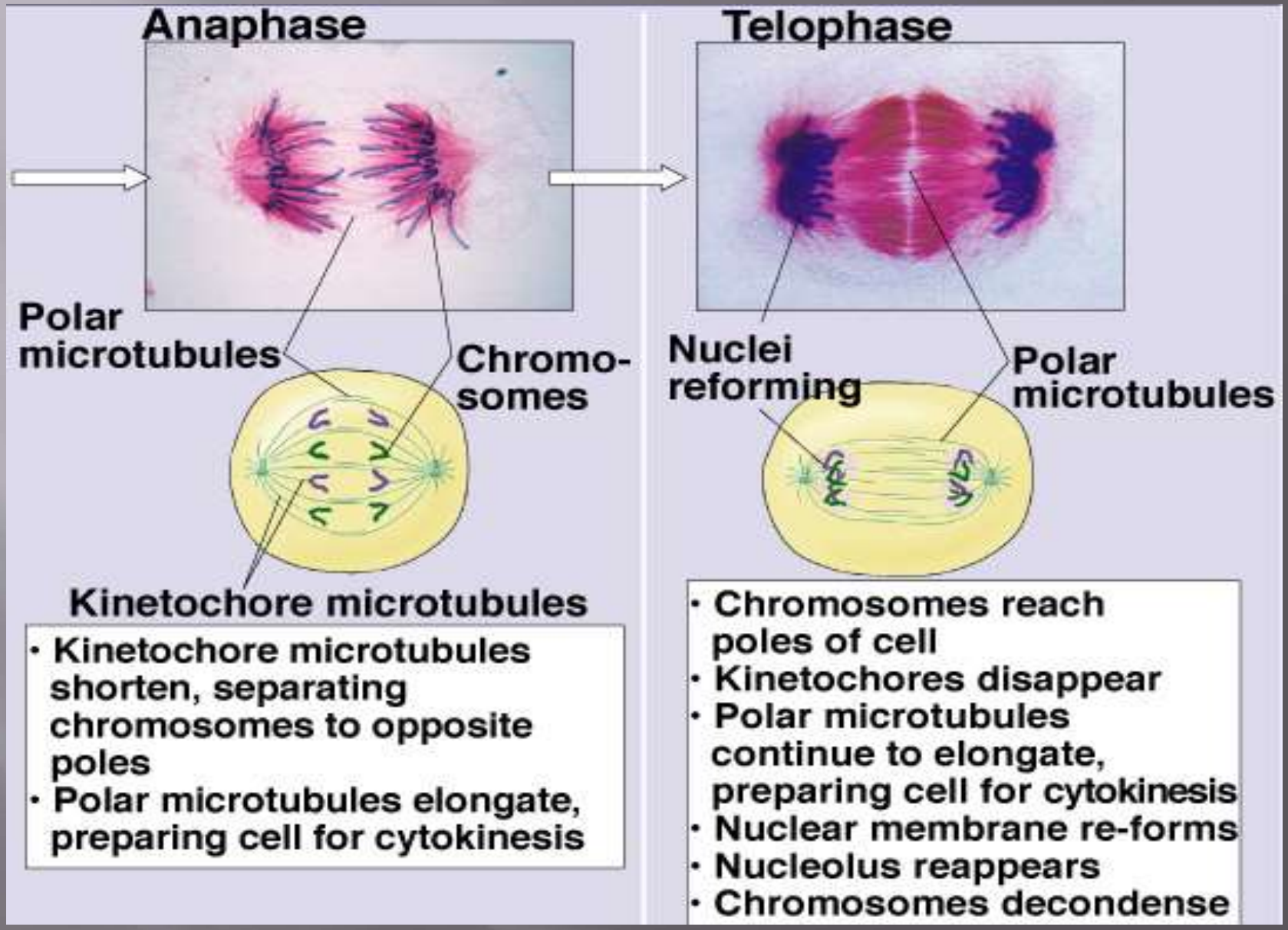
Centromeres divide in two.
Spindle fibers pull sister chromatids to opposite poles of cell.
Each pole (future daughter cell) now has an identical set of genes.

Telophase

- Finally, once anaphase is complete, the cell enters the last stage of the division process — **telophase**. During telophase, the newly separated chromosomes reach the mitotic spindle and a nuclear membrane forms around each set of chromosomes, thus creating two separate nuclei inside the same cell. As Figure 4 illustrates, the cytoplasm then divides to produce two identical cells.



Comparison of Anaphase & Telophase



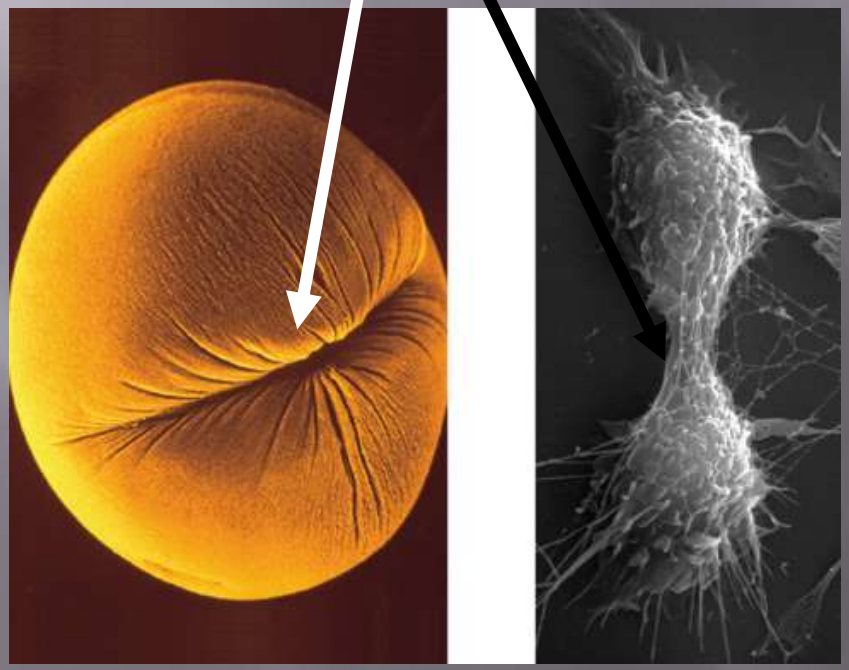
Cytokinesis

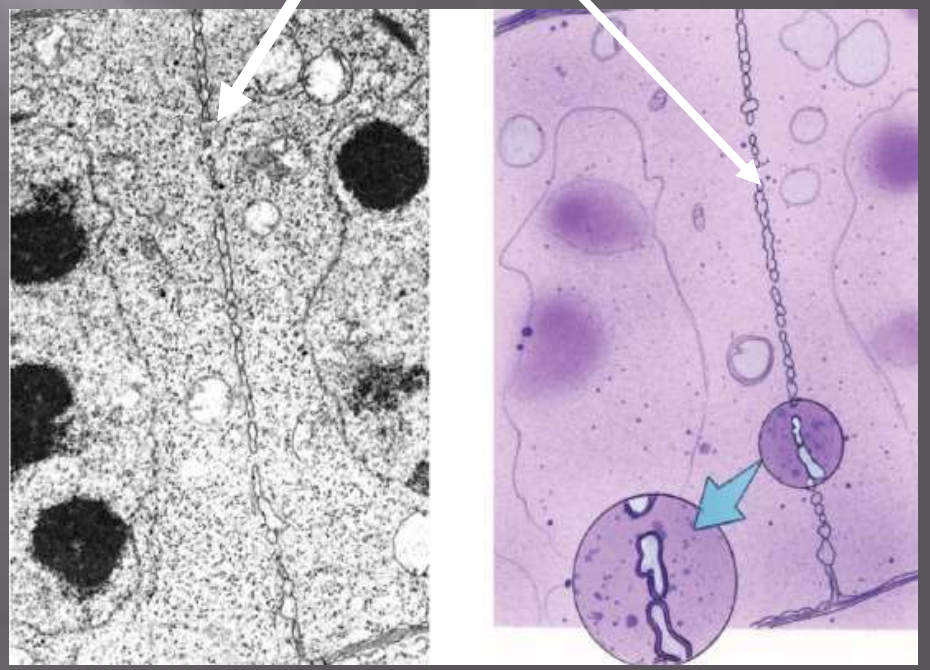
- Means division of the cytoplasm
- Division of cell into two, identical halves called daughter cells
- In plant cells, cell plate forms at the equator to divide cell
- In animal cells, cleavage furrow forms to split cell

Cytokinesis

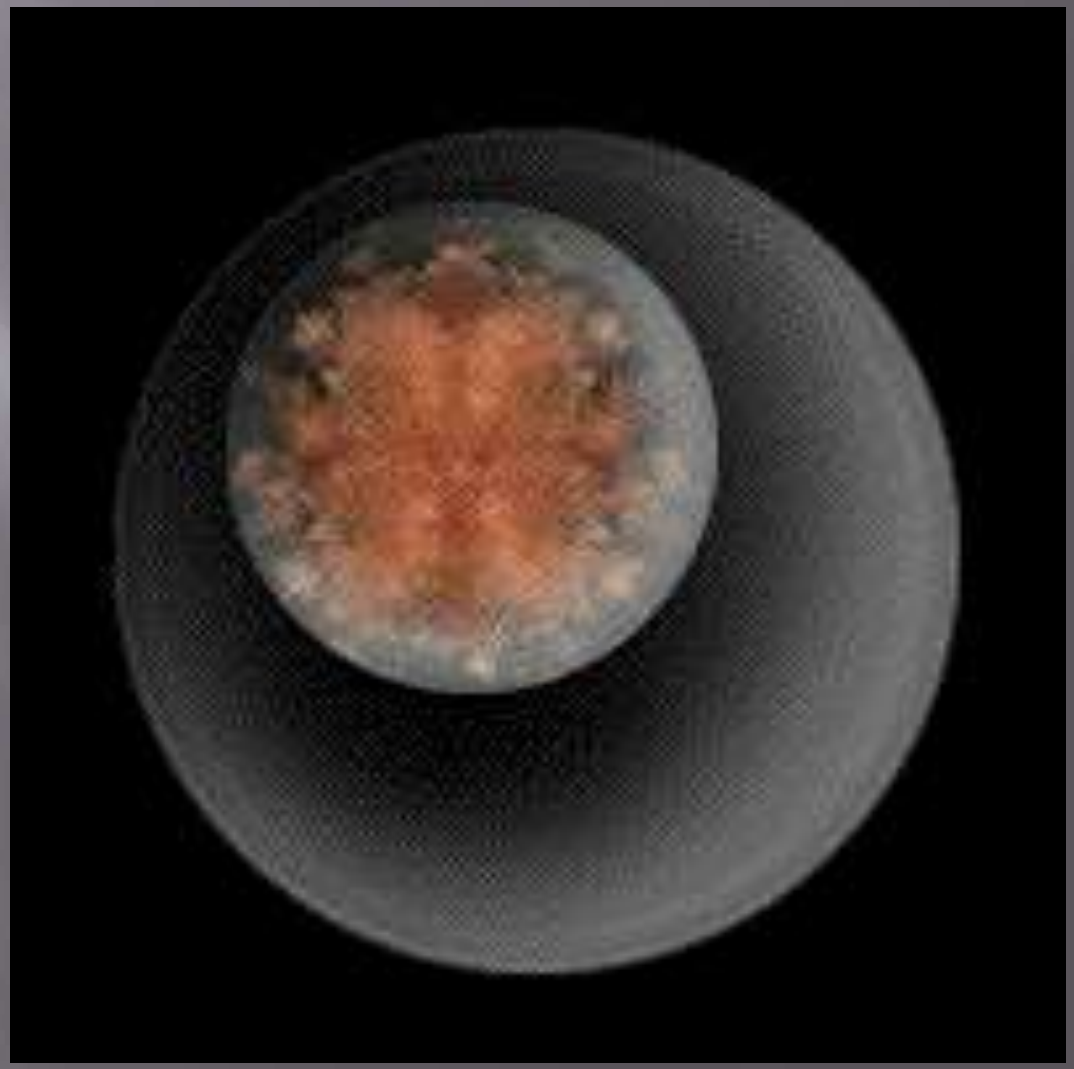
Cleavage furrow in animal cell

Cell plate in plant cell





Review of Mitosis



Why is mitosis important?

- As previously mentioned, most eukaryotic cells that are not involved in the production of gametes undergo mitosis.
- These cells, known as **somatic cells**, are **important to the survival of eukaryotic organisms, and it is essential that somatic parent and daughter cells do not vary from one another.**

- **Mitosis** ensures that each successive cellular generation has the same genetic composition as the previous generation, as well as an identical chromosome set.

Questions