Cell Division and Mitosis

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Cell Biology, 1st Semester/W7

Outline

- Prokaryotic Cell divison
- The cell cycle
- Eukaryotic cell division
- Mitosis

Why do cells divide?

- Growth
- Repair and replace dead cells
- Asexual reproduction

Why do cells divide?

- All cells come from other living cells.
- Every day, every hour, every second one of the most important events in life is going on in your body—cells are dividing.
- When cells divide, they make new cells. A single cell divides to make two cells and these two cells then divide to make four cells, and so on.
- We call this process "cell division" and "cell reproduction," because new cells are formed when old cells divide. The ability of cells to divide is unique for living organisms.

- Cells divide for many reasons. For example, when you skin your knee, cells divide to replace old, dead, or damaged cells.
- Cells also divide so living things can grow. When organisms grow, it isn't because cells are getting larger.
- Organisms grow because cells are dividing to produce more and more cells. In human bodies, nearly two trillion cells divide every day.
- Cells must also divide because old cells die and need new cells to replace them!

Cell Division

- Cells regulate their division by communicating with each other using chemical signals from special proteins called cyclins.
- These signals act like switches to tell cells when to start dividing and later when to stop dividing.
- It is important for cells to divide so you can grow and so your cuts heal. It is also important for cells to stop dividing at the right time. If a cell can not stop dividing when it is supposed to stop, this can lead to a disease called cancer.

- Some cells, like skin cells, are constantly dividing. We need to continuously make new skin cells to replace the skin cells we lose.
- Did you know we lose 30,000 to 40,000 dead skin cells every minute? That means we lose around 50 million cells every day. This is a lot of skin cells to replace, making cell division in skin cells is so important. Other cells, like nerve and brain cells, divide much less often.

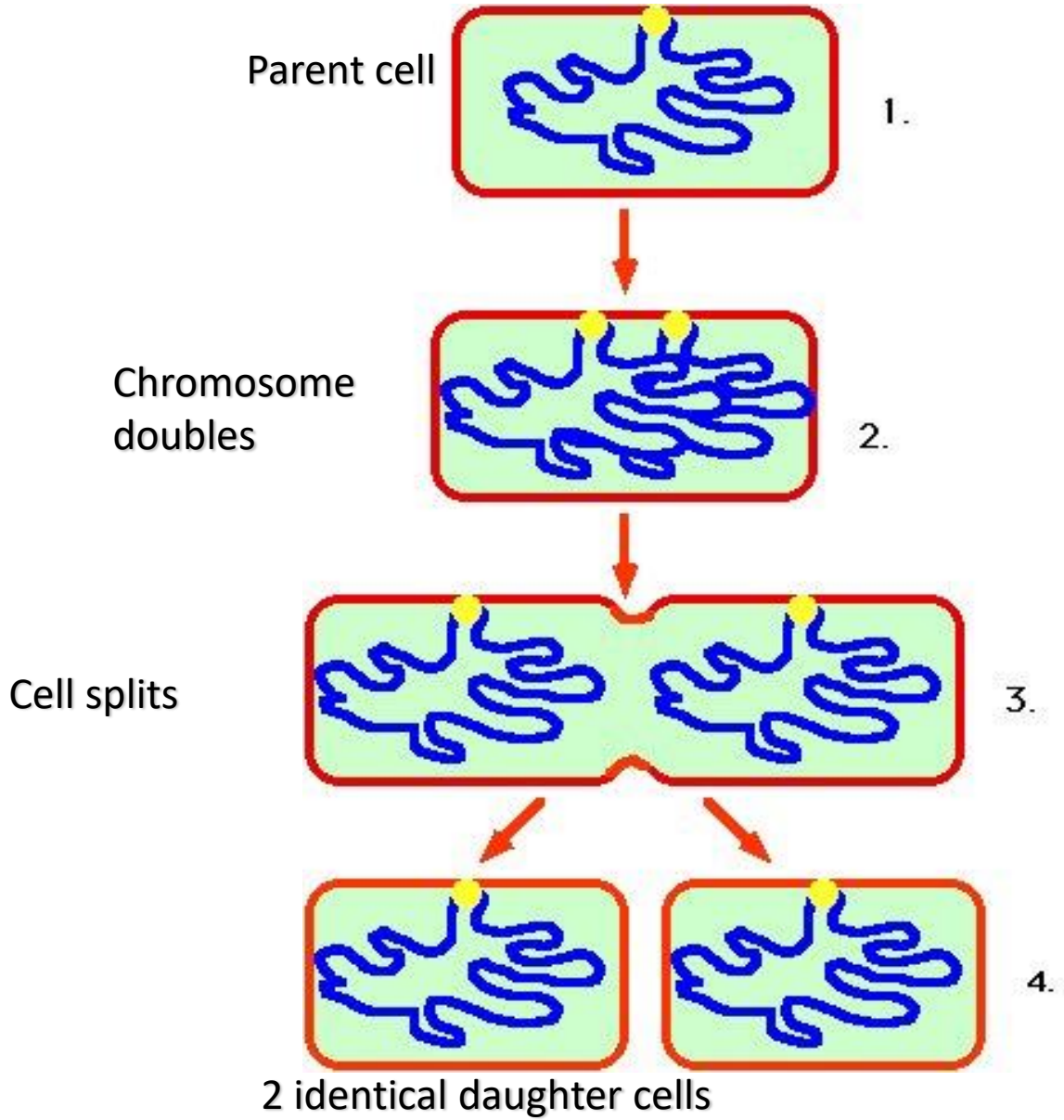
Cell Division in Prokaryotes

- **Asexual reproduction** is the creation of offspring from a single parent.
  - **Binary fission** produces two daughter cells genetically identical to the parent cell.

✓ Prokaryotes such as bacteria divide into 2 identical cells by the process of binary fission

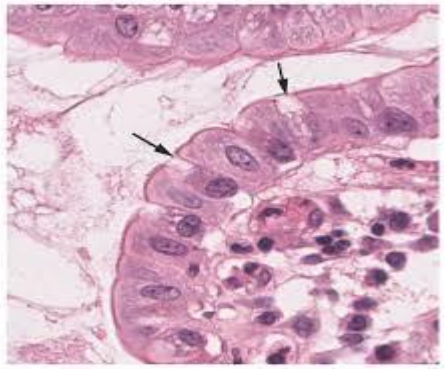
✓ Single chromosome makes a copy of itself

✓ Cell wall forms between the chromosomes dividing the cell



Eukaryotic Cells

- Somatic cells- a body cell; a cell whose genes will not be passed on to future generations.
- Somatic cells make your organs and tissues.
- Some cells divide constantly; cells in the embryo, skin cells, gut lining cells etc.

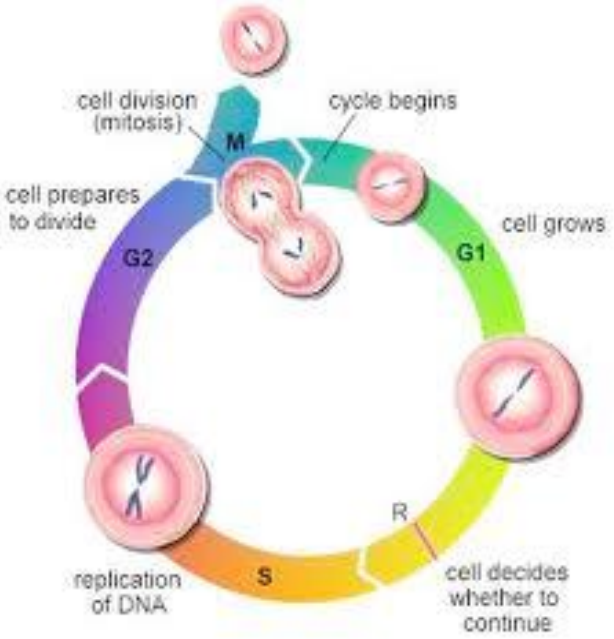


•Germ Cells- a cell that is destined to become a gamete (egg or sperm).

•A cell whose genes can be passed on to future generation.

The Cell Cycle

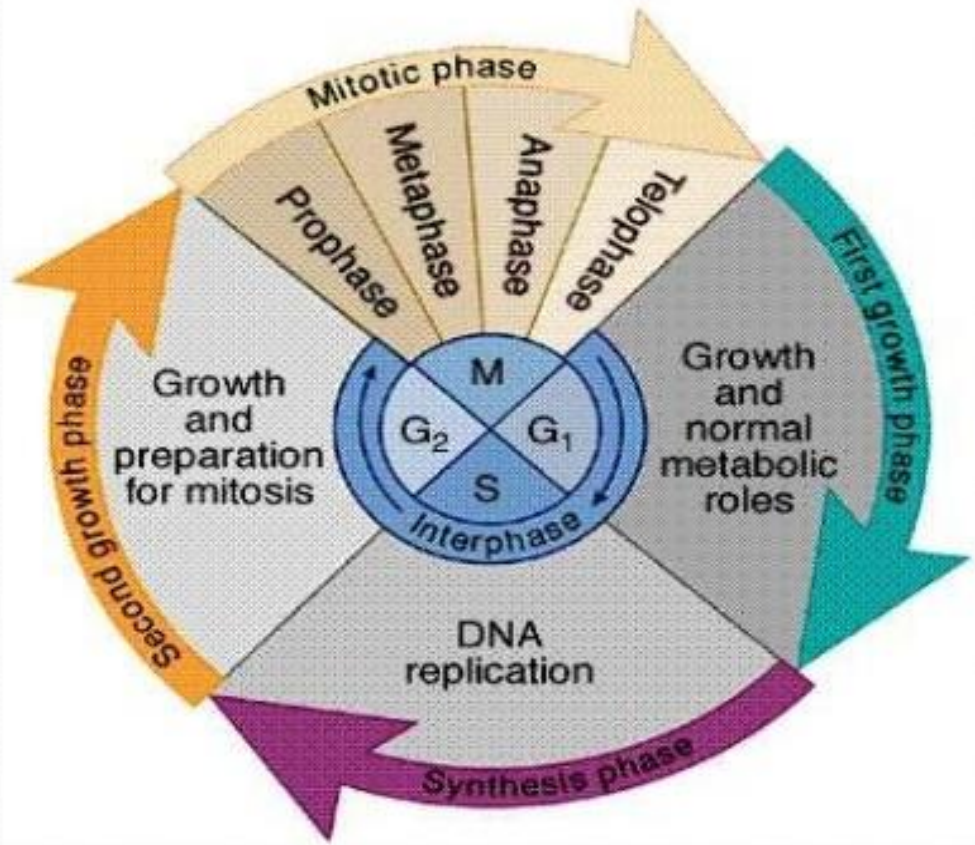
- **Cell cycle –**the cell that is dividing is called the "parent" cell. The parent cell divides into two "daughter" cells. The process then repeats in what is called the cell cycle.



- Most of the cell cycle is spent in *interphase*.
- Following interphase, the *mitotic stage* of cell division occurs.
- regular sequence of growth and division that eukaryotic cells undergo.
  - Prokaryotic cells undergo binary fission

- Divided into three main stages:
  - **Interphase** – cell grows into its mature size, makes a copy of its DNA, and prepares for division.
  - **Mitosis** – one copy of the DNA is distributed into each of its daughter cells
  - **Cytokinesis** – the cytoplasm divides and organelles are distributed into the two new cells

PHASES OF CELL CYCLE



Cell Cycle consist of three phases

- **Interphase**
- During interphase, the cell undergoes normal growth processes while also preparing for cell division. In order for a cell to move from interphase into the mitotic phase, many internal and external conditions must be met. The three stages of interphase are called *G_1, S, and G_2*.
- **G1 phase;** growth and synthesis
- **S phase;** DNA synthesis phase
- **G2 phase;** preparation for division
- **M phase;** M phase includes the overlapping processes of mitosis and cytokinesis

- **G_1 Phase (First Gap)**
- The first stage of interphase is called the **G_1 phase** (first gap) because, from a microscopic point of view, little change is visible.
- However, during the G_1 stage, the cell is quite active at the biochemical level.
- The cell is accumulating the building blocks of chromosomal DNA and the associated proteins as well as accumulating sufficient energy reserves to complete the task of replicating each chromosome in the nucleus.

- **S Phase (Synthesis of DNA)**
- Throughout interphase, nuclear DNA remains in a semi-condensed chromatin configuration.
- In the **S phase**, DNA replication can proceed through the mechanisms that result in the formation of identical pairs of DNA molecules—sister chromatids—that are firmly attached to the centromeric region.

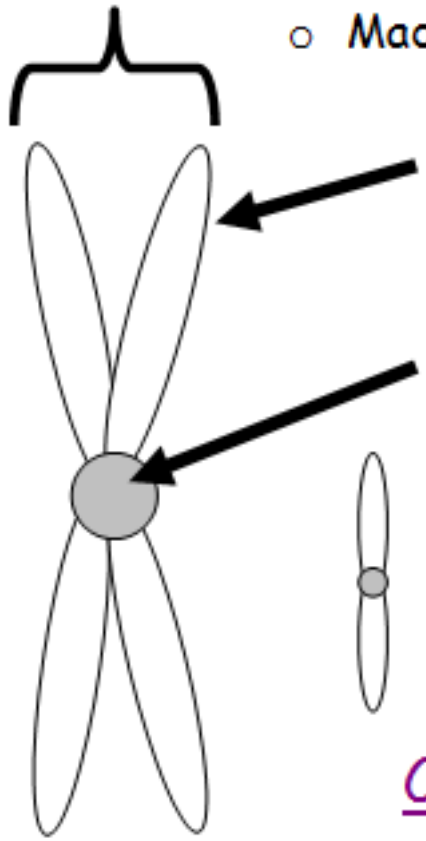
DNA

- Chromatin – long, thin strands made up of DNA and protein. The protein helps the DNA to stay together when chromosomes form.
- Chromosomes -

  Genetic information is passed from one generation to the next on **chromosomes**.

  Before cell division, each chromosome is duplicated, or copied.

Chromosome Structure



Chromosomes = structures that contain genetic information
- Made up of DNA and proteins that carry genetic information

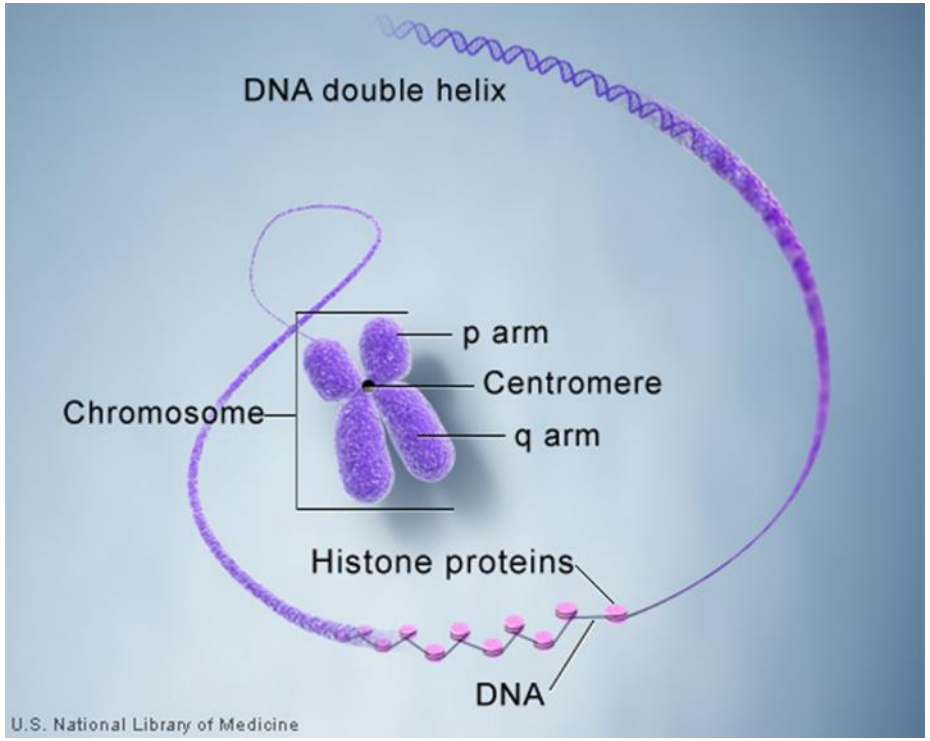
Genes = segments of DNA that code for a particular protein

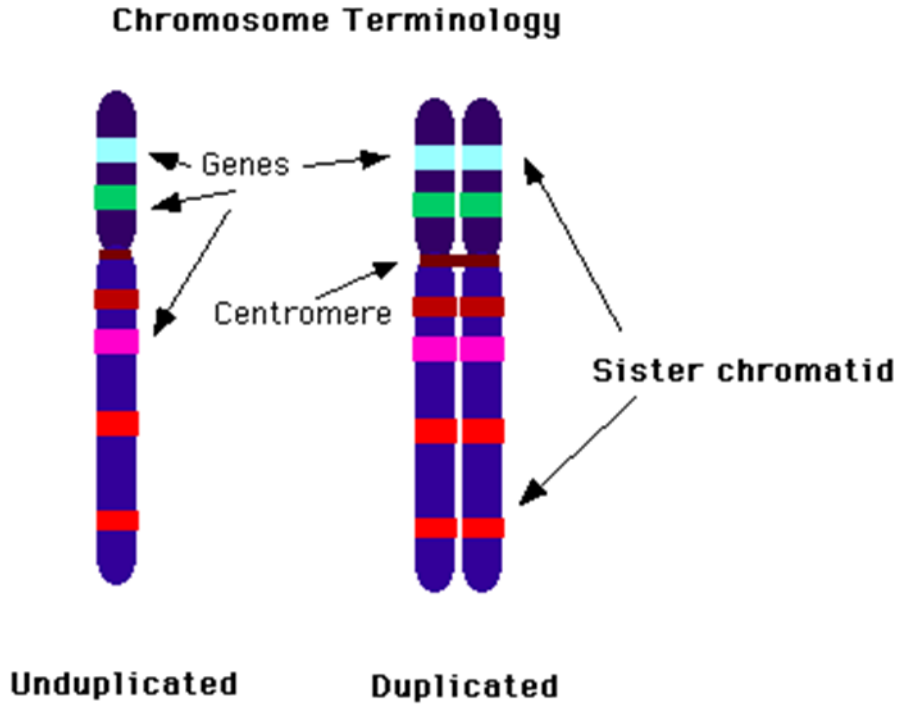
Centromere = Point where the chromatids are joined

Chromatid = chromosomes contain identical parts
- Strands composed of chromatin that makes up the chromosome

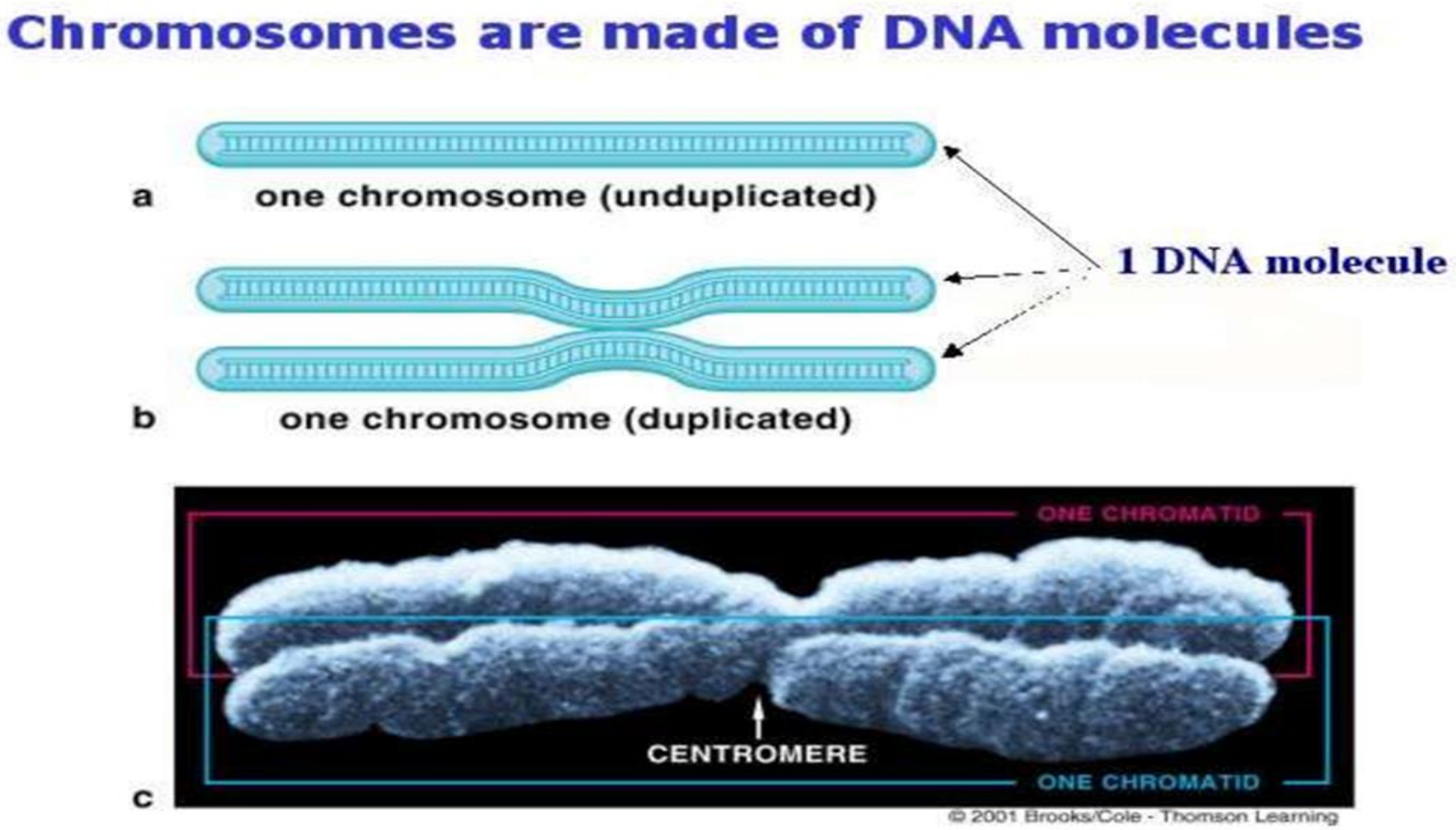
Chromatin = makes up the chromatid
- Composed of DNA and proteins

CHROMOSOMES – Condensed Chromatin



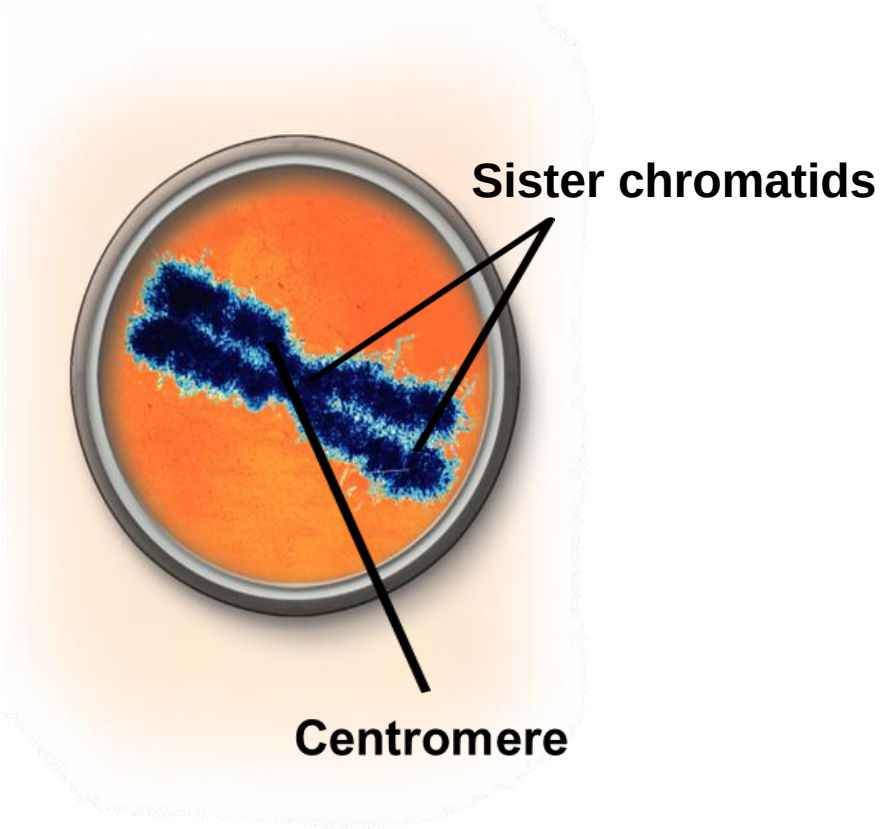


Chromosomes



Chromosomes

- Each chromosome consists of two identical “sister chromatids ”.
- Each pair of chromatids is attached at an area called the centromere.



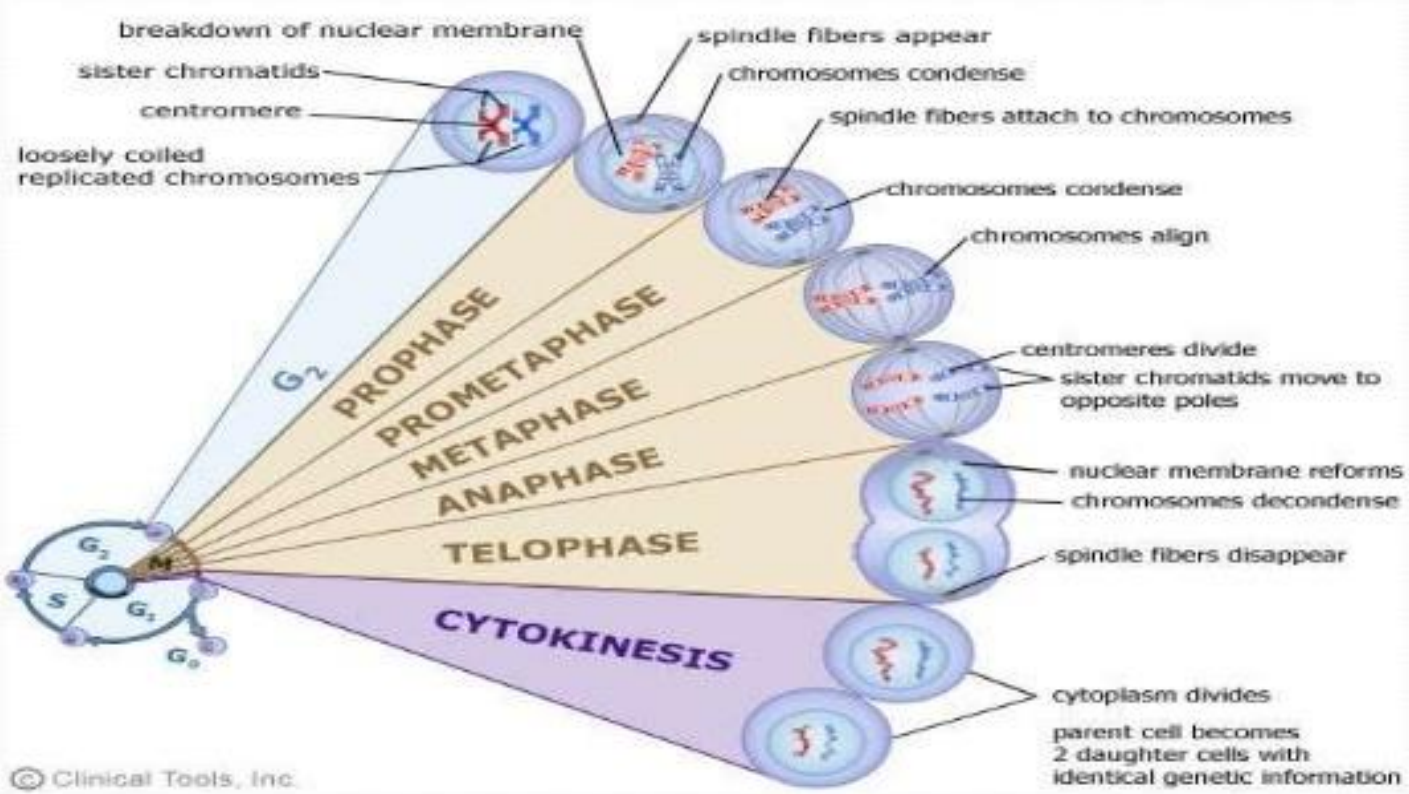
- The centrosome is also duplicated during the S phase. The two centrosomes of homologous chromosomes will give rise to the **mitotic spindle**, the apparatus that orchestrates the movement of chromosomes during mitosis.
- For example, roughly at the center of each animal cell, the centrosomes are associated with a pair of rod-like objects, the **centrioles**, which are positioned at right angles to each other. Centrioles help organize cell division.
- We should note, however, that centrioles are not present in the centrosomes of other eukaryotic organisms, such as plants and most fungi.

- **G_2 Phase (Second Gap)**
- In the **G_2 phase**, the cell replenishes its energy stores and synthesizes proteins necessary for chromosome manipulation and movement.
- Some cell organelles are duplicated, and the cytoskeleton is dismantled to provide resources for the mitotic phase.
- There may be additional cell growth during G_2.
- The final preparations for the mitotic phase must be completed before the cell is able to enter the first stage of mitosis.

M Phase- Mitosis

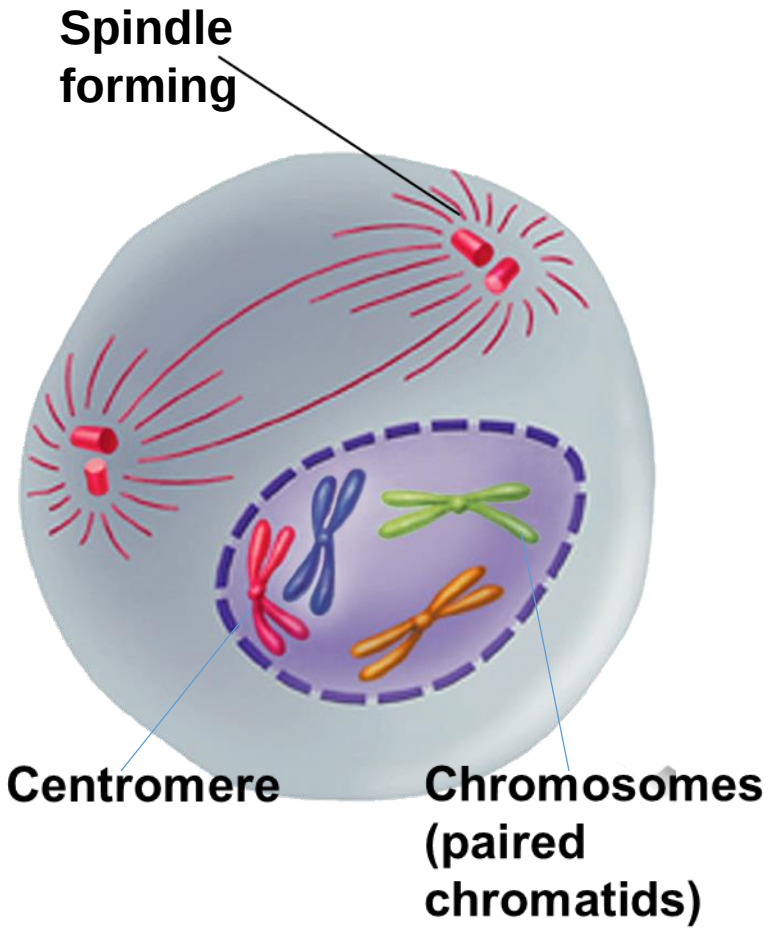
- Occurs in body cells – somatic cells
- Forms two identical daughter cells – exactly like the original
- Biologists divide the events of mitosis into four phases: (PMAT)
    - **Prophase**
    - **Metaphase**
    - **Anaphase**
    - **Telophase**

Representation of mitosis stages



Prophase

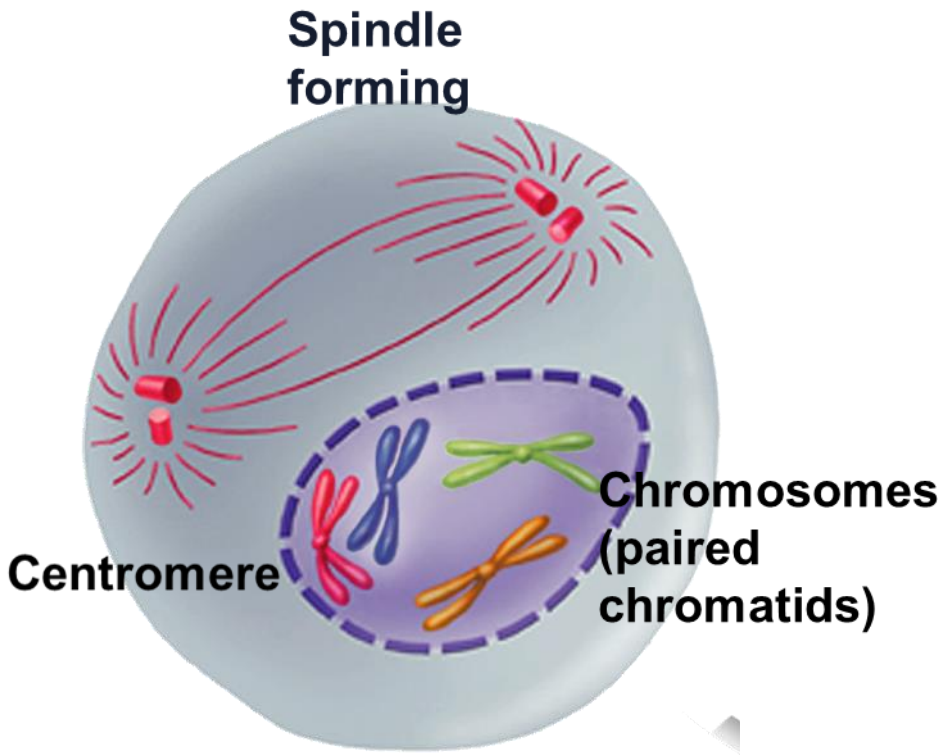
- Prophase is the first and longest phase of mitosis (90%).
- The centrioles separate and take up positions on opposite sides of the nucleus.



Prophase

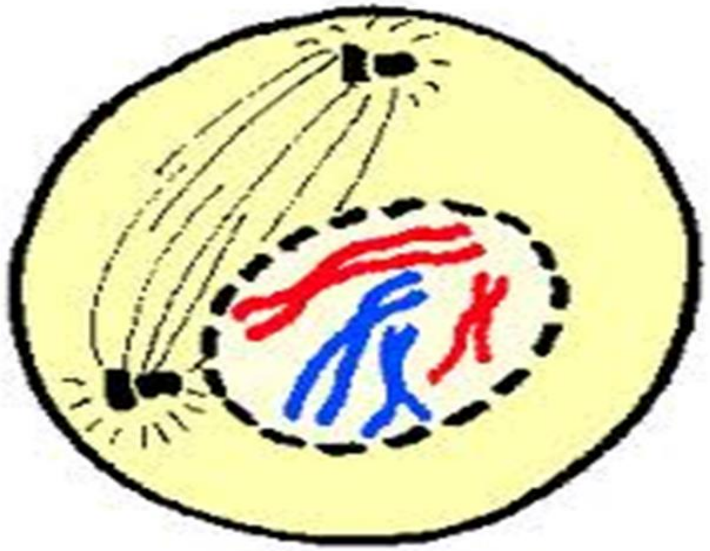
The centrioles lie in a region called the centrosome.

The centrosome helps to organize the spindle, a fanlike microtubule structure that helps separate the chromosomes.



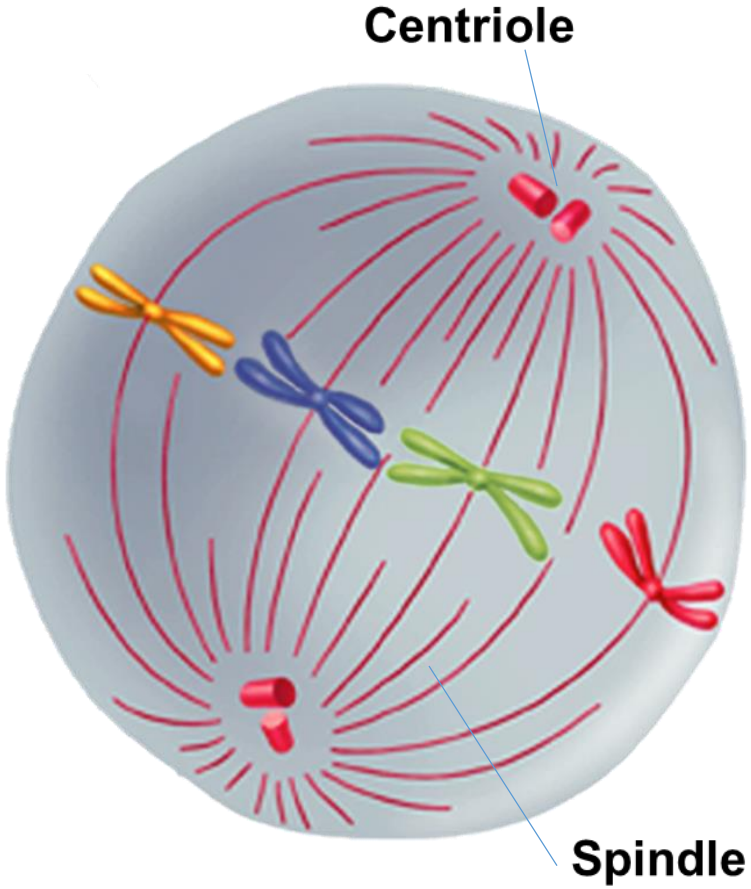
Summary of Prophase

- First phase of MITOSIS Longest Phase
- Chromosomes become visible
- Centrioles separate and move to opposite poles (ends)
- Spindle fibers appear
- Nucleolus and nuclear membrane (envelope) disappear



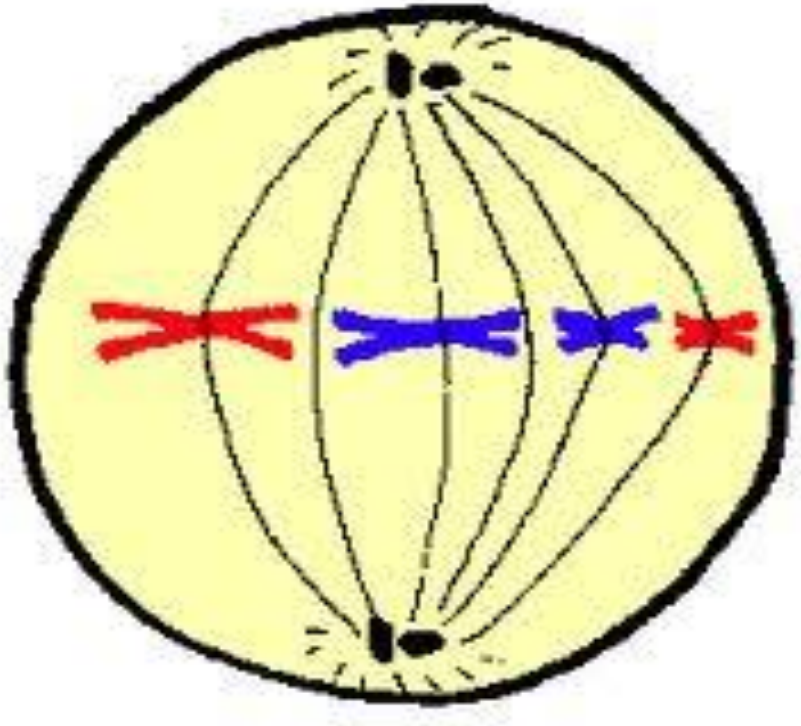
Metaphase

- The second phase of mitosis is metaphase.
- The chromosomes line up across the center of the cell.
- Microtubules connect the centromere of each chromosome to the poles of the spindle



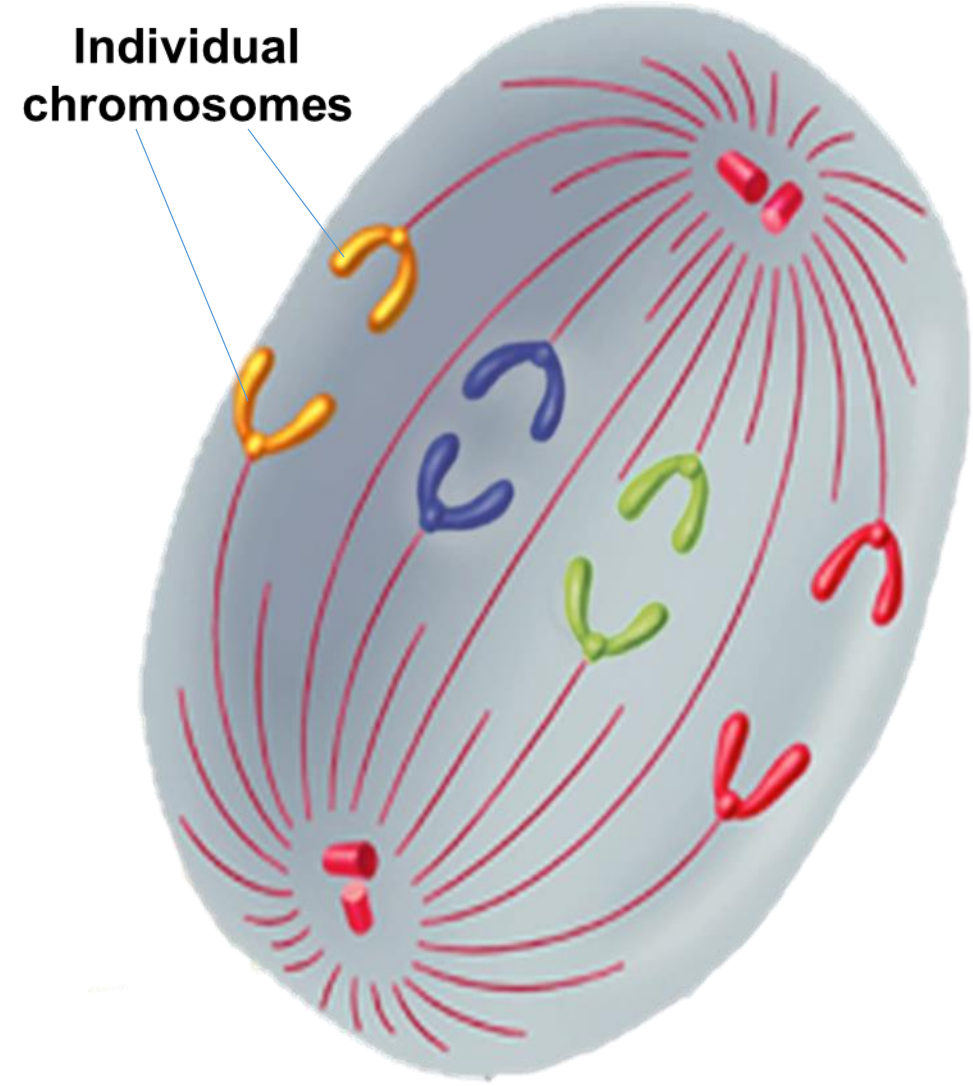
Summary of Metaphase

- Shortest Phase
- Chromosomes attach to spindle fibers in center of the cell



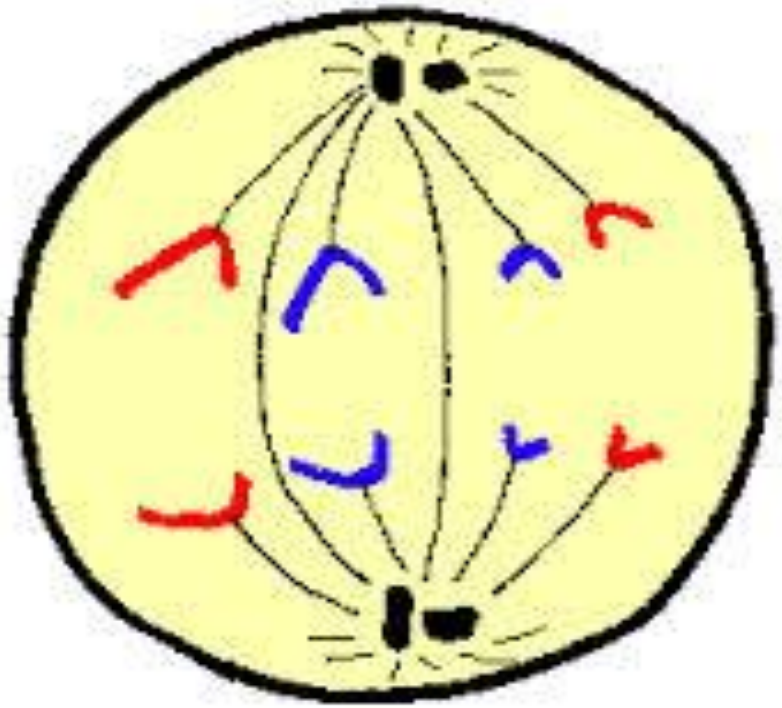
Anaphase

- The third phase of mitosis.
- The sister chromatids separate into individual chromosomes.
- The chromosomes continue to move until they have separated into two groups.



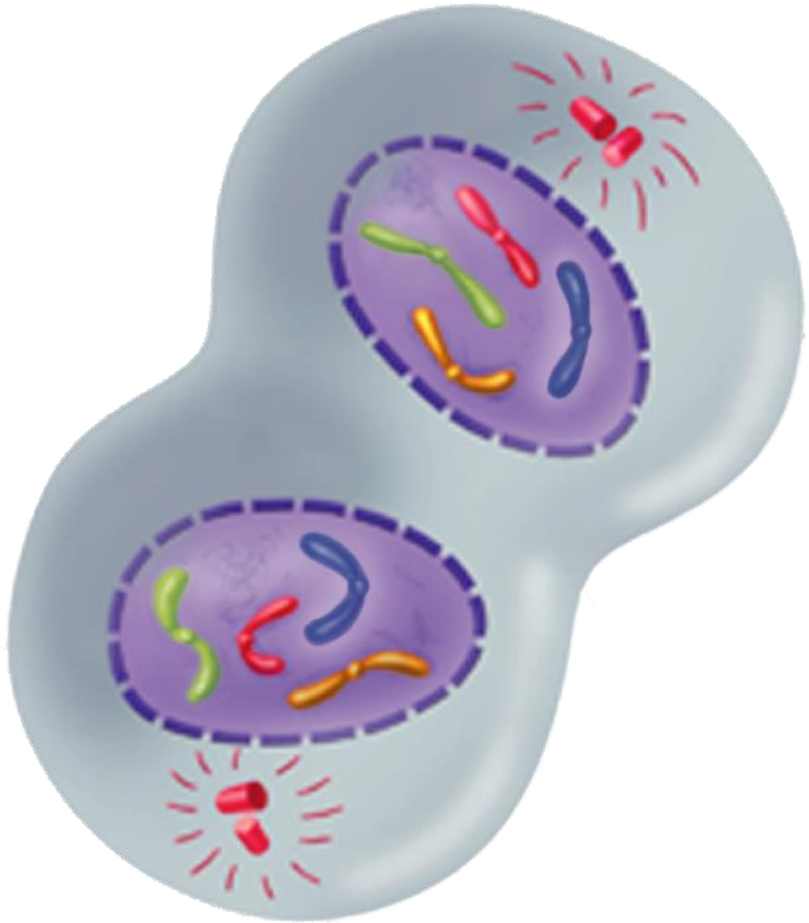
SUMMARY OF Anaphase

- Centromeres split apart and chromatids separate from one another. Each chromatid moves to opposite poles.



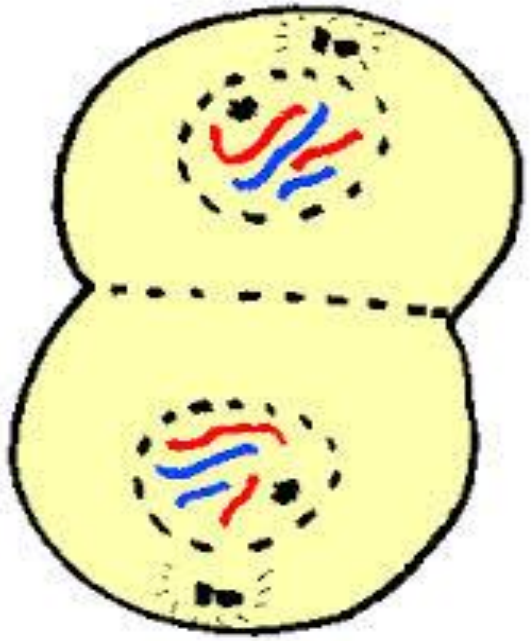
Telophase

- The fourth and final phase of mitosis.
- Chromosomes gather at opposite ends of the cell and lose their distinct shape
- A new nuclear envelope forms around each cluster of chromosomes



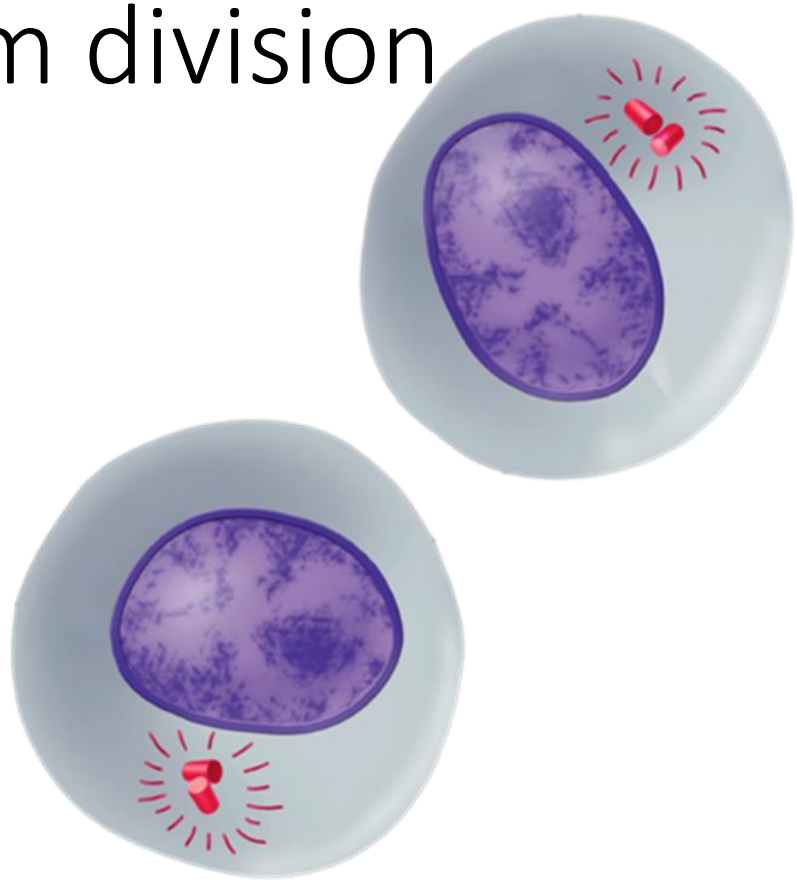
Summary of Telophase

- Chromosomes reach opposite poles of cell
- Chromatids unwind back into chromatin
- Nuclear envelope and nucleolus reappear reforming the nucleus
- Spindle fibers disappear
- New membrane (cell membrane) gain to form between 2 nuclei (cell pinches)
- Animal cell – cleavage
- Plant cell – cell plate

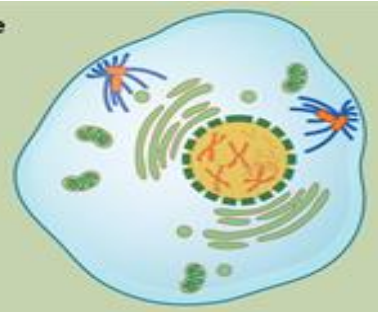


Cytokinesis – cytoplasm division

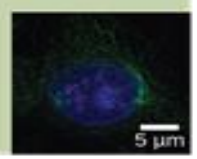
- During cytokinesis, the cytoplasm pinches in half.
- Each daughter cell has an identical set of duplicate chromosomes



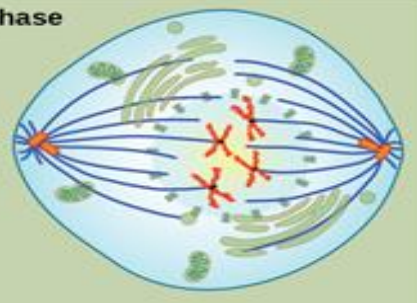
Prophase



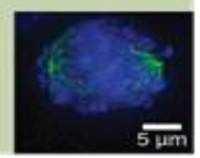
- Chromosomes condense and become visible
- Spindle fibers emerge from the centrosomes
- Nuclear envelope breaks down
- Nucleolus disappears



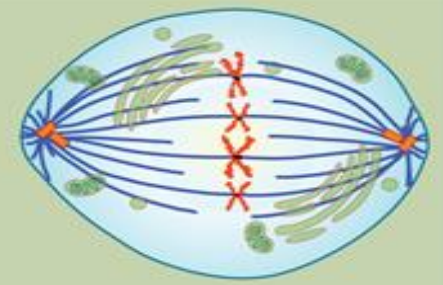
Prometaphase



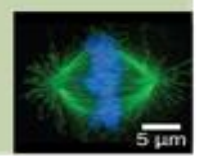
- Chromosomes continue to condense
- Kinetochores appear at the centromeres
- Mitotic spindle microtubules attach to kinetochores
- Centrosomes move toward opposite poles



Metaphase

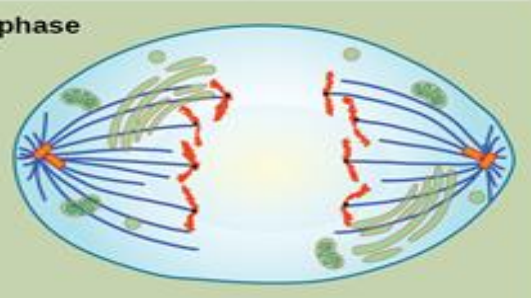


- Mitotic spindle is fully developed, centrosomes are at opposite poles of the cell
- Chromosomes are lined up at the metaphase plate
- Each sister chromatid is attached to a spindle fiber originating from opposite poles

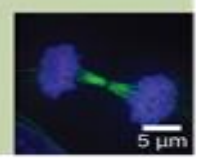


MITOSIS

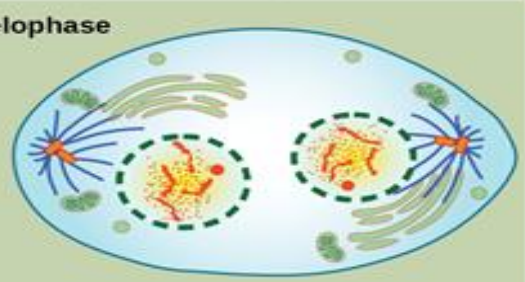
Anaphase



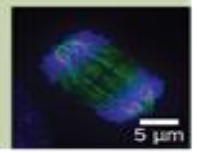
- Cohesin proteins binding the sister chromatids together break down
- Sister chromatids (now called chromosomes) are pulled toward opposite poles
- Non-kinetochore spindle fibers lengthen, elongating the cell



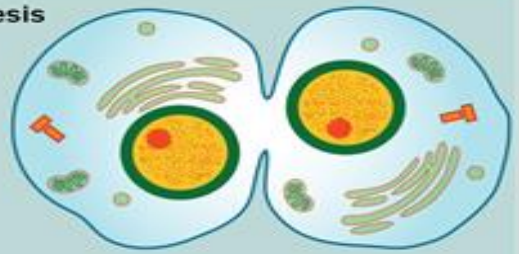
Telophase



- Chromosomes arrive at opposite poles and begin to decondense
- Nuclear envelope material surrounds each set of chromosomes
- The mitotic spindle breaks down



Cytokinesis



- Animal cells: a cleavage furrow separates the daughter cells
- Plant cells: a cell plate separates the daughter cells