Cell division: MITOSIS

PREPARED BY:

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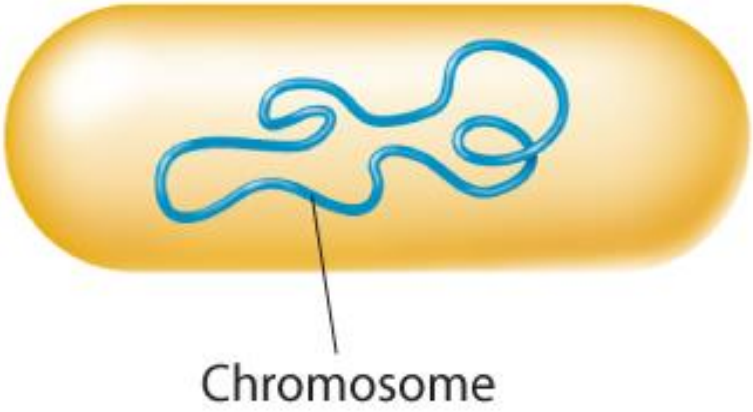
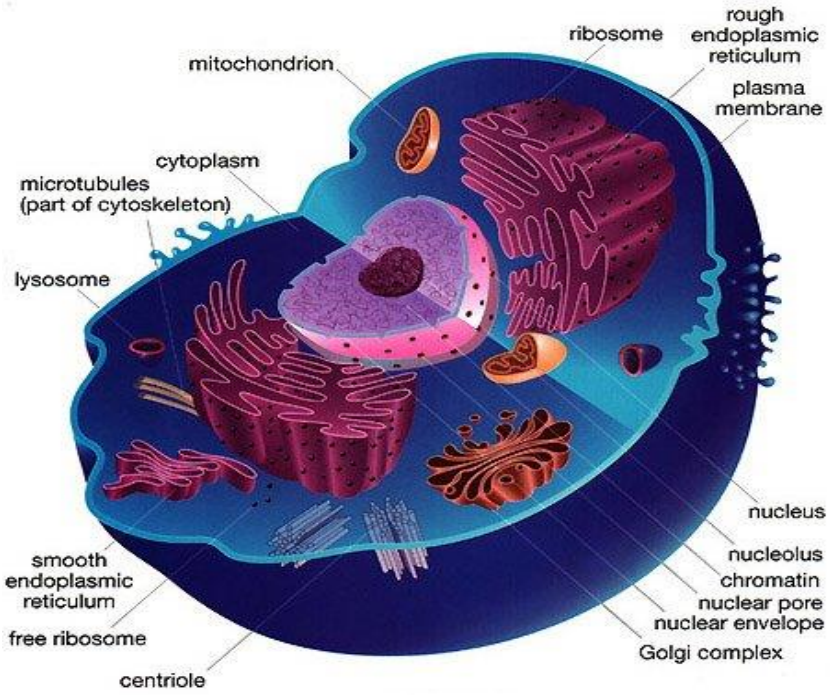
Remember – All Living Things Made of Cells

- **Prokaryotic cell**
  - Prokaryotic cells **lack nuclei.** Instead, their DNA molecules are found in the cytoplasm.
  - Most prokaryotes contain a single, **circular DNA** molecule, or **chromosome**, that contains most of the cell's genetic information.



- **Eukaryotic Cells**

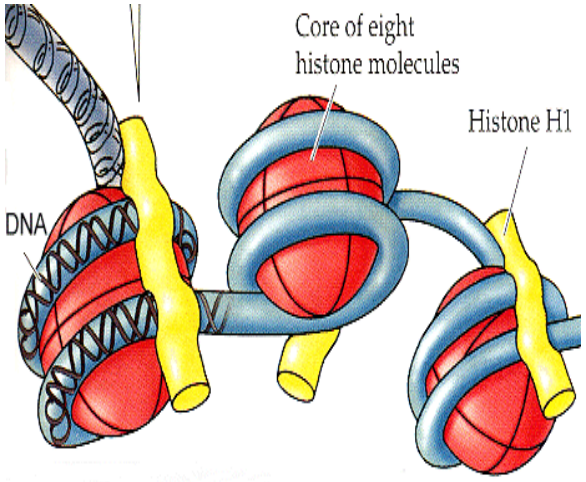


Prokaryote VS Eukaryote

PROKARYOTES	EUKARYOTES
single chromosome	many chromosomes
made only of DNA	made of chromatin, a nucleoprotein (DNA coiled around histone
circular chromosome	linear chromosomes proteins)
found in cytoplasm	found in a nucleus
copies its chromosome and divides immediately afterwards	copies chromosomes, then the cell grows, then goes through mitosis to organise chromosomes in two equal groups

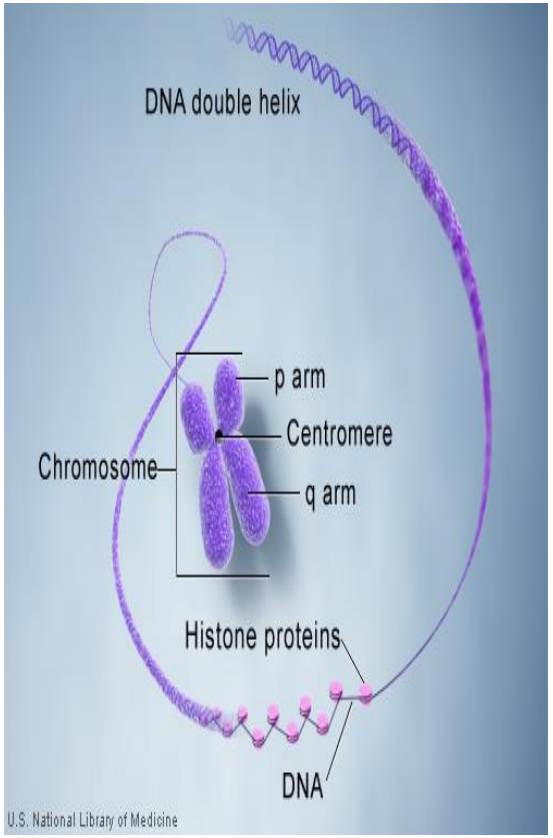
Chromosomes

- Structures in Nucleus, made of DNA (**Hereditary material)**
- **Chromatin (DNA+ histone)**
- **Not** dividing = Chromatin (long thin threads)
- When dividing = Chromatin forms a numbers of clearly distinguishable **Chromosomes**
- **Chromosomes (DNA** & gene regulating Protein)



❑ A chromosome contains hundreds of genes, which are composed of DNA.

- Each **species** has a **definite no.** of Chromosomes.
- Humans= **46 chromosomes**
- The cell's **chromatin** condenses into **chromosomes**
- The chromosomes look like an "X"
  - Each chromosome is made up of two identical sister **chromatids** attached by a **centromere**
  - A protein complex, that links sister chromatids, is **cohesin**



– This is "created" in **S phase of interphase**

Centromeres and Telomeres

Centromeres and telomeres are two essential features of all eukaryotic chromosomes.

Each provide a unique function i.e., absolutely necessary for the stability of the chromosome.

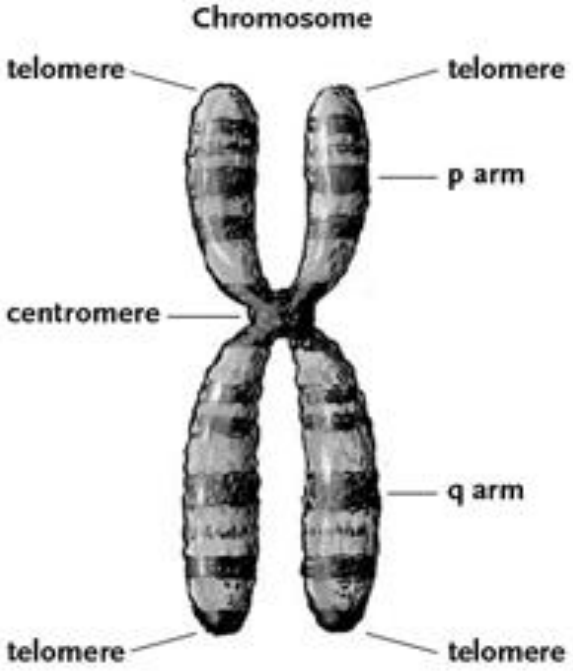
The region where two sister chromatids of a chromosome appear to be joined or "held together" during metaphase is called Centromere

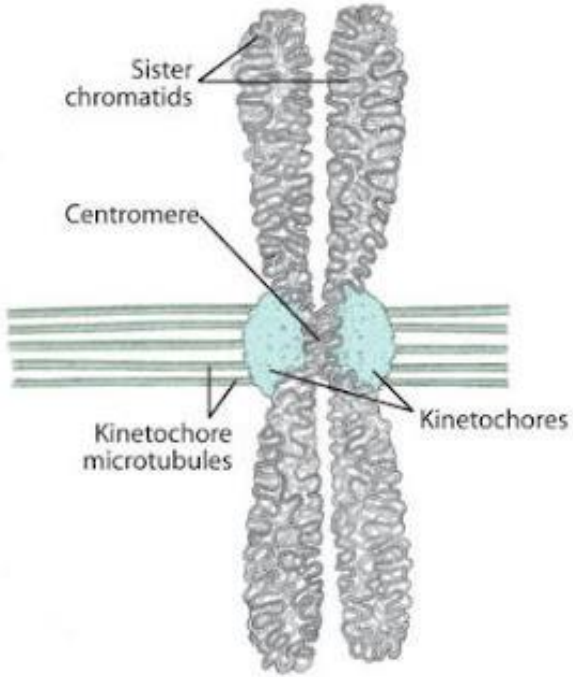
Centromeres are required for the **segregation** of the chromosomes during meiosis and mitosis.

Telomeres the two ends of a chromosome are known as telomeres and they provide **terminal stability** to the chromosome and ensure its survival

Kinetochore

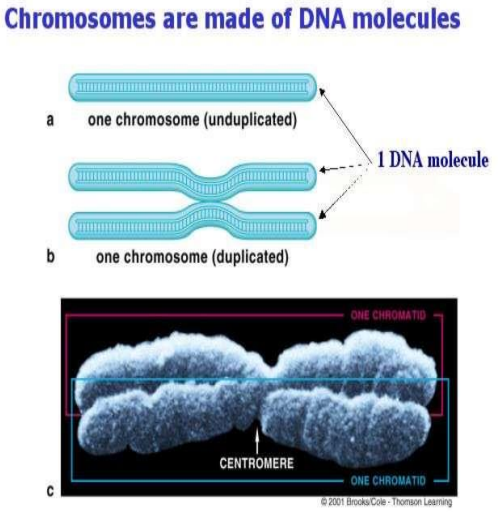
The actual location where the **attachment of spindle** fibers to centromere occurs is called the kinetochore and is composed of both DNA and protein.





Function:

- chromosomes carry the genetic information of a cell from one cell generation to the next , from one organism to its offspring
- Every cell must copy its genetic information before cell division begins
- **gene loci** not observed when performing a karyotype



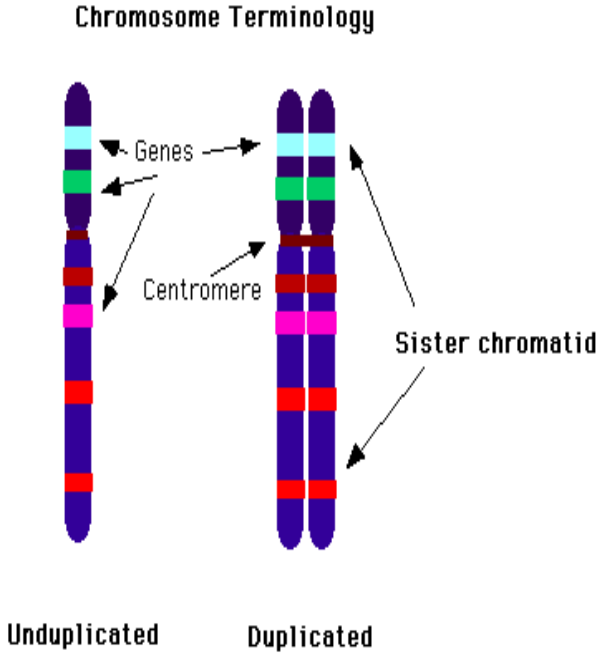
Any change in the nucleotide sequence of the DNA of a gene is called **mutation.**

Haploid n=23

Haploid cell has one set of chromosomes, has only one set of each type of chromosomes in the nucleus. In humans, eggs and sperm are haploid

Diploid 2n=46

Chromosomes are in pairs in diploid cell, called homologous pairs.



Types of Cell Reproduction

Asexual

single cell dividing to 2 new, identical cells

- Mitosis
- binary fission

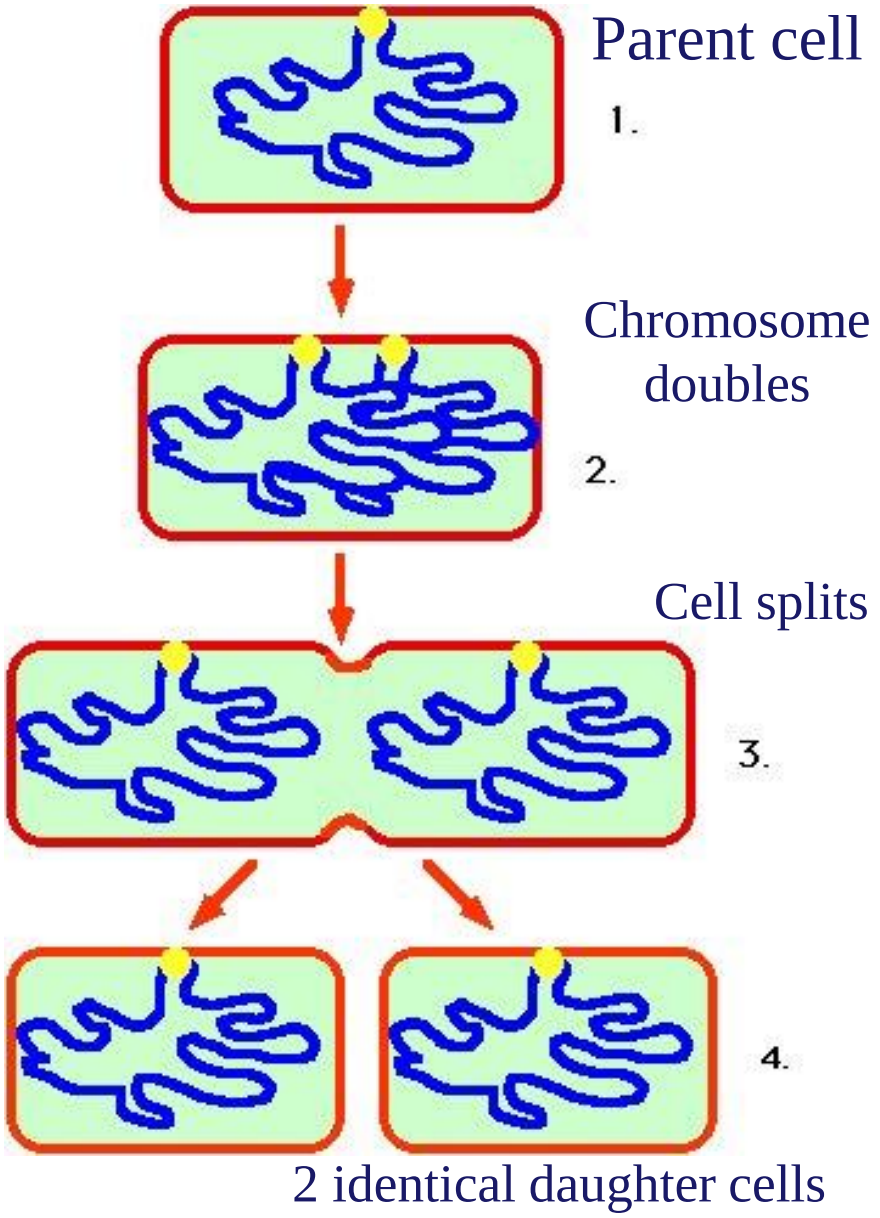
Sexual

two cells (egg & sperm) joining to new cell (zygote) NOT identical to original one

- Meiosis

Binary Fission in Bacteria

- Prokaryotes (bacteria) reproduce by a type of cell division called **binary fission**
- In binary fission, the chromosome replicates and the two daughter chromosomes actively move apart
- The plasma membrane pinches inward, dividing the cell into two



The Cell Cycle

- The cell cycle is a sequence of cell growth and division.
- The cell cycle is the period from the beginning of one division to the beginning of the next.

- **The cell cycle consists of 2 major phases:**
  - **Interphase** (cell growth and copying of chromosomes in preparation for cell division

✓ G_1 - primary growth phase

✓ S – synthesis; DNA replicated

✓ G_2 - secondary growth phase

collectively these **3 stages** are **called interphase**

- **Mitotic (M) phase :** (Karyokinesis and cytokinesis)

✓ M – Karyokinesis (**mitosis)**

✓ C - cytokinesis

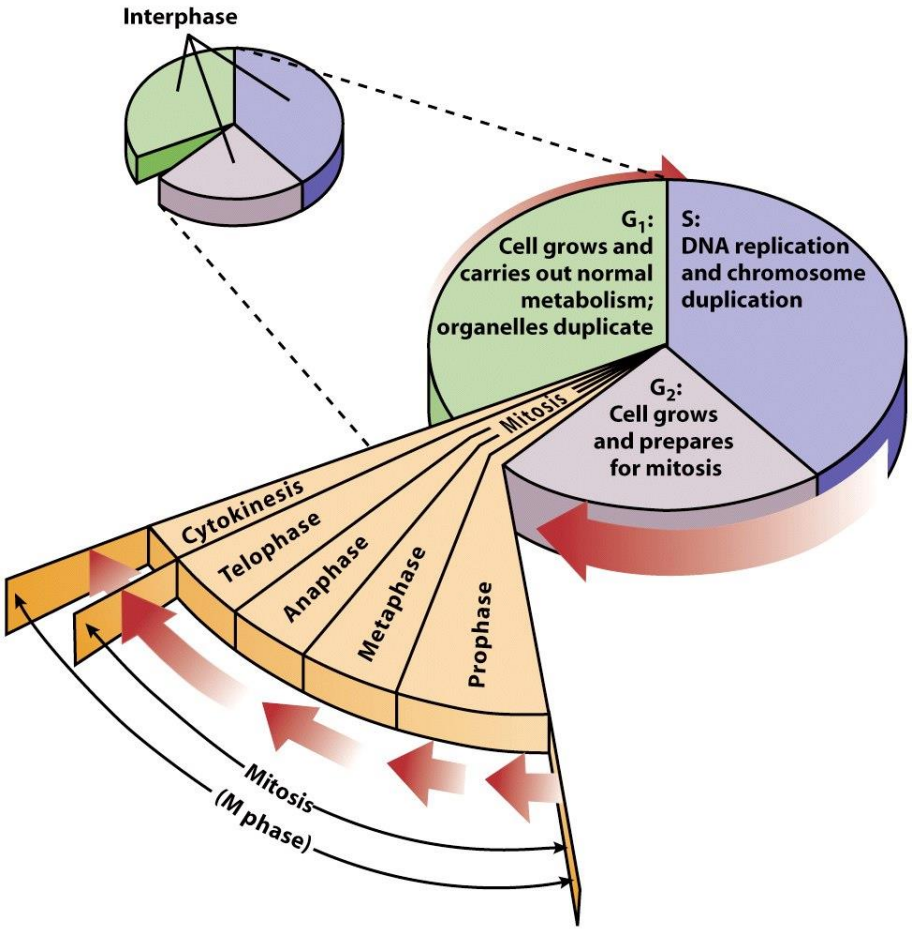
✓ Daughter cells of mitosis two identical to the original cell

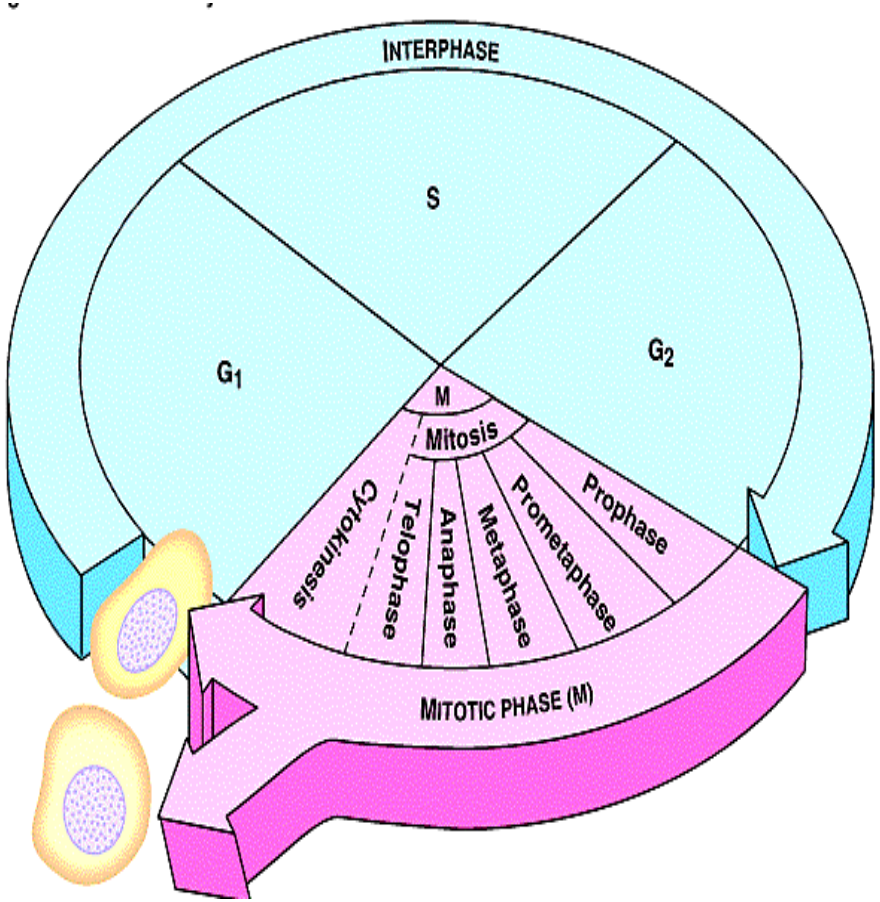
✓ Have the same number of chromosomes as each other and as the parent cell from which they were formed cells are (diploid (2n)

✓ Identical to each other, but smaller than parent cell

✓ Must grow in size to become mature cells (G_1 of Interphase)

Cell Cycle





https://youtu.be/DwAFZb8juMQ

Interphase

- **Interphase - G_1 Stage**

✓ 1st growth stage after cell division

✓ Cells mature by making more cytoplasm & organelles

✓ increase the metabolic activity

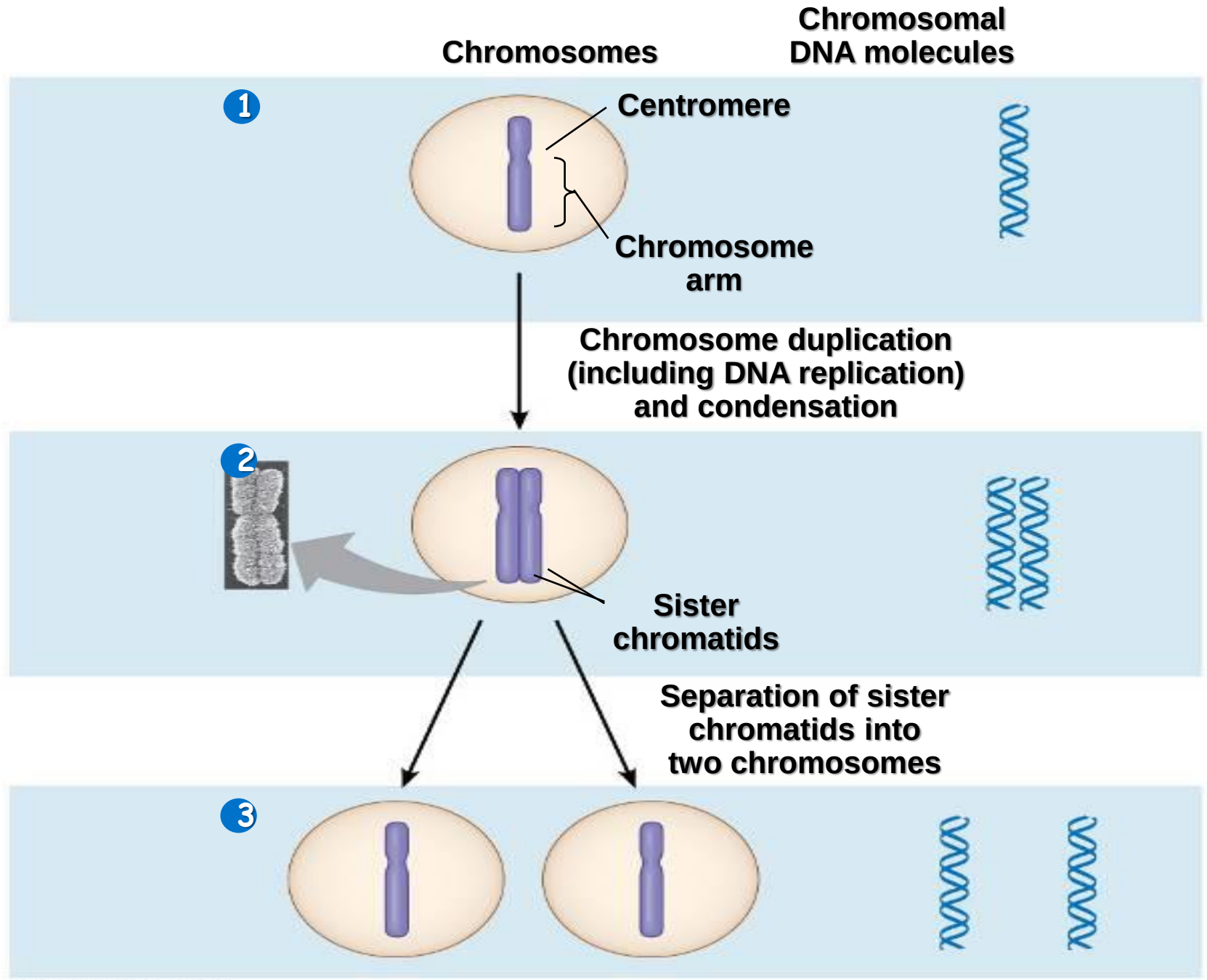
✓ Syntesis of protein needed for DNA duplication & tubulin protein for formation of mitotic spindle .

- **Interphase – S Stage**

❑ Synthesis stage

❑ DNA is copied or replicated

❑ **Centrosome** duplication also takes place in this phase



Interphase – G_2 Stage

- ✓ 2nd Growth Stage
- ✓ Occurs after DNA has been copied
- ✓ All cell structures needed for division are made (e.g. centrioles)
- ✓ Both organelles & proteins (tubulin) are synthesized

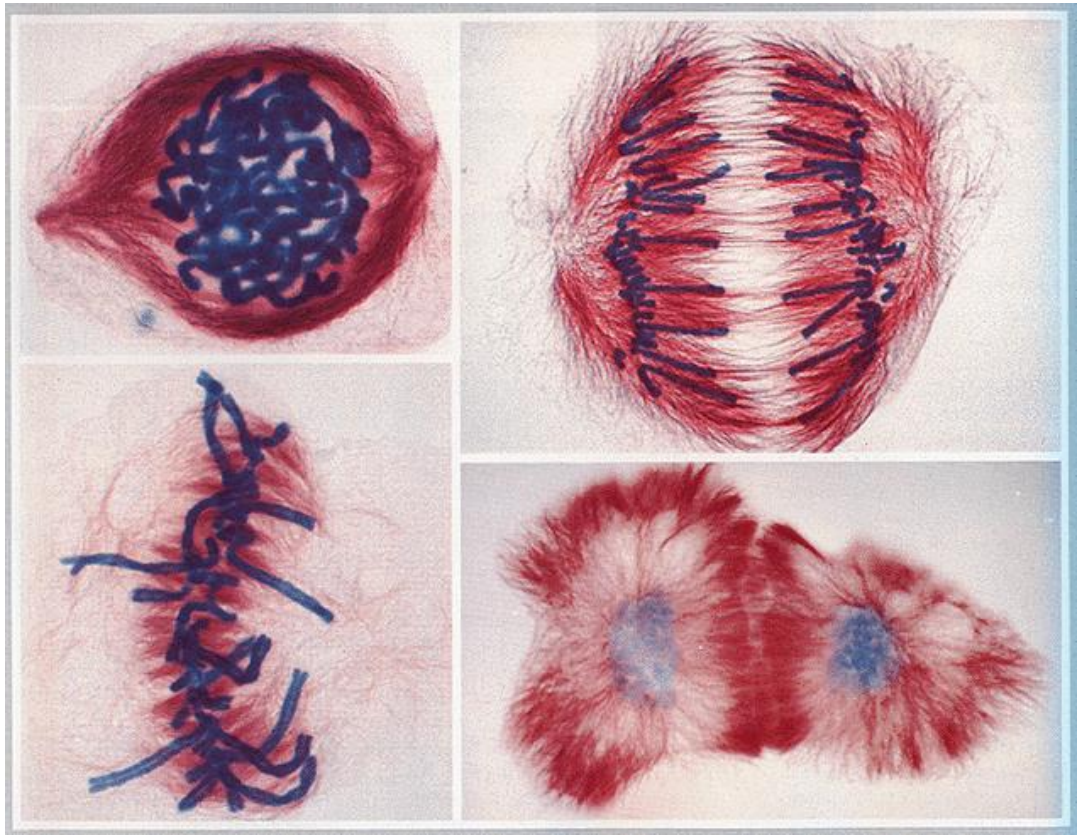
preparation for Mitosis.

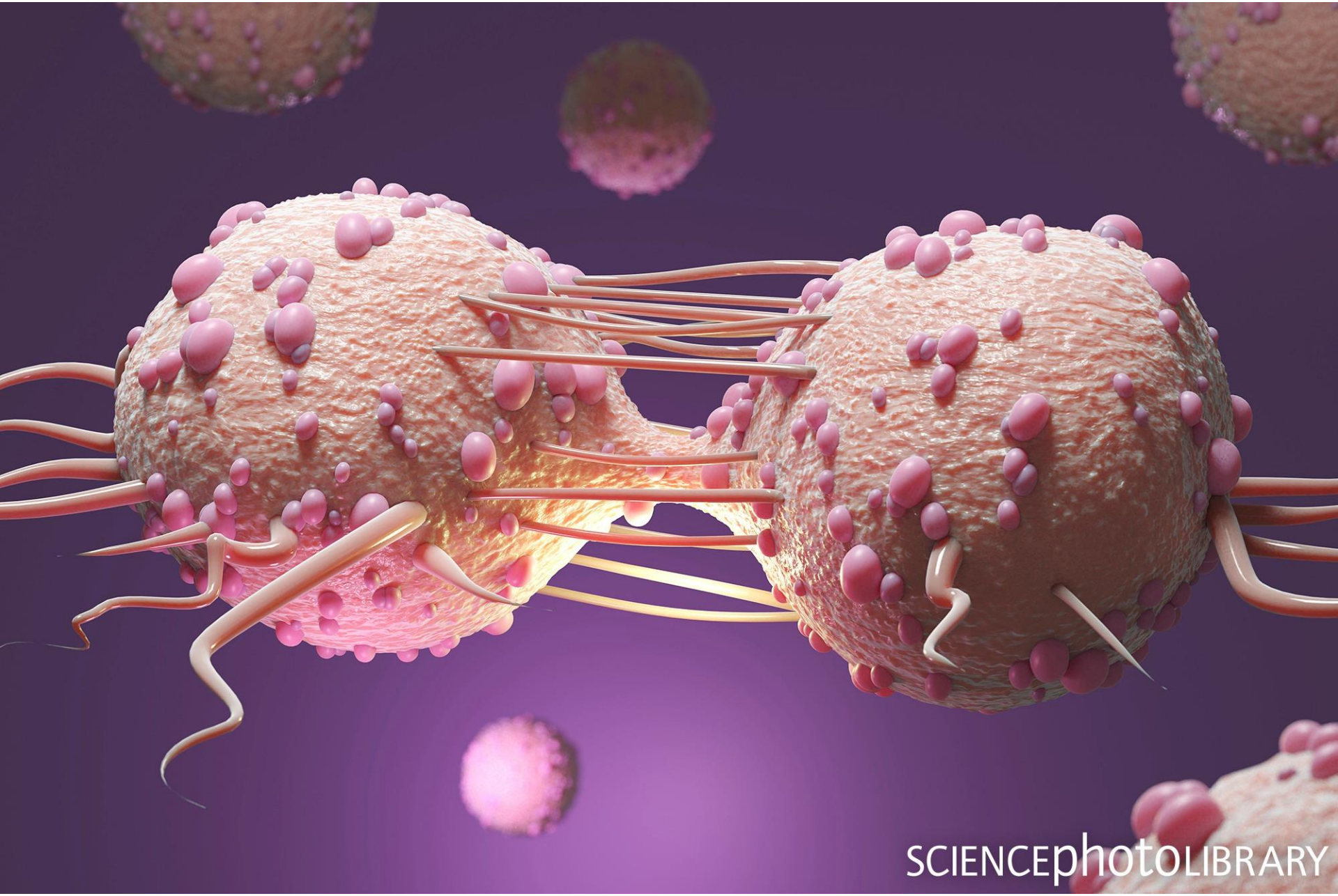
- Chromatin condenses & the nuclear envelope begins to disperse.
- There is also production of mRNA and tRNA
- similar to G1 & some cells miss this stage

❑ **G0 (stop phase) arrest of cell division**

Mitosis

- ✓ **Division of the nucleus called karyokinesis**
- ✓ **Division of the cytoplasm called Cytokinesis**

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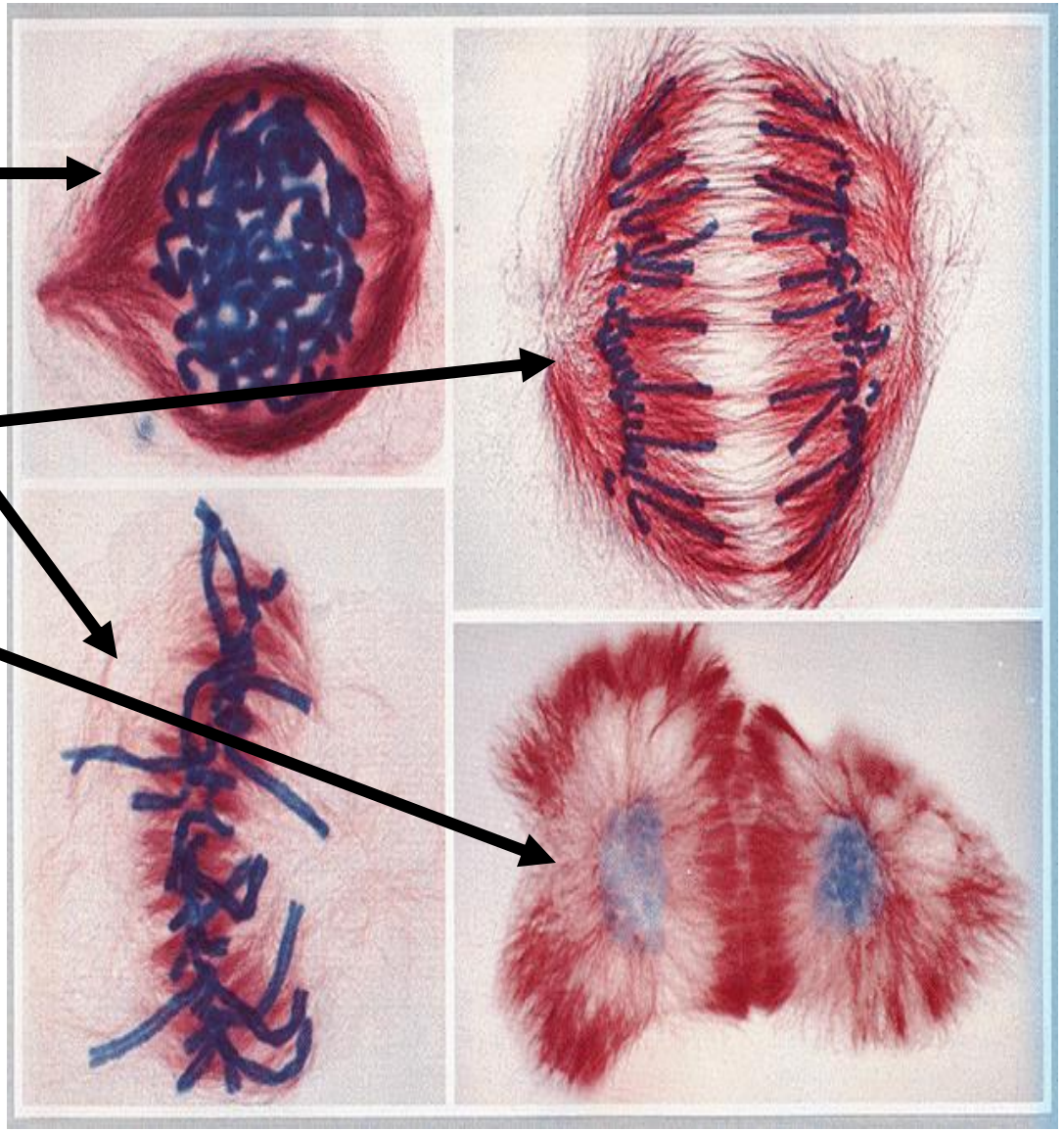
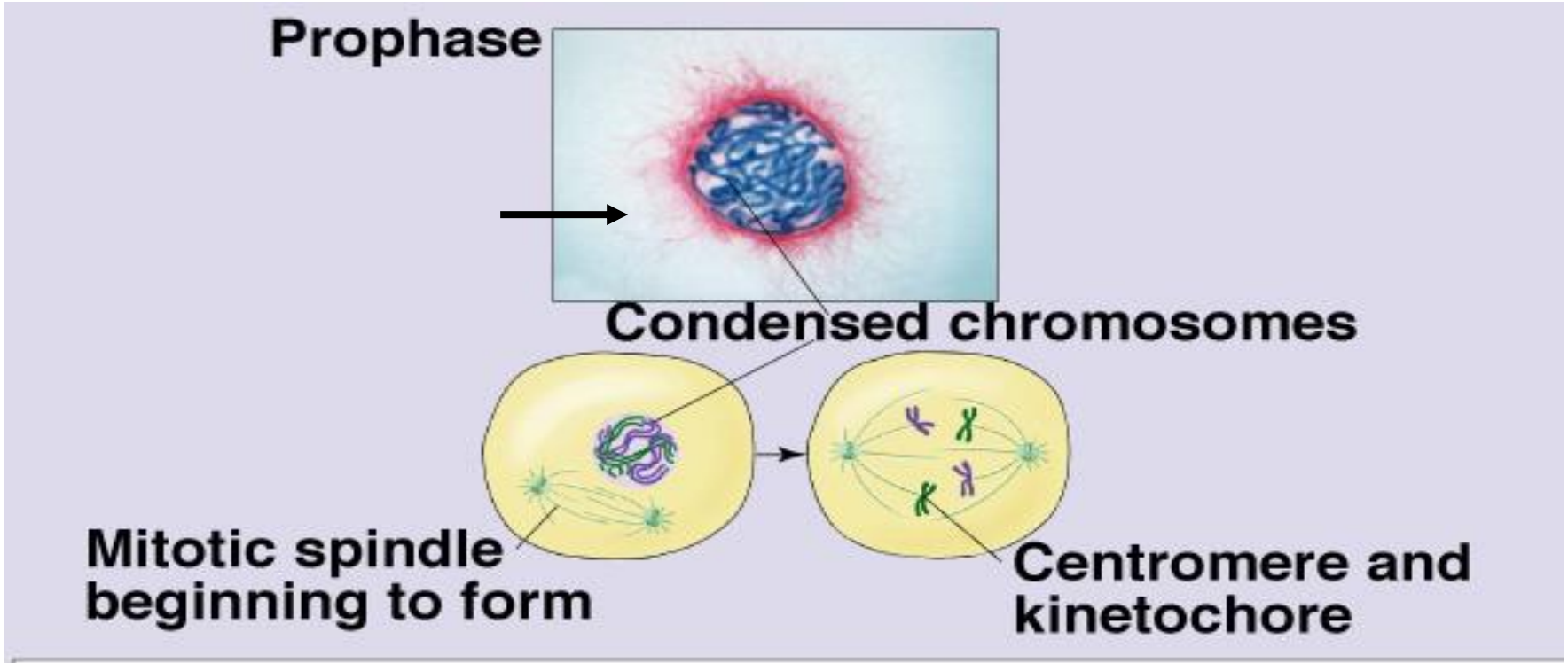
Four Mitotic Stages

- ✓Prophase
- ✓Metaphase
- ✓Anaphase
- ✓Telophase



Prophase

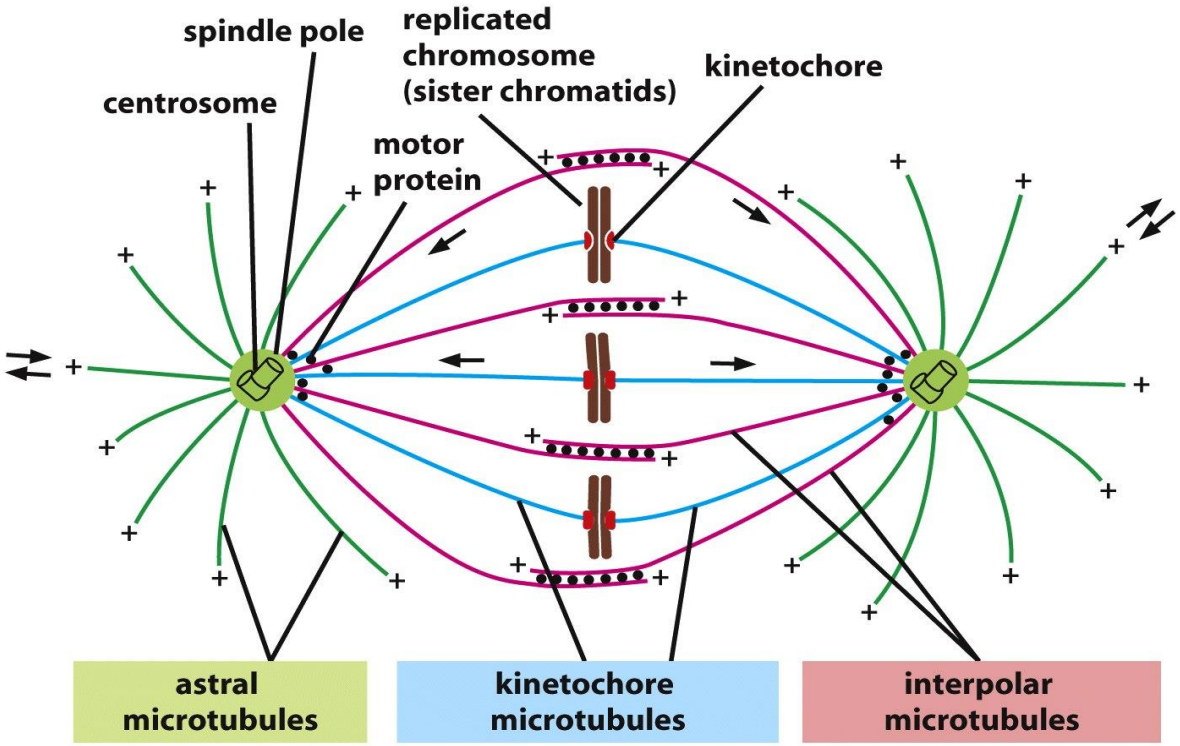


- Nuclear membrane disintegrates, and nucleolus disappears
- Chromosomes condense
- Mitotic spindle begins to form and is complete at the end of prophase
- Kinetochores begin to mature and attach to spindle

Individual chromosomes become distinct through a light microscope during this mitotic stage(Prophase)

Spindle Fibers

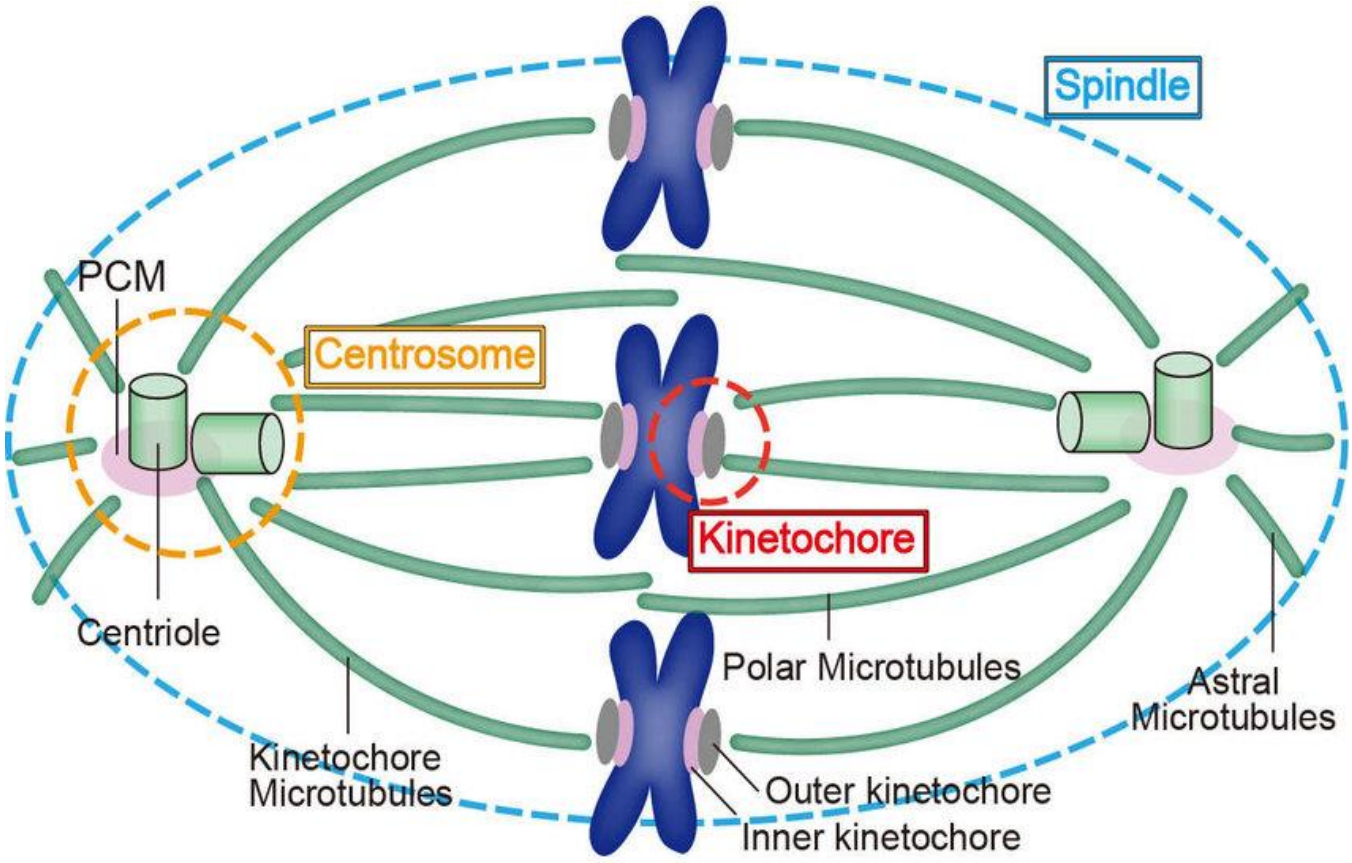
- ✓ The mitotic spindle form from the centrioles
- ✓ Polar fibers extend from one pole of the cell to the opposite pole
- ✓ Kinetochore fibers extend from the pole to the centromere of the chromosome to which they attach
- ✓ Asters are short fibers radiating from centrioles



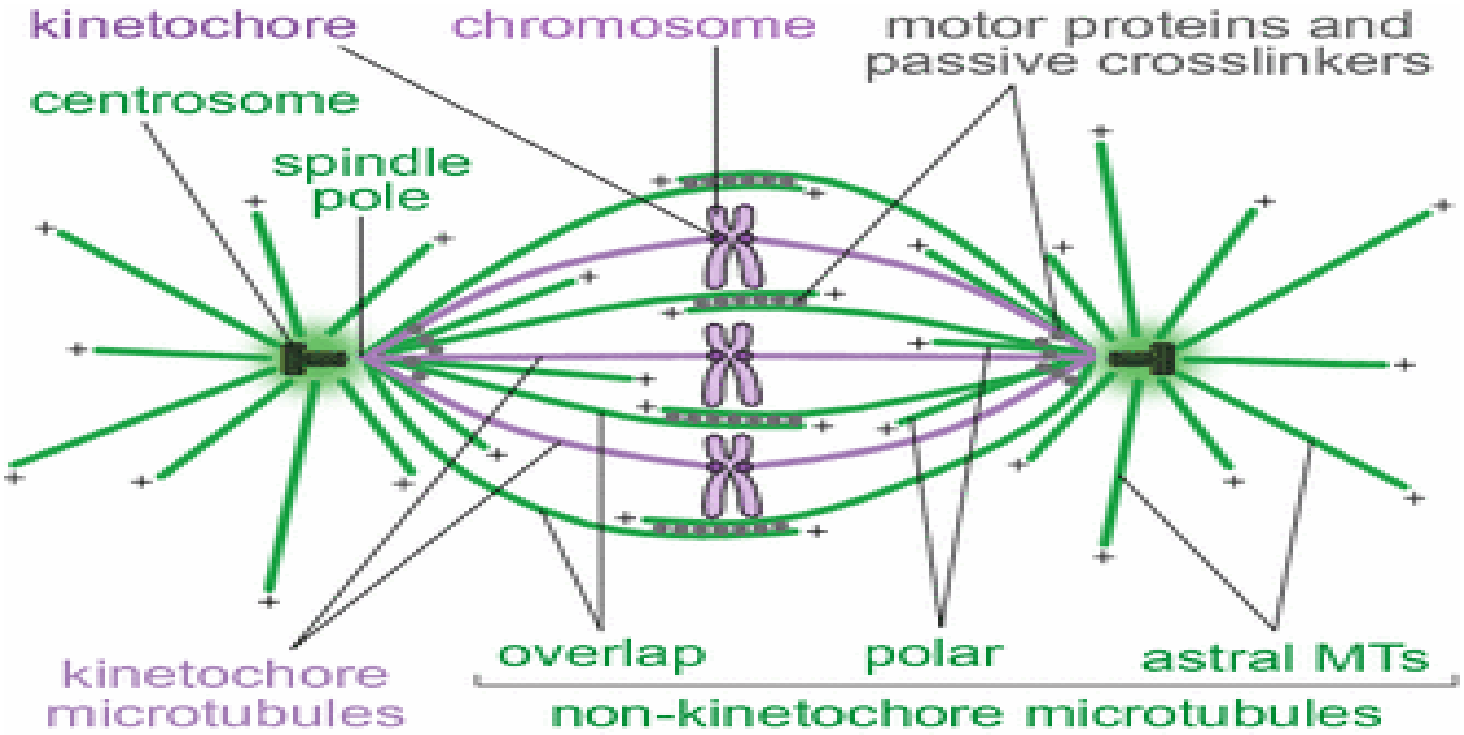
The Mitotic Spindle

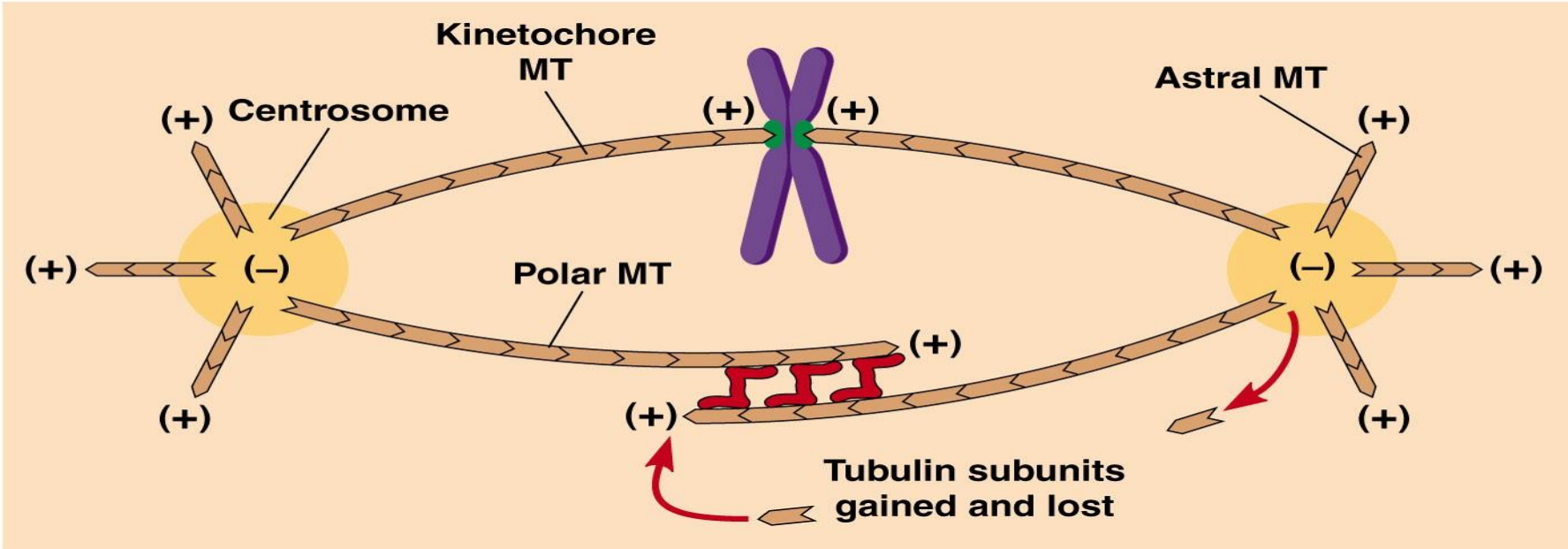
- The **mitotic spindle** is a structure made of microtubules that controls chromosome movement during mitosis
- In animal cells, assembly of spindle microtubules begins in the **centrosome**, the microtubule organizing center
- The centrosome replicates during interphase, forming two centrosomes that migrate to opposite ends of the cell during prophase and prometaphase
- An **aster** (a radial array of short microtubules) extends from each centrosome
- The spindle includes the centrosomes, the spindle microtubules, and the asters
- During prometaphase, some spindle microtubules attach to the kinetochores of chromosomes and begin to move the chromosomes
- **Kinetochores** are protein complexes associated with centromeres
- At metaphase, the chromosomes are all lined up at the **metaphase plate**, an imaginary structure at the midway point between the spindle's two poles
- In anaphase, sister chromatids separate and move along the kinetochore microtubules toward opposite ends of the cell
- The microtubules shorten by depolymerizing at their kinetochore ends

- Nonkinetochore microtubules from opposite poles overlap and push against each other, elongating the cell
- In telophase, genetically identical daughter nuclei form at opposite ends of the cell
- Cytokinesis begins during anaphase or telophase and the spindle eventually disassembles

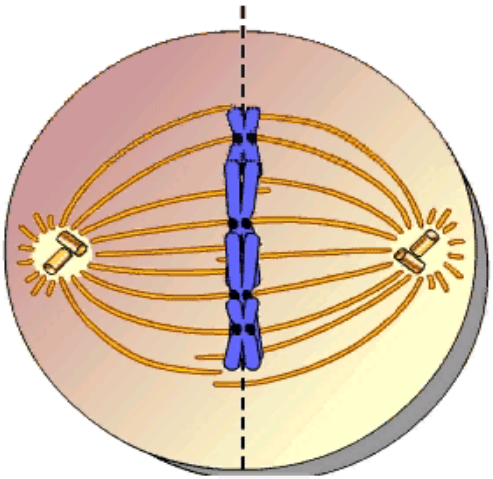


Mitotic apparatus


kinetochore
chromosome
motor proteins and passive crosslinkers
centrosome
spindle pole
kinetochore microtubules
overlap
polar
astral MTs
non-kinetochore microtubules


Kinetochore MT
Astral MT
(+) Centrosome
(+)
(+)
(+)
(+)
(–)
Polar MT
(–)
(+)
(+)
(+)
(+)
(+)
Tubulin subunits gained and lost

Metaphase



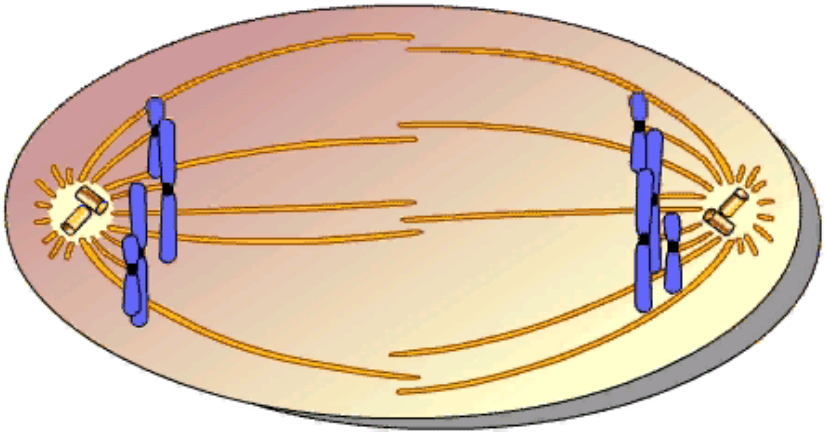
The best stage at which the total number of chromosomes can be counted in any species is metaphase

3-Anaphase

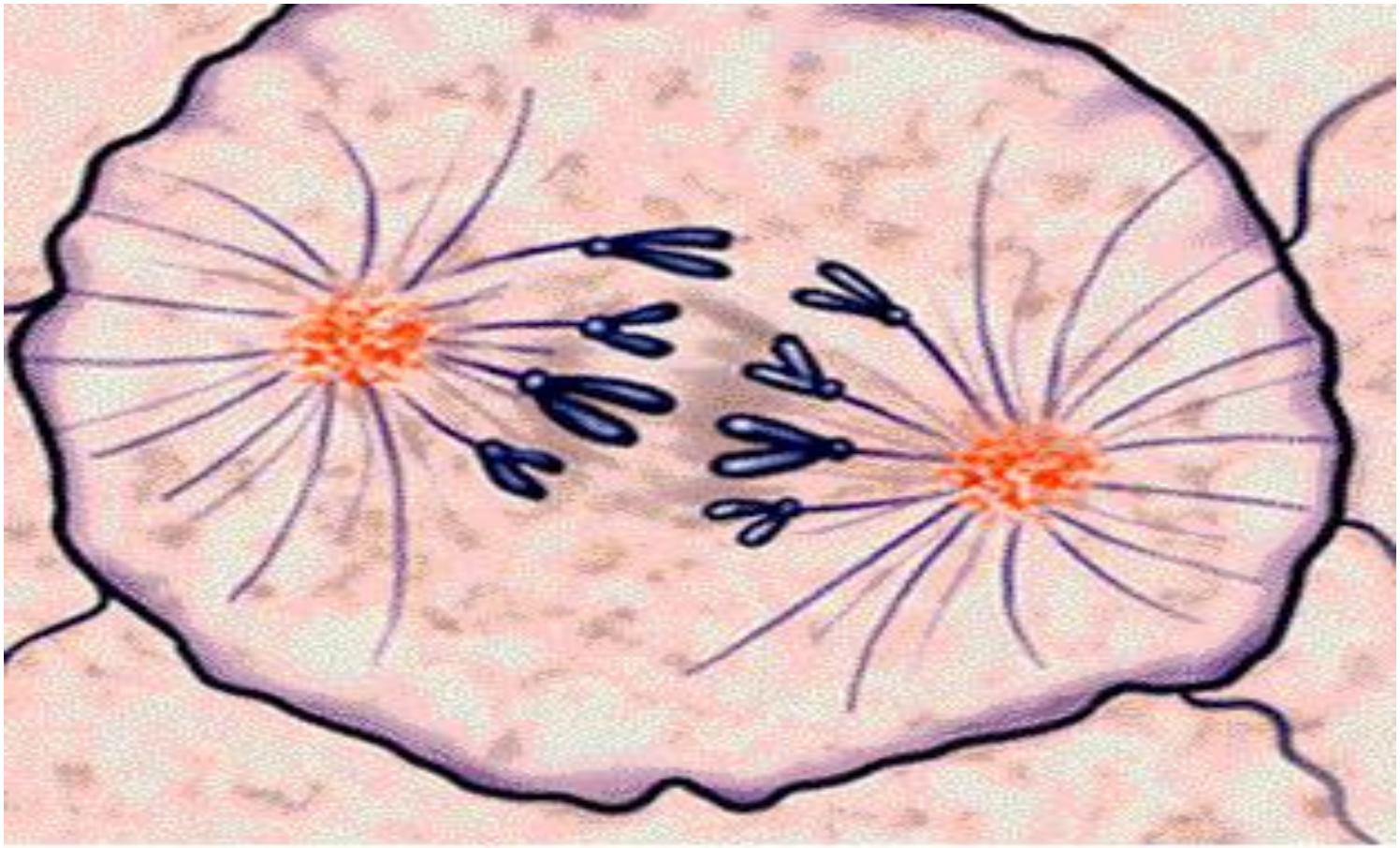
- Each centromere splits making two chromatids free
- Each chromatid moves toward a pole
- Cell begins to elongate, caused by microtubules not associated with the kinetochore

✓Occurs rapidly

✓Sister chromatids are pulled apart to opposite poles of the cell by kinetochore fibers



Anaphase



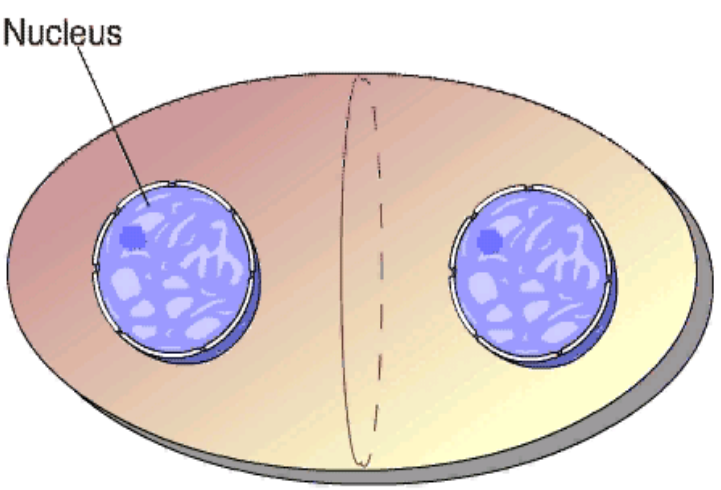
Anaphase

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.

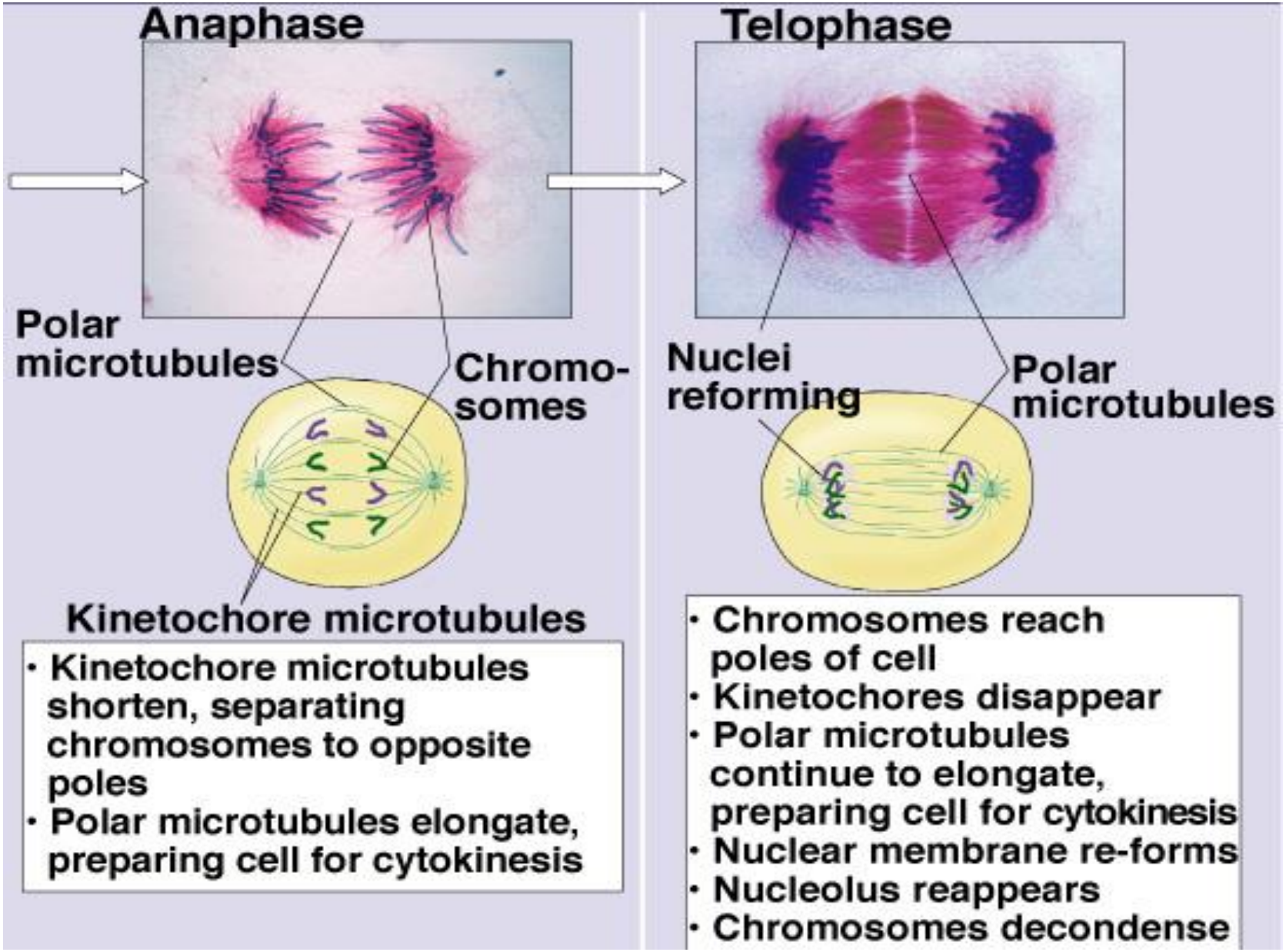
4. Telophase

- Formation of nuclear membrane and nucleolus
- Short and thick chromosomes begin to elongate to form long and thin chromatin
- Formation of the cleavage furrow - a shallow groove in the cell near the old metaphase plate
- **Formation of cell plate starts at telophase**

- **Cytokinesis =** division of the cytoplasm
  - ✓Sister chromatids at opposite poles
  - ✓Spindle disassembles
  - ✓Nuclear envelope forms around each set of sis
  - ✓Nucleolus reappears
  - ✓CYTOKINESIS occurs
  - ✓Chromosomes reappear as chromatin



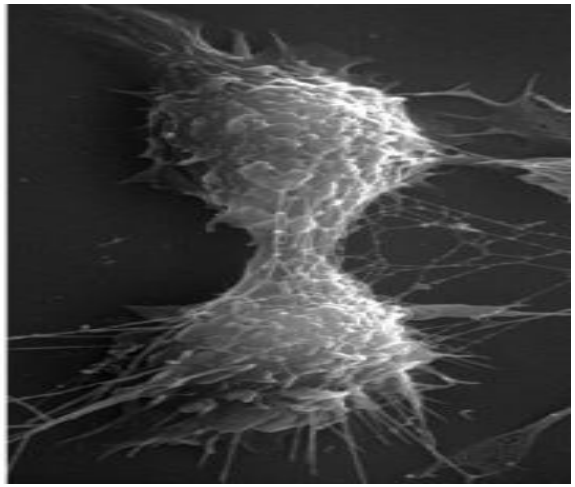
Comparison of Anaphase & Telophase



Cytokinesis

- ✓ Means division of the cytoplasm
- ✓ Division of cell into two, identical halves called daughter cells
- ✓ cleavage furrow forms to split cell
- Nuclear membranes form around the two new sets of chromosomes.
- The spindle fiber disappears.
- Chromosomes start to uncoil (chromatin) and become less visible.
- Cell starts to make a groove (furrow) in the middle to eventually split into two identical cells.

❑ If cells undergo mitosis and not cytokinesis, this will result in cell with two nuclei.



The Key Roles of Cell Division

- The ability of organisms to produce more of their own kind best distinguishes living things from nonliving matter
- The **continuity of life** is based on the reproduction of cells, or **cell division**
- In unicellular organisms, division of one cell reproduces the entire organism
- Multicellular organisms depend on cell division for
  - Development from a fertilized cell
  - Growth
  - Repair
- Cell division is an integral part of the **cell cycle**, the life of a cell from formation to its own division
- **Most cell division results in genetically identical daughter cells**
- Most cell division results in daughter cells with identical genetic information, DNA
- The exception is meiosis, a special type of division that can produce sperm and egg cells