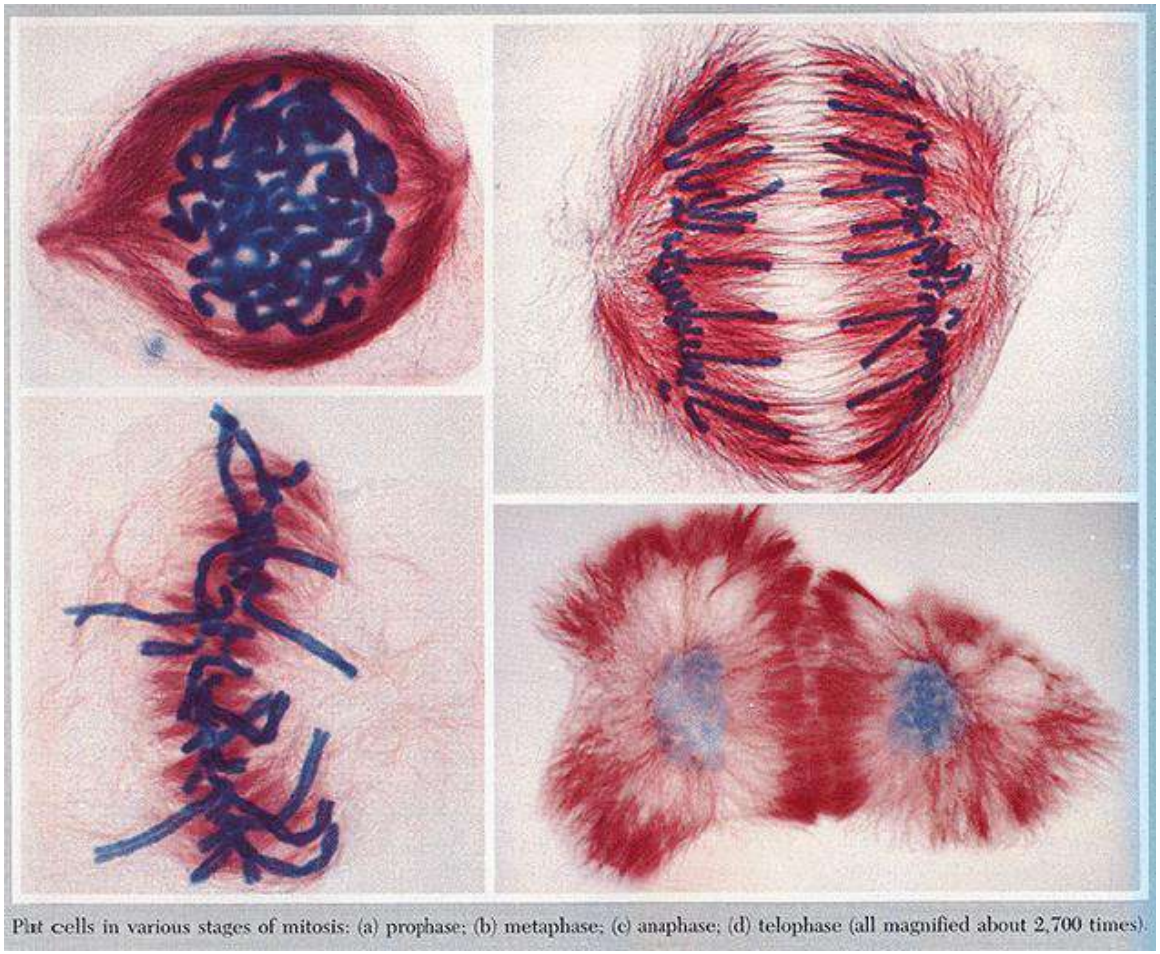
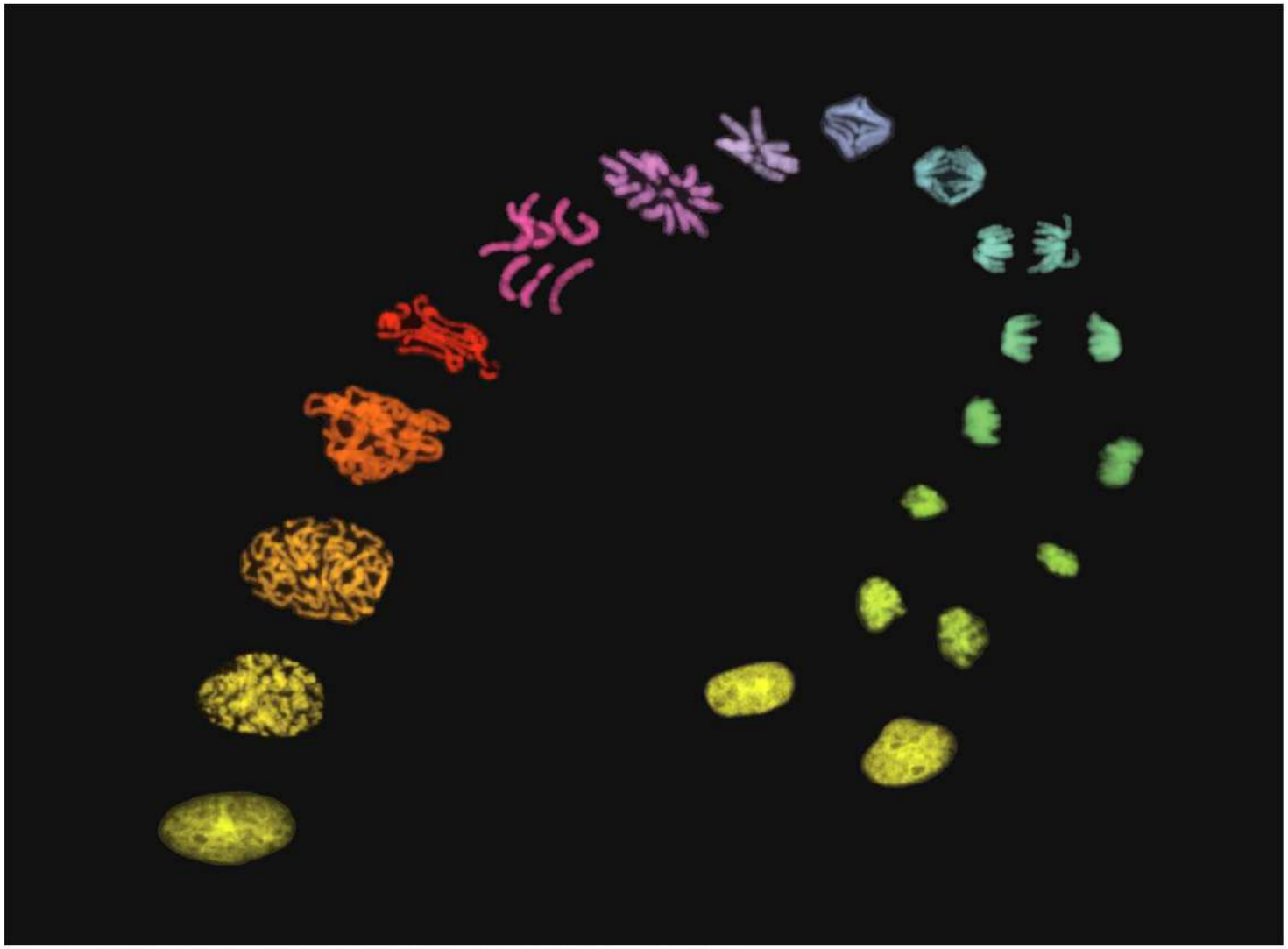
CH 12 NOTES, part 1:
Chromosomes, the Cell Cycle, and Cell Division (12.1-12.2)

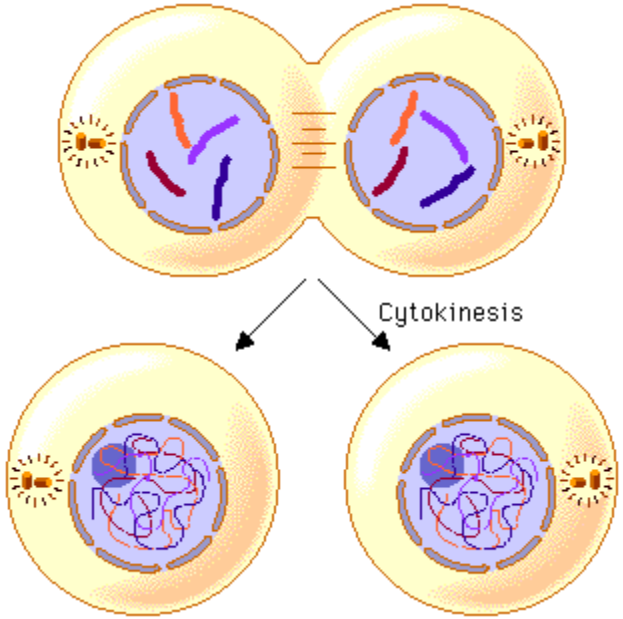


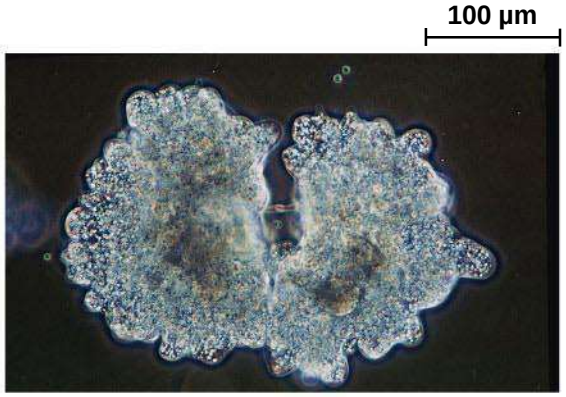
Plant cells in various stages of mitosis: (a) prophase; (b) metaphase; (c) anaphase; (d) telophase (all magnified about 2,700 times).

- The ability of organisms to reproduce best distinguishes living things from nonliving matter
- The continuity of life is based upon the reproduction of cells, or cell division

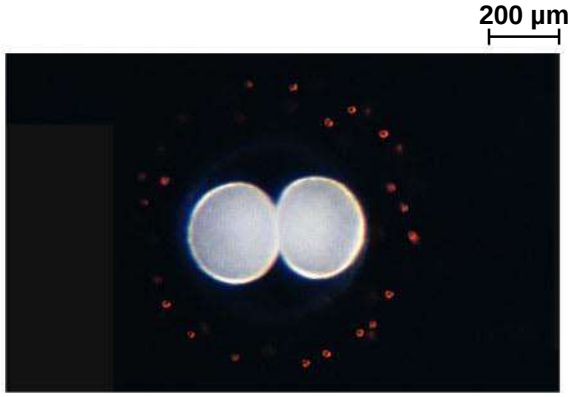


- In unicellular organisms, division of one cell <u>reproduces the entire organism</u>
- Multicellular organisms depend on cell division for:
  - ➔ **<u>Development from a fertilized cell</u>**
  - ➔ **<u>Growth</u>**
  - ➔ **<u>Repair</u>**

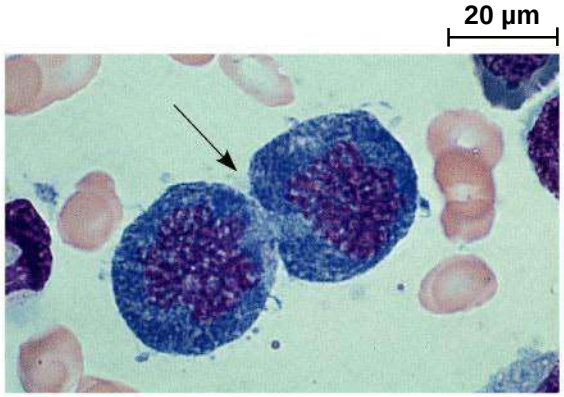




(a) Reproduction



(b) Growth and development



(c) Tissue renewal

12.1 – Most cell division results in genetically identical daughter cells

- Cells duplicate their genetic material (DNA) before they divide, ensuring that each daughter cell receives an exact copy of the genetic material
- A dividing cell duplicates its DNA, allocates the two copies to opposite ends of the cell, and only then splits into **DAUGHTER CELLS**

Cellular Organization of the Genetic Material:

- A cell's endowment of DNA (its genetic information) is called its **GENOME**
- DNA molecules in a cell are packaged into **CHROMOSOMES**

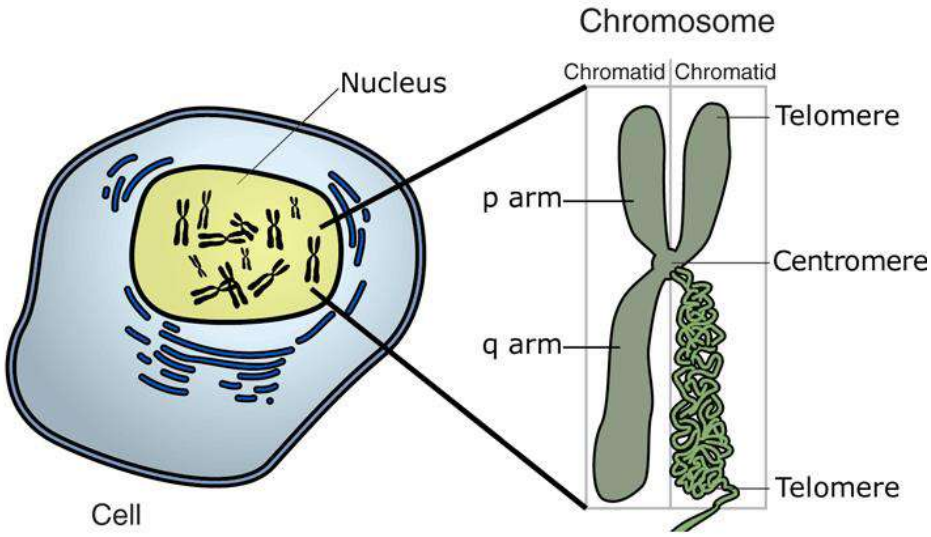
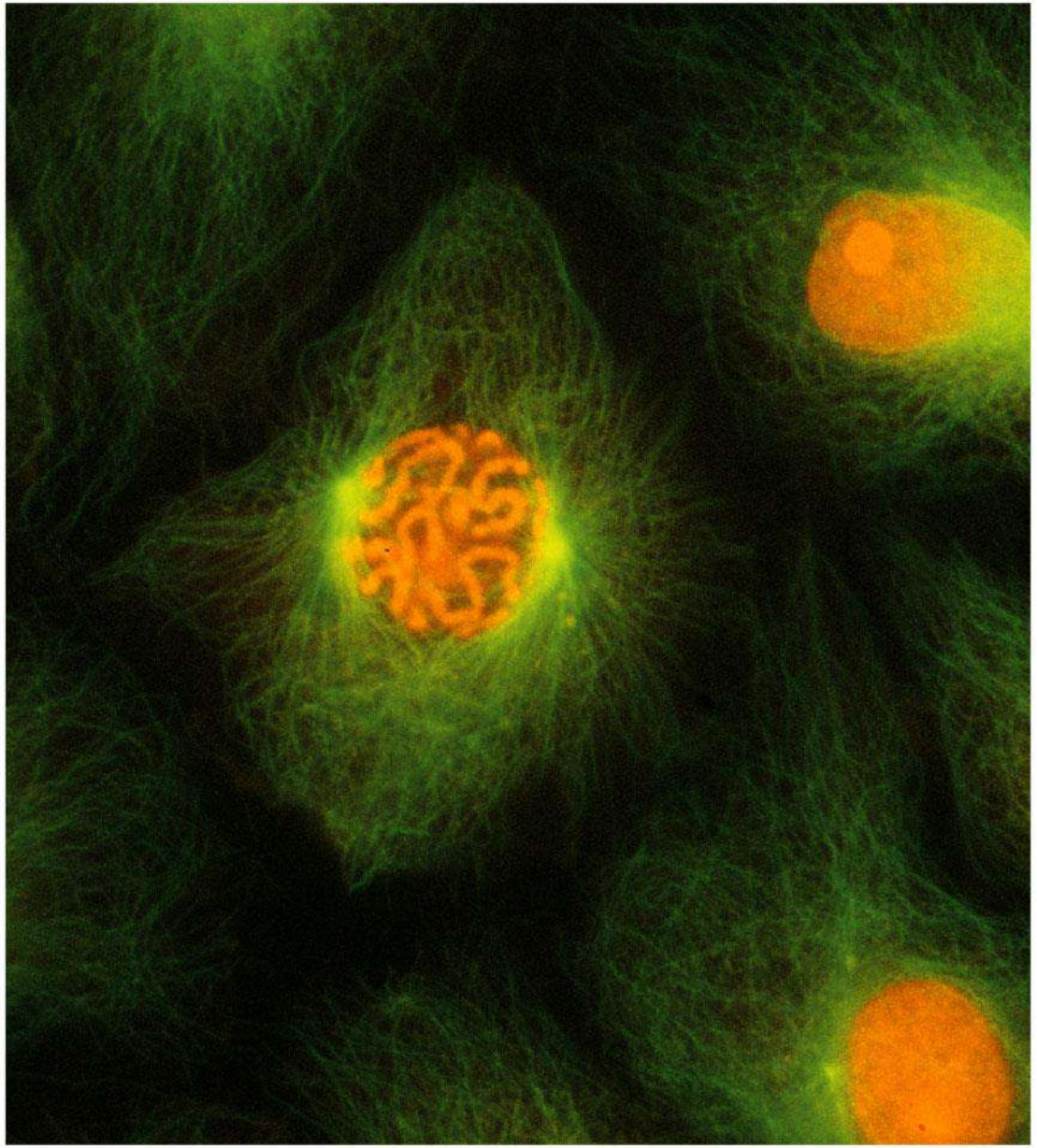
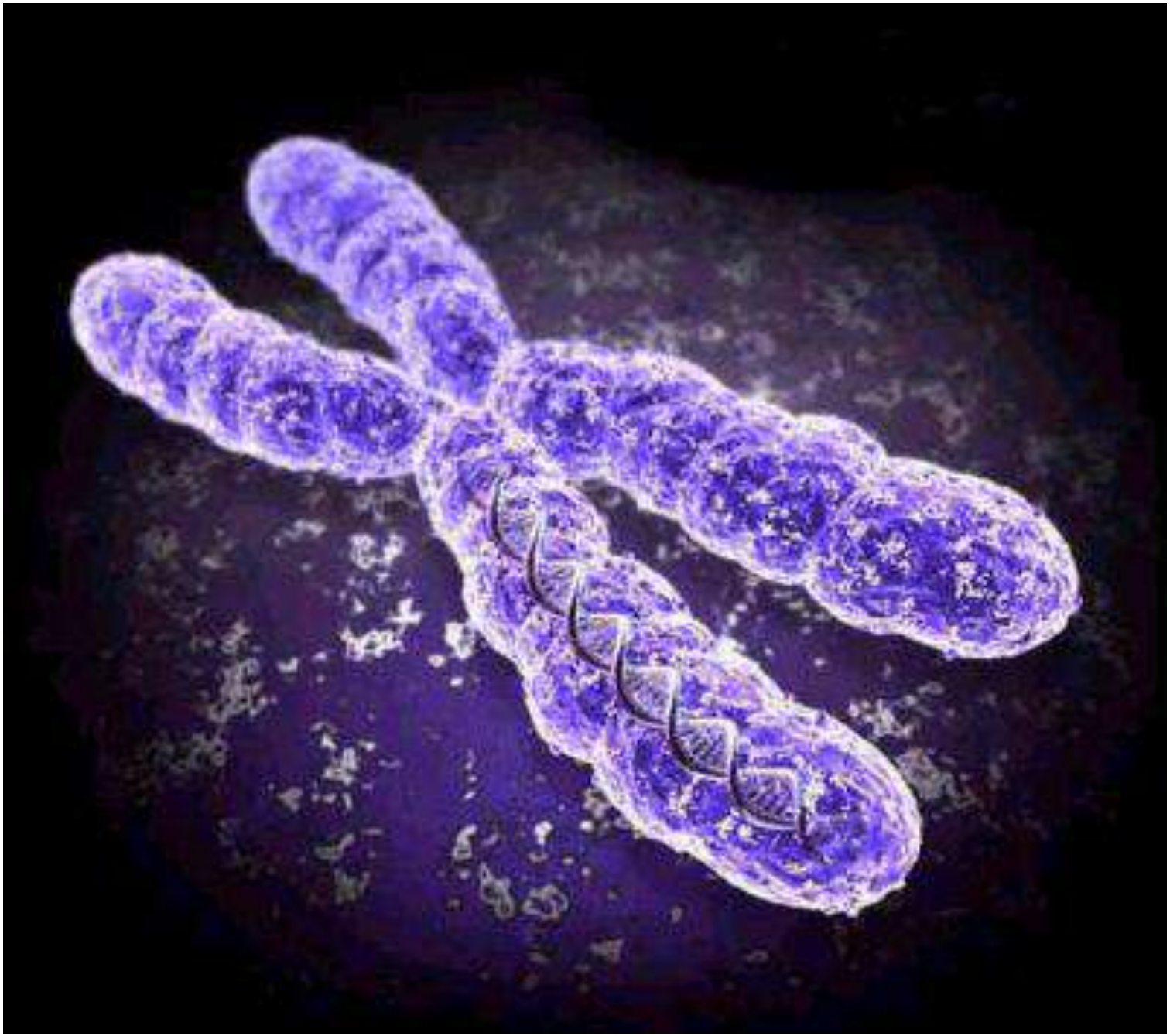


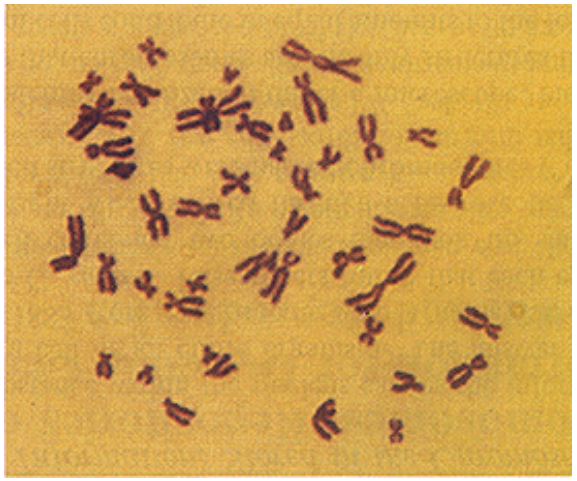
Image adapted from: National Human Genome Research Institute.

- Every eukaryotic species has a characteristic number of chromosomes in each cell nucleus
- **Somatic** (nonreproductive) cells have two sets of chromosomes (**DIPLOID**)
- **Gametes** (reproductive cells: sperm and eggs) have half as many chromosomes as somatic cells (**HAPLOID**)
- Eukaryotic chromosomes consist of **CHROMATIN**, a complex of DNA and protein (i.e. histone proteins) that condenses during cell division

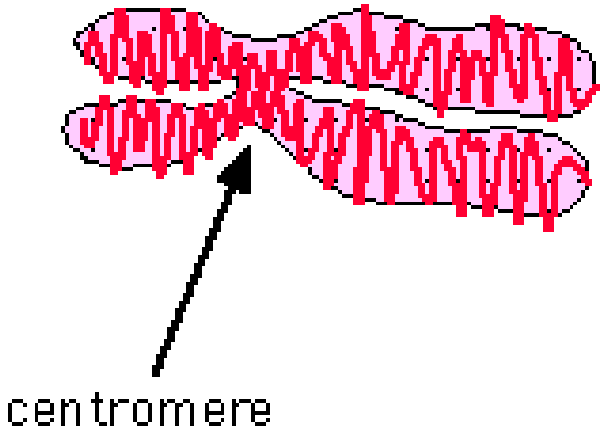




- **Chromosomes** = after the DNA replicates in the S phase of interphase, a chromosome consists of **tightly coiled** chromatin (DNA);

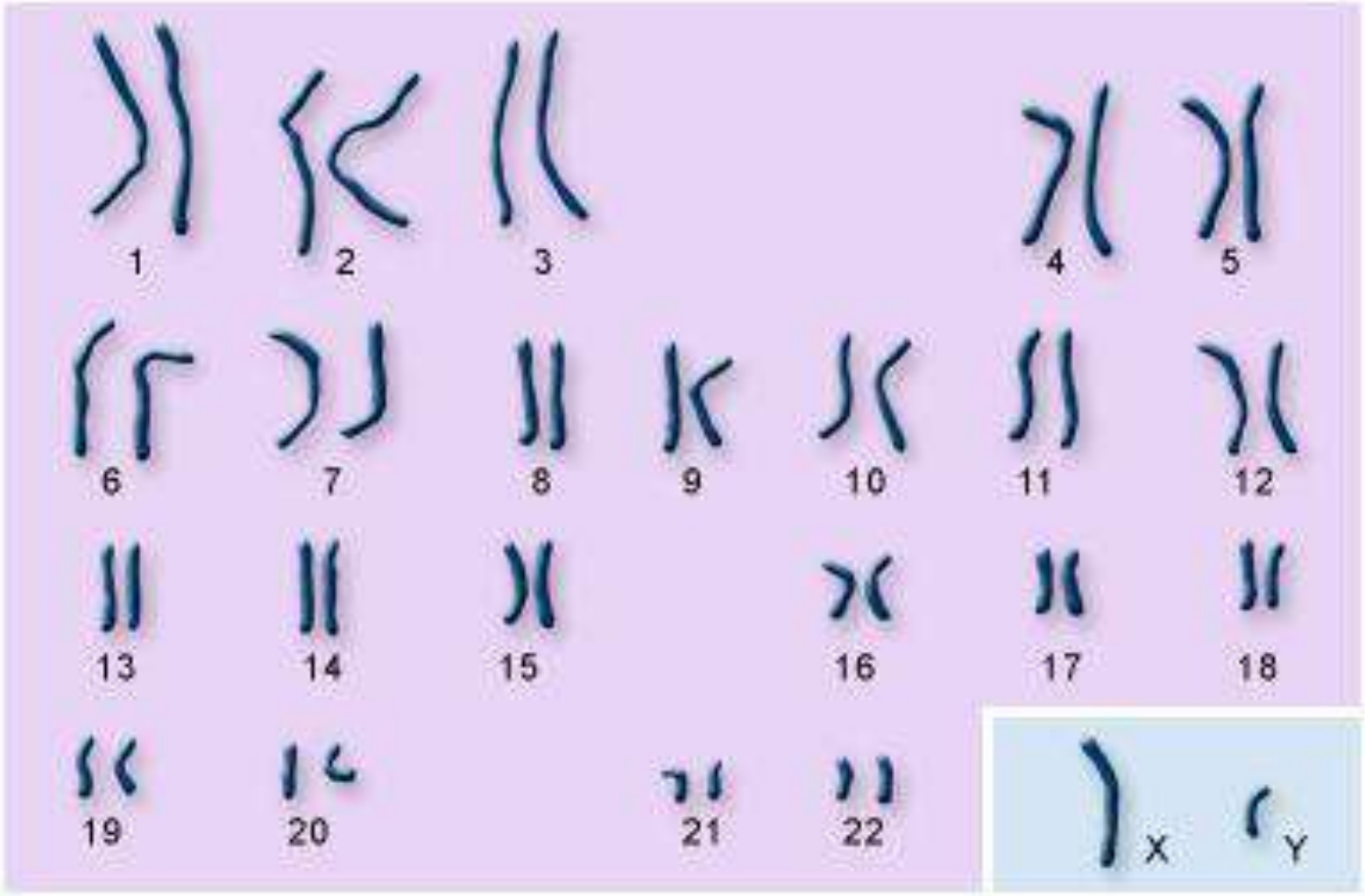


- a chromosome consists of 2 identical **chromatids** (sister chromatids) which are connected in the center by a **CENTROMERE**



****a human cell entering mitosis contains**

46 chromosomes

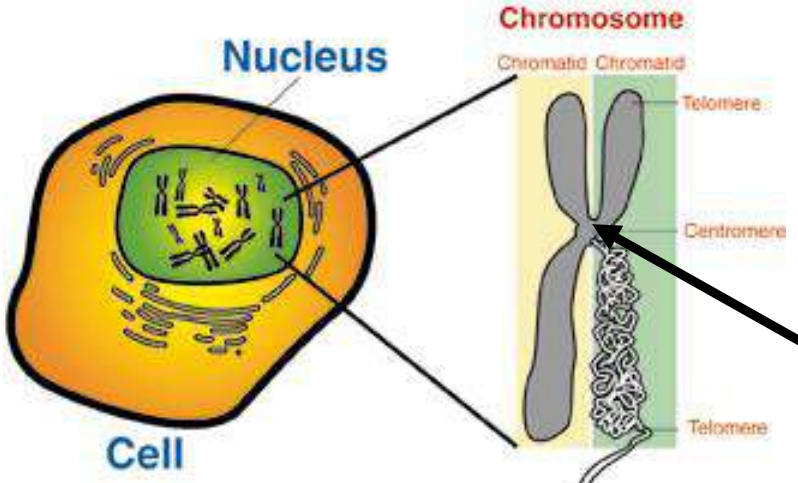


autosomes

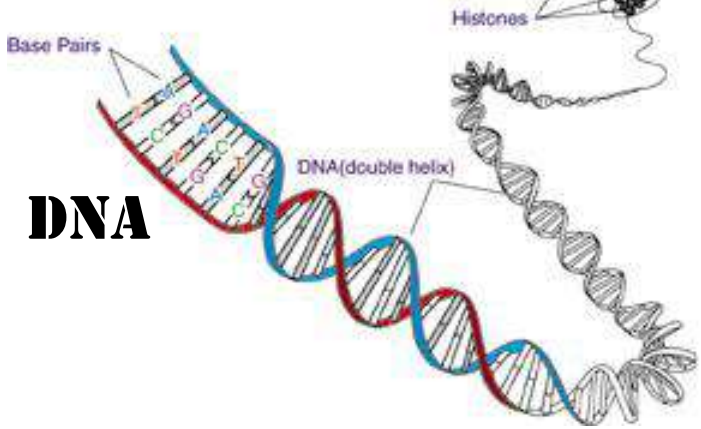
sex chromosomes

U.S. National Library of Medicine

CHROMOSOME

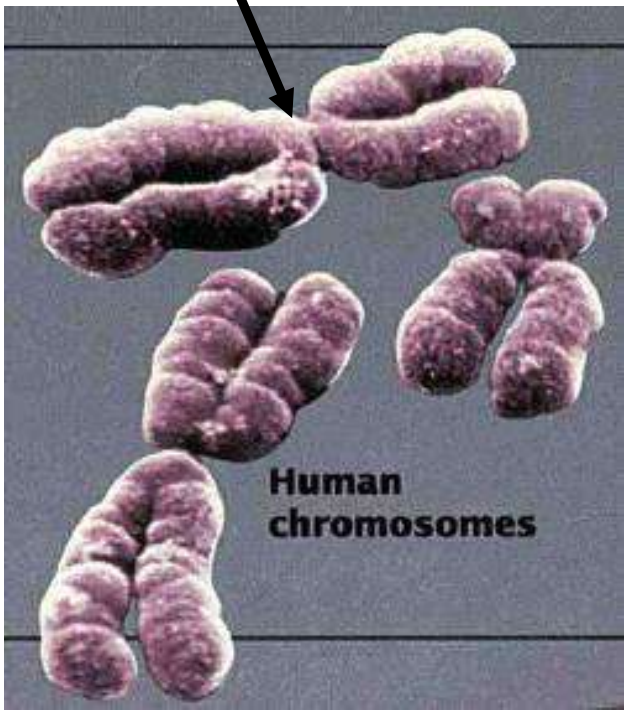


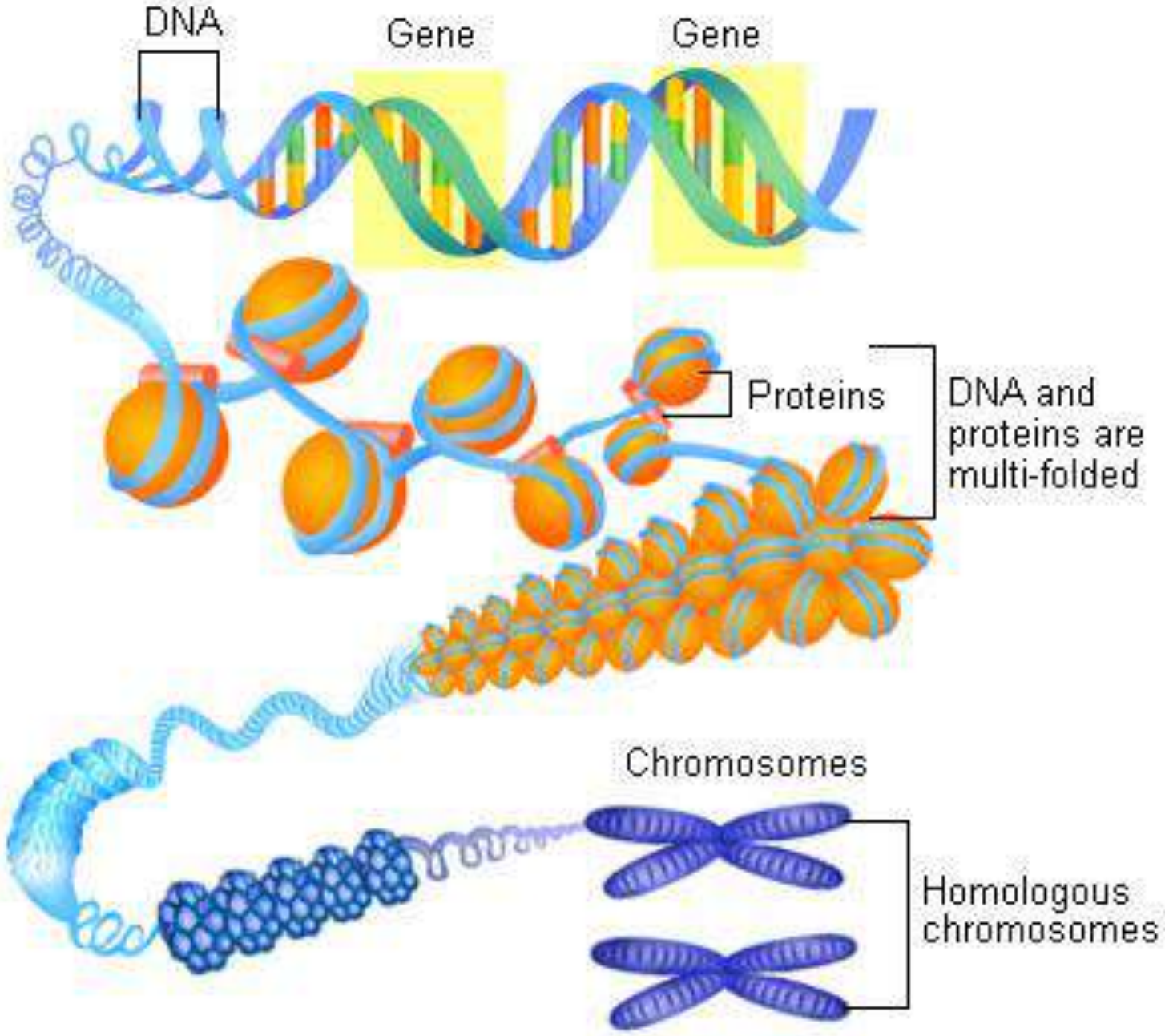
CHROMATIN

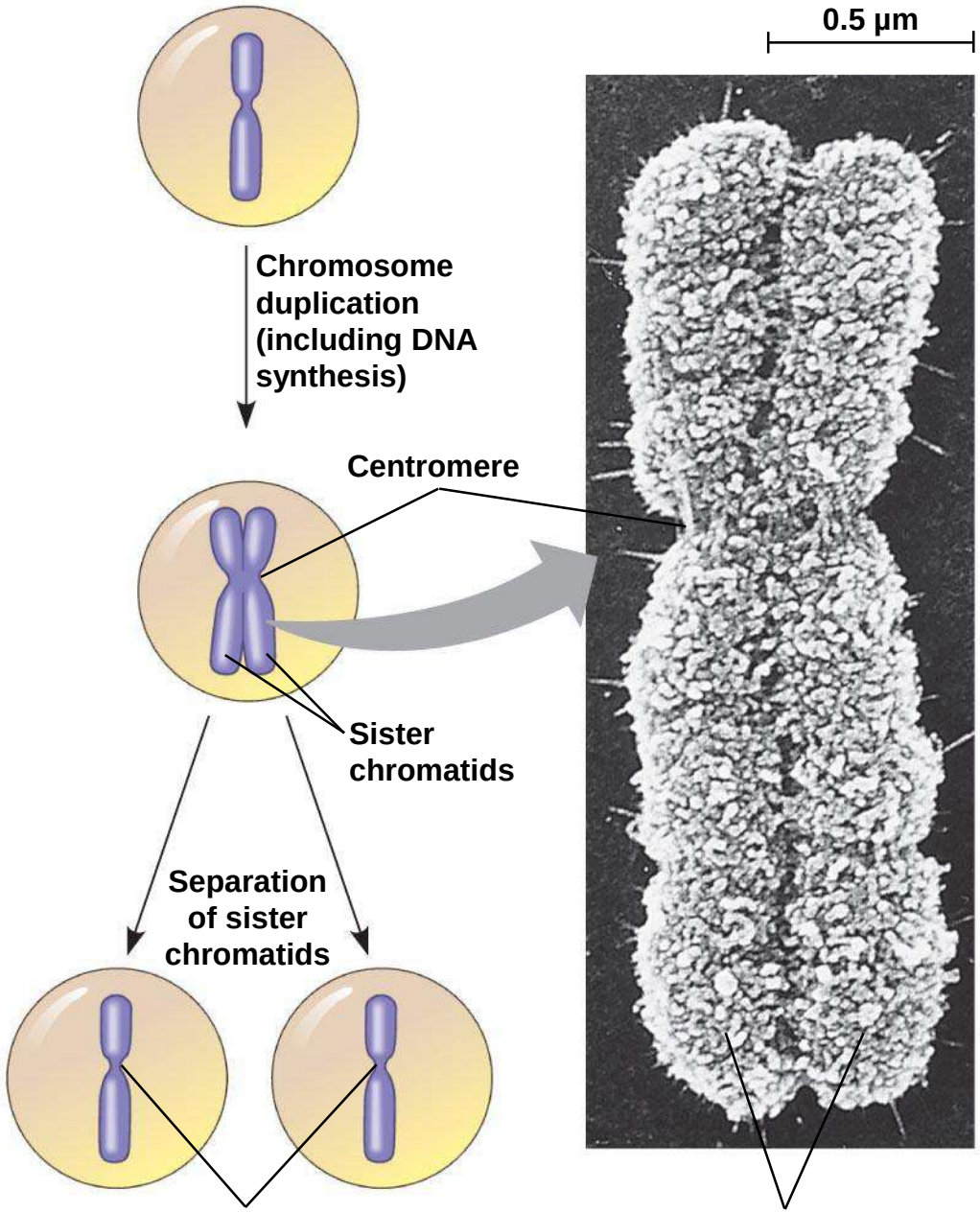


DNA

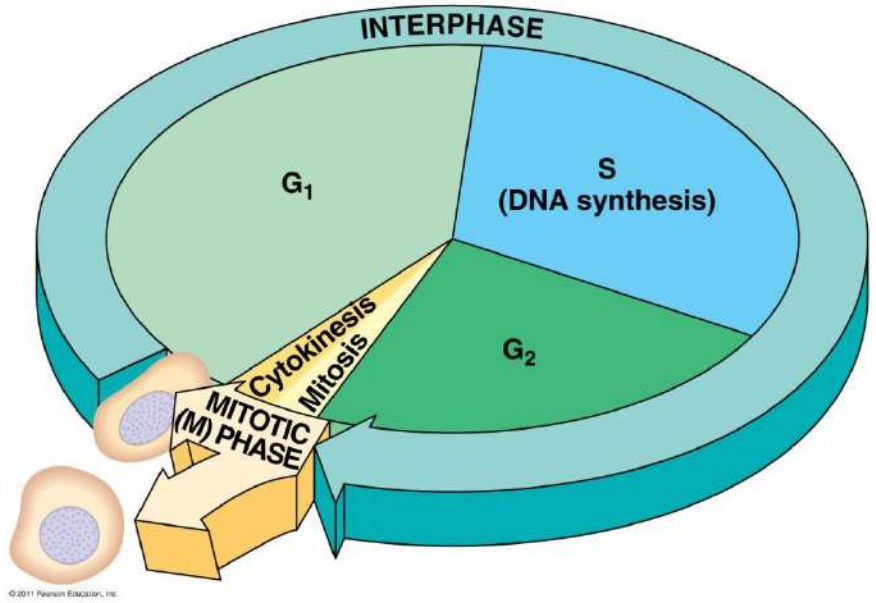
centromere




DNA
Gene
Gene
Proteins
DNA and proteins are multi-folded
Chromosomes
Homologous chromosomes

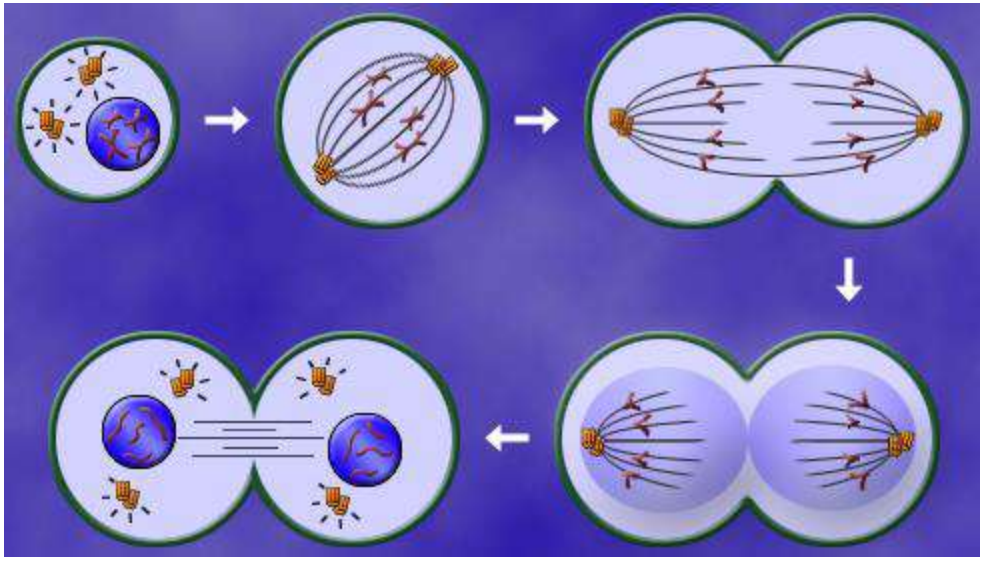


12.2 – The mitotic phase alternates with interphase in the cell cycle



- Eukaryotic cell division consists of:
  - **Mitosis: <u>the division of the nucleus</u>**
  - **Cytokinesis: <u>the division of the cytoplasm</u>**
- Gametes are produced by a variation of cell division called **meiosis (CH 13)**

  ***Meiosis yields nonidentical daughter cells that have only one set of chromosomes, half as many as the parent cell*

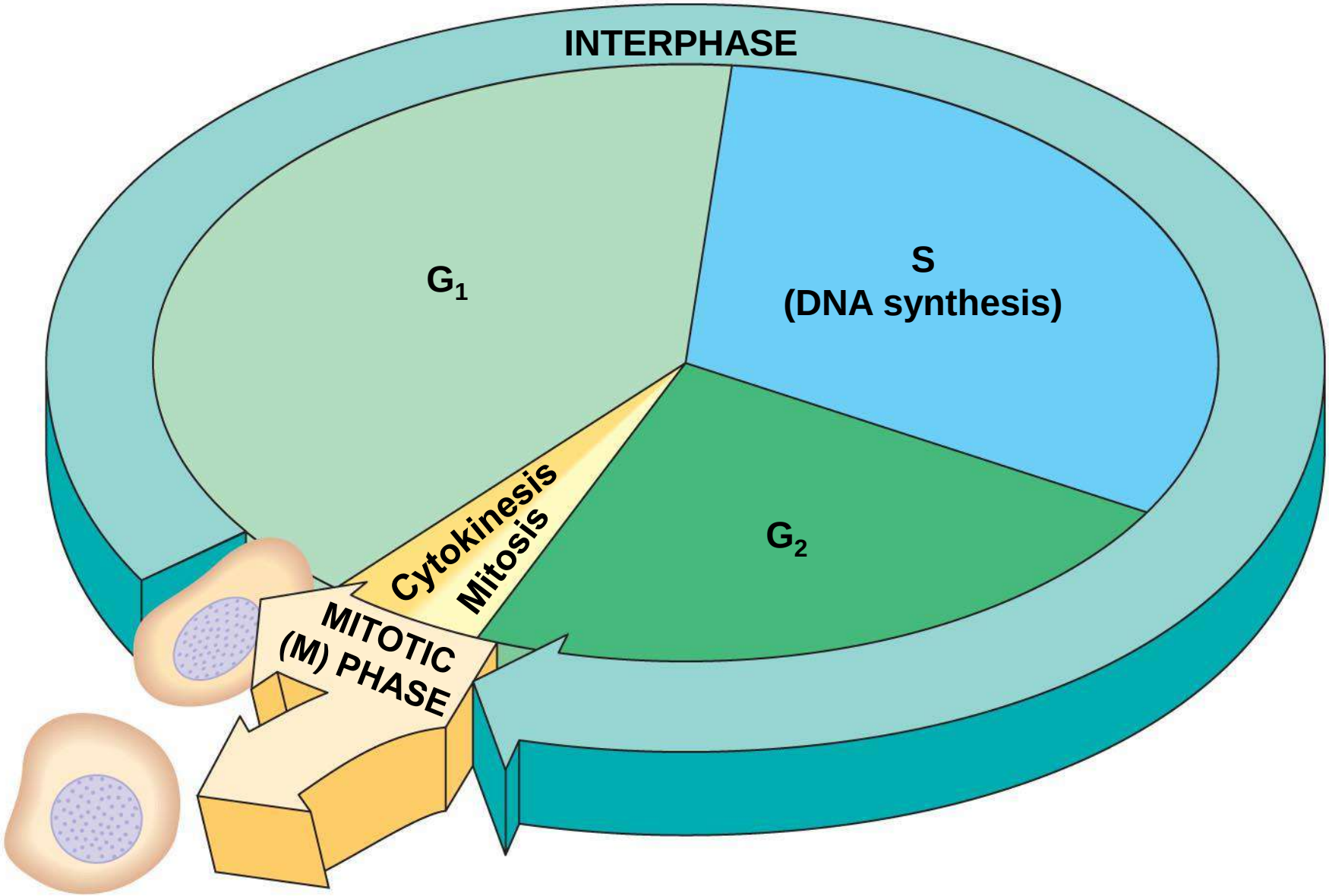


3 main stages of the cell cycle

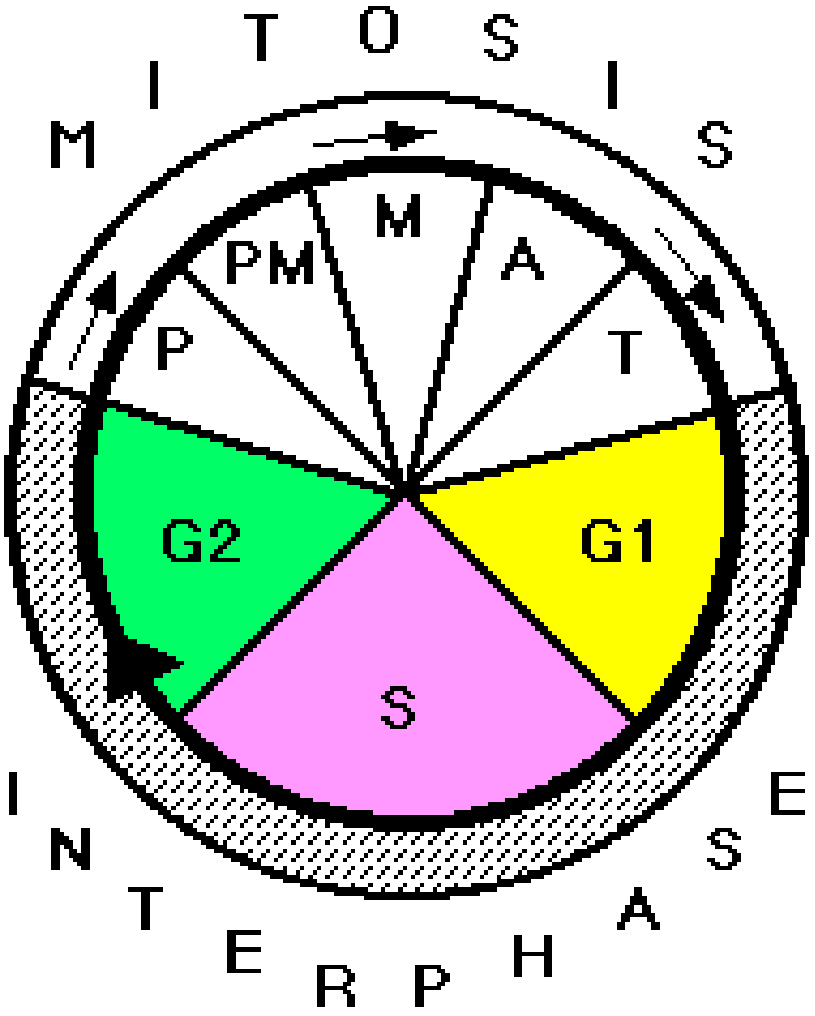
1) Interphase: longest stage (90%); includes preparation for cell division

2) Mitosis (10%): nucleus divides into 2 nuclei, each with the same # and kind of chromosomes (DNA) as the parent cell

3) Cytokinesis: cytoplasm divides forming 2 distinct cells



Cell Cycle



G_1 = "first gap"; cell growth (producing proteins & organelles)

S = DNA "Synthesis" (cell copies its DNA) & more growth

G_2 = "second gap"; more growth & completes preparation for division

Next: the stages of MITOSIS!

Mitosis is one, continuous event, but it can be described as happening in 5 phases:

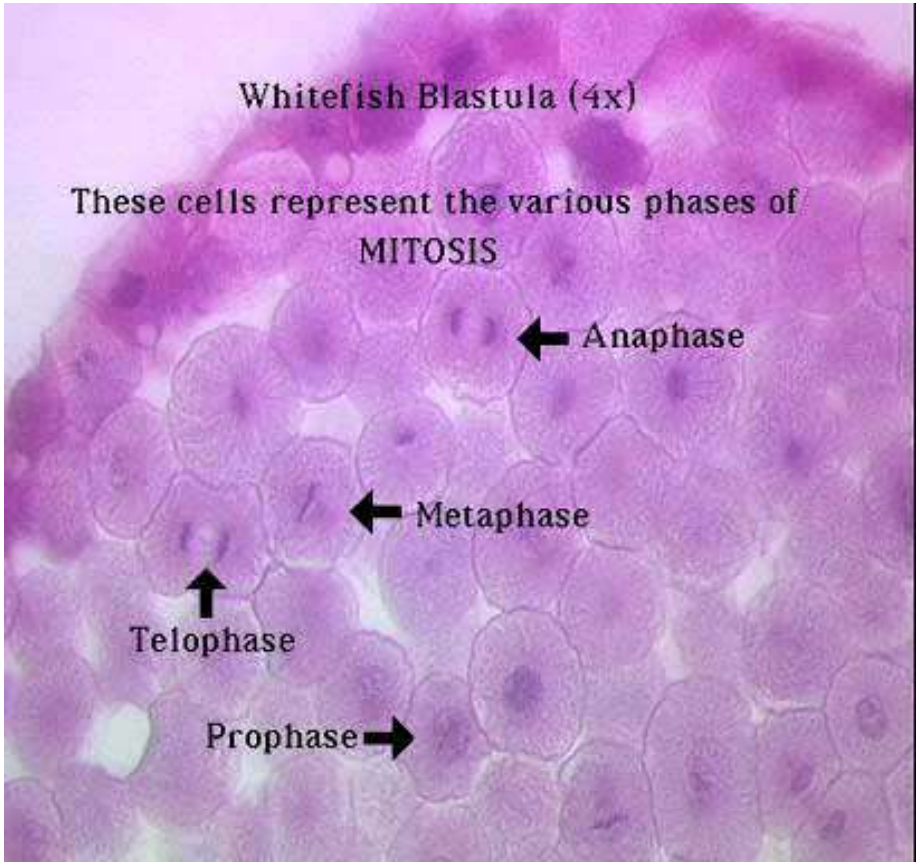
1) Prophase

2) Prometaphase

3) Metaphase

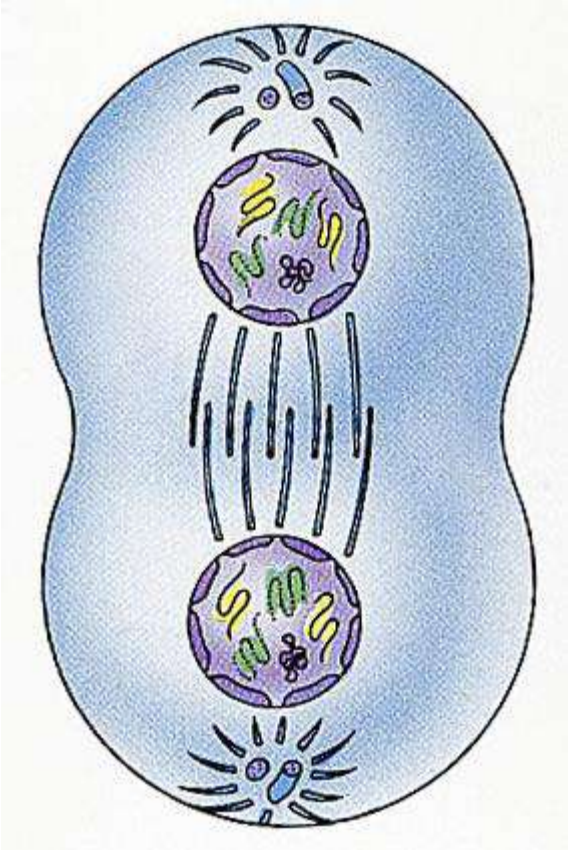
4) Anaphase

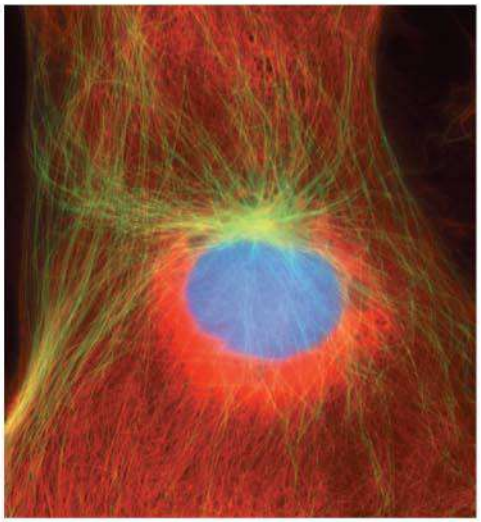
5) Telophase



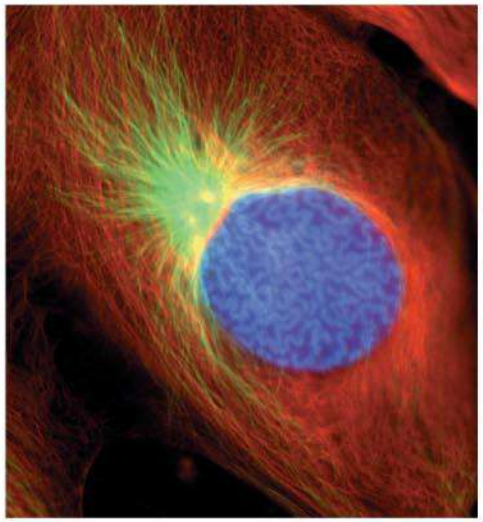
(followed by CYTOKINESIS!)

Cytokinesis is well underway by late telophase

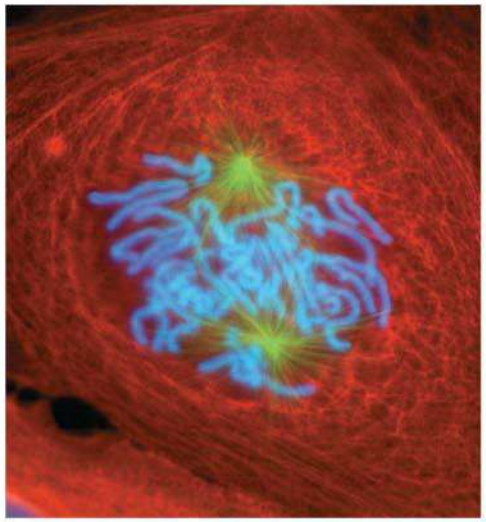




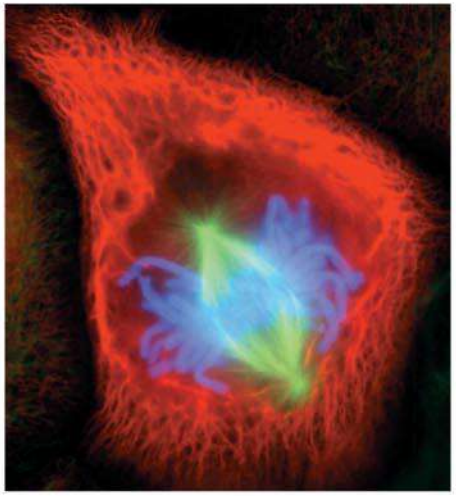
G_2 OF INTERPHASE

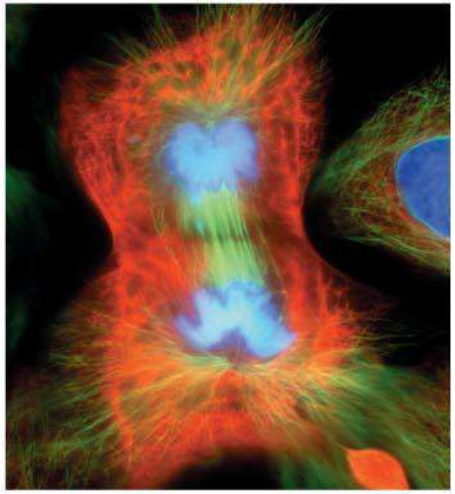


PROPHASE



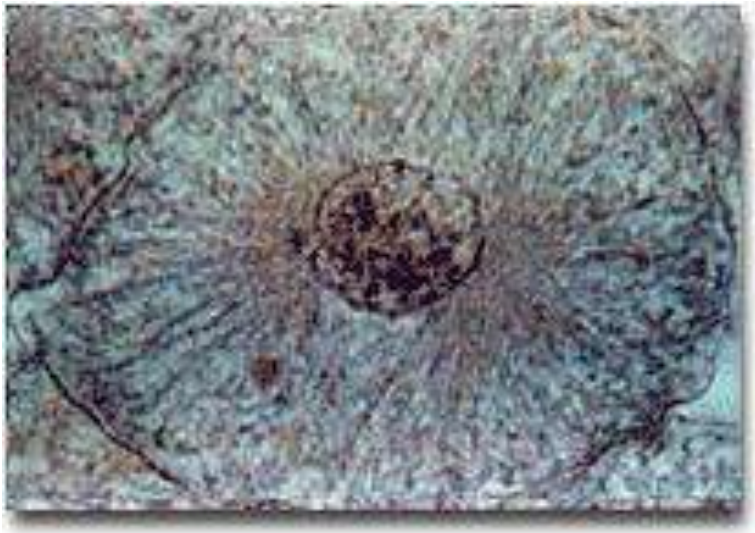
PROMETAPHASE

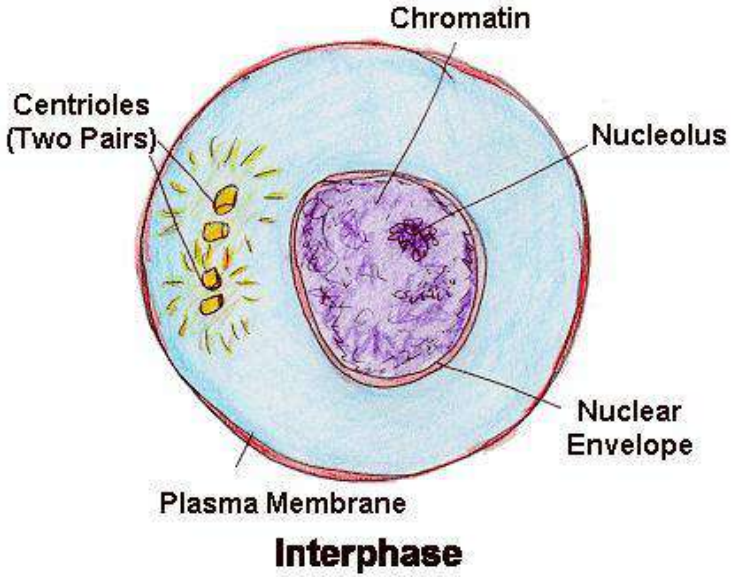




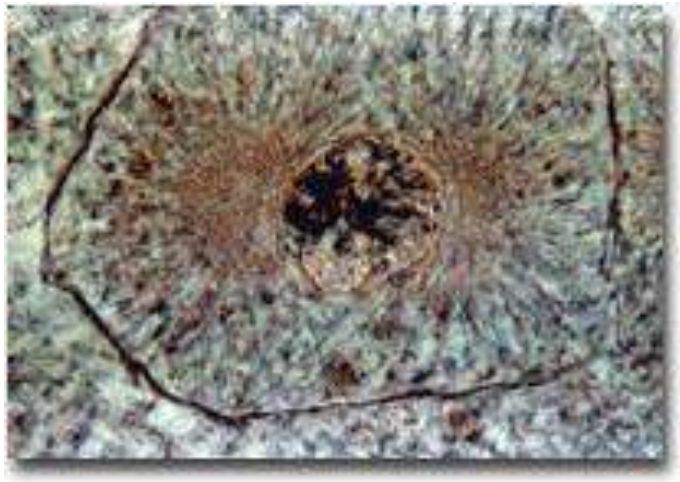
METAPHASE **ANAPHASE** **TELOPHASE AND CYTOKINESIS**

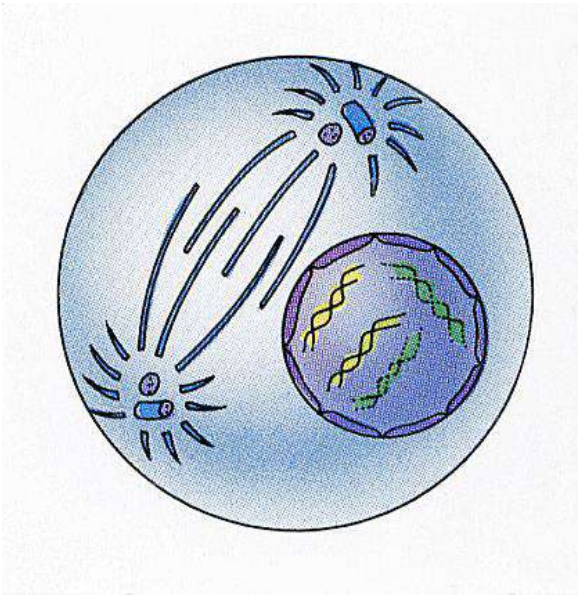
**Remember, the cell is coming out of Interphase…





PROPHASE

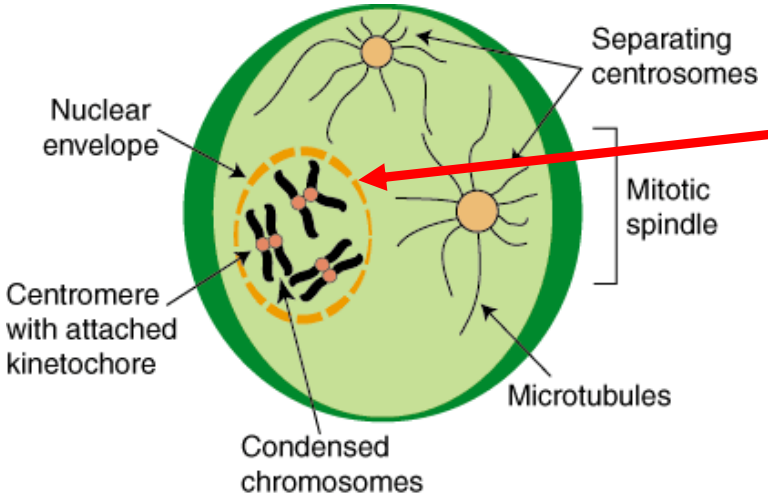




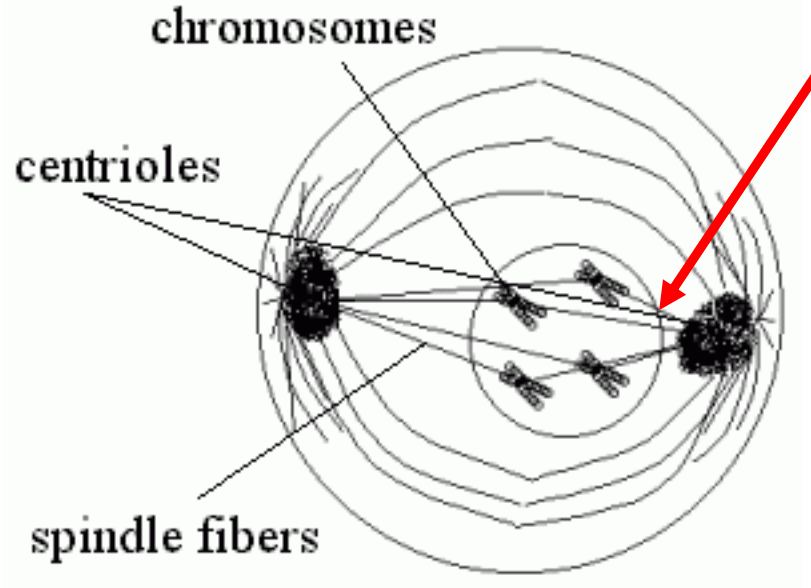
- chromatin condenses & chromosomes become visible;

- centrosomes / centrioles separate and move to the opposite sides of the nucleus

PROMETAPHASE



- nuclear envelope breaks down and the nucleolus disappears;

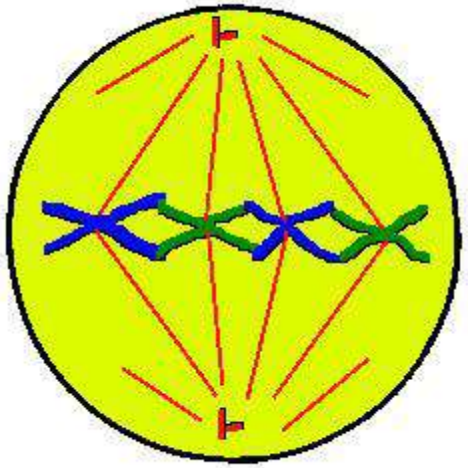


- spindle fibers (from centrioles of centrosomes) connect to chromosomes at their centromeres (**KINETOCHORE**)

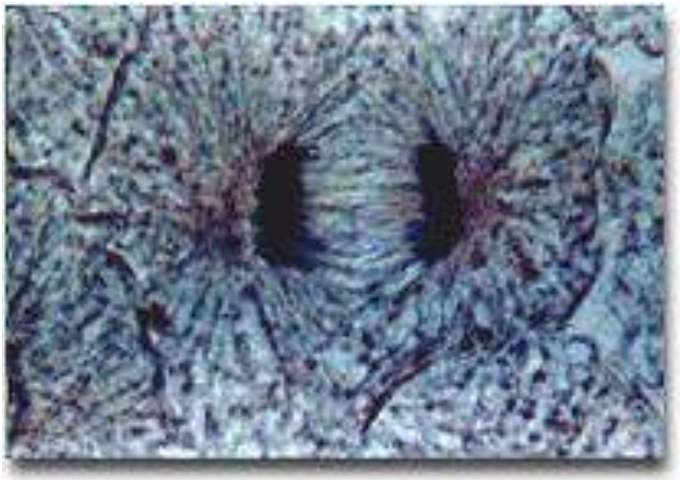
METAPHASE

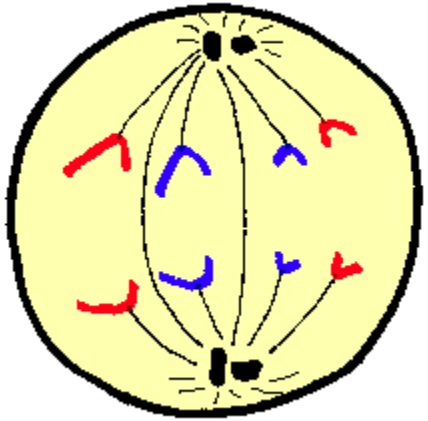
- chromosomes line up in the center of the cell (metaphase plate);

- spindle fibers connect from the poles (end) of the spindle to the centromere / kinetochore of each chromosome



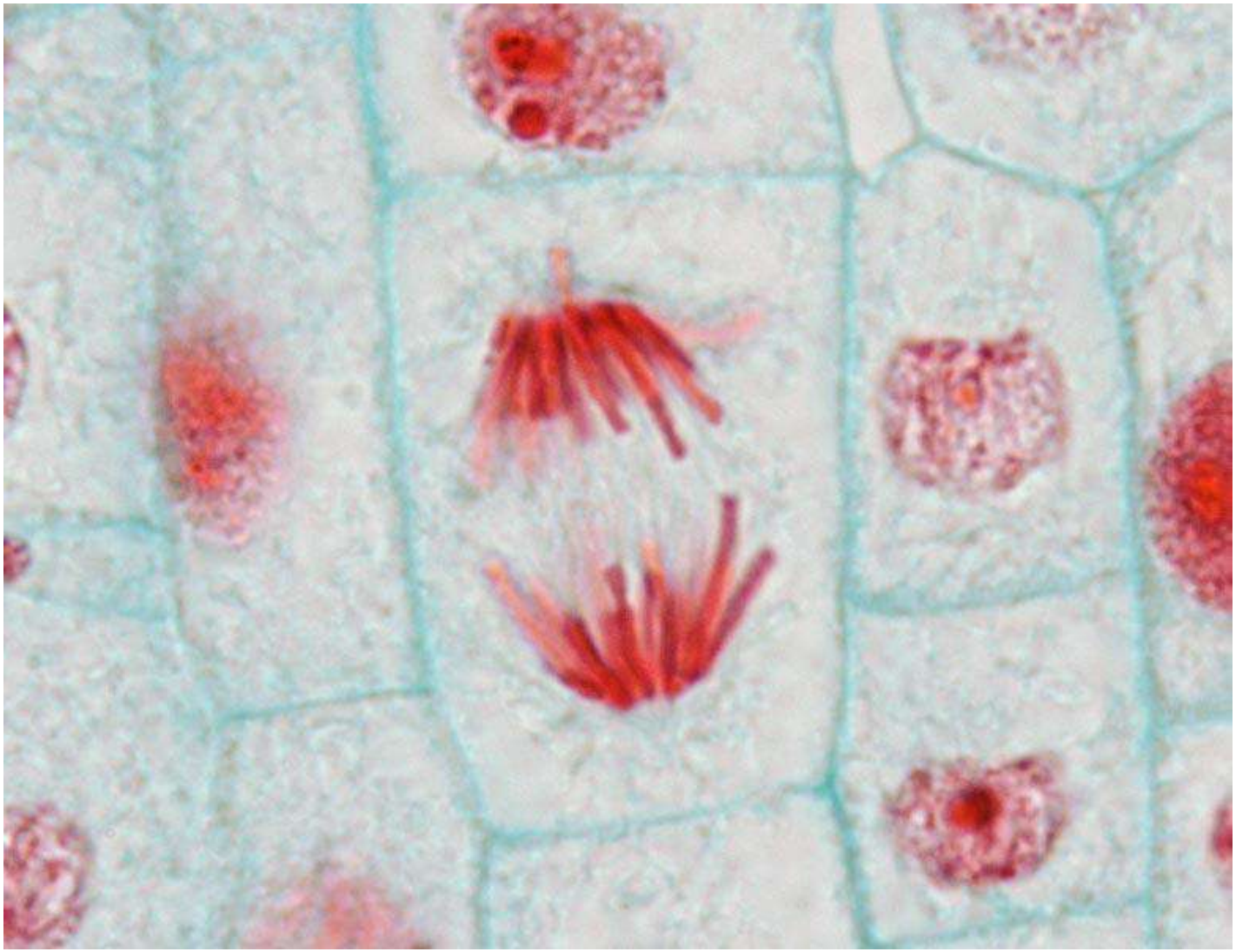
ANAPHASE





- centromeres split, causing the sister chromatids to separate, **becoming individual chromosomes**

- chromosomes are pulled apart to opposite ends of the cell as the spindle fibers shorten and “reel them in” to the poles



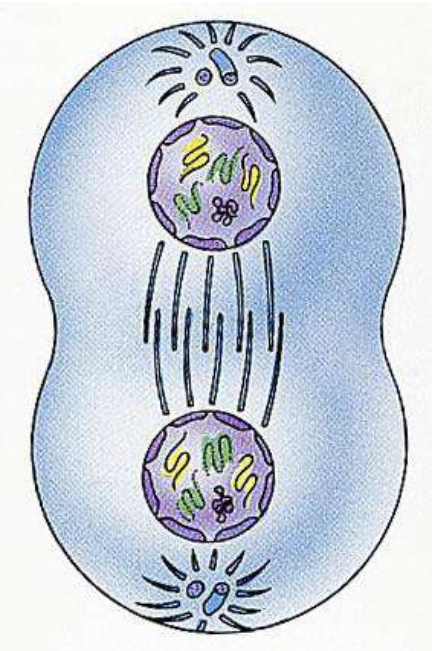
TELOPHASE

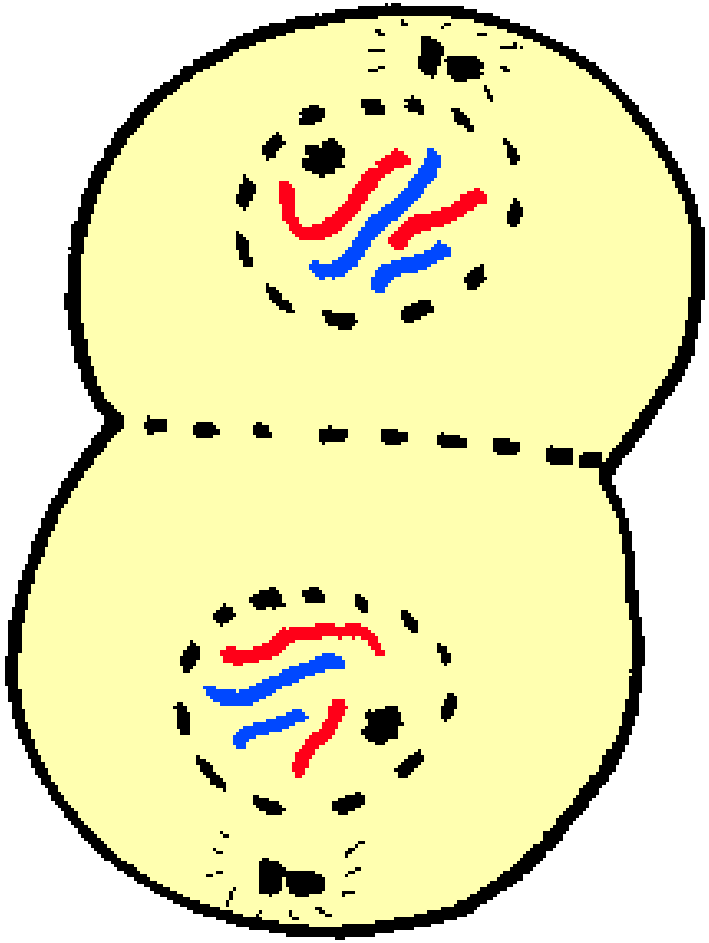
● chromosomes uncoil into chromatin;

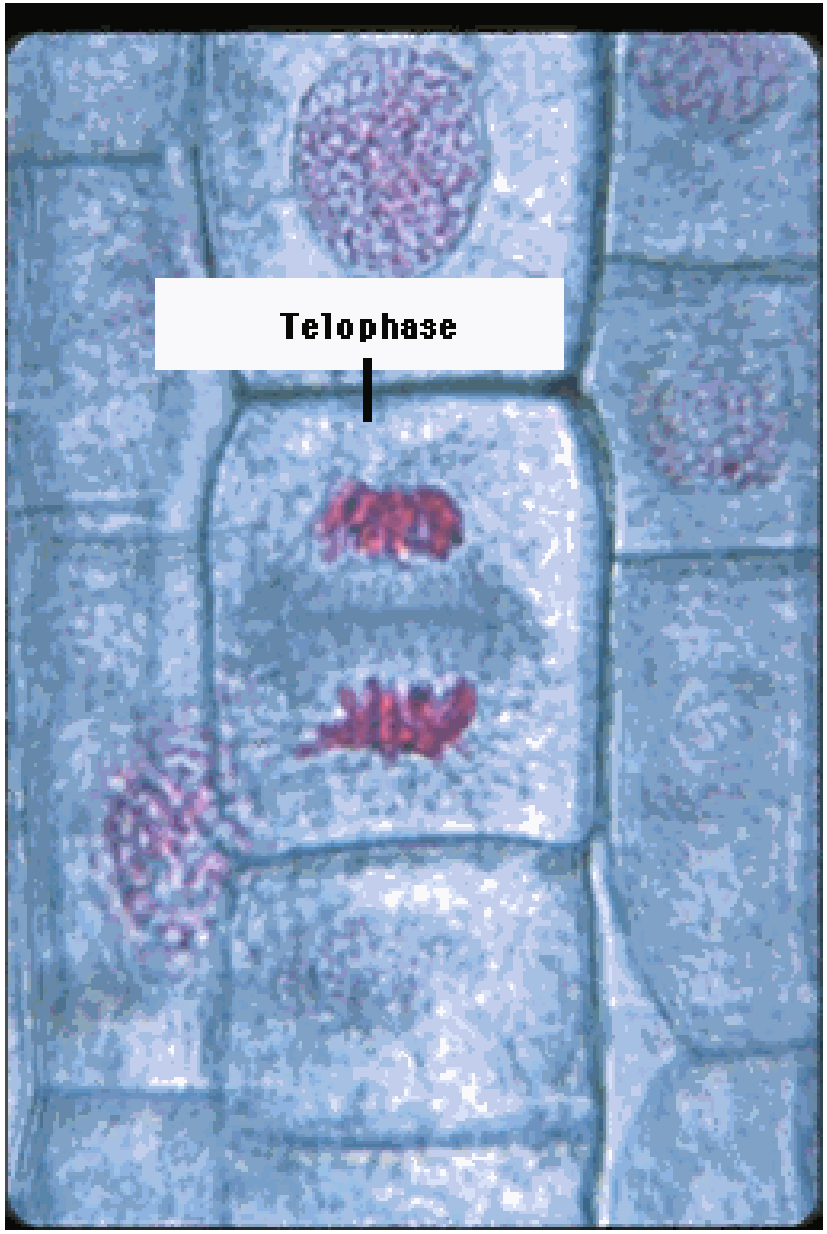
● new nuclear envelope forms around the chromatin;

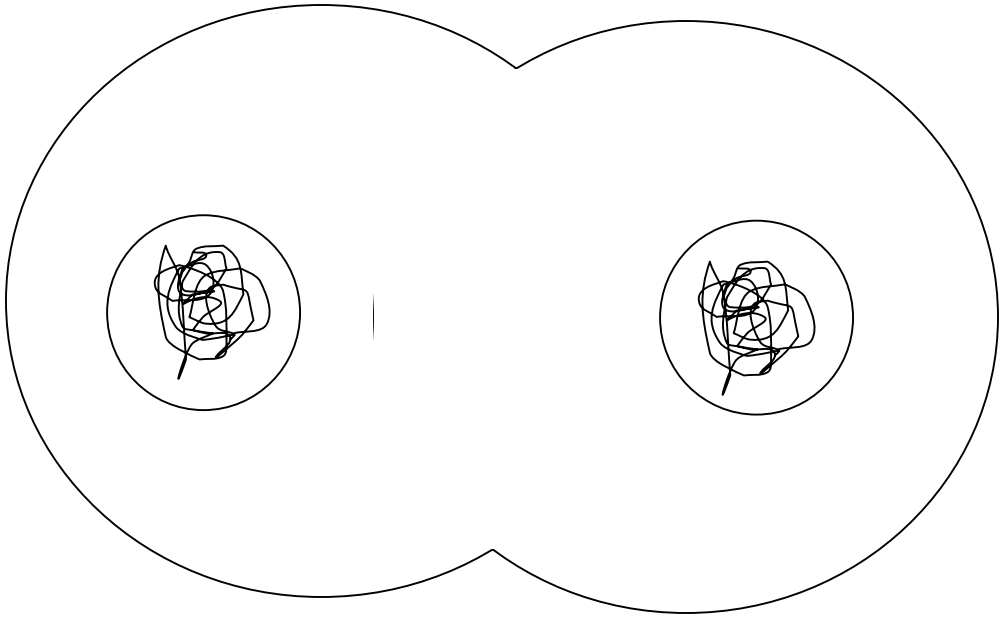
● spindle breaks apart;

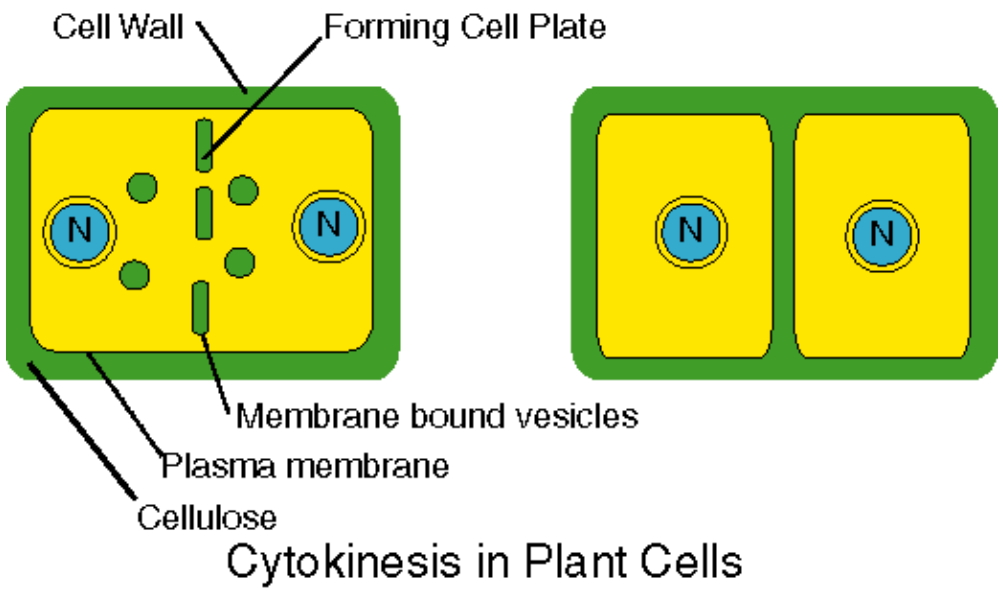
● nucleolus reappears in each new nucleus






Telophase

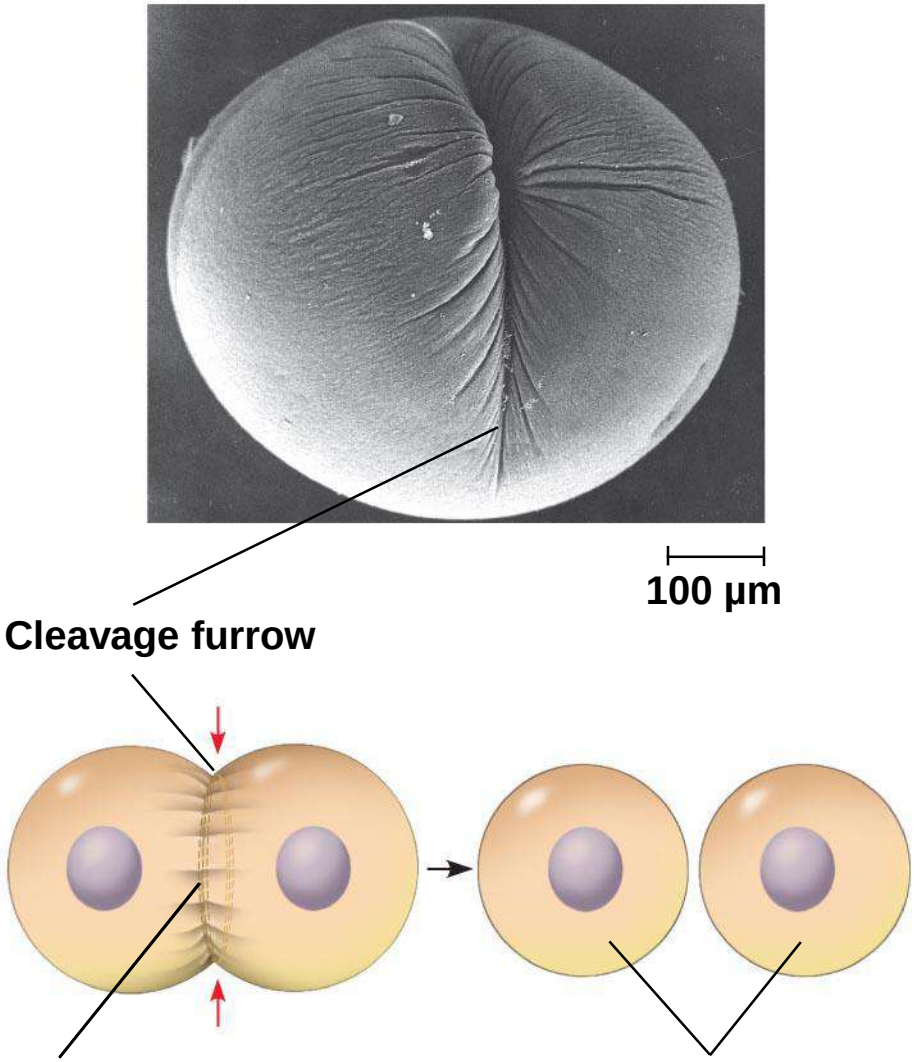




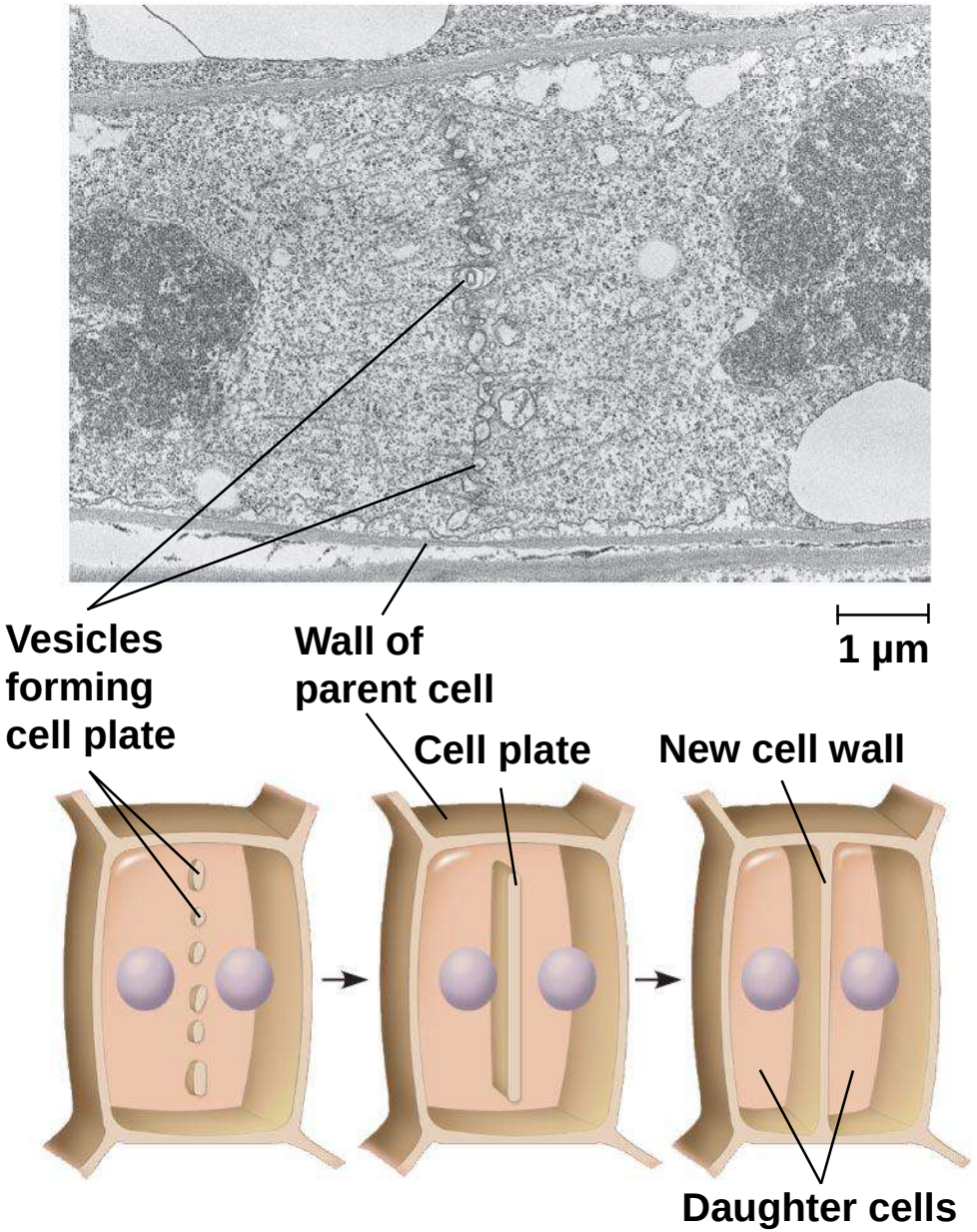
Cytokinesis in Plant Cells

Finally…
CYTOKINESIS

- in animal cells: cell membrane pinches in & divides (cleavage furrow)
- in plant cells: a cell plate (**new cell wall**) forms

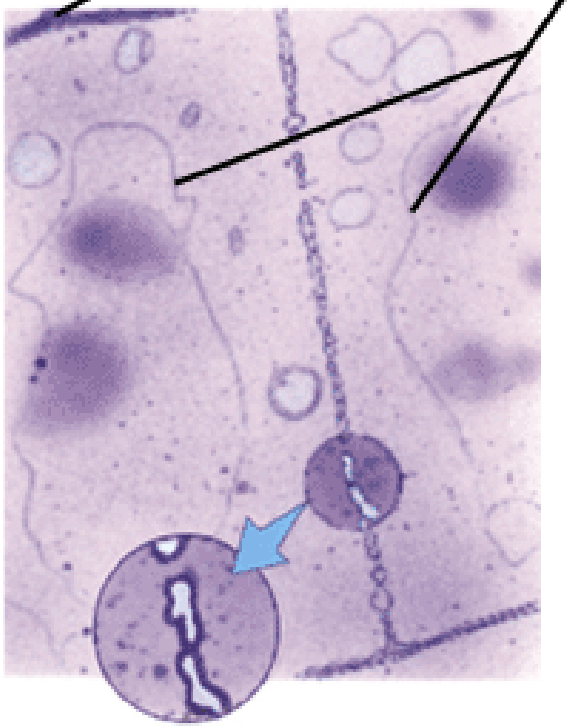


(a) Cleavage of an animal cell (SEM)



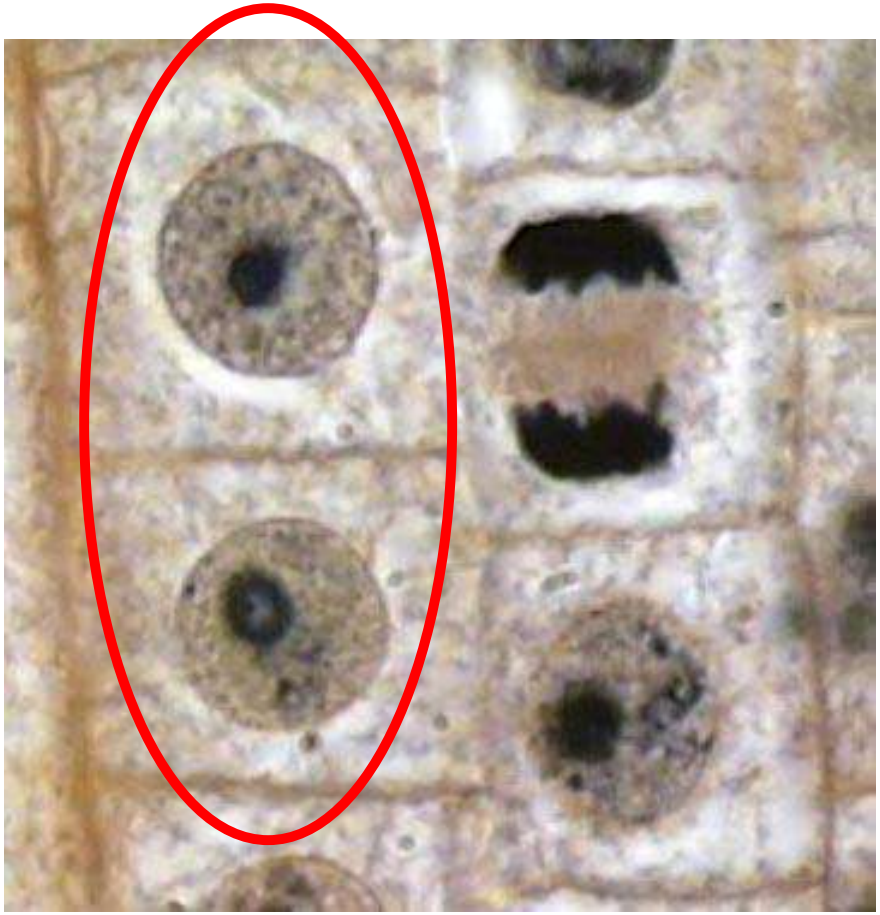
(b) Cell plate formation in a plant cell (TEM)

Cytokinesis in plant cells

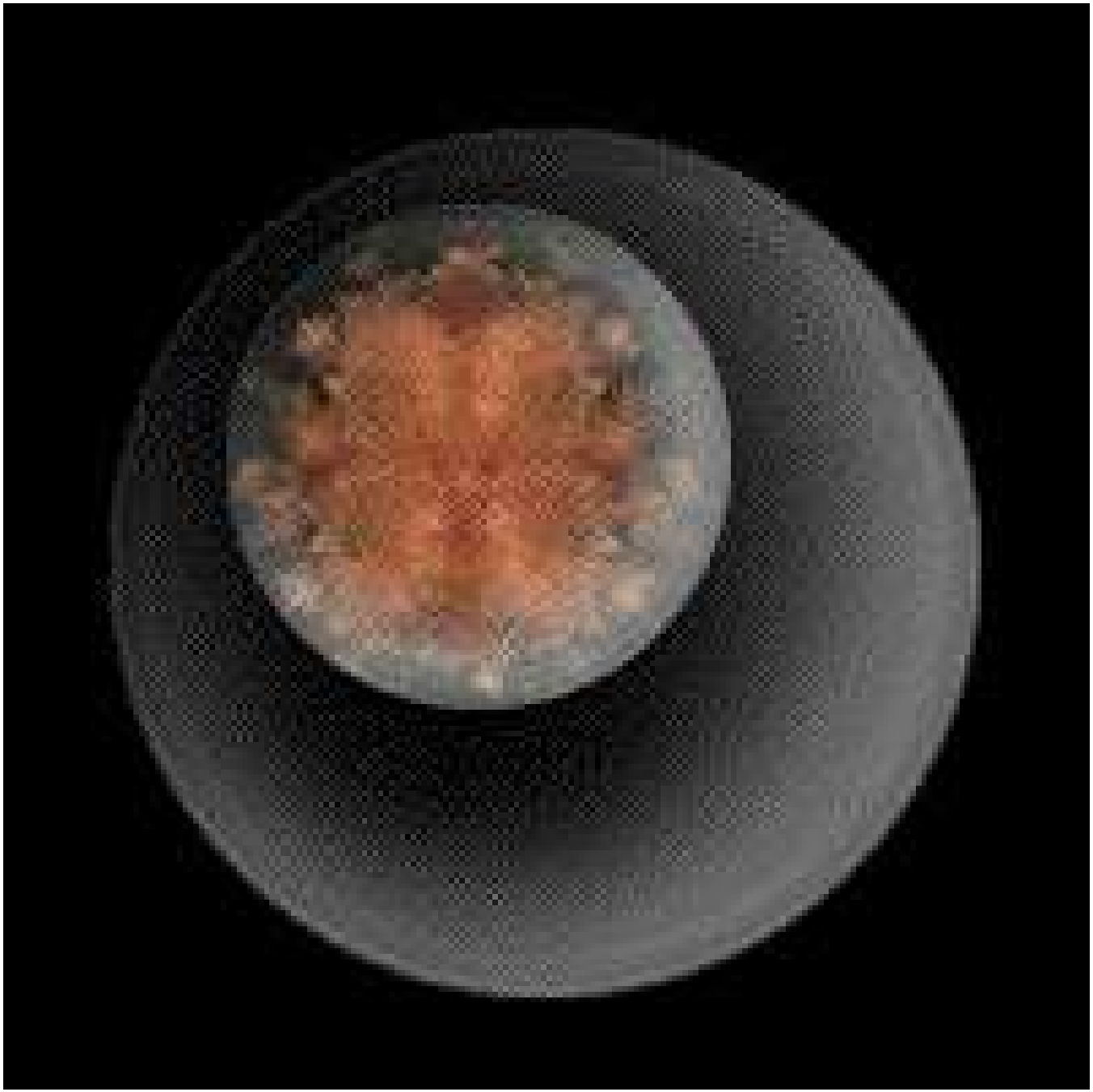


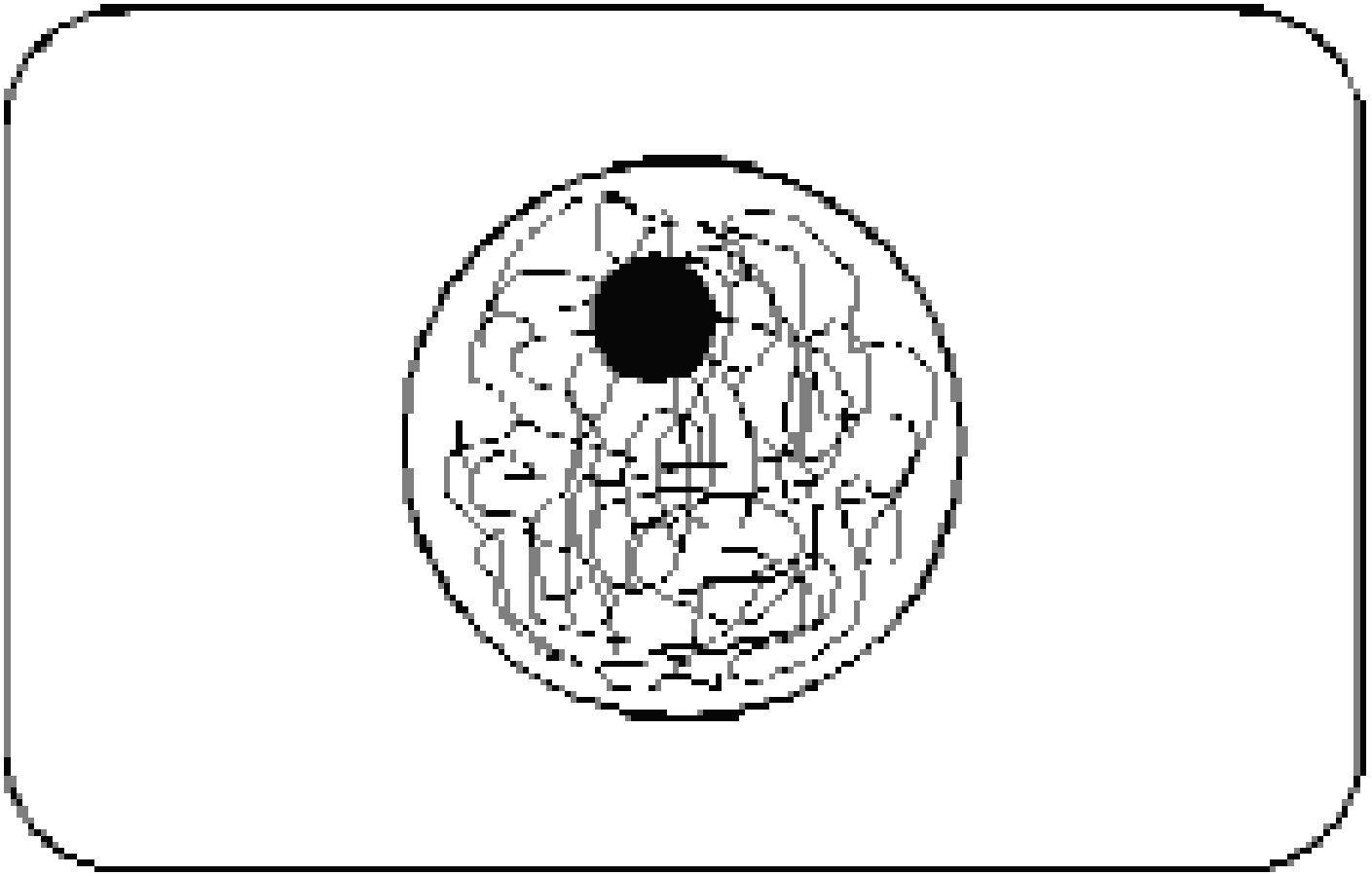
vesicles containing membrane components fusing to form cell plate

Then the cell returns to Interphase… and the process continues

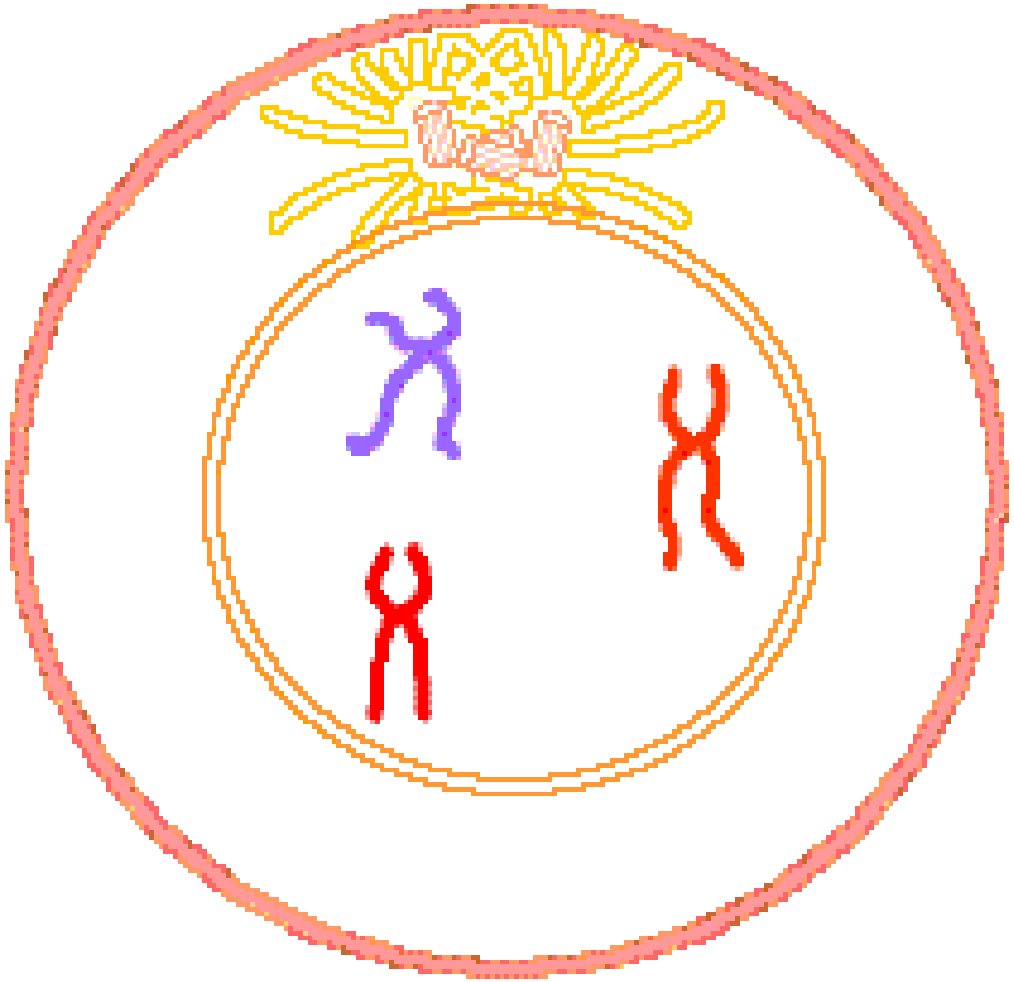


One More Time!





INTERPHASE



Prophase:

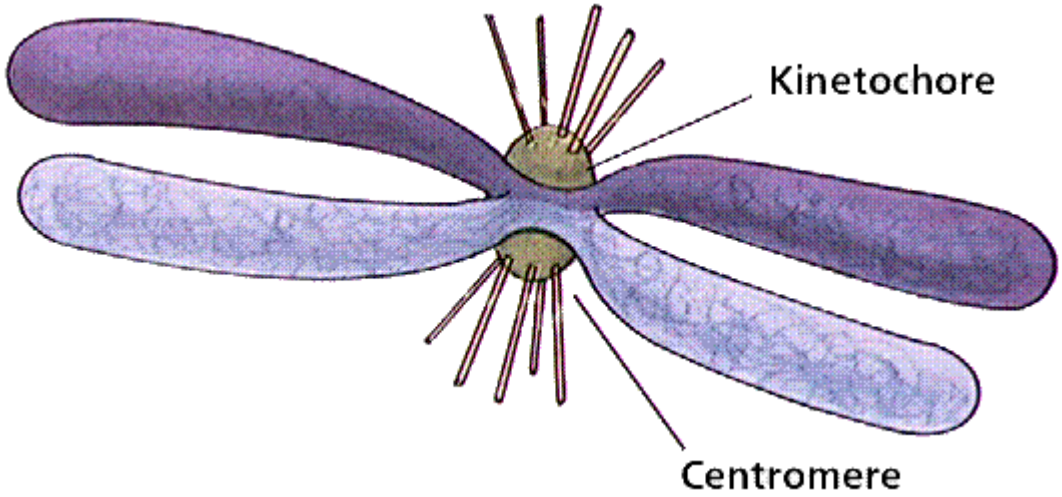
- condensation of chromosomes
- disappearance of nucleoli and nuclear envelope

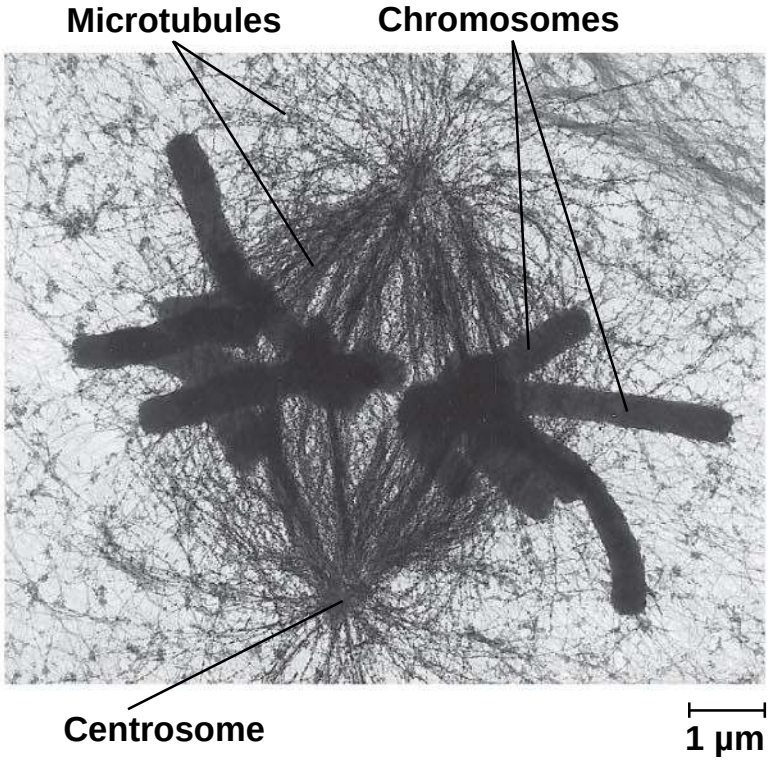
Mitosis in Animal Cells

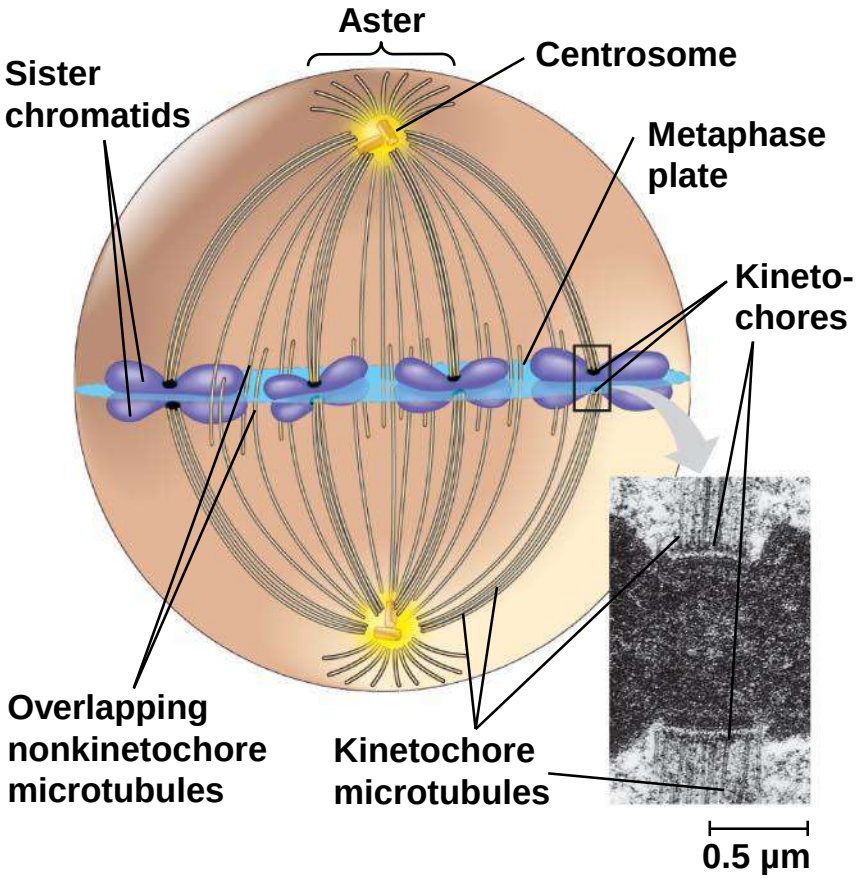
The Mitotic Spindle: *A Closer Look*

- The mitotic spindle is an apparatus of microtubules that controls chromosome movement during mitosis
- Assembly of spindle microtubules begins in the **CENTROSOME**, the microtubule organizing center
- The centrosome replicates, forming two centrosomes that migrate to opposite ends of the cell, as spindle microtubules grow out from them
- An aster (a radial array of short microtubules) extends from each centrosome

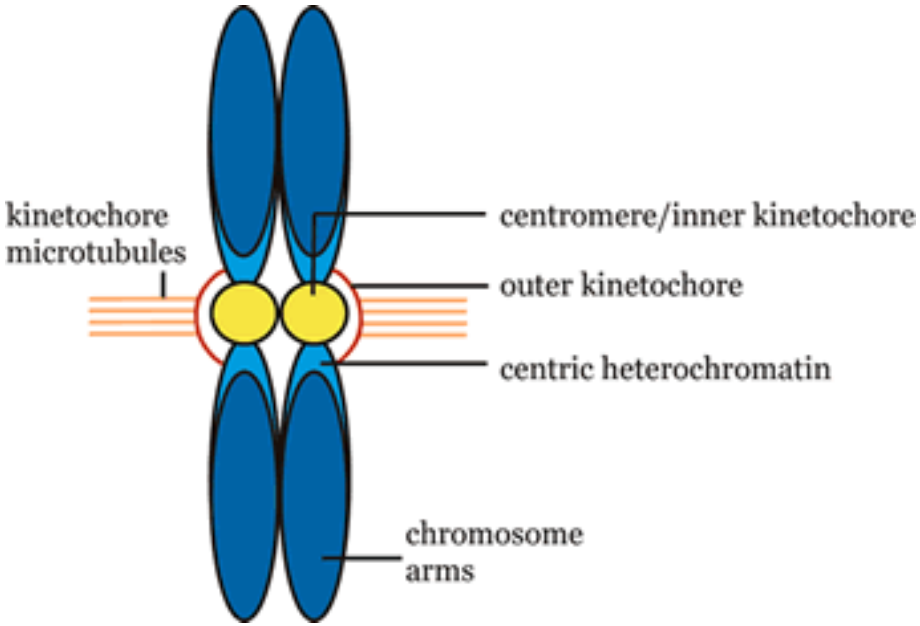
- The spindle includes: the centrosomes, the spindle microtubules, and the asters
- Some spindle microtubules attach to the kinetochores of chromosomes and move the chromosomes to the metaphase plate

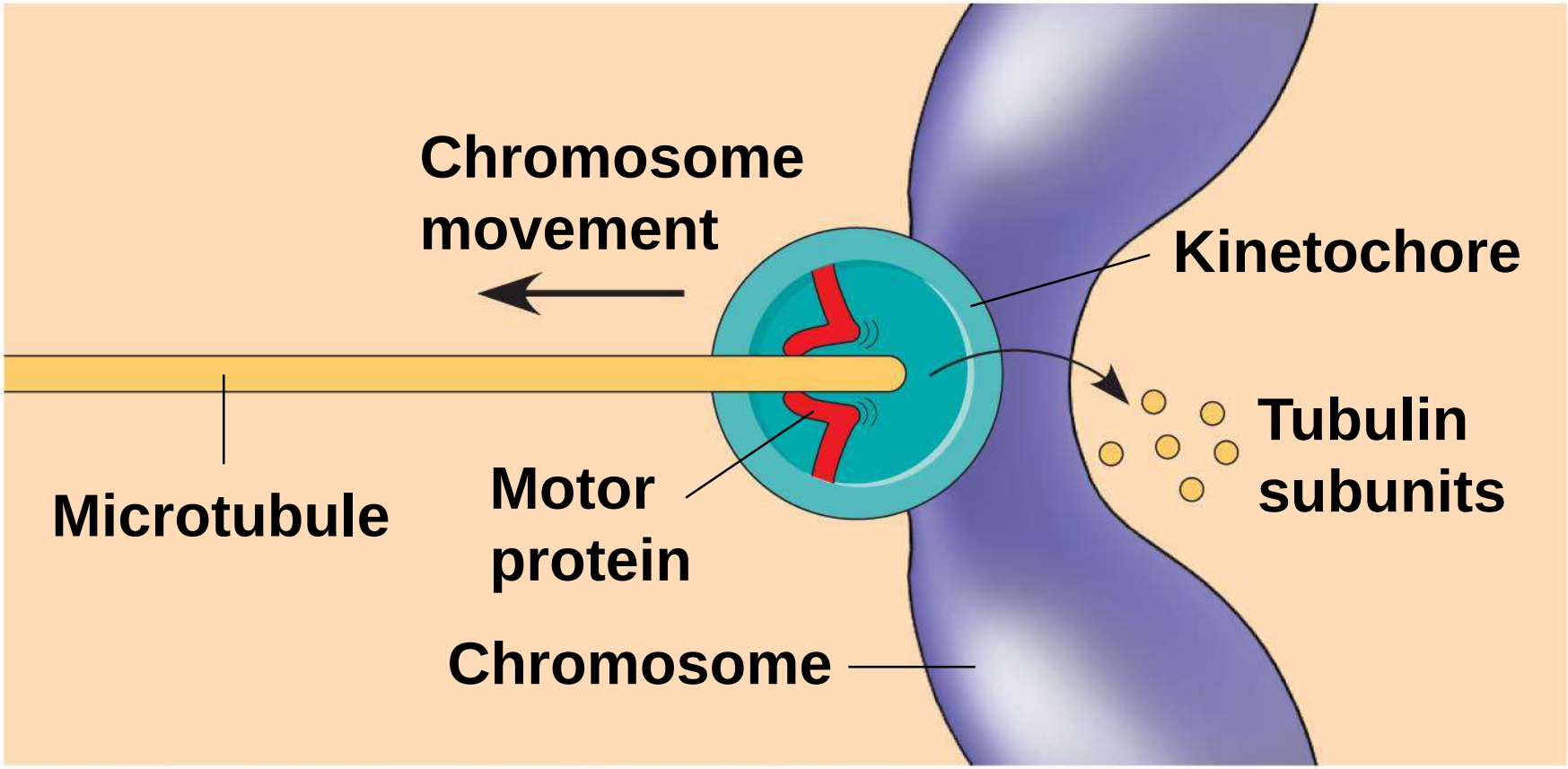




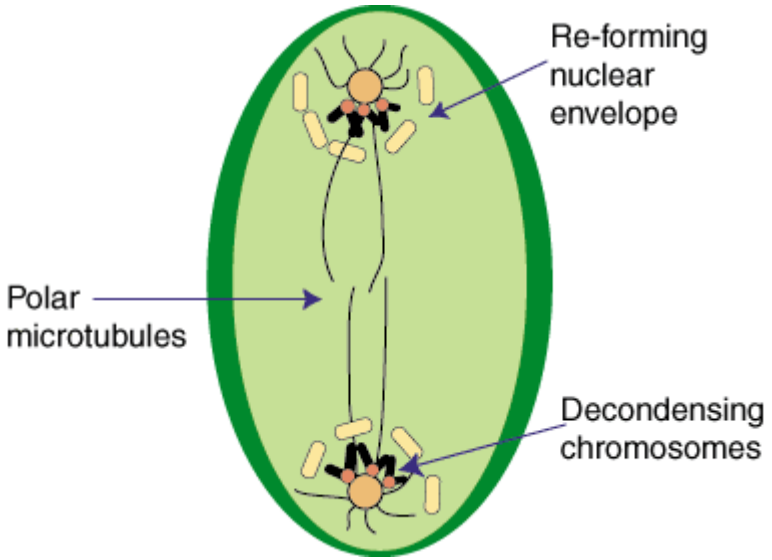


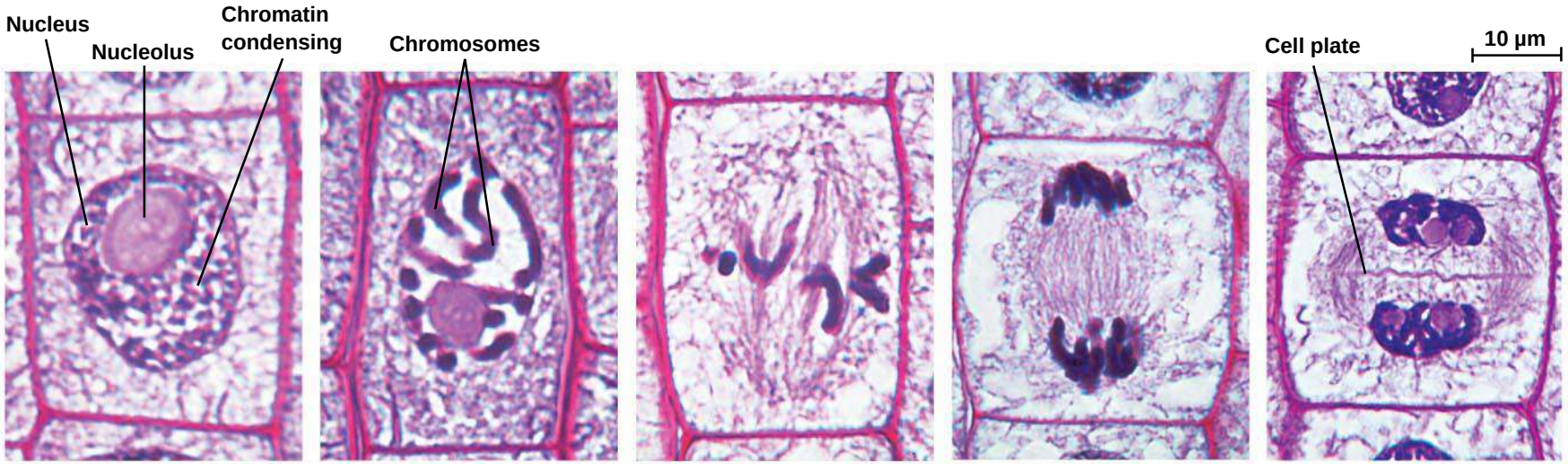
- In anaphase, sister chromatids separate and move along the kinetochore microtubules toward opposite ends of the cell
- The microtubules shorten by <u>depolymerizing at their kinetochore ends</u>





- 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





1 **Prophase. The chromatin is condensing. The nucleolus is beginning to disappear. Although not yet visible in the micrograph, the mitotic spindle is starting to form.**

2 **Prometaphase. We now see discrete chromosomes; each consists of two identical sister chromatids. Later in prometaphase, the nuclear envelope will fragment.**

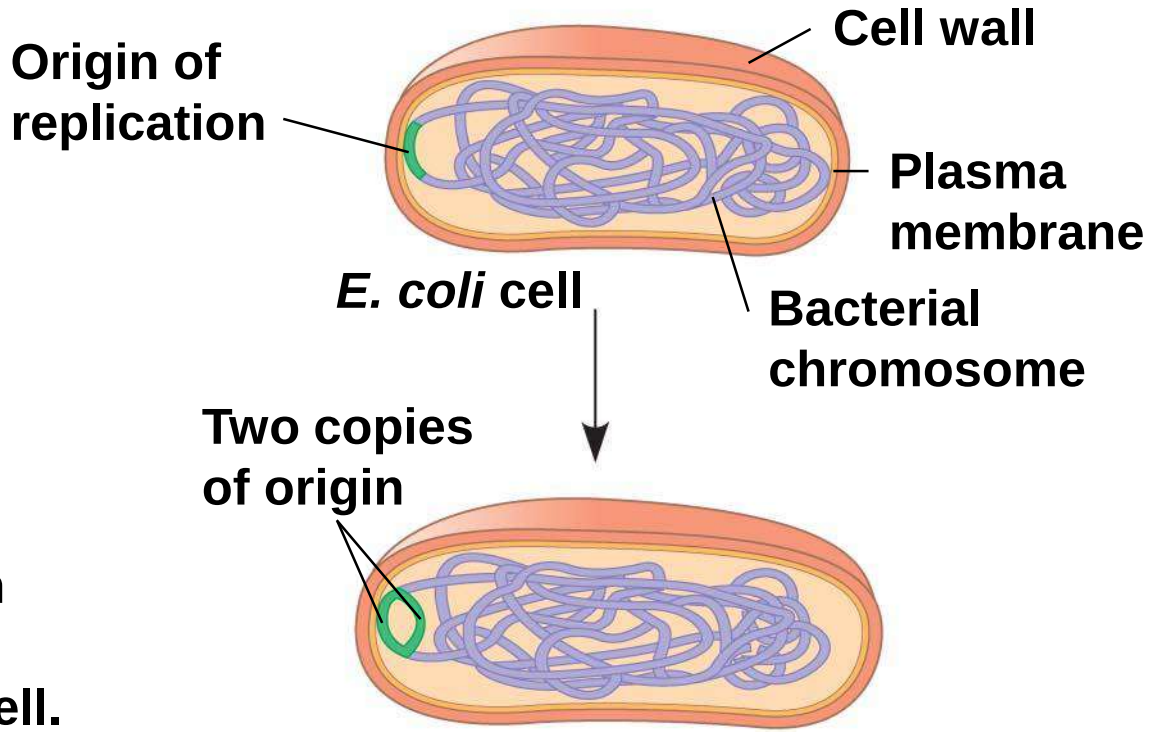
3 **Metaphase. The spindle is complete, and the chromosomes, attached to microtubules at their kinetochores, are all at the metaphase plate.**

4 **Anaphase. The chromatids of each chromosome have separated, and the daughter chromosomes are moving to the ends of the cell as their kinetochore microtubules shorten.**

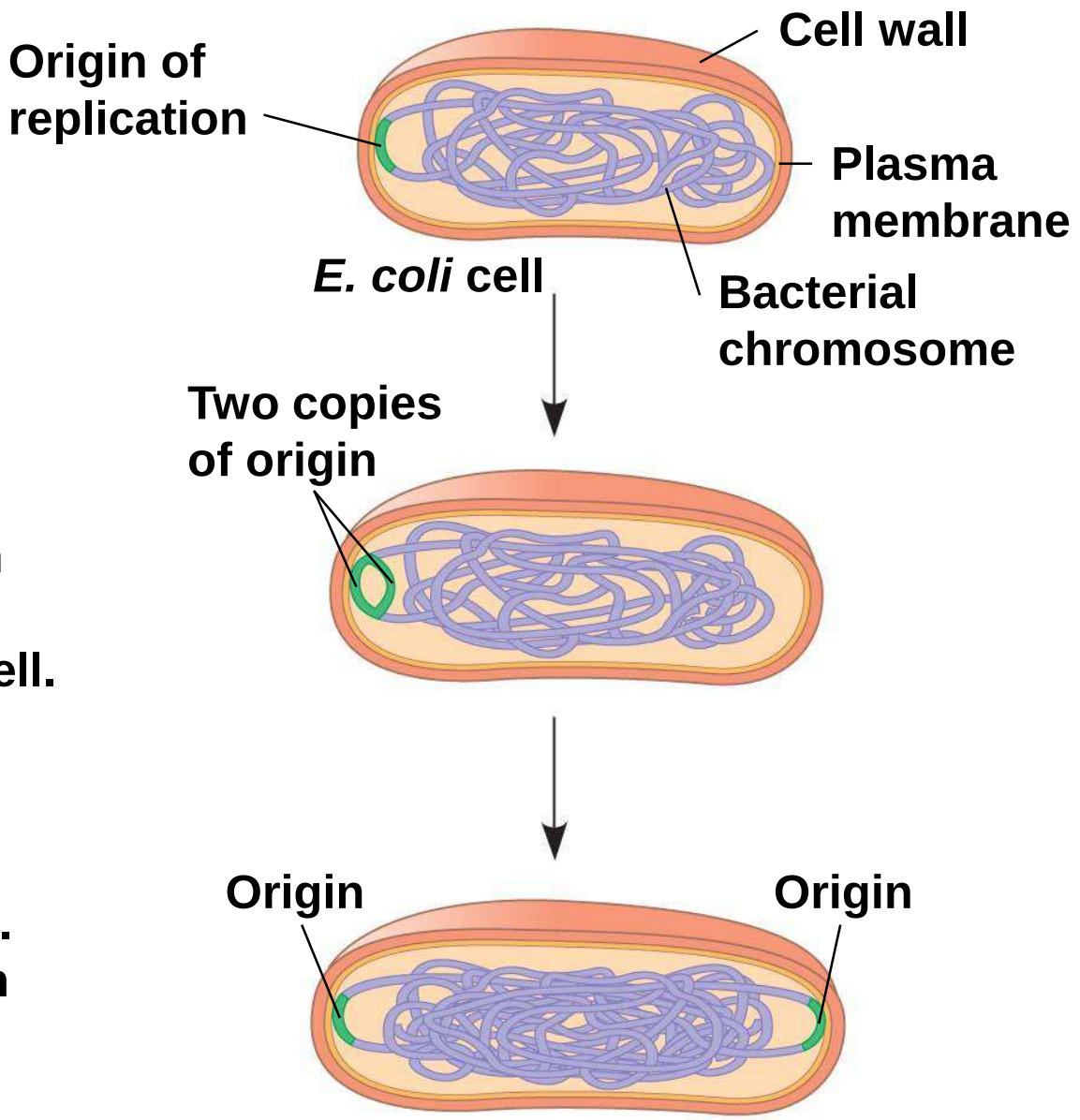
5 **Telophase. Daughter nuclei are forming. Meanwhile, cytokinesis has started: The cell plate, which will divide the cytoplasm in two, is growing toward the perimeter of the parent cell.**

BINARY FISSION

- Prokaryotes (bacteria and archaea) reproduce by a type of cell division called **BINARY FISSION**
- In binary fission, the chromosome replicates (beginning at the origin of replication), and the two daughter chromosomes actively move apart

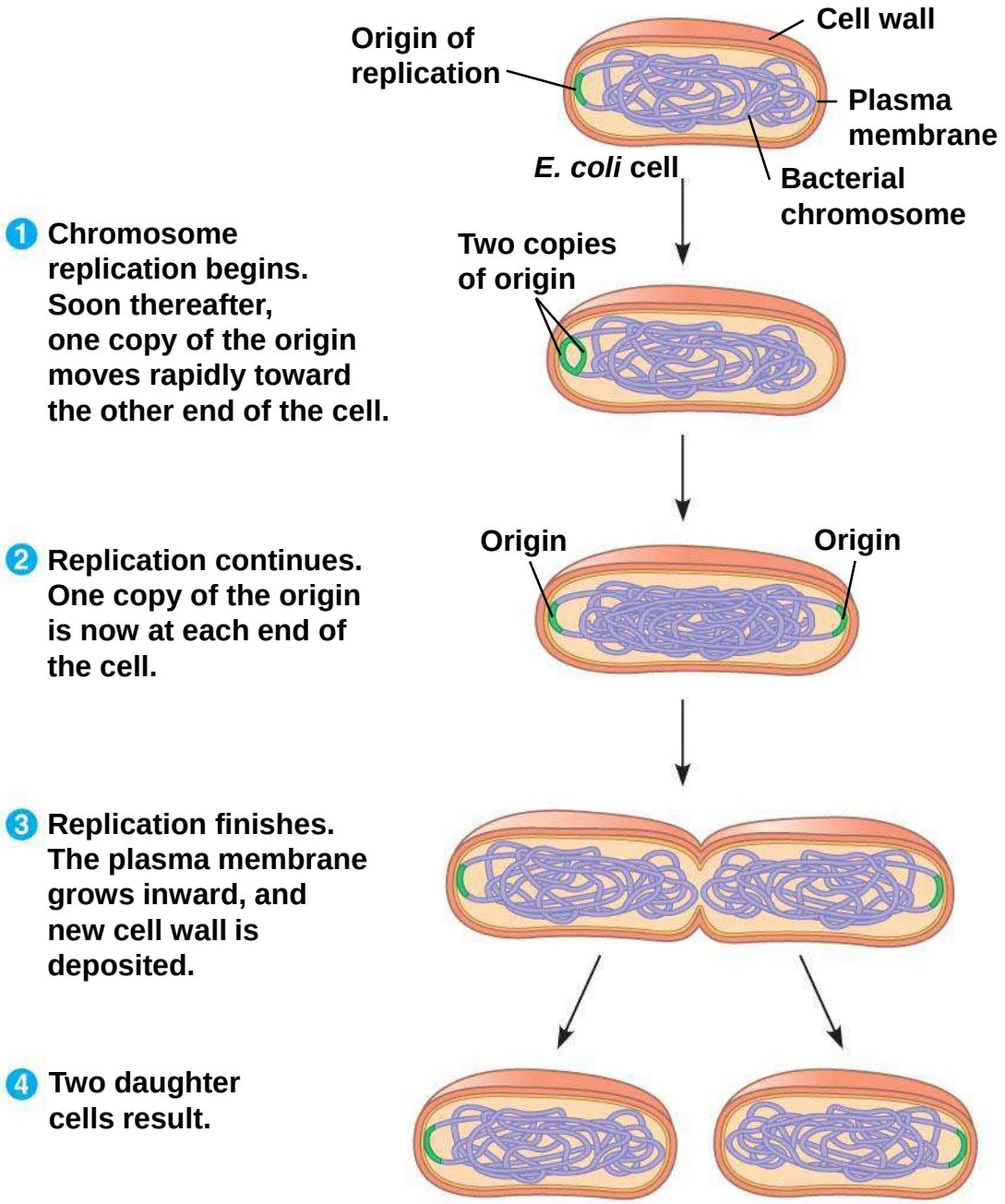


1. Chromosome replication begins. Soon thereafter, one copy of the origin moves rapidly toward the other end of the cell.



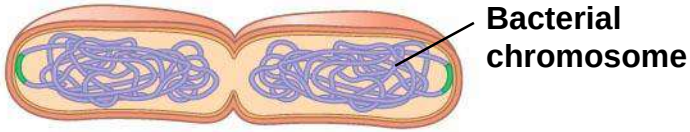
1. Chromosome replication begins. Soon thereafter, one copy of the origin moves rapidly toward the other end of the cell.

2. Replication continues. One copy of the origin is now at each end of the cell.

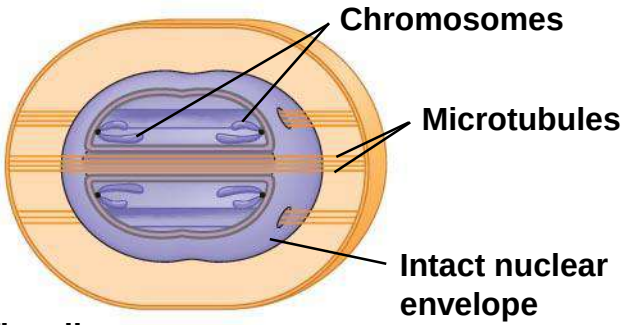


The Evolution of Mitosis

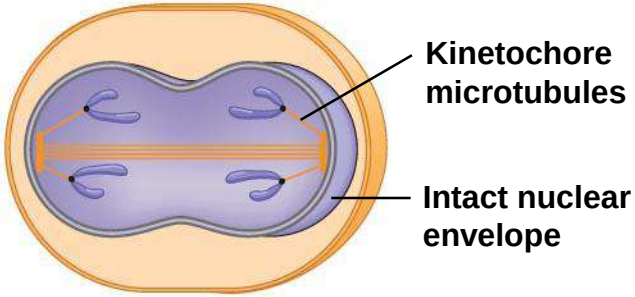
- Since prokaryotes evolved before eukaryotes, mitosis probably evolved from binary fission
- Certain protists exhibit types of cell division that seem intermediate between binary fission and mitosis



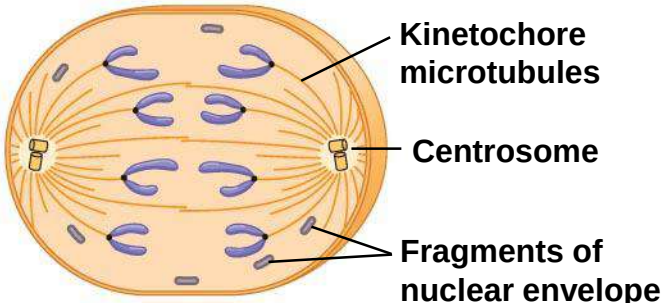
(a) Prokaryotes



(b) Dinoflagellates



(c) Diatoms



(d) Most eukaryotes