# Zoo-352 Principles of genetics
# Lecture 4

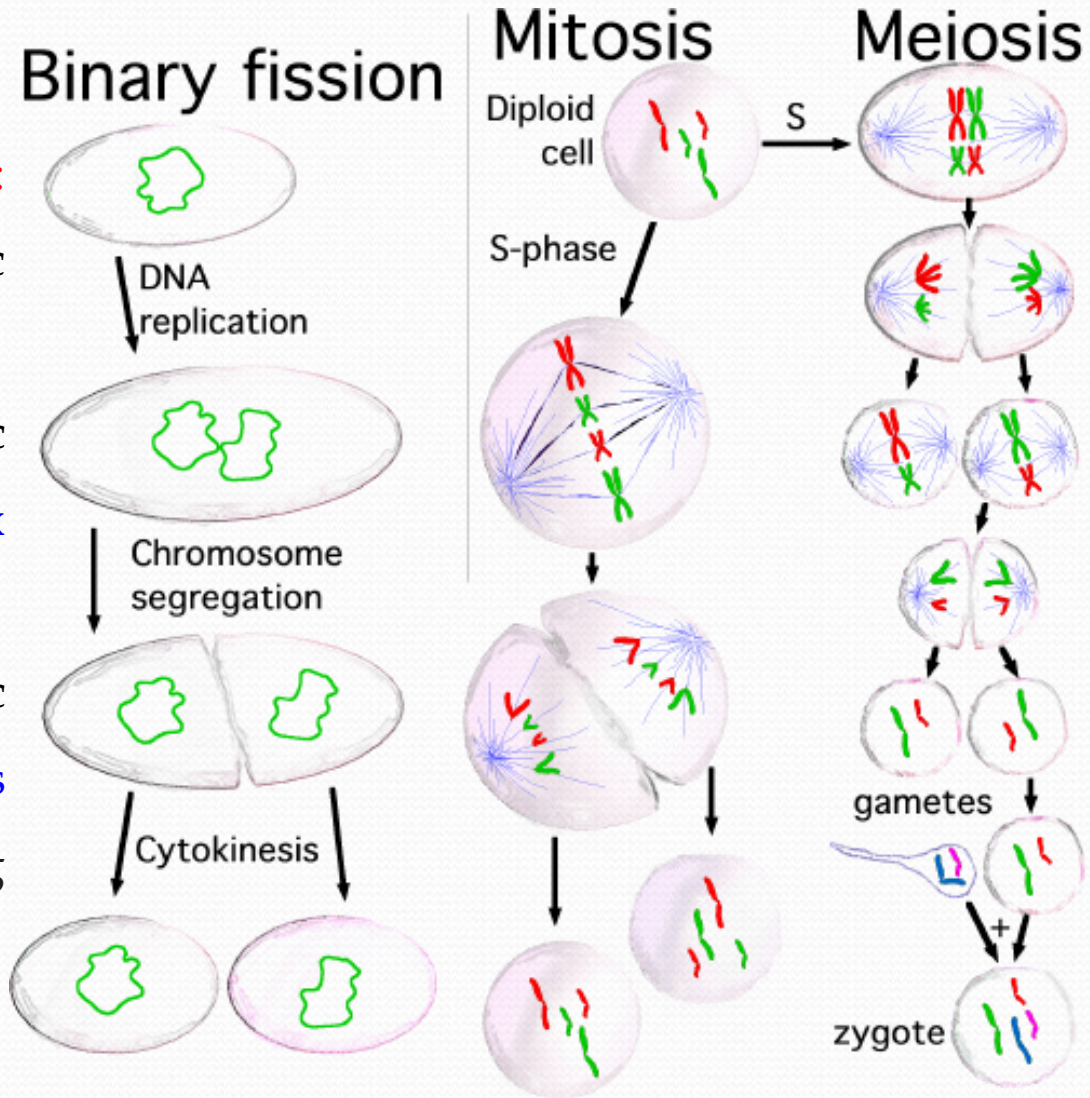
## Mitosis

## Outlines:

- The types of cell division.
- The definition of mitosis.
- Significance of mitosis.
- The phases of mitotic division.
- The events of each phase during mitosis.
- Microscopic view for mitotic division phases.

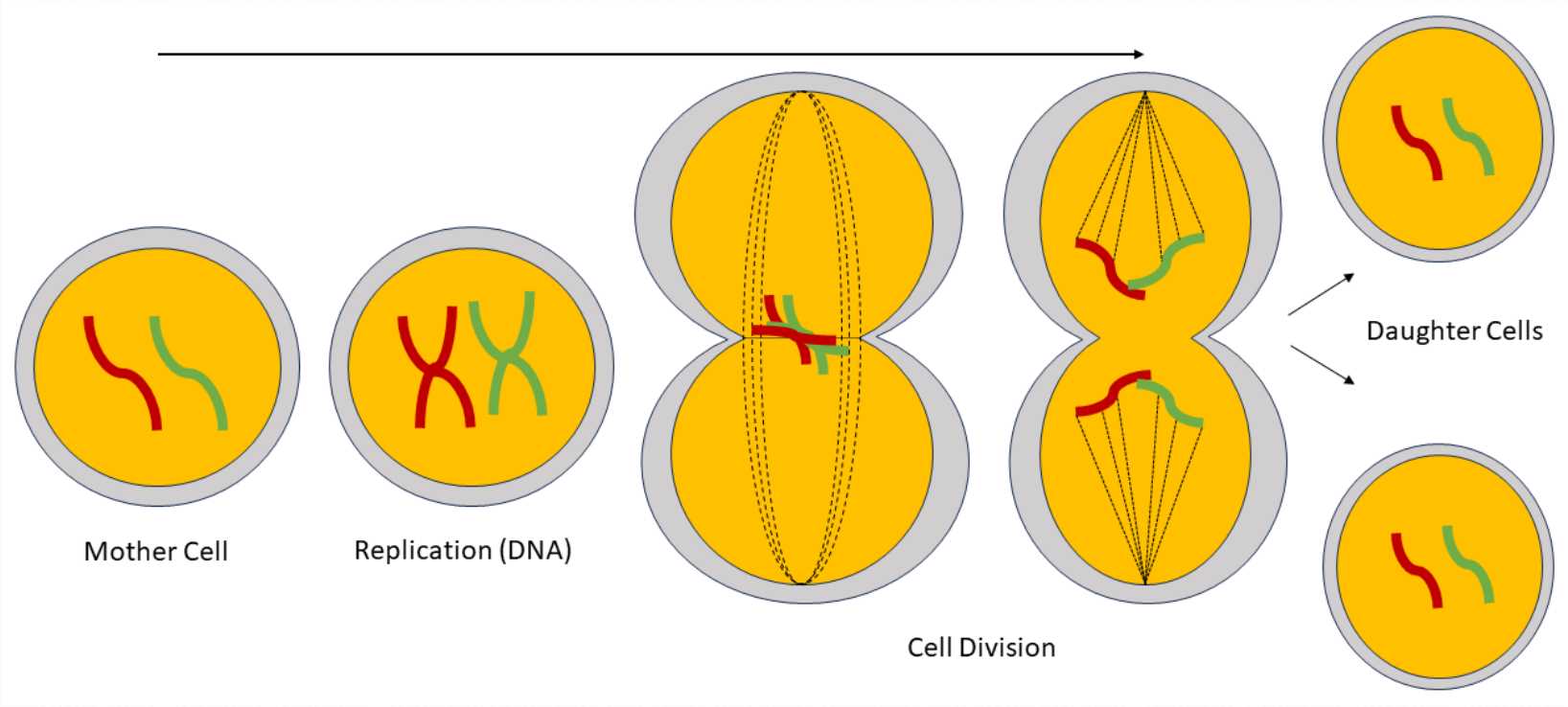
# The types of cell divisions:

1. Binary fission (Amitosis): occurs only in prokaryotic cells.
2. Mitosis: occurs in eukaryotic cells particularly in non-sex cells (somatic cells).
3. Meiosis: occurs in eukaryotic cells particularly in sex cells (germ cells; sperm or egg cells).



# The definition of mitosis :

- Mitosis is a part of the cell cycle process by which chromosomes in a cell nucleus are separated into two identical sets of chromosomes, each in its own nucleus.



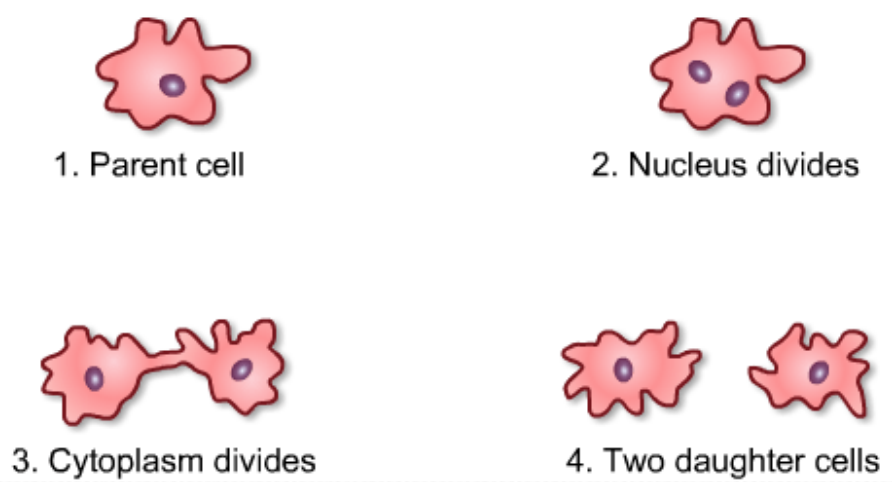
# Significance of mitosis :

1) In multicellular organisms:

- Mitosis produces more cells for growth and repair of damaged cells or tissues (wound healing).

2) In unicellular organisms:

- Mitosis is a type of asexual reproduction.

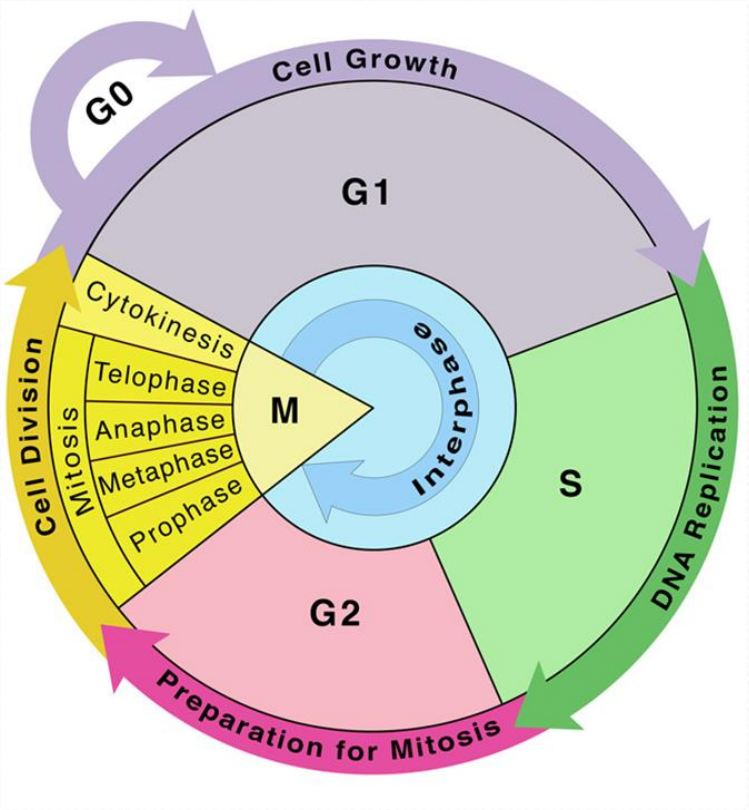



Asexual reproduction in Amoeba

Wound healing

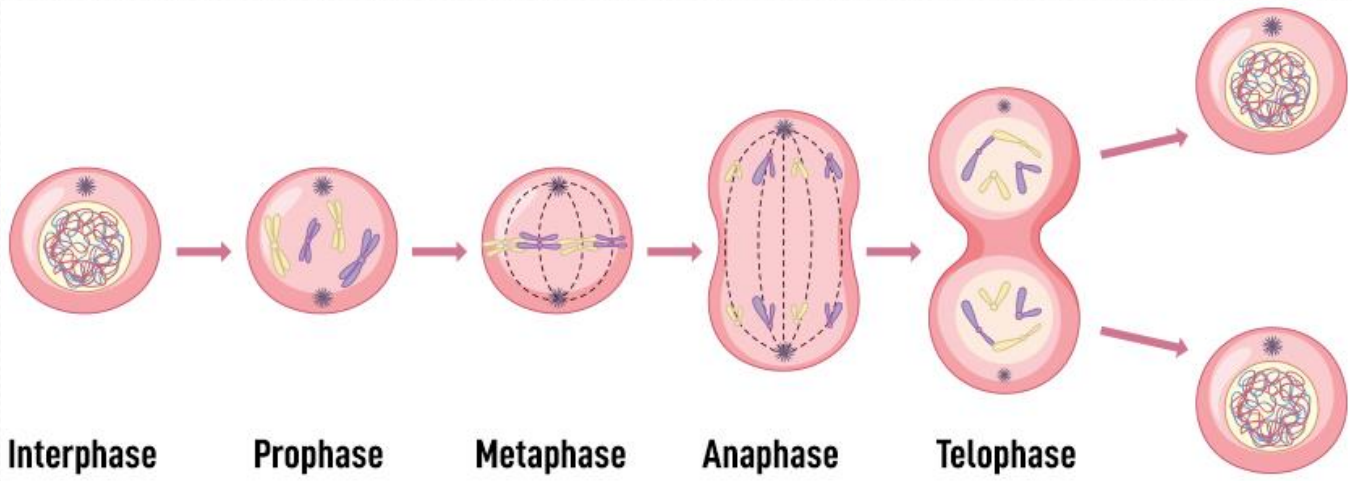
# The steps of mitotic division:

- Mitosis (M phase) has two steps:
  1. Karyokinesis: Division of the nucleus into 4 phases ), followed by
  2. Cytokinesis: Division of the cytoplasm).



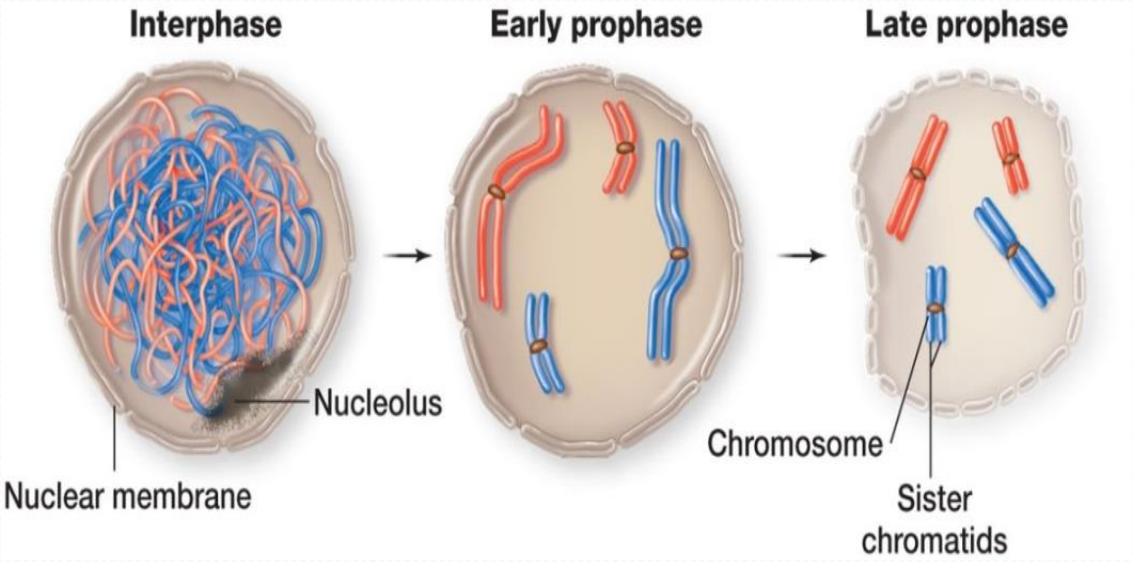
# The phases of mitotic division:

- Karyokinesis of mitosis is divided into **four stages**: *prophase*, *metaphase*, *anaphase* and *telophase* (Greek: *pro-*, before; *meta-*, mid; *ana-*, back; *telo-*, end).
- The timing of the four stages varies from species to species and from organ to organ.



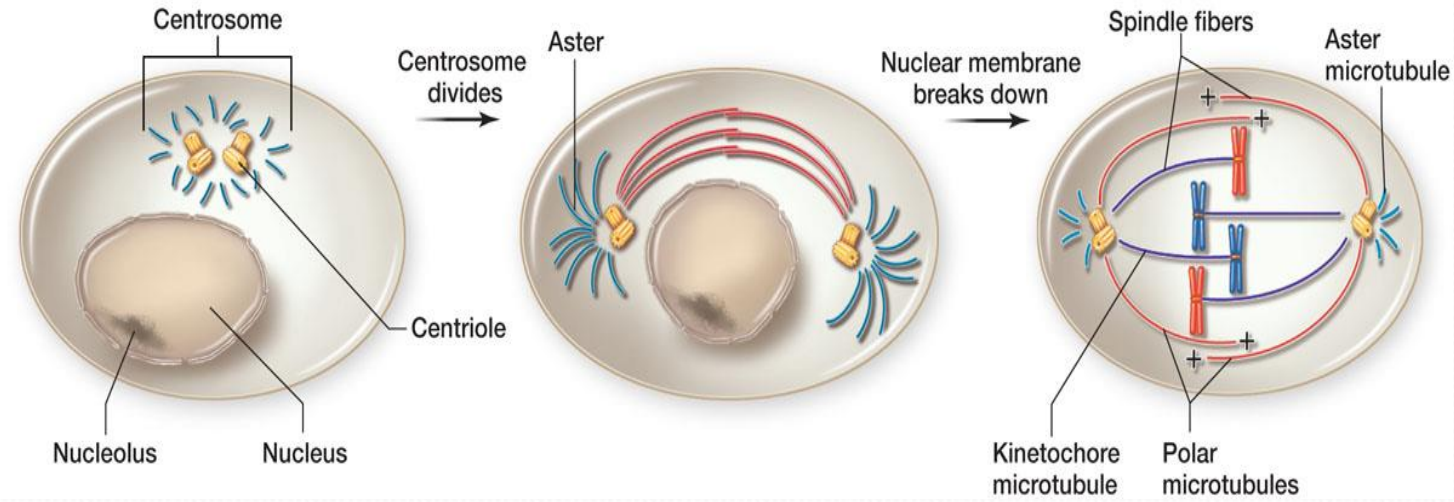
# 1- Prophase:

- The first stage of mitosis begins with the shorting and thickening of the chromosomes.
- Each chromosome is composed of two sister chromatids, which are identical double-stranded DNA molecules.
- The nuclear membrane breaks down and the nucleolus disappears.




Nuclear events during interphase and prophase of mitosis

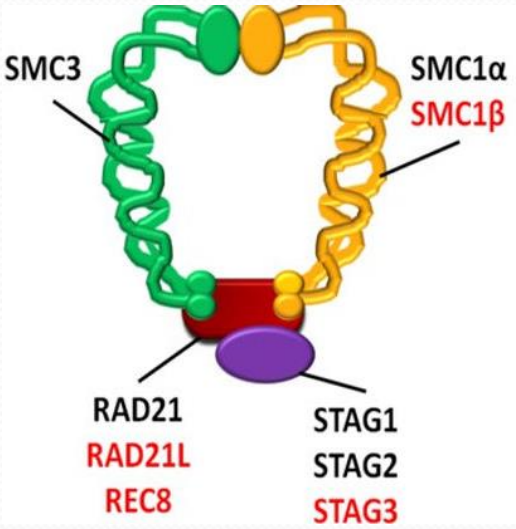
- The centrosome divides and moves to opposite poles of the cell, around the nucleus.
- The newly divided centrosomes radiate microtubules, which are called spindle fibers.
- Microtubules also spread out from the centrosome in the opposite direction from the spindle itself, forming an aster microtubule.
- The second microtubules that attach to a kinetochore on a sister chromatid are called kinetochore microtubules.
- The third class of microtubules fail to attach to kinetochore are called polar microtubules.

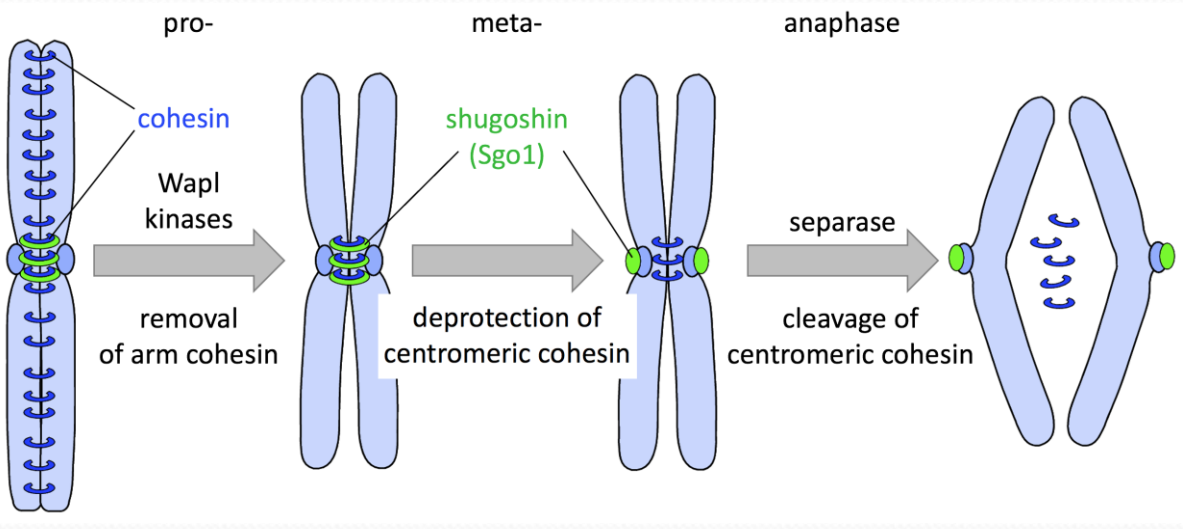



The centrosome divides in prophase, and separate halves move to opposite poles of the cell

# Cohesin:

- Cohesin is a protein complex that mediates the cohesion of sister chromatids.
- Cohesin in mitosis is made up of at least four different proteins (SMC1, SMC3, SCC1 (RAD21), and SCC3 (STAG1 and STAG2).
- Cohesin complexes connect the arms and centromere of sister chromatids at the early prophase.
- At the late prophase, the cohesin complexes holding the arms are released; however, the sister chromatids remain connects only at the centromere.

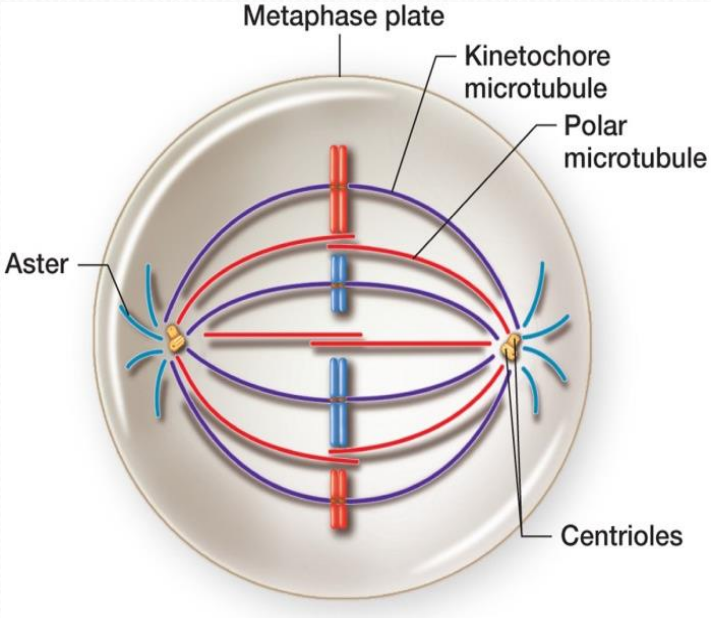



Meiosis cohesin subunits are marked with RED

# 2- Metaphase:

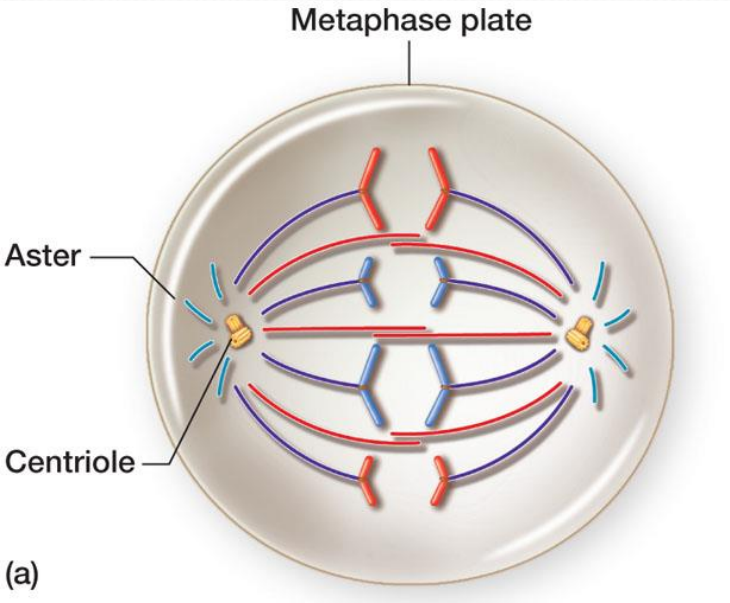
- The spindle fibers are form and each centromere attached to a kinetochore microtubule from each centrosome.
- The two centrosomes begin pulling the chromosomes towards opposite ends of the cell.
- The resulting tension causes the chromosomes to align along the metaphase plate.



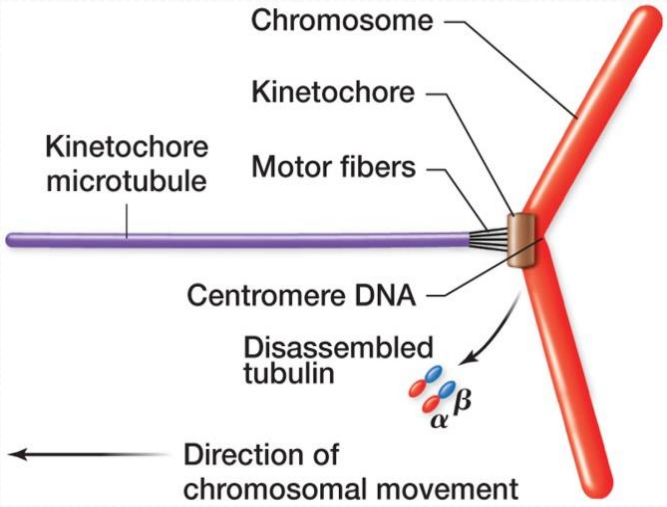

The mitotic spindle fibers during metaphase

# 3- Anaphase:

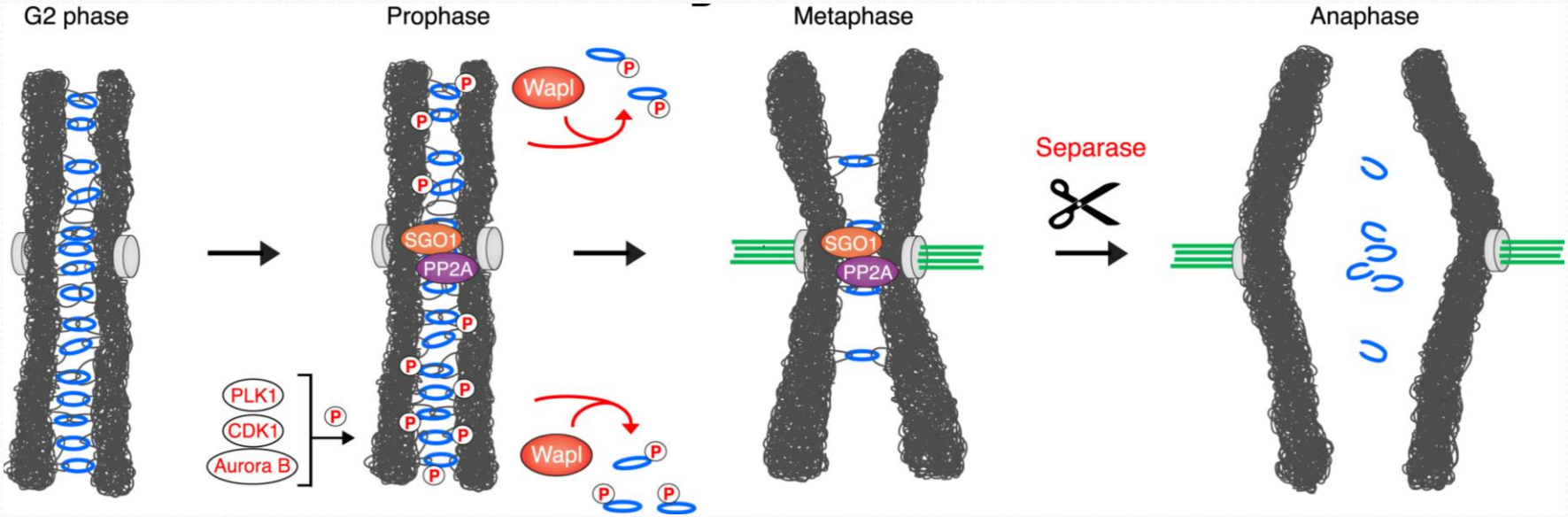
- Anaphase begins with the two sister chromatids separating and moving toward opposite poles on the spindle fibers.
- The sister chromatids are joined together by cohesins.
- The degradation of cohesin at the centromere allowing the sister chromatids to separate.




The mitotic spindle fibers during anaphase



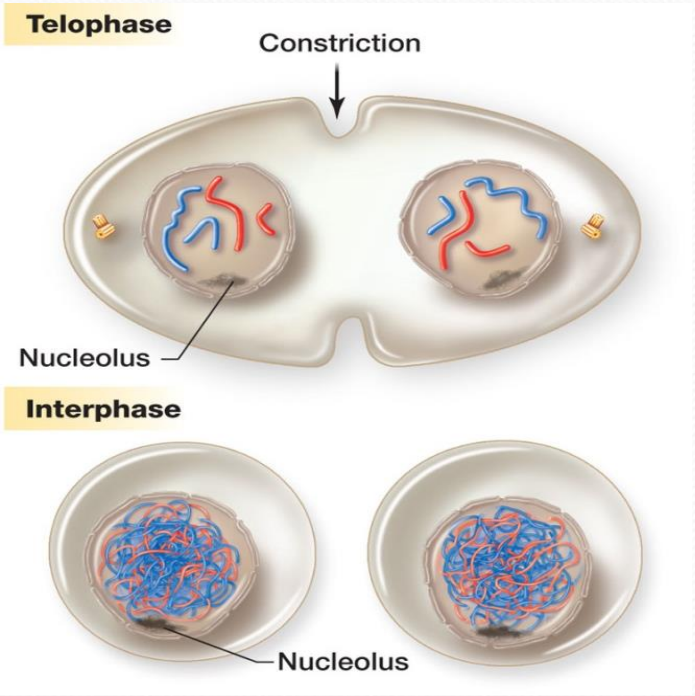

The kinetochore




Sister chromatid cohesion and separation

# 4- Telophase:

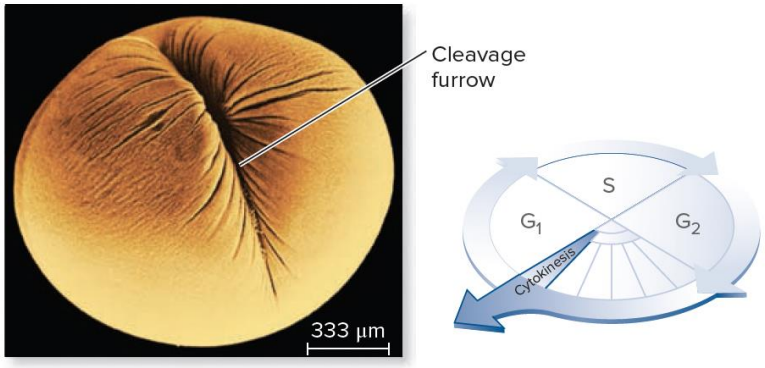
- In telophase, the cell reverses the steps of prophase to return to the interphase stage.
- The nuclear membrane reforms around each set of chromosomes and the nucleolus forms again. Then, cytokinesis takes place.



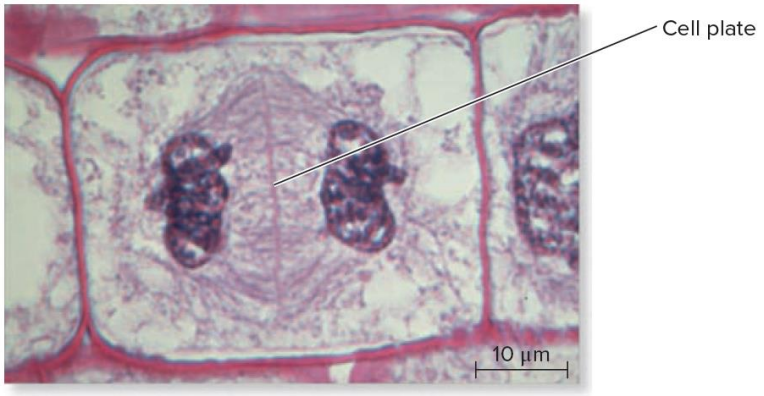

Telophase and interphase of mitosis

# The difference between cytokinesis of animal and plant cells:

- In animals, cytokinesis is first apparent by constriction between the two poles (Figure 6).
- In plants, a cell plate grows in the approximate location of the metaphase plate.
- After completing cytokinesis, the daughter cells enter the G1 phase of the cell cycle.



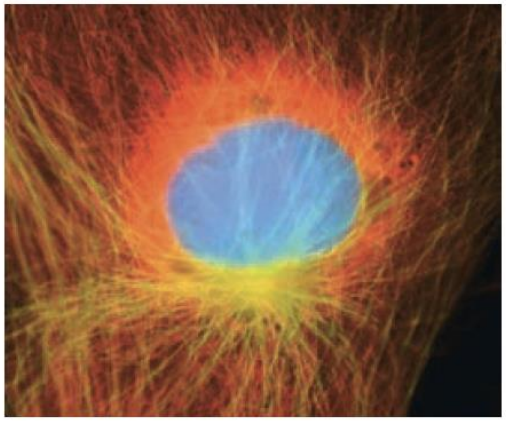

(a) Cleavage of an animal cell



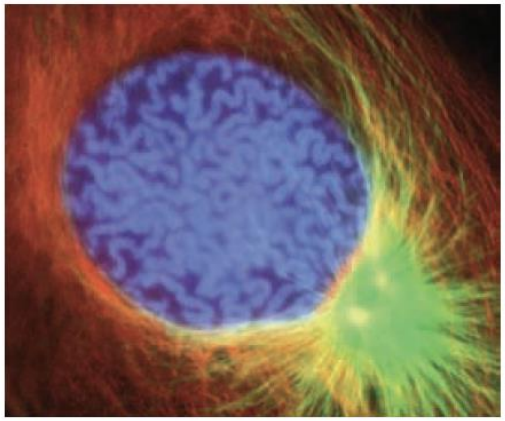

(b) Formation of a cell plate in a plant cell

**FIGURE 3.9** **Cytokinesis in animal and plant cells.** **(a)** In an animal cell, cytokinesis involves the formation of a cleavage furrow. **(b)** In a plant cell, cytokinesis occurs via the formation of a cell plate between the two daughter cells.

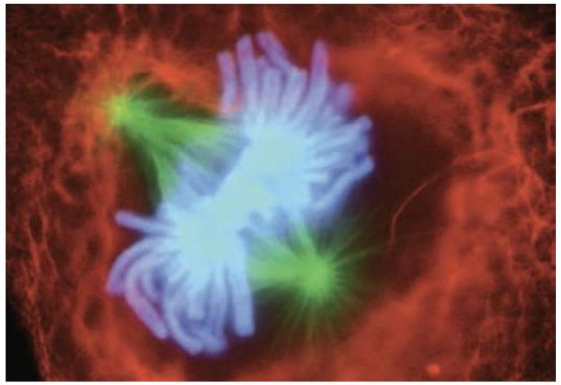
# Microscopic view for mitotic division phases in animal cells:



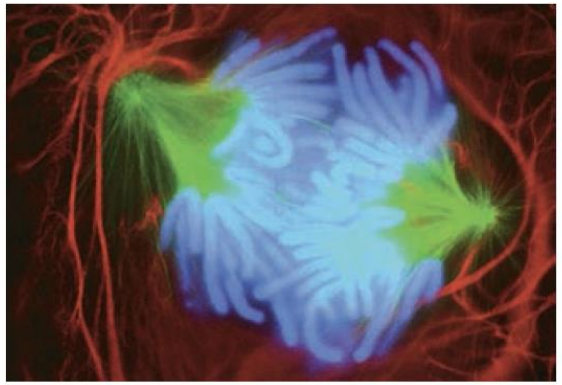
Interphase



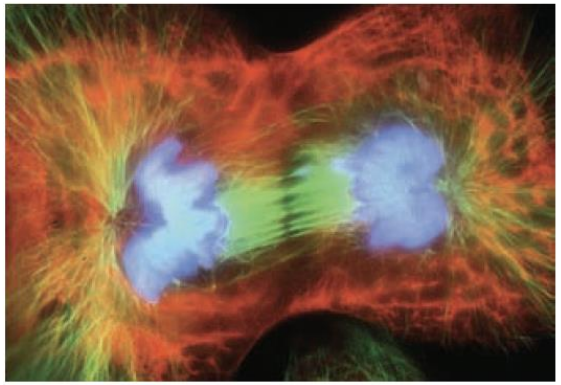
Prophase



Metaphase



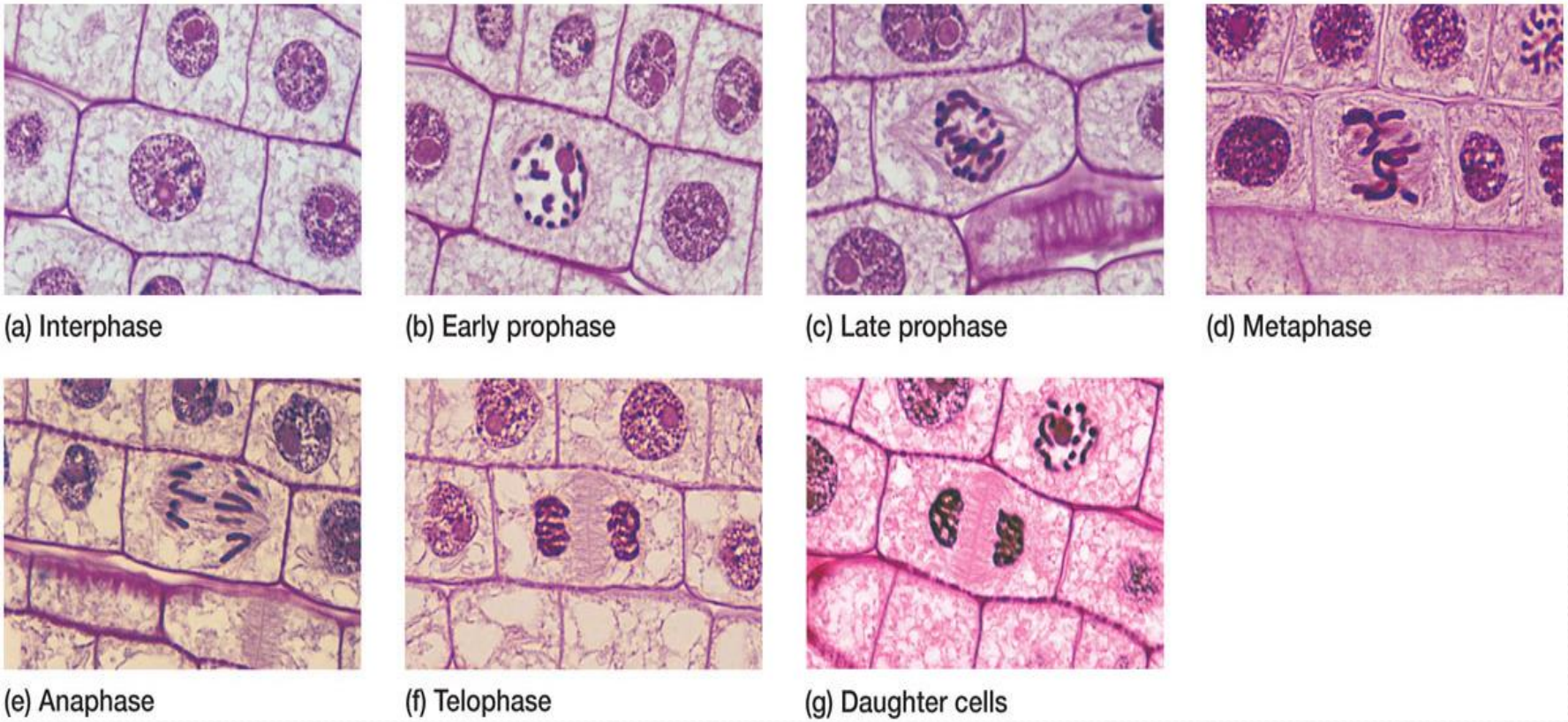
Anaphase



Telophase and cytokinesis

The phases of mitosis in a fish embryo cells

# Microscopic view for mitotic division phases in plant cells:




The phases of mitosis in onion root tip cells

# Quiz: Mitosis

1. The two major phases of mitosis are ____ and ___ .
   - karyokinesis, prophase
   - karyokinesis, cytokinesis
   - prophase, cytokinesis
   - anaphase and telophase

2. The timing of the four stages of karyokinesis is consistent among different cell types.
   - True
   - False

3. During mitosis, cells replicate and divide ____.
   - genetic materials
   - centrioles
   - organelles
   - all above

4. The cohesin holding the chromosome centromere gets released at ____.
   - early prophase
   - late prophase
   - anaphase
   - telophase