

Zoo-352 Principles of genetics
Lecture 4

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.
- In general, **karyokinesis** (division of the **nucleus**) is followed by **cytokinesis** (division of the **cytoplasm**).
- The **sister chromatids** are held together at a specific region of the chromosome called the **centromere**.
- Mitosis is a **continuous** process and occurs only in eukaryotic cells particularly in **non-sex cells** (**somatic** cells).

- Prokaryotic cells divide by a different process called **binary fission**.
- Mitosis is divided into **four stages**: *prophase*, *metaphase*, *anaphase* and *telophase* (Greek: *pro-*, before; *meta-*, mid; *ana-*, back; *telo-*, end).
- **Replication** (duplication) of the genetic material occurs during the **S phase** of the cell cycle.
- The timing of the four stages varies from species to species and from organ to organ.

The phases of Mitotic division:

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 (Figure 1).

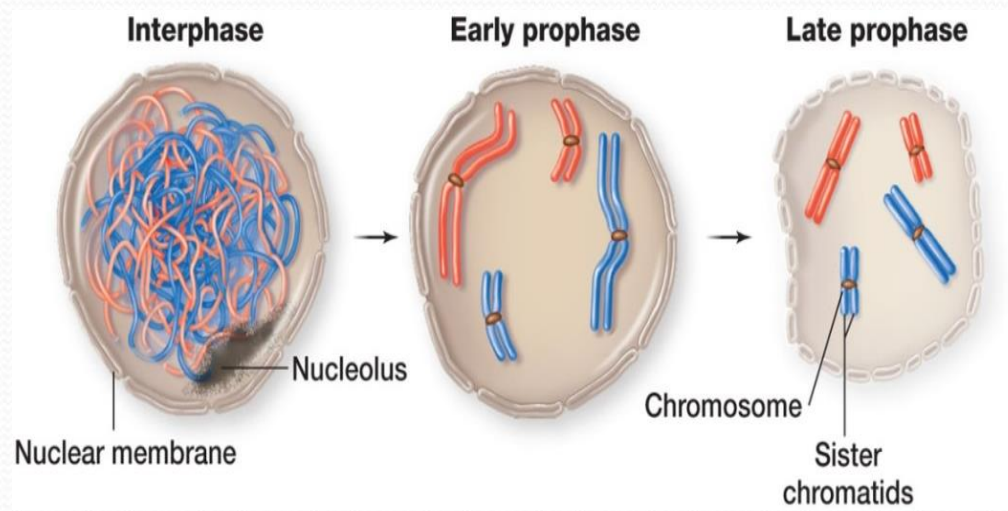


Figure 1: Nuclear events during interphase and prophase of mitosis

- The **centrosome** divides and moves to opposite poles of the cell, around the nucleus (Figure 2).
- 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** (Figure 2).
- The **second** microtubules that attach to a kinetochore on a sister chromatid are called **kinetochore microtubules** (Figure 2).

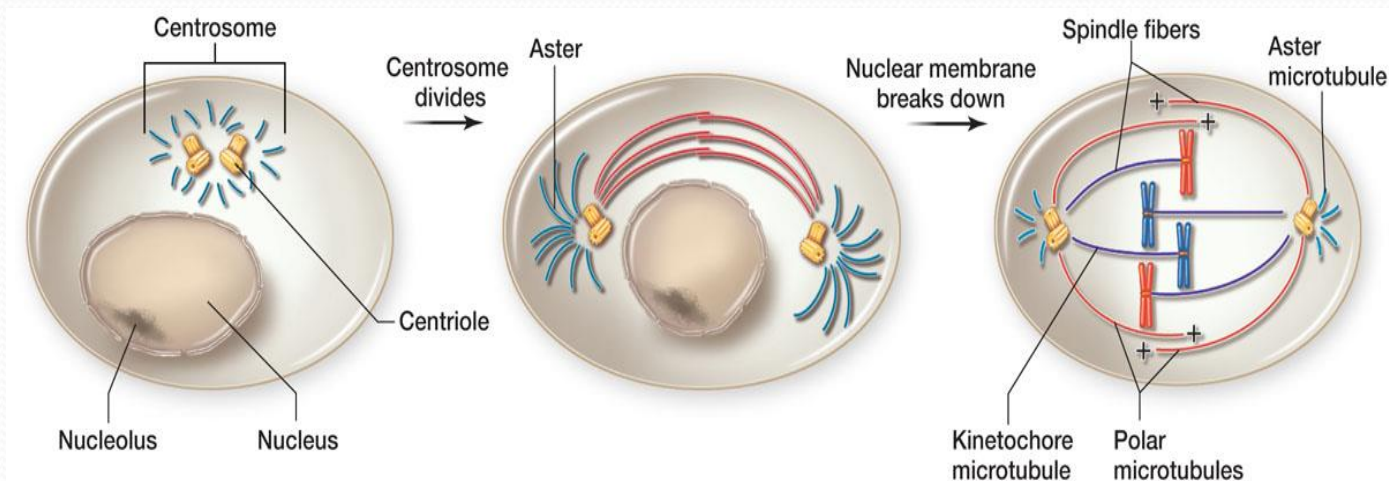


Figure 2: The centrosome divides in prophase, and separate halves move to opposite poles of the cell

- The **third** class of microtubules fail to attach to kinetochore are called **polar microtubules**.
- The sister chromatids are held together by a complex called **cohesin**, made up of at least four different proteins.
- Cohesin complexes connect the **arms** and **centromere** of sister chromatids at **the early prophase**.
- At the end of prophase (late prophase), the cohesin complexes holding the **arms** are **released**; however, the sister chromatids **remain connects** only at the **centromere**.

2. Metaphase:

- The spindle fibers are formed 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 (Figure 3).

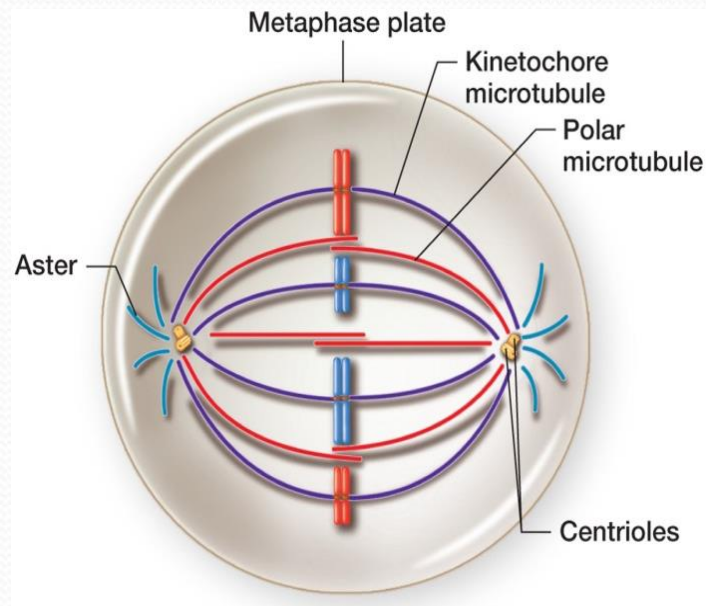


Figure 3: The mitotic spindle fibers during metaphase

3. Anaphase:

- Anaphase begins with the **two sister chromatids separating** and moving toward opposite poles on the spindle fibers (Figure 4).
- The sister chromatids are joined together by **cohesins**.
- The **degradation** of cohesin at the **centromere** allowing the sister chromatids to **separate** (Figure 5).

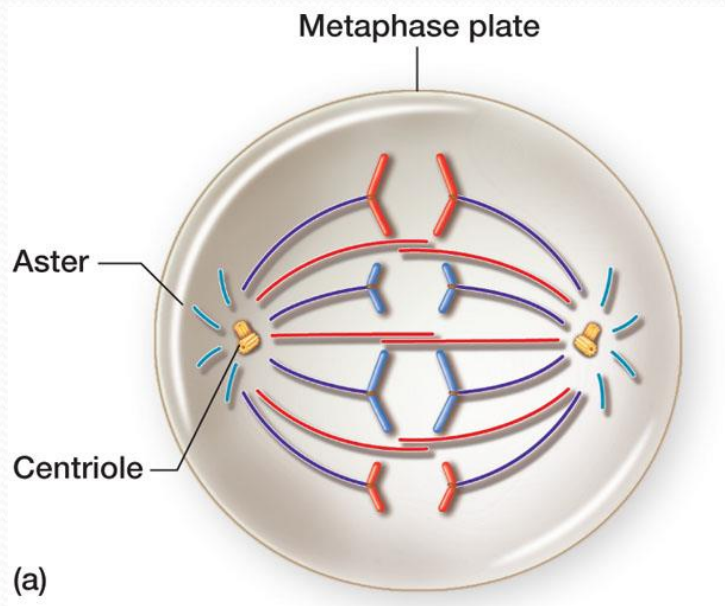


Figure 4: the mitotic spindle fibers during anaphase

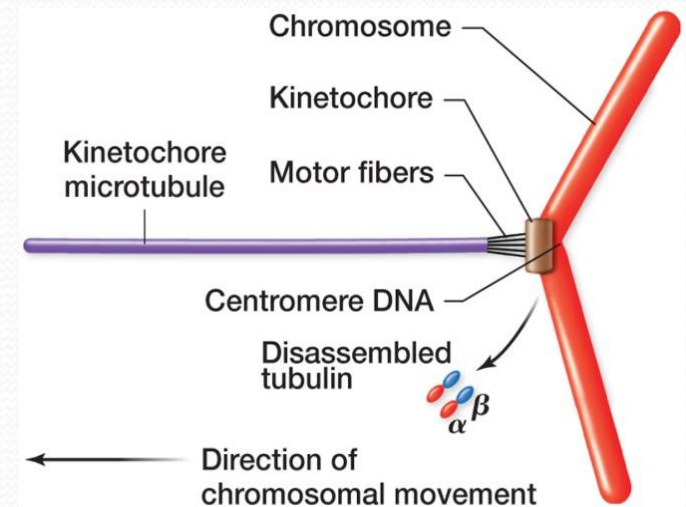


Figure 5: The kinetochore

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.
- **Cytokinesis** takes place.
- 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.

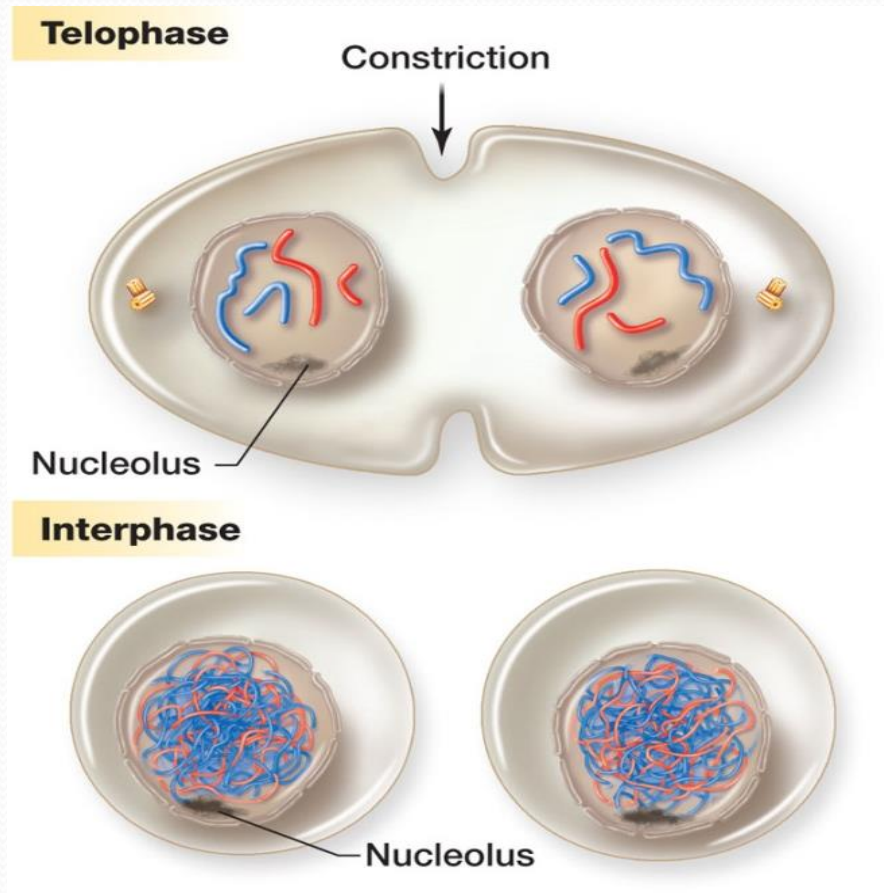
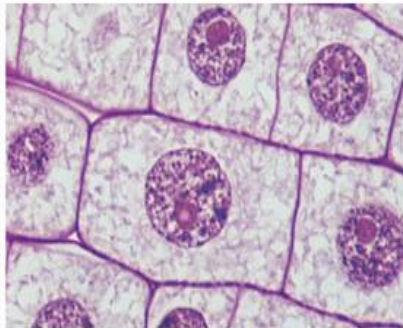
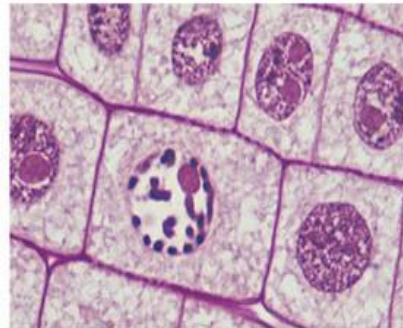


Figure 6: Telophase and interphase of mitosis

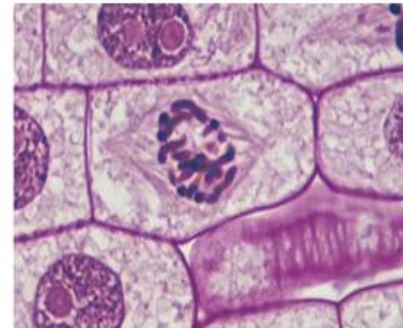
- The phases of mitosis in **onion root tip cells** are summarized in Figure 7.



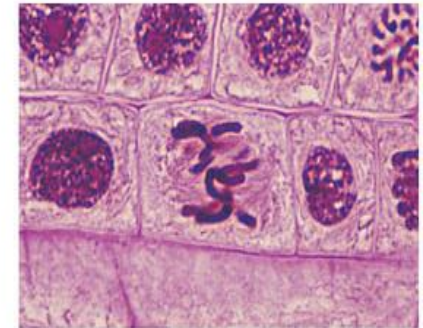
(a) Interphase



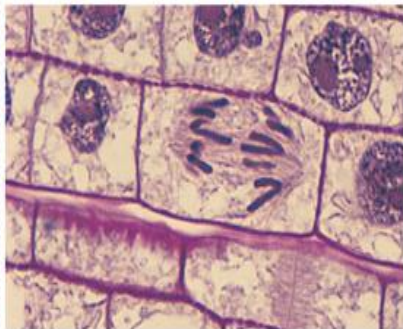
(b) Early prophase



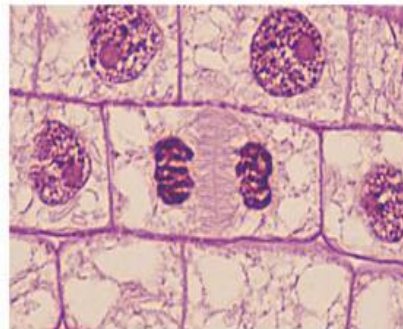
(c) Late prophase



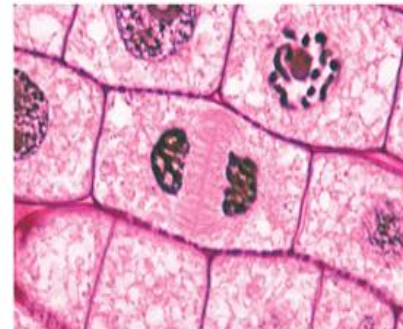
(d) Metaphase



(e) Anaphase



(f) Telophase



(g) Daughter cells

Figure 7: Cells in interphase and in various stages of mitosis in the onion root tip

Significance of mitosis:

1) In **multicellular** organisms:

- Mitosis produces more cells for growth and repair.

2) In **unicellular** organisms:

- Mitosis is a type of asexual reproduction.

Videos

http://highered.mheducation.com/sites/007298760x/student_view0/chapter3/mitosis_and_cytokinesis.html

http://highered.mheducation.com/sites/007298760x/student_view0/chapter3/the_function_of_cohesin.html