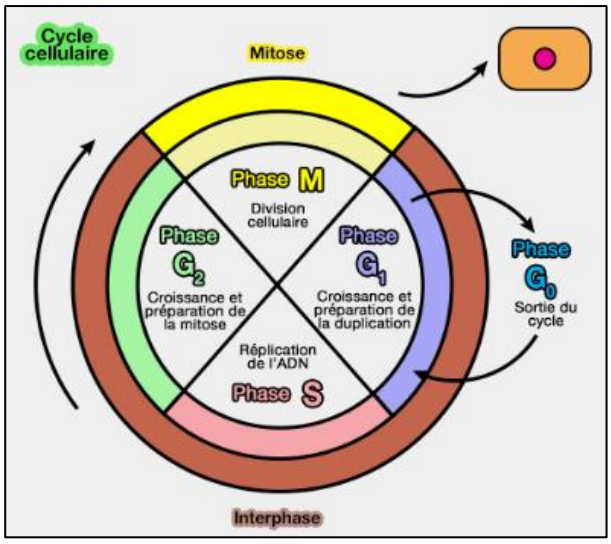
THE CELL CYCLE

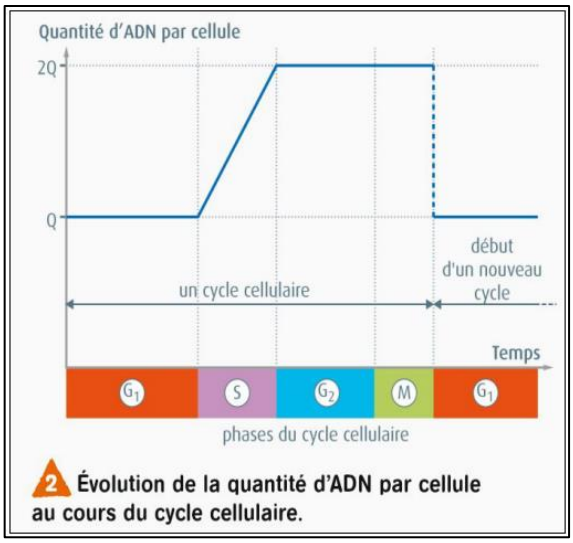
I. Definition:
The cell cycle is the set of changes a cell undergoes from its formation following the division of a parent cell until it divides into two daughter cells, both possessing the same morphological and physiological characteristics as the parent cell.
All cells divide, except for red blood cells and nerve cells.

II. Phases of the Cell Cycle:
Cells alternate between **mitosis** and an intermitotic phase called the "**Interphase**."



A. Interphase:
This is the longest period of the cycle, occurring between the end of one division and the beginning of the next. Its duration varies depending on the cell's nature and physiological conditions.
Example: Intestinal cells divide twice a day, while liver cells divide once or twice a year.
Interphase consists of three successive phases: the G1 phase, the S phase, and the G2 phase (*G* stands for "Gap").

1. **G1 Phase:**
   This is a pre-synthesis phase during which:



2 Évolution de la quantité d'ADN par cellule au cours du cycle cellulaire.

- The cell prepares for replication (synthesizing enzymes) and accumulates reserves for cell division.
- **Duration:** Variable depending on the cell type.
- **Key Characteristics:**
  - *No DNA synthesis*; the DNA quantity remains constant.
  - *Cytoplasmic growth*: The cell synthesizes RNA (messenger, ribosomal, and transfer RNA) and proteins necessary for cell growth.
  - The cell monitors its size and environment. The transition from G1 to S phase is *critical*, as the cell *irreversibly* commits to the cycle. However, the cell may exit the cycle and enter a quiescent G0 phase, where it can remain for days, weeks, or even years without dividing.

2. **S Phase:**
   This is the synthesis phase, characterized by:

- ***Duration*:** Fixed (6 to 8 hours).
- *DNA duplication and histone synthesis*: The DNA quantity doubles through replication.
- *Centriole duplication*.
  At the end of replication, chromosomes consist of two filaments (chromatids) with identical structures connected by a centromere.

3. **G2 Phase:**
   This pre-mitotic phase involves the synthesis of certain factors, particularly those required for chromatin condensation. Like G1, it is a phase of cytoplasmic growth.

B. M Phase (Mitosis):

I. General Features:
Mitosis is a continuous process involving:

- A specific stage in the life cycle of eukaryotic cells known as the "cell cycle."
- The division of a parent cell into two identical daughter cells.
- The phase when chromosomes become clearly visible.

- **Consequences:** Cell division consists of two distinct and continuous processes:

  1. **Karyokinesis:** Division of the nucleus.
  2. **Cytokinesis:** Division of the cytoplasm.

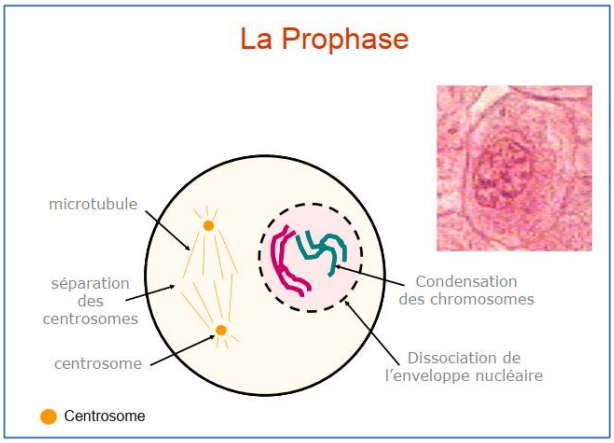
II. Characteristics:
Mitosis is characterized by:

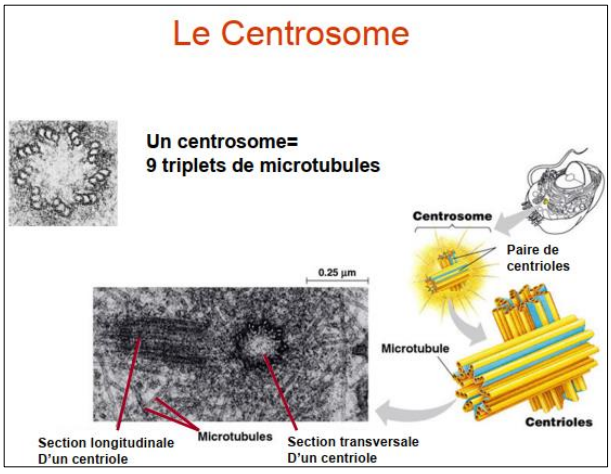
- Chromosome spiralisation.
- Formation of a spindle of microtubules (mitotic spindle) in the cytoplasm.
- Disappearance of the nuclear envelope.
- Equal distribution of DNA between the two daughter cells.
- Reconstitution of the nuclei in the daughter cells.

III. Stages of Mitosis:
Mitosis occurs in four distinct stages: prophase, metaphase, anaphase, and telophase. It lasts between 1 and 3 hours.

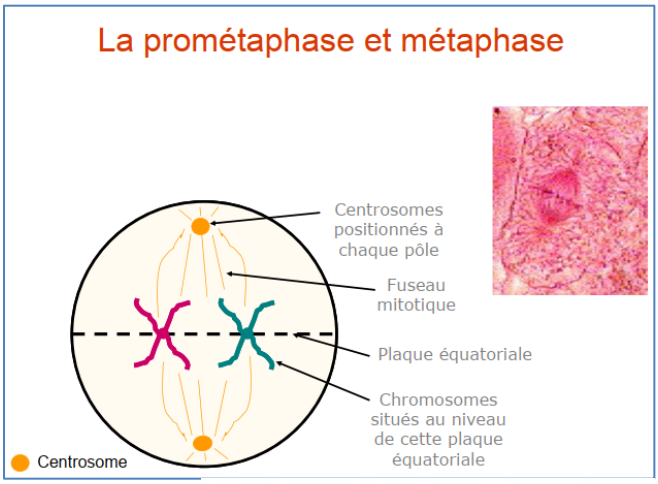
1. **Prophase:**
   Lasting 20 to 30 minutes, this stage is marked by:

- **Chromatin condensation** into highly ordered and individualized structures called chromosomes due to increased coiling of chromatin fibers.
- **Centrosome activity:** Initially composed of two centrioles, the centrosome duplicates during the S phase into four centrioles. These separate to form two centrosomes that migrate to opposite poles of the cell.
- Reduction and disappearance of the nucleolus.
- Reorganization of the microtubule cytoskeleton into a bipolar structure called the mitotic spindle, which extends between the two centrosomes.



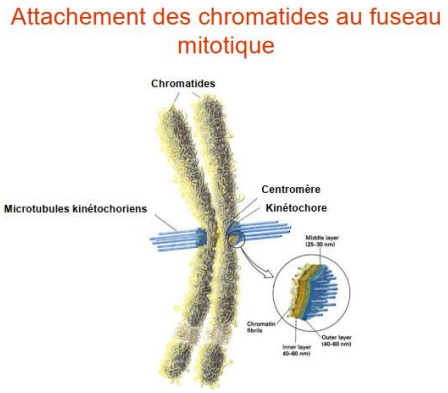


2. **Prometaphase and Metaphase:**
a) Prometaphase:



- Begins with the breakdown of the nuclear envelope, which disperses into vesicles within the cytoplasm due to the dissolution of the nuclear lamina.
- Formation of protein complexes (kinetochores) at the centromeres.
- Interaction of the mitotic spindle with chromosomes via kinetochores (two per chromosome, one per chromatid).

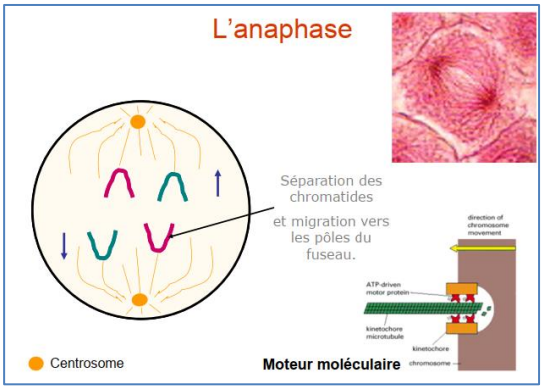
- Spindle microtubules are classified as:
  - **Kinetochore microtubules** (attached to chromosomes).
  - **Polar microtubules** (not in contact with chromosomes).
  - **Astral microtubules** (not part of the spindle).



b) Metaphase:

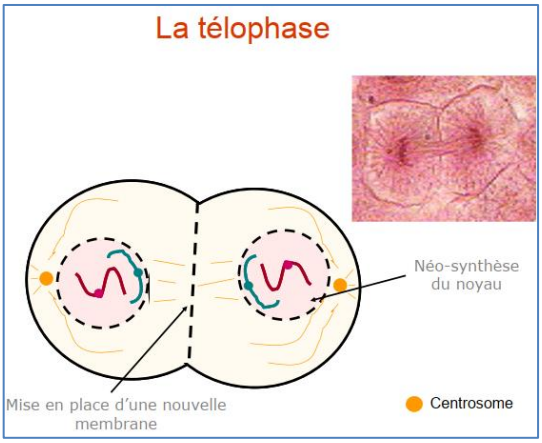
- Chromosomes align along the equatorial plate (middle of the cell), fixed by their kinetochores equidistant from the poles.
- Maximum condensation of chromosomes occurs, forming metaphase chromosomes, each consisting of two chromatids joined by a centromere.

3. **Anaphase:**



- Separation of chromatids and migration toward spindle poles.
- Centromere cleavage transforms chromatids into independent chromosomes.
- Shortening of kinetochore microtubules drives chromosomal migration, distributing identical chromosome sets to each pole.
- Elongation of polar microtubules lengthens the cell.

4. **Telophase:**



- Chromosomes cluster at cell poles, forming a fan-like arrangement.
- **Decondensation** (**despiralization**) of chromatids.
- Reformation of the nuclear envelope and reappearance of the nucleolus.

5. **Cytokinesis:**

- Formation of a **contractile ring** composed of actin and myosin filaments.
- Appearance of a cleavage furrow perpendicular to the

mitotic spindle's axis, dividing the cell into two.

- The cleavage furrow tightens to form a narrow intermediate structure containing the remnants of the spindle.
- Final contraction of the ring physically separates the two daughter cells.