Lesson 02: TRANSMISSION OF GENETIC CHARACTERS IN EUKARYOTES

Introduction:

The transmission of genetic characteristics within a species or a cell line occurs from one generation to the next. This inheritance ensures the continuity of traits across generations.

- **Segregation Law**

• Each individual possesses two factors (now called genes) for each trait.

• These factors separate during gametogenesis (gamete formation)

• Fertilization restores two factors for each new individual.

Thus, the transmission of traits from one generation to the next occurs through cell division.

Cell division is the fundamental process by which a cell reproduces itself and is essential for the perpetuation of life. The purposes of cell division are:

- To create a new generation identical to the parent in unicellular organisms.

- To enable growth in multicellular organisms.

- To ensure development in multicellular organisms.

- To allow repair and regeneration in multicellular organisms.

Cell division requires the precise duplication and equal distribution of DNA, which carries the genetic information (the genome).

1- The cycle cellular

The duration of the cell cycle varies depending on the cell type: some cells divide actively, while others may remain quiescent for long periods.

Regardless of the cell type, the cycle has the same main phases:

- **Interphase**: subdivided into three stages.
- **G1 phase:** The amount of DNA per cell remains constant (quantity = q). During this phase, the cell grows, carries out its functions, and uses its genetic information.
- **S phase (synthesis**): DNA replication occurs, progressively doubling the amount of DNA (quantity = 2q).

- **G2 phase**: The cell prepares for mitosis. The DNA quantity is stable and doubled compared to G1.
- **Mitosis**: The phase during which chromosomes become visible and are distributed equally between two daughter cells. This stage lasts about one hour.

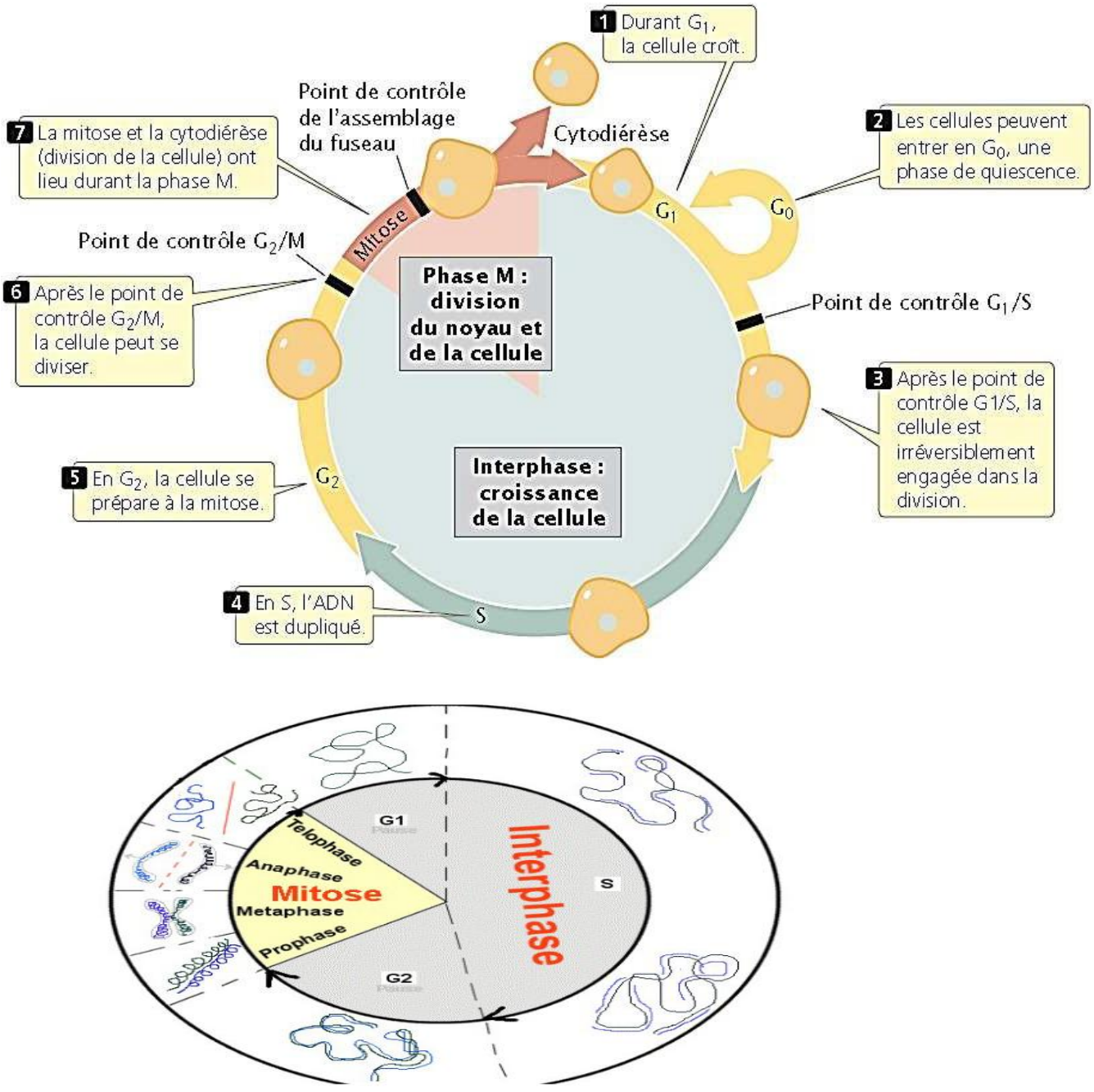


Figure: Phases of the cell cycle (somatic cell)

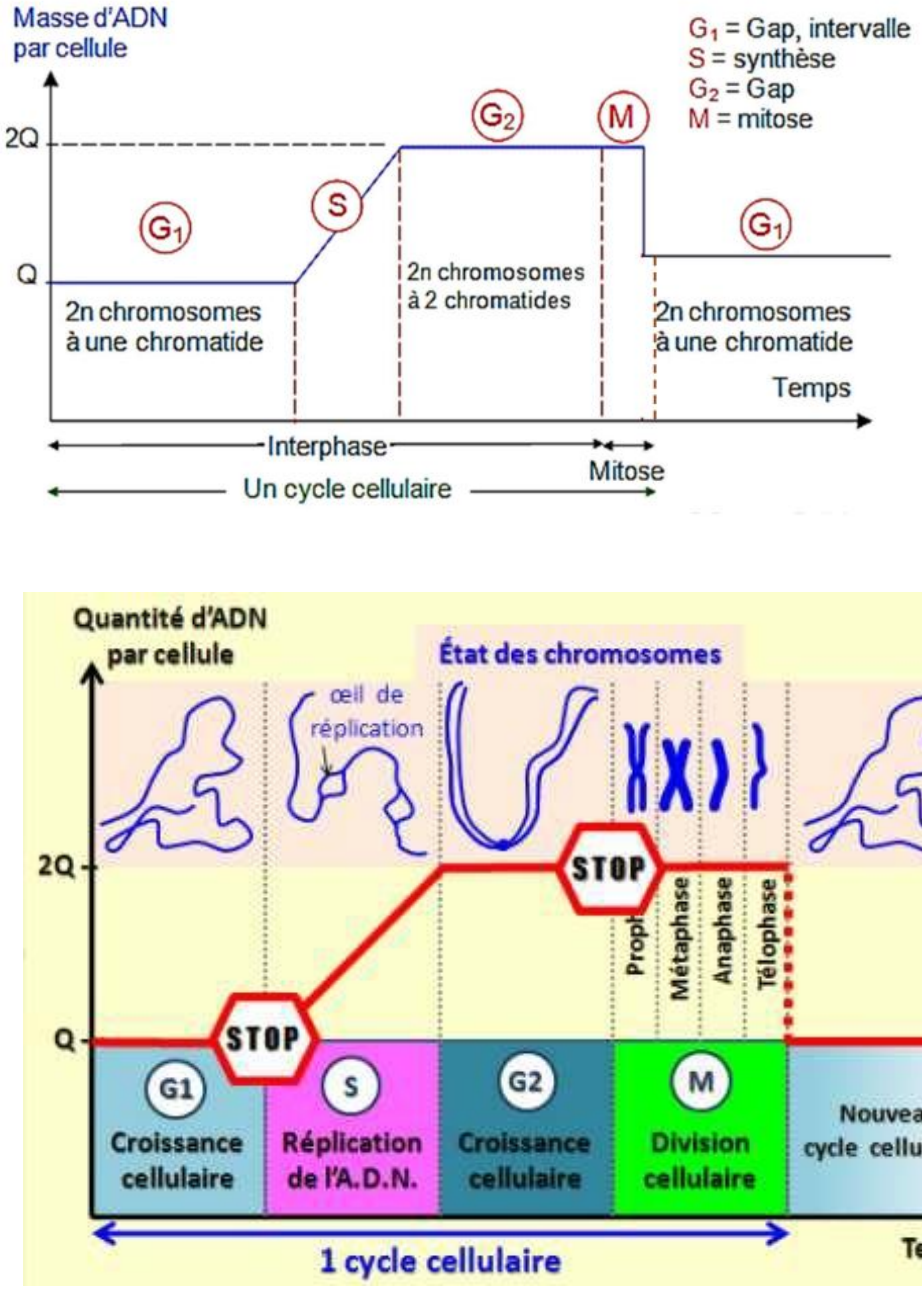


Figure : Cell cycle summary (somatic cell)

2- Mitosis

All somatic cells of multicellular organisms derive from a single original cell, the fertilized egg (zygote), through successive cell divisions called mitosis.

Mitosis has two main functions:

- To create an exact copy of each chromosome.
- To distribute an identical set of chromosomes to each daughter cell.

Mitosis occurs in four main phases: **prophase, metaphase, anaphase and telophase.**

- **Prophase:** Chromosomes condense; the nuclear membrane and nucleolus begin to fragment.
- **Prometaphase :** Chromosomes attach to spindle fibers and begin to move
- **Metaphase:** Chromosomes align on the equatorial plate. Homologous chromosomes do not pair.
- **Anaphase:** Sister chromatids separate at the centromere and migrate to opposite poles.
- **Telophase:** Chromosomes decondense, the spindle disappears, and nuclear envelopes reform. Cytokinesis divides the cytoplasm, producing two identical daughter cells.

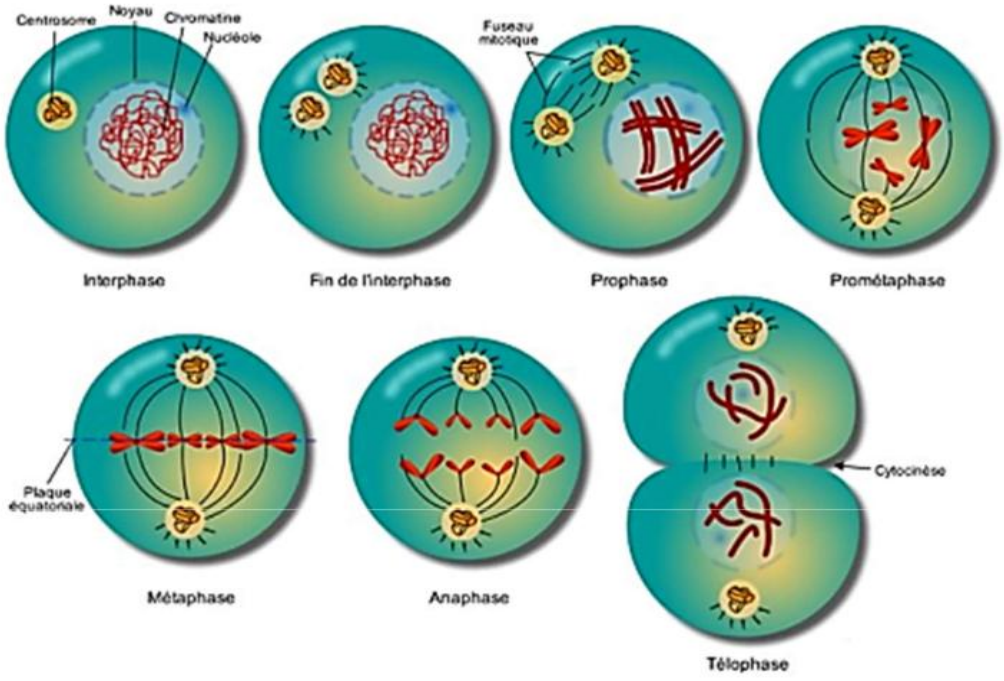
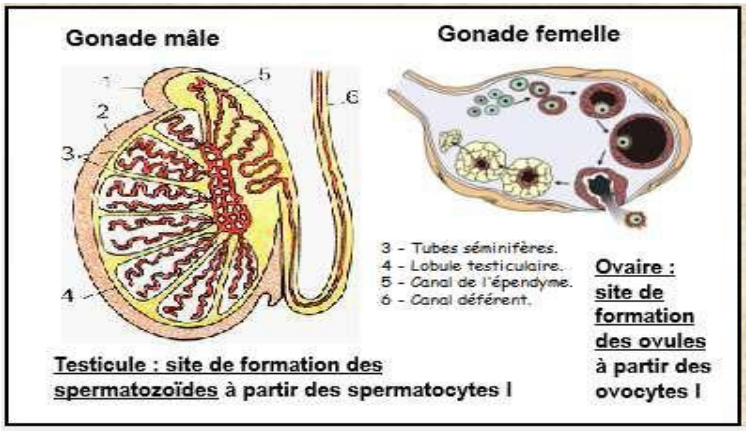
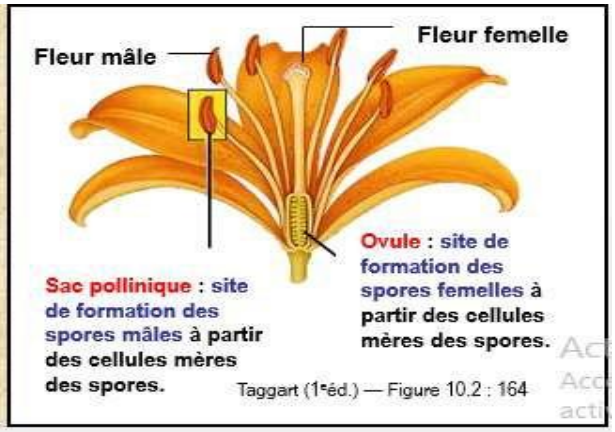


Figure: Stages of mitosis

3. Meiosis

Meiosis occurs in reproductive organs (gonads in animals; flowers in plants) and reduces the chromosome number by half. It produces gametes (sperm and eggs) in animals and spores in plants.





At the house of animals at	the plants
Meiosis takes place in the male gonads (testes) and female gonads (ovaries). The cells produced are gametes (sperm and egg), also called sex cells or reproductive cells	Meiosis takes place in the male flowers (stamens) and female flowers (pistils). The cells produced are spores, which will develop by mitosis and give rise to male and female gametes.

Meiosis transforms a diploid mother cell into four haploid daughter cells. Each daughter cell receives one homologue from each chromosome pair.

Meiosis introduces genetic variability because gametes combine the genetic contributions of two parents.

Roles of meiosis:

- ✓ To produce gametes for sexual reproduction.
- ✓ To maintain a constant chromosome number across generations by halving it in gametes and restoring it by fertilization.
- ✓ To create genetic diversity among offspring through recombination and independent assortment.
- ➢ **Phases of meiosis**

Meiosis consists of two successive divisions: **__Meiosis I (reductional division)__** and **__Meiosis II (equational division)__**, producing four haploid cells.

1. **Meiosis I (the first meiotic division):**

It is a reductional division because it reduces the number of chromosomes in the initial cell.

1.1 Prophase I: Prophase of meiosis I is subdivided into 5 stages: leptotene, zygotene , pachytene, diplotene and diakinesis .

1. **Leptotene :** During this stage, chromatin condenses into very long, thin strands.
2. **Zygotene (joined filament stage)** : At this stage, Homologous chromosomes begin to pair. They are still very elongated.
3. **Pachytene (thick filament stage):** Synapsis is complete, forming bivalents (tetrads of four chromatids). Crossing-over begins between non-sister chromatids.
4. **Diplotene (double filament stage):** Homologous chromosomes begin to separate but remain attached at chiasmata (sites of crossing-over**)**

5. **Diakinesis :** Chromosomes fully condense; the nuclear envelope and nucleolus disappear, and the spindle forms.

1.2. Metaphase I: Bivalents align randomly at the equatorial plate.

1.3. Anaphase I: Homologous chromosomes separate and move to opposite poles. Each chromosome still consists of two chromatids.

1.4. Telophase I: Cytokinesis produces two haploid daughter cells.

2. Meiosis II (second meiotic division):

No DNA replication occurs between meiosis I and II. Each chromosome still contains two chromatids. Meiosis II resembles mitosis.

2.1. Prophase II: The spindle reforms.

2.2. Metaphase II: Chromosomes align on the equatorial plate.

2.3. Anaphase II: Sister chromatids separate at the centromeres and migrate to opposite poles.

2.4. Telophase II: Cytokinesis produces four haploid daughter cells.

Le cycle méiotique (Méiose I et Méiose II) permet donc d'obtenir 4 cellules filles haploïdes, à partir d'une cellule mère diploïde.

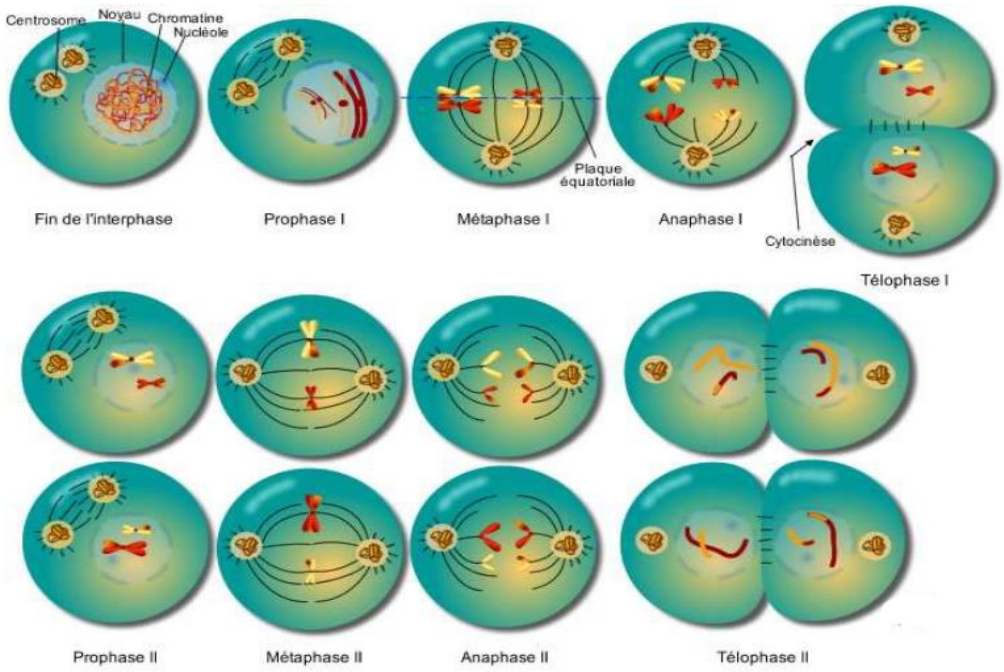


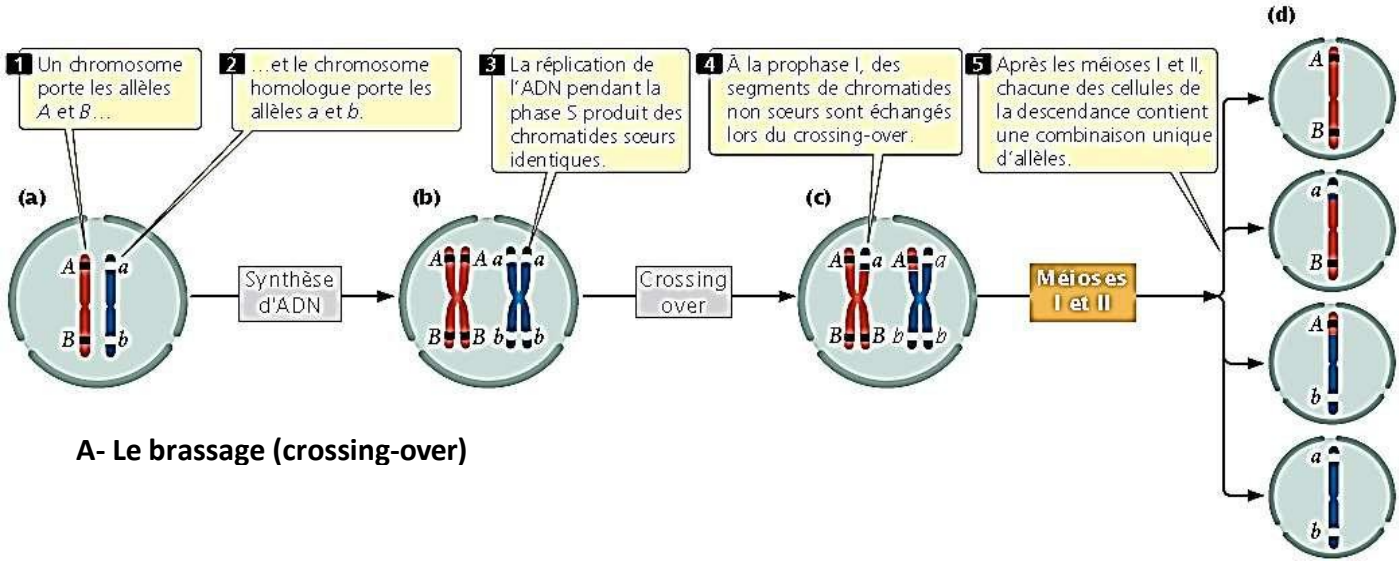
Figure: Stages of Meiosis

- **Consequences of meiosis**

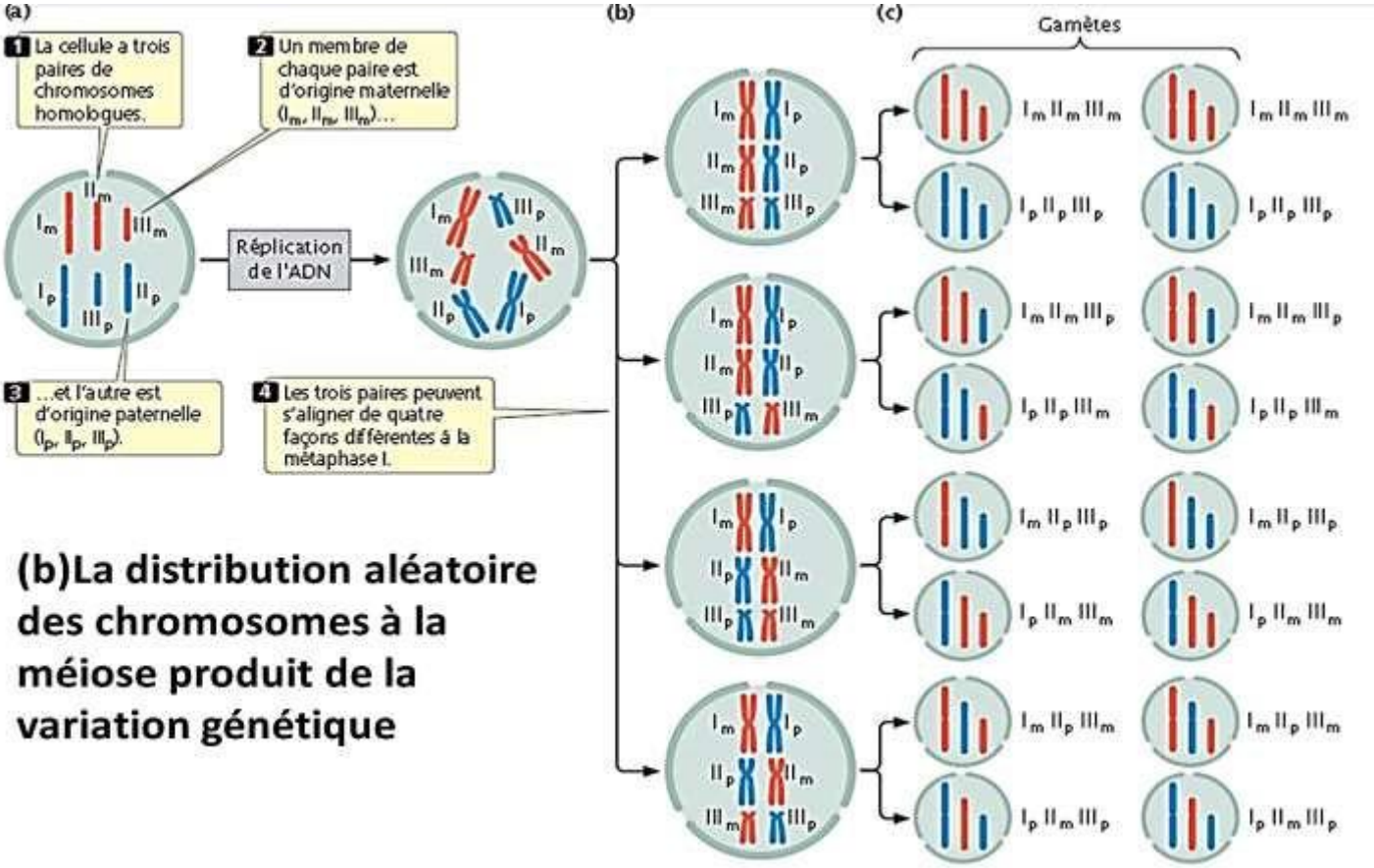
Meiosis generates genetic diversity in two main ways:

A- Crossing-over: (during prophase I), which exchanges genetic material between homologous chromosomes , they mix genes parental.

B- Independent assortment: (during metaphase I), which randomly distributes homologous chromosome pairs into gametes**.**



A- Le brassage (crossing-over)



(b)La distribution aléatoire des chromosomes à la méiose produit de la variation génétique

Figure : Consequences of meiosis – a: crossing-over; b: independent assortment

4. Comparison between mitosis and meiosis

Painting 1 : Differences features between mitosis and meiosis

Mitosis	Meiosis
A division equational separated chromatids sisters .	The first step (meiosis 1) is a reduction division that separates homologous chromosomes has there first anaphase . THE chromatid sisters separate during there equational division (meiosis2) of the second anaphase
A division by cycle, either a cytoplasmic division (cytokinesis) by chromosome division equational	Two divisions per cycle, or two cytoplasmic divisions , one following reductional division , And the other has there following of there division equational .
THE chromosomes do not enter not in synapsis; Not of training of chiasm .	THE chromosomes enter in synapsis And form of the chiasmas .
Not exchange genetic between THE chromosomes counterparts.	Of the exchanges genetics produce between THE counterparts .
Two cells girls are produced by cycle .	Four cells (gametes Or spores) are produced by cycle.
THE content genetic of the cells girls East identical has the one of the mother cell .	THE content genetic of the cells girls East different of the one of the mother cell .
THE number of chromosome of the daughter cells East identical to that of the cell mother .	THE number of chromosome of the cells girls East reduced has there half by report to that of there cell mother .
The cells issues of mitosis are generally capable of to undergo others mitoses	THE cells issues of there meiosis to can not to undergo a other meiosis but can to undergo a mitosis .
To product in the most cells somatic	To product only In THE cells specialized of there line germinal .
Begin At stadium zygote And continues throughout the life of the organism .	Occurs in organisms mature superiors . product at the house of THE zygotes of there most of the algae and mushrooms.