CELL DIVISION

Cell division is a process by which a cell divides to give rise to daughter cells. In single celled organisms like amoeba, this process results into increase in number of organisms while in multicellular organisms cell division brings about growth, repair of worn out tissues and formation of reproductive cells (gametes). During cell division, the nucleus divides into two followed by the division of the cytoplasm. The cell membrane constricts to surround the formed cells each containing a nucleus. This results into formation of daughter cells.

There are two types of cell division.

1. Mitosis.
2. Meiosis.

Important terms used

Chromosome; this is a thread-like structure in the nucleus that carries the genes of an organism.

Chromatid; this is one half of a chromosome.

Sister chromatids; these are chromatids of the same chromosome.

Homologous chromatids; these are chromatids of different chromosomes in a bivalent.

Bivalent; this is a pair of homologous chromosomes.

Centromere; this is a structure of chromatid attachment and separation on a chromosome.

Chiasmata; this is a crossing over point between two homologous chromatids.

Haploid; this is where a cell has half the number of chromosomes compared to the parent cell.

Diploid; this is where a cell has a whole set of chromosomes.

Replication; this is where a structure produces an exact copy of itself.

MITOSIS

This is a type of cell division where a cell divides to give rise to two daughter cells each having the same number of chromosomes as the parent cell and each having exactly the same number of chromosomes as the parent cell.

The daughter cells are diploid i.e. they have 2 sets of chromosomes.

This cell division consists of 4 stages namely:

1. Prophase
2. Metaphase

3. Anaphase
4. Telophase

The resting stage in between the 2 division is called interphase. Though interphase is regarded as a resting phase, the cell is engaged in several activities to prepare for division.

The following are the significant features of the stage.

i) Chromosomes are drawn into long threads of chromatids.

ii) The genetic material or chromosomes replicate to provide enough space for the two cells.

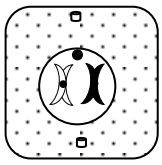
iii) The cell manufactures and stores energy through respiration in preparation for cell division.

iv) The centrioles replicate if present.

Stage 1: prophase

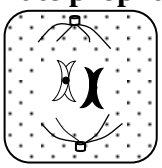
- The chromosomes thicken and become visible.
- Each chromosome appears to consist of two chromatids lying parallel to each other and attached at a point called the centromere as shown below.
- The nucleolus disappears.
- The centrioles migrate to opposite poles and start forming microtubules known as spindle fibers. The region between the two opposite poles is known as the equator.
- The nuclear membrane disintegrates and disappears towards the end of prophase.

Early prophase.



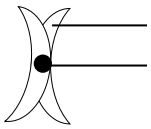
Centrioles at opposite poles

Late prophase.



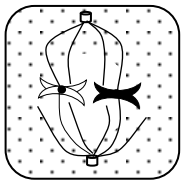
Centrioles form spindle fibers. The nuclear membrane disappears.

Chromosome



Stage 2: metaphase

- Chromosomes move to the center of the cell and arrange themselves at the spindle equator.
- Chromosomes attach to the spindle fibers at the centromeres.
- Sister chromatids face opposite poles of the spindle.



Chromosomes align at the equator

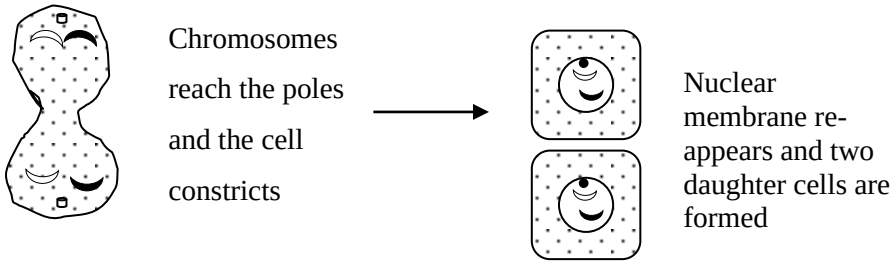
Stage 3: anaphase

- Centromeres divide and the two chromatids of each chromosome move to opposite poles.
- Each chromatid now becomes a chromosome.
- Spindle fibers shorten as they pull the chromatids apart.

Stage 4: Telophase

- The chromosomes reach the poles.
- The cell divides by constriction of the cell membrane in animals or by forming a cell wall plate in plants.
- The nuclear membrane reappears.
- Spindle fibers disintegrate (break down).
- The nucleolus reappears.
- Chromosomes uncoil, become threadlike and invisible.
- This leads to interphase and the cycle repeats.

Animal cell at telophase.



Note; plant cells do not have centrioles but can form spindle fibers during cell division.

Major events during mitosis

1. Replication of DNA, chromosomes and cell organelles during interphase.
2. Formation of the spindle and disappearance of the nuclear membrane during prophase.
3. Chromosomes align at the equator during metaphase.
4. Sister chromatids are pulled to opposite poles and they become chromosomes during anaphase.
5. Cells divide into two during telophase.

Significance/importance of mitosis

1. Mitosis results into growth. As cells divide, they produce new similar cells. This causes an increase in the number of cells in an organism and consequently growth.
2. It brings about repair. During the course of life cells are damaged and they die. New cells are produced by mitosis to repair the body by replacing damaged and dead cells.
3. It is important in asexual reproduction. Cells divide by mitosis to form spores or tissues that develop into a new individual.
4. It maintains the genetic composition of the organism. Cells produced during mitosis are similar genetically to the parent cell. This ensures that the organisms' identity (genotype) does not change.
5. Gametes in bryophytes (mosses) are produced by mitosis.

Where mitosis occurs

In man, it mainly occurs in;

- The bone marrow
- The epidermal cells of the gut
- The malpighian cells of the epidermis

In plants, it occurs in;

- The apical meristems
- The cambium

MEIOSIS

This is a type of cell division where a cell divides into four haploid daughter cells each with half the number of chromosomes as the parent cell. It is also called reduction division

because it halves the number of chromosomes in the daughter cells. Meiosis takes place in reproductive organs during the formation of reproductive cells (gametes).

Meiosis occurs in two major phases.

1. Meiosis I (first meiotic division)
2. Meiosis II (second meiotic division)

The first meiotic division results into separation of homologous chromosomes while the second meiotic division results into separation of sister chromatids.

Like in mitosis, during interphase, the cell carries out several activities to prepare for division. These include;

- Replication of the genetic material
- Replication of the centrioles
- Large stores of energy built up

MEIOSIS 1

The stages of meiosis are;

1. **Prophase 1**
   - This is the longest stage in meiosis. During this stage;
   - The nucleolus disappears.
   - Centrioles migrate to opposite poles.
   - Spindle formation starts.
   - Homologous chromosomes lie side by side. This is called **synapsis**. A pair of homologous chromosomes at this stage is called a **bivalent**.
   - Chromatids of homologous chromosomes (homologous chromatids) exchange portions at certain points called chiasmata in a process called crossing over.
   - The nuclear membrane disintegrates.

2. Metaphase 1

During metaphase I

- Spindle formation continues.
- Homologous chromosomes – now in a pair – align themselves at the equator of the spindle with their centromeres facing opposite poles.
- Spindle fibers attach at the centromere of each chromosome.

3. Anaphase 1

During anaphase I;

- Homologous chromosomes separate and they move to opposite poles.

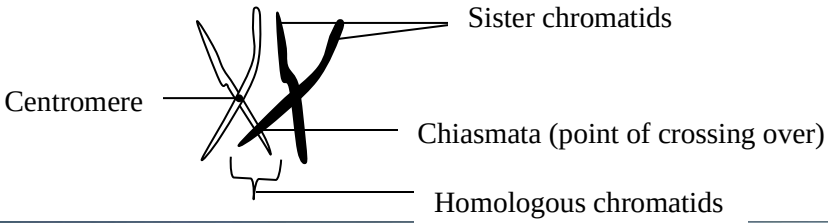
4. telophase 1

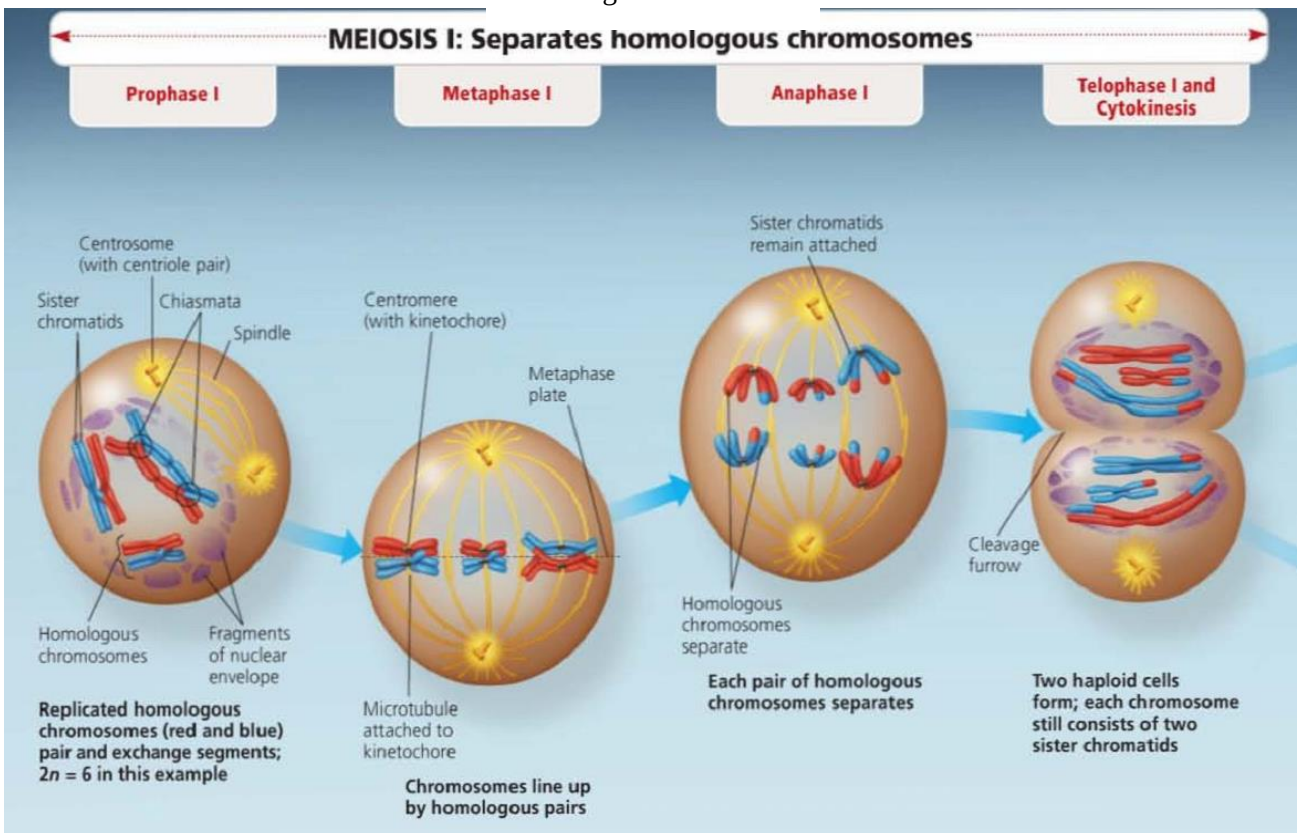
During telophase I

- Chromosomes arrive at the poles.
- The cell divides into two as in mitosis.
- The nuclear membrane reforms in each of the new cells.

Note: A bivalent is a pair of homologous chromosomes. Bivalents are formed during prophase 1

Structure of a bivalent





MEIOSIS II

After meiosis I there is usually a short period of interphase but some times it does not occur.

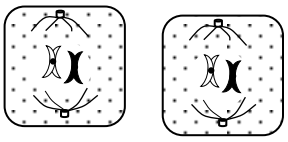
Meiosis II is also divided into the following stages.

1. Prophase II
2. Metaphase II

3. Anaphase II
4. Telophase II

1. Prophase II

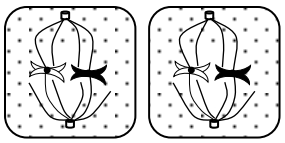
- A spindle starts to form.
- Centrioles replicate and migrate to opposite poles.
- The nuclear membrane disintegrates at the end of prophase II



2. Metaphase II

During metaphase II;

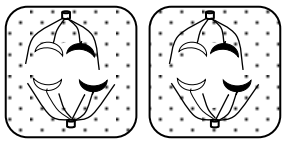
- Chromosomes align at the equator with centromeres facing opposite poles.
- Centromeres divide and sister chromatids separate.
- Spindle fibers attach to the sister chromatids at the centromere.



3. Anaphase II

During anaphase II;

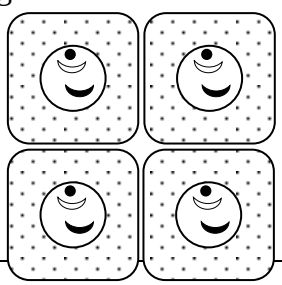
- Chromatids separate and move to opposite poles.
- Chromatids now become chromosomes.

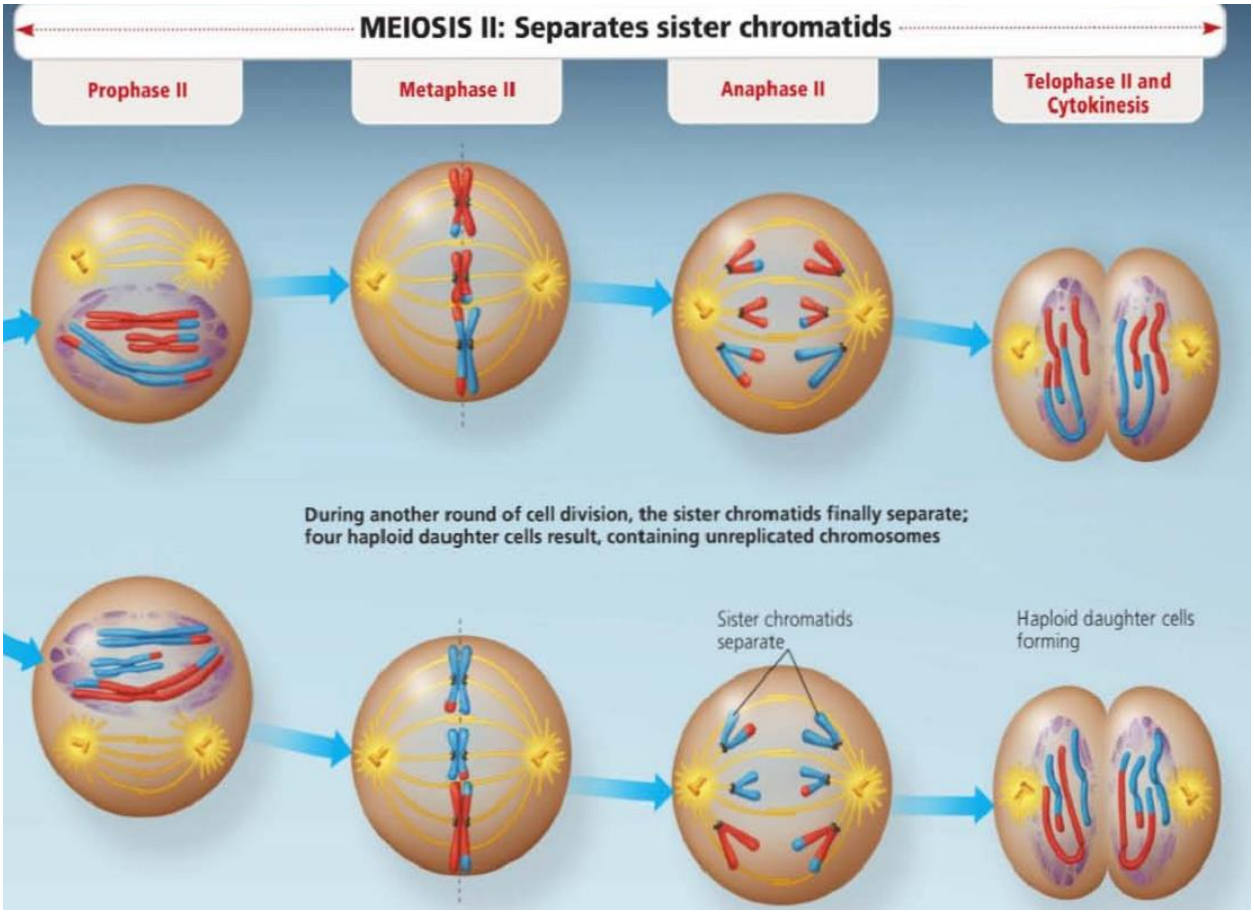


4. Telophase II

During telophase II;

- Each cell divides into two. These results into 4 daughter cells formed.
- The nuclear membrane reappears in each cell.
- Spindle fibers disappear.
- The nucleolus reappears.
- Chromosomes uncoil and become thread-like





Significance/importance of meiosis

1. It is important in formation of gametes.
2. It halves the chromosome number to ensure that the total number is restored during fertilization.
3. It introduces variations within cells through crossing over during prophase I
4. It results into rapid multiplication of cells since 4 are produced in a single division.
5. Since it occurs in reproductive cells, it results into varied offspring during sexual reproduction. This provides a basis for natural selection, which ensures evolution of the species.

Comparison between mitosis and meiosis

Similarities:

1. Both are types of cell division.
2. They both involve replication of chromosomes.
3. They both involve similar stages e.g., prophase, metaphase, anaphase, telophase and interphase.

4. In both chromosomes arrange themselves at the equator.
5. In both a spindle is formed.
6. Both begin with a diploid parent cell.

Differences:

Mitosis	**Meiosis**
Occurs in somatic cells.	Occurs in reproductive cells.
Involves a single division of chromosomes and cytoplasm	Involves two divisions of chromosomes and cytoplasm.
Does not involve the process of synapsis	It involves synapsis
Crossing over does not occur	It involves crossing over between homologous chromatids.
Formation of bivalents does not occur.	There is formation of bivalents.
Two daughter cells are produced.	Four daughter cells are formed.
Diploid cells are formed.	Haploid cells are formed.
Daughter cells formed have the same number of chromosomes as the parent cell	Daughter cells formed have half the number of chromosomes compared to the parent cell
Does not involve formation of chiasmata.	It involves formation of chiasmata