Meiosis

Learning Objectives:

- Define the terms: “Haploid genome”, “Diploid genome”, “Homozygous diploid ”, “hetrozygous diploid”, “haploid cells”, “Gametogenesis”, and “Fertilization”.

- Describe briefly Meiosis I and II and describe the changes in the amount of DNA per cell starting from S phase till the end of Meiosis II.

- Compare between Mitosis and Meiosis using the following criteria: ***The Number of divisions, Synapses of homologous chromosomes, Daughter cell number & genetic Composition, and Roles in the body.***

Glossary for Meiosis & Sexual Reproduction:

- **MEIOSIS** prepares gametes for the process of "sexual reproduction", that involves mixing of genetic information from two parent organisms and results in offspring that are genetically unpredictably dissimilar, both from each other and from the parents.

- **A HAPLOID GENOME** contains a single gene trait (allele), on a single set of chromosomes.

- **DIPLOID GENOMES** consist of a double set of chromosomes with two copies or alleles, of genetic information for a particular trait.

- **HOMOZYGOUS** diploid organisms have two identical alleles for a particular trait.

- **HETEROZYGOUS** diploid organisms have different alleles for the same trait. The allele that is physically expressed is said to be dominant, and the allele that is not physically expressed is said to be recessive.

- **GENOTYPE** refers to the genetic makeup of an organism, while **PHENOTYPE** refers to the physical appearance of an organism.

Glossary for Meiosis & Sexual Reproduction:

- **HAPLOID CELLS** that are specialized for reproduction are called gametes. Female gametes are referred to as ***eggs or ova***, and male gametes are referred to as ***sperm or spermatozoa.***

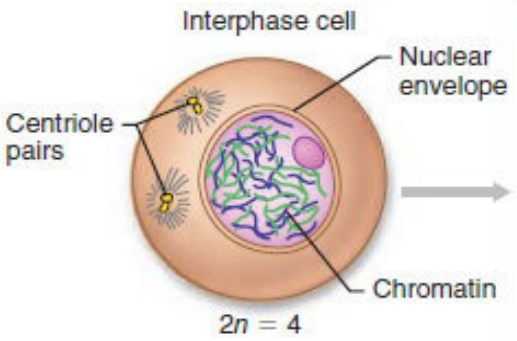
- **GAMETOGENESIS** is the process of producing gametes, and takes place within organs called gonads. ***The female gonads are ovaries, and the male gonads are testes***.

- **FERTILIZATION**, or the ***union of egg and sperm***, results in a diploid egg called a ***zygote.***

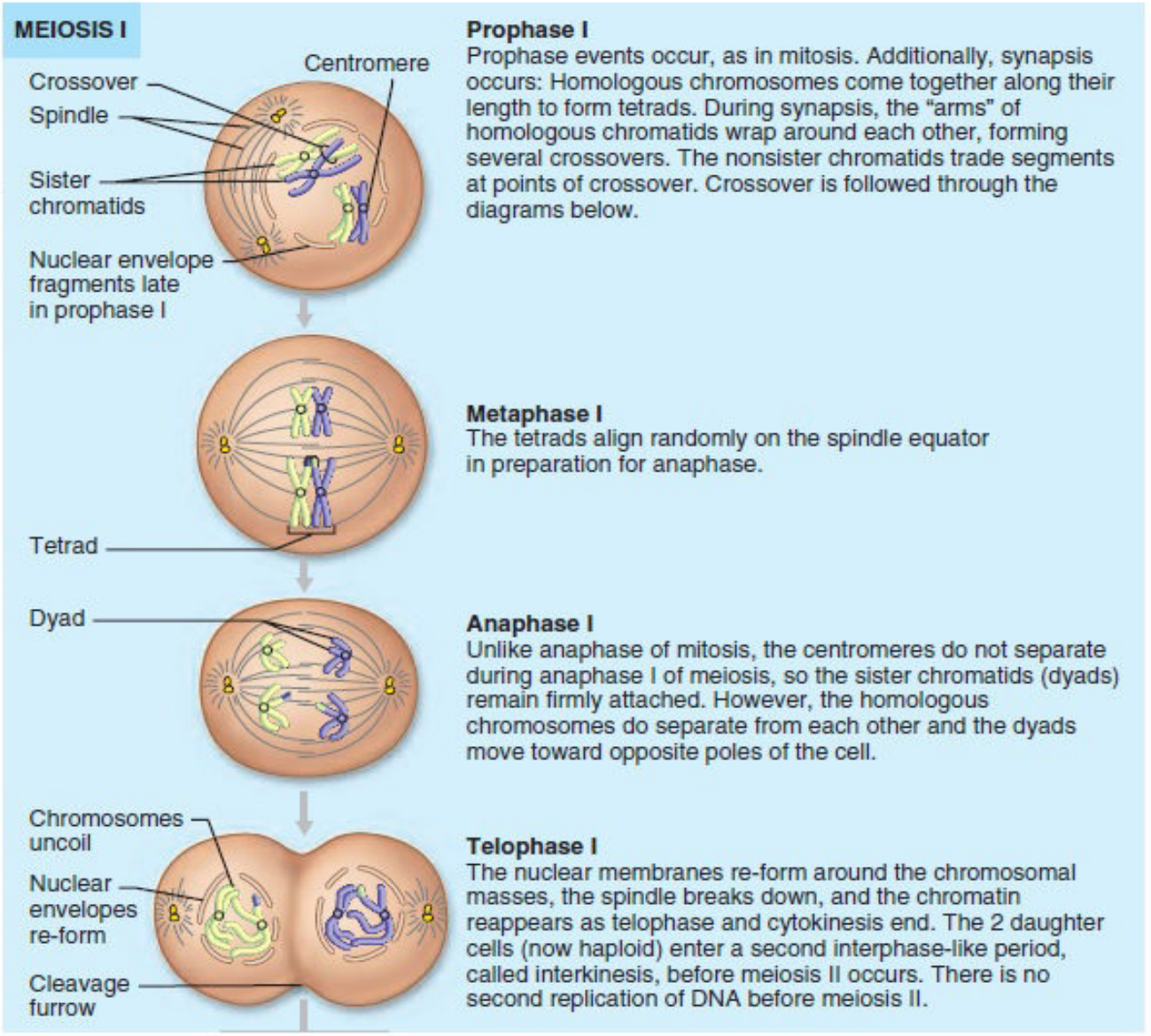
- **MEIOSIS** involves ***two successive nuclear divisions with only one duplication of chromosomes***. The product of meiosis is four daughter nuclei with ***one set of chromosomes per nucleus***. Meiosis begins with an initial chromosome replication followed by two successive division events.

- **AMOUNT OF DNA PER CELL:** ***The amount of DNA per cell rises from 2C to 4C during replication. In Meiosis, the first division (Meiosis I) reduces the DNA back to 2C. The 2nd division (Meiosis II) reduces the DNA to the 1C level found in the four daughter cells. After fertilization, the amount of DNA is restored to the 2C level in the zygote.***

Meiosis I:



Interphase events
As in mitosis, meiosis is preceded by DNA replication and other preparations for cell division.



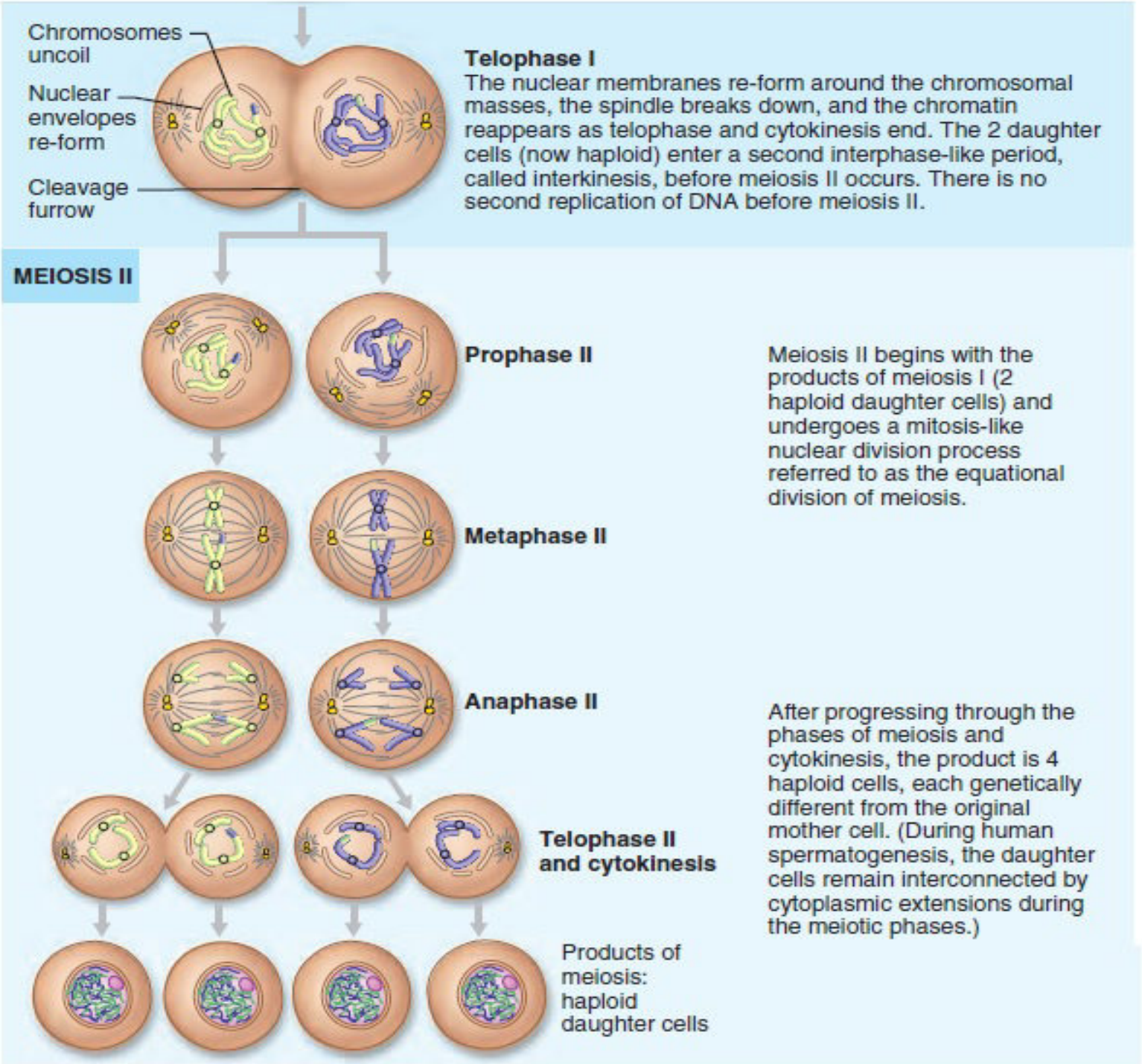
Prophase I
Prophase events occur, as in mitosis. Additionally, synapsis occurs: Homologous chromosomes come together along their length to form tetrads. During synapsis, the "arms" of homologous chromatids wrap around each other, forming several crossovers. The nonsister chromatids trade segments at points of crossover. Crossover is followed through the diagrams below.

Metaphase I
The tetrads align randomly on the spindle equator in preparation for anaphase.

Anaphase I
Unlike anaphase of mitosis, the centromeres do not separate during anaphase I of meiosis, so the sister chromatids (dyads) remain firmly attached. However, the homologous chromosomes do separate from each other and the dyads move toward opposite poles of the cell.

Telophase I
The nuclear membranes re-form around the chromosomal masses, the spindle breaks down, and the chromatin reappears as telophase and cytokinesis end. The 2 daughter cells (now haploid) enter a second interphase-like period, called interkinesis, before meiosis II occurs. There is no second replication of DNA before meiosis II.

Meiosis II:


Chromosomes uncoil
Nuclear envelopes re-form
Cleavage furrow
Telophase I
The nuclear membranes re-form around the chromosomal masses, the spindle breaks down, and the chromatin reappears as telophase and cytokinesis end. The 2 daughter cells (now haploid) enter a second interphase-like period, called interkinesis, before meiosis II occurs. There is no second replication of DNA before meiosis II.
MEIOSIS II
Prophase II
Metaphase II
Anaphase II
Telophase II and cytokinesis
Products of meiosis: haploid daughter cells
Meiosis II begins with the products of meiosis I (2 haploid daughter cells) and undergoes a mitosis-like nuclear division process referred to as the equational division of meiosis.
After progressing through the phases of meiosis and cytokinesis, the product is 4 haploid cells, each genetically different from the original mother cell. (During human spermatogenesis, the daughter cells remain interconnected by cytoplasmic extensions during the meiotic phases.)

Meiosis – Conclusion:

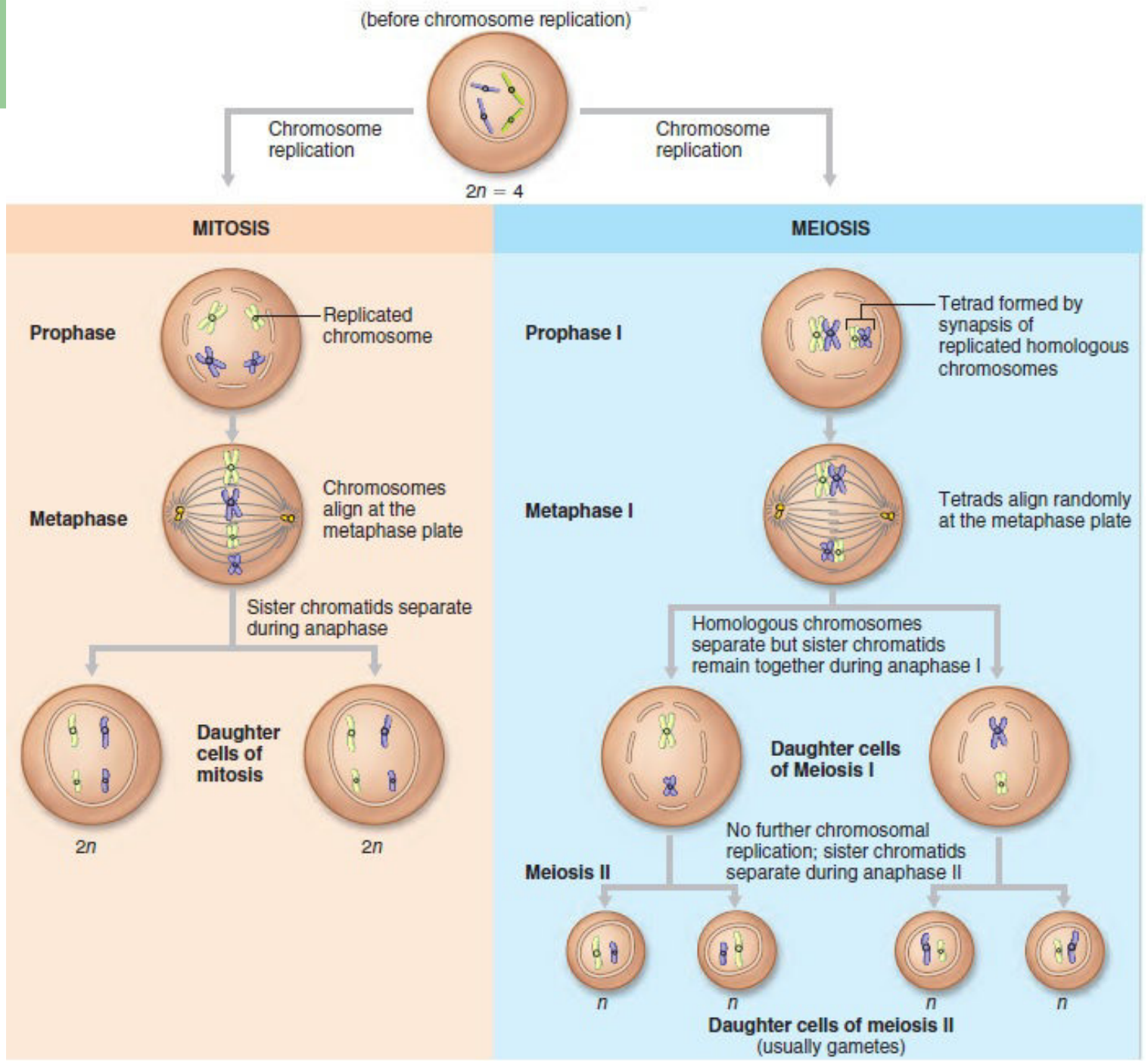
- Meiosis starts with DNA contents doubled from ***2C level to the 4C*** level during the ***S phase preceding division*** (this is similar to mitosis).

- Each daughter cell from ***Meiosis I gives rise to two daughter cells with 2C amount of DNA in half the normal number (haploid)of the chromosomes.***

- Consequently, the entire meiotic process ***(after Meiosis II)*** results in ***four haploid daughter cells with the 1C amount of DNA.***

- ***After fertilization***, the amount of ***DNA is restored to the 2C level in the zygote.***

Comparison Between Mitosis & Meiosis:



Comparison Between Mitosis & Meiosis:

	MITOSIS	MEIOSIS
Number of divisions	One, consisting of prophase, metaphase, anaphase, and telophase.	Two, each consisting of prophase, metaphase, anaphase, and telophase. DNA replication does not occur between the two nuclear divisions.
Synapsis of homologous chromosomes	Does not occur.	Occurs during prophase I; tetrads form, allowing crossovers.
Daughter cell number and genetic composition	Two. Each diploid ($2n$) cell is identical to the mother cell.	Four. Each haploid (n) cell contains half as many chromosomes as the mother cell and is genetically different from the mother cell.
Roles in the body	For development of multicellular adult from zygote. Produces cells for growth and tissue repair as multicellular adult develops. Ensures genetic makeup of all body cells is constant.	Produces cells for reproduction (gametes). Introduces genetic variability in the gametes and reduces chromosomal number by half so that when fertilization occurs, the normal diploid chromosomal number is restored (in humans, $2n = 46$).

Comparison of mitosis and meiosis in a mother cell with a diploid number ($2n$) of 4.