➢ ZOOLOGY

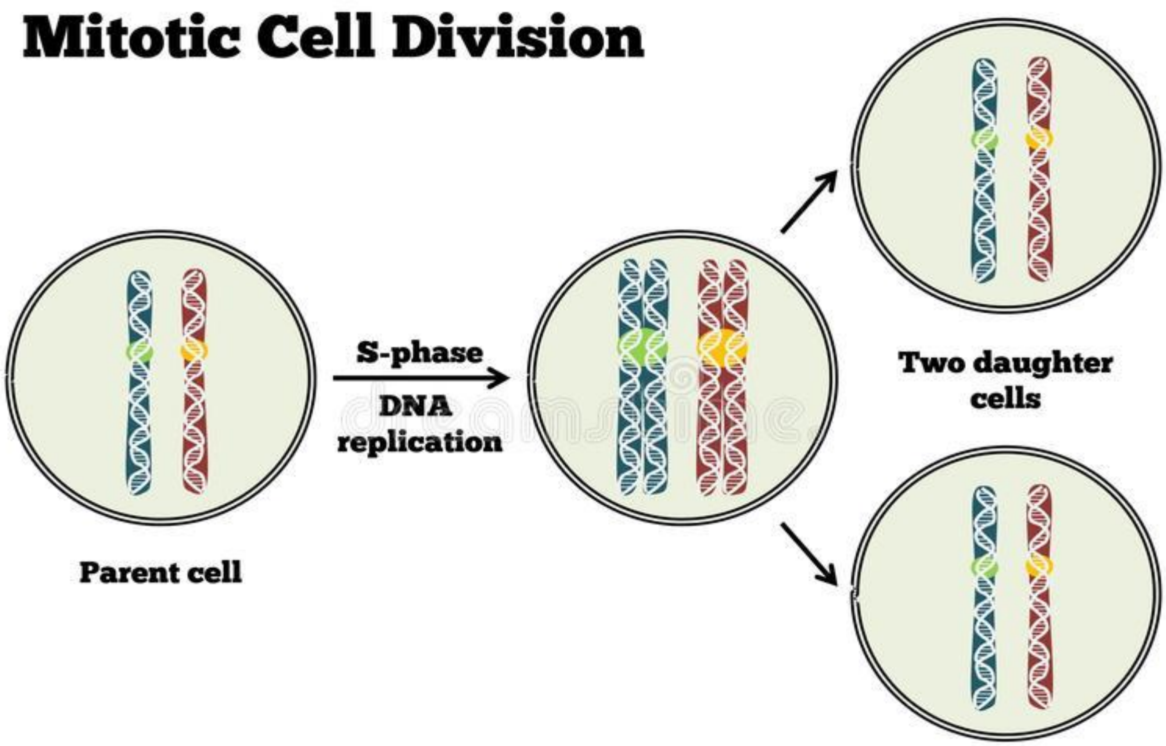
○ CELL DIVISION

❖ MITOTIC CELL DIVISION:

- ✓ ***Cell division*** occurs in all animals during growth and repair processes. Cells divide in two basic stages: Mitosis is division of the nucleus, and cytokinesis (*Gr. kytos, hollow vessel kinesis*, *motion*) is division of the cytoplasm. Between divisions (interphase), the cell must grow and carry out its various metabolic processes.

The cell cycle is that period from the time a cell is produced until it completes mitosis . The ***G1*** (first growth or gap) phase represents the early growth phase of the cell. During the S (*DNA synthesis*) phase, growth continues, but this phase also involves DNA replication.

The ***G2*** (second growth or gap) phase prepares the cell for division. It includes replication of the mitochondria and other organelles, synthesis of microtubules and protein that will make up the mitotic spindle fibers, and chromosome condensation. The ***M (mitotic)*** phase includes events associated with partitioning chromosomes between two daughter cells and the division of the cytoplasm (***cytokinesis***).

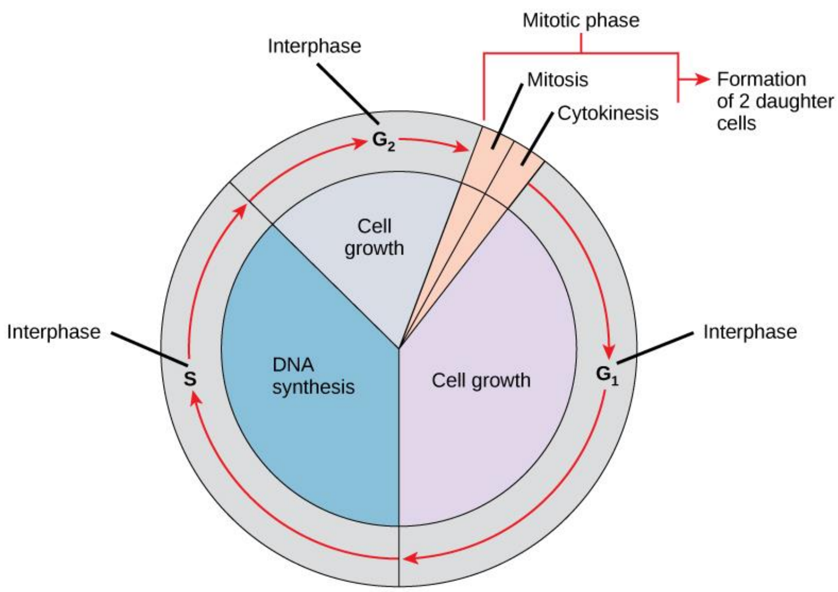


❖ INTERPHASE: REPLICATING THE HEREDITARY MATERIAL:

Interphase (L. inter,between) (includes the G1, S, and G2 phases) typically occupies about 90% of the total cell cycle. It is the period during which the normal activities of the cell take place. Interphase also sets the stage for cell division because *DNA* replication is completed during the S phase of interphase. Before a cell divides, an exact copy of the DNA is made. This process is called replication, because the double-stranded DNA makes ***a replica, or duplicate***, of itself.

Replication is essential to ensure that each daughter cell receives the same genetic material as is present in the parent cell. The result is a pair of *sister chromatids* . A chromatid is a copy of a chromosome produced by replication. Each chromatid attaches to its other copy, or sister, at a point of constriction called a centromere. The centromere is a specific DNA sequence of about ***220 nucleotides*** and has a specific location on any given chromosome.

Bound to each centromere is a disk of protein called a kinetochore, which eventually is an attachment site for the microtubules of the *mitotic spindle*. As the cell cycle moves into *the G2 phase* the chromosomes begin condensation. During the G2 phase, the cell also begins to assemble the structures that it will later use to move the chromosomes to opposite poles (ends) of the cell. For example, centrioles replicate, and there is extensive synthesis of the proteins that make up the microtubules.



❖ **MITOSIS**:

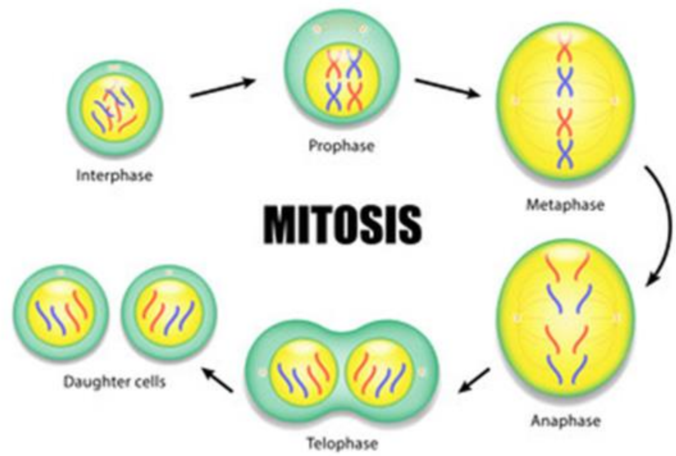
Mitosis is divided into four phases**: prophase, metaphase**, **anaphase, and telophase**. In a dividing cell, however, the process is actually continuous, with each phase smoothly flowing into the next . The first phase of mitosis, prophase (Gr. pro, before phase), begins when chromosomes become visible with the light microscope as threadlike structures.

The **nucleoli** and nuclear envelope begin to break up, and the two centriole pairs move apart. By the end of prophase, the centriole pairs are at opposite poles of the cell. The centrioles radiate an array of microtubules called **asters** (L. aster, little star), which brace each centriole against the plasma membrane. Between the centrioles, the microtubules form a spindle of fibers that extends from pole to pole. The asters, spindle, centrioles, and microtubules are collectively called the mitotic spindle (or mitotic apparatus). As prophase continues, a second group of microtubules grows out from the kinetochore to the poles of the cell.

These **kinetochore microtubules** connect each sister chromatid to the poles of the spindle. As the dividing cell moves into metaphase (Gr. meta, after phase), the chromatids (replicated chromosomes) begin to align in the center of the cell, along the spindle equator. Toward the end of metaphase, the centromeres divide and detach the two sister chromatids from each other, although the chromatids remain aligned next to each other. After the centromeres divide, the sister chromatids are considered full-fledged chromosomes (**called daughter chromosomes).**

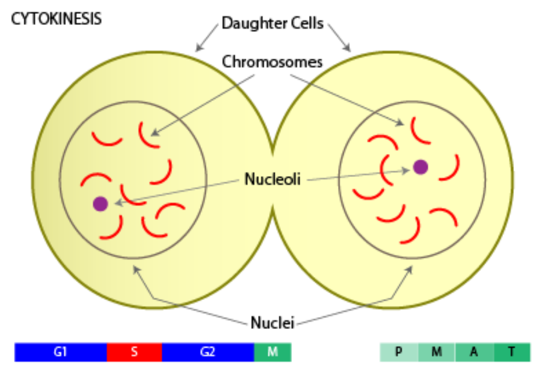
During **anaphase** (Gr. ana, back again phase), the shortening of the microtubules in the mitotic spindle pulls each daughter chromosome apart from its copy and toward its respective pole. Anaphase ends when all the daughter chromosomes have moved to the poles of the cell. Each pole now has a complete, identical set of chromosomes.

Telophase (Gr. telos, end phase) begins once the daughter chromosomes arrive at the opposite poles of the cell. During telophase, the mitotic spindle disassembles. A nuclear envelope reforms around each set of chromosomes, which begin to uncoil for gene expression, and the nucleolus is resynthesized. The cell also begins to pinch in the middle. Mitosis is over, but cell division is not.



❖ CYTOKINESIS: PARTITIONING THE CYTOPLASM:

The final phase of cell division is cytokinesis, in which the cytoplasm divides**. Cytokinesis** usually starts sometime during late anaphase or early telophase. A contracting belt of microfilaments called the contractile ring pinches the plasma membrane to form the cleavage furrow. The furrow deepens, and two new, genetically identical



Daughter cells forms.

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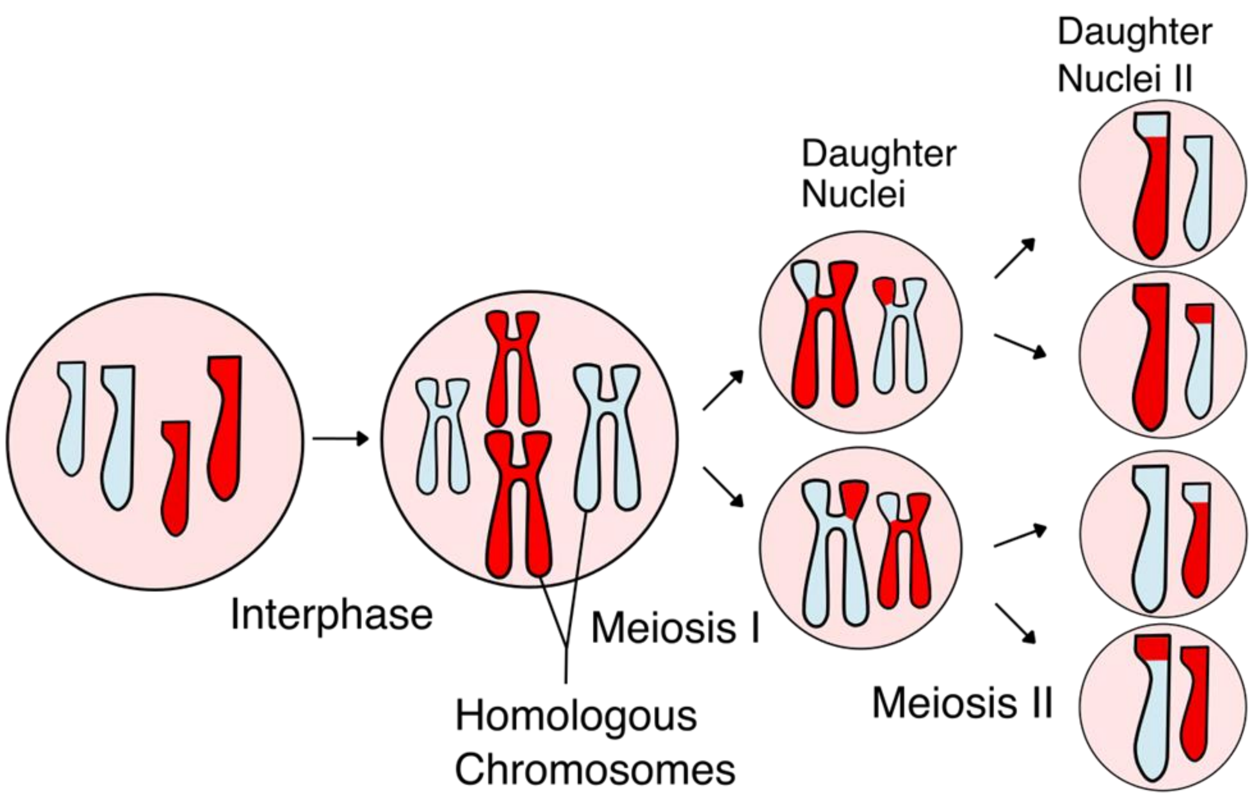
❖ <u>**MEIOSIS: THE BASIS OF SEXUAL REPRODUCTION:**</u>

Sexual reproduction requires a genetic contribution from two different sex cells. Egg and sperm cells are specialized sex cells called gametes (<u>***Gr. gamete,wife; gametes,husband***</u>). In animals, a male gamete (sperm) unites with a female gamete (egg) during fertilization to form a single cell called a zygote (<u>***Gr. zygotos, yoked together***</u>). The fusion of gametes is <u>*called syngamy(Gr. gamos,marriage*</u>).

The zygote is the first cell of the new animal. Each of the two gametes contributes half of the genetic information to the zygote. To maintain a constant number of chromosomes in the next generation, animals that reproduce sexually must produce gametes with half the chromosome number of their ordinary body cells (<u>***called somatic cells***</u>). All of the cells in the bodies of most animals, except for the egg and sperm cells, have the diploid (2N) number of chromosomes.

A type of cell division called meiosis (Gr. meiosis, dimunition) occurs in specialized cells of the ovaries and testes and reduces the number of chromosomes to the haploid (1N) number. The nuclei of the two gametes combine during fertilization and restore the diploid number. Meiosis begins after the G2 phase in the cell cycle—after DNA replication. Two successive nuclear divisions, designated meiosis I and meiosis II, take place.

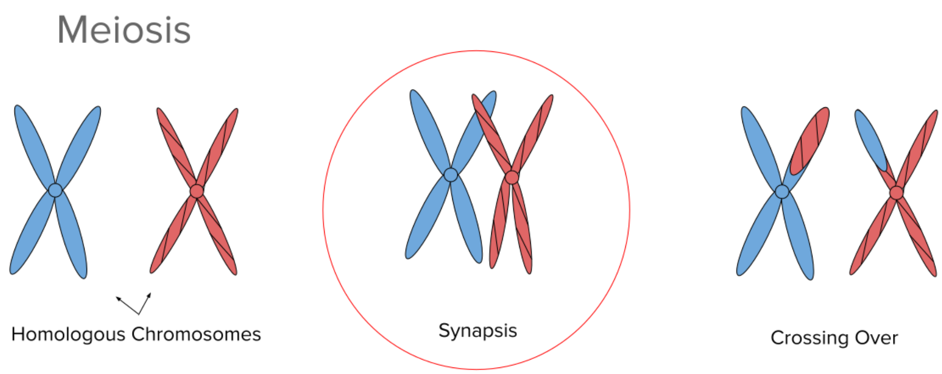
The two nuclear divisions of meiosis result in four daughter cells, each with half the number of chromosomes of the parent cell. Moreover, these daughter cells are not genetically identical. Like mitosis, meiosis is a continuous process, and biologists divide it into the phases that follow only for convenience.



❖ THE FIRST MEIOTIC DIVISION:

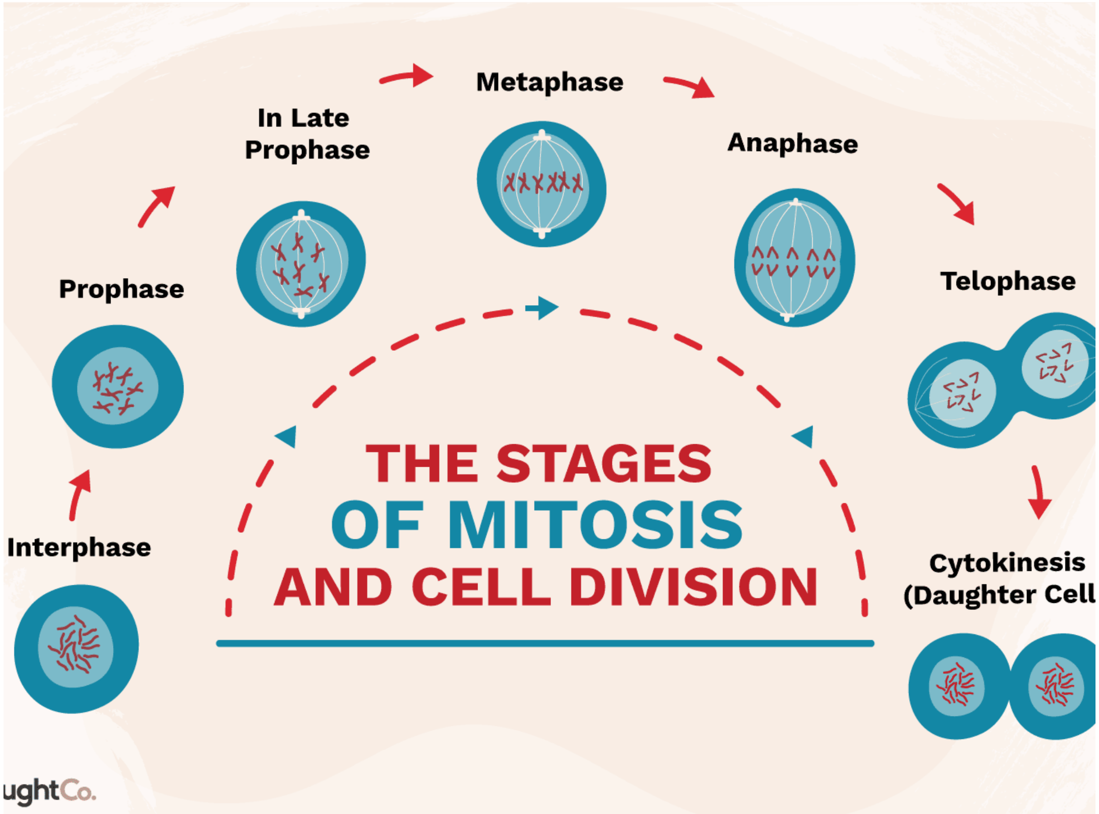
In prophase I; chromatin folds and chromosomes become visible under a light microscope . Because a cell has a copy of each type of chromosome from each original parent cell, it contains the diploid number of chromosomes. Homologous chromosomes (homologues) carry genes for the same traits, are the same length, and have a similar staining pattern, making them identifiable as matching pairs. During prophase I, homologous chromosomes line up side-by-side in a process called synapsis (Gr. synapsis, conjunction), forming a tetrad of chromatids (also called a bivalent). The tetrad thus contains the two homologous chromosomes, each with its copy, or sister chromatid . A network of protein **and RNA** is laid down between the sister chromatids of the two homologous chromosomes. This network holds the sister chromatids in a precise union so that each gene is directly across from its sister gene on the homologous chromosome

Synapsis also initiates a series of events **called crossingover**, whereby the nonsister chromatids of the two homologous chromosomes in a tetrad exchange DNA segments . This process effectively redistributes genetic information among the paired homologous chromosomes and produces new combinations of genes on the various chromatids in homologous pairs. Thus, each chromatid ends up with new combinations of instructions for a variety of traits. Crossing-over is a form of genetic recombination and is a major source of genetic variation in a population of a given species.



In metaphase I, the microtubules form a spindle apparatus just as in mitosis . However, unlike mitosis, where homologous chromosomes do not pair, each pair of homologues lines up in the center of the cell, with centromeres on each side of the spindle Anaphase I begins when homologous chromosomes separate and begin to move toward each pole. Because the orientation of each pair of homologous chromosomes in the center of the cell is random, the specific chromosomes that each pole receives from each pair of homologues are also random quator.

Meiotic telophase I is similar to mitotic telophase. The transition to the second nuclear division is called **interkinesis**. Cells proceeding through interkinesis do not replicate their DNA. After a varying time period, meiosis II occurs.



❖ <u>THE SECOND MEIOTIC DIVISION:</u>

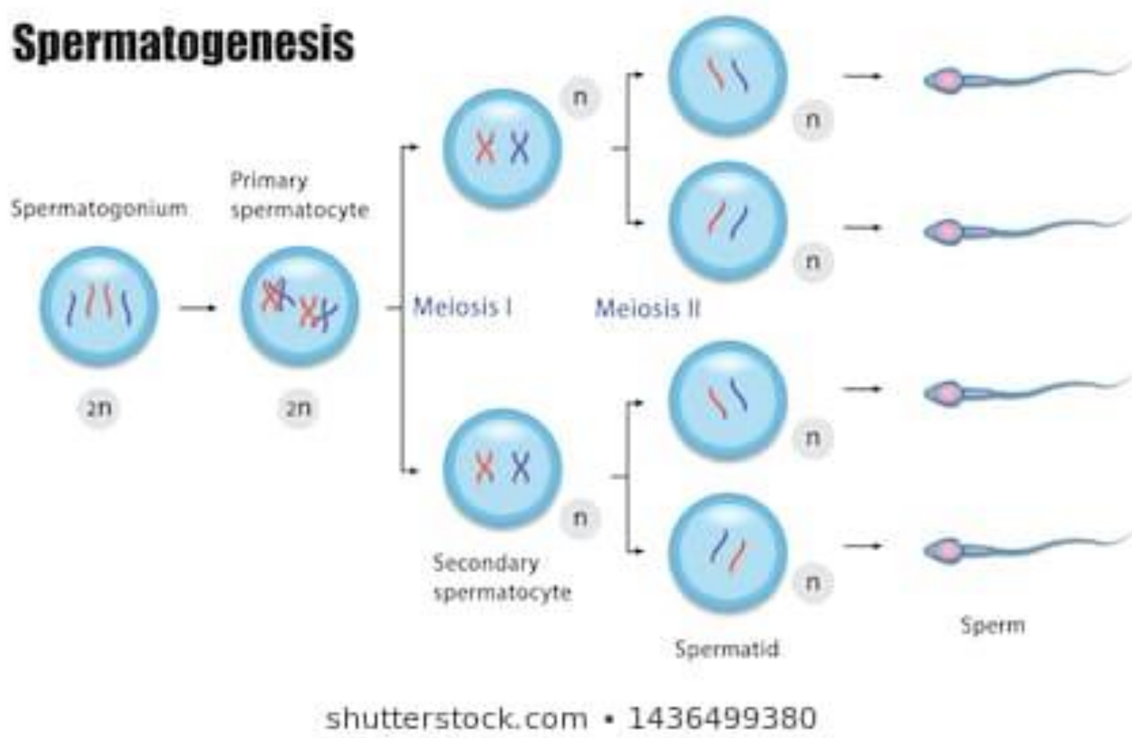
The second meiotic division (meiosis II) resembles an ordinary mitotic division , except the number of chromosomes has been reduced by half. The phases are **<u>prophase II,</u>**

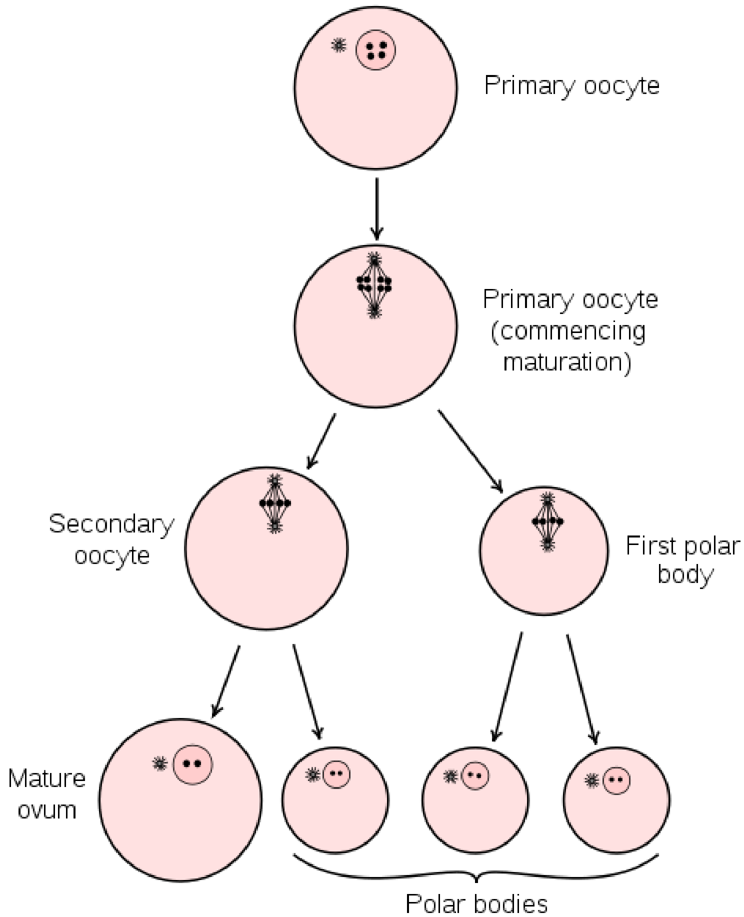
<u>metaphase II, anaphase II, and telophase II</u>. At the end of telophase II and cytokinesis, the final products of these two divisions of meiosis are four new "**division products**." In most animals, each of these "**division products**" is haploid and may function directly as a gamete (sex cell).

❖ <u>SPERMATOGENESIS AND OOGENESIS:</u>

The result of meiosis in most animals is the formation of sperm and egg cells**. Spermatogenesis** produces mature sperm cells and follows the sequence previously described. All four products of meiosis often acquire a flagellum for locomotion and a caplike structure that aids in the penetration of the egg.

Oogenesis produces a mature ovum or egg. It differs from spermatogenesis in that only one of the four meiotic products develops into the functional gamete. The other products of meiosis are called polar bodies and eventually disintegrate. In some animals the mature egg is the product of the first meiotic division and only completes meiosis if it is fertilized.





✓ ***<u>Oogenesis.</u>***