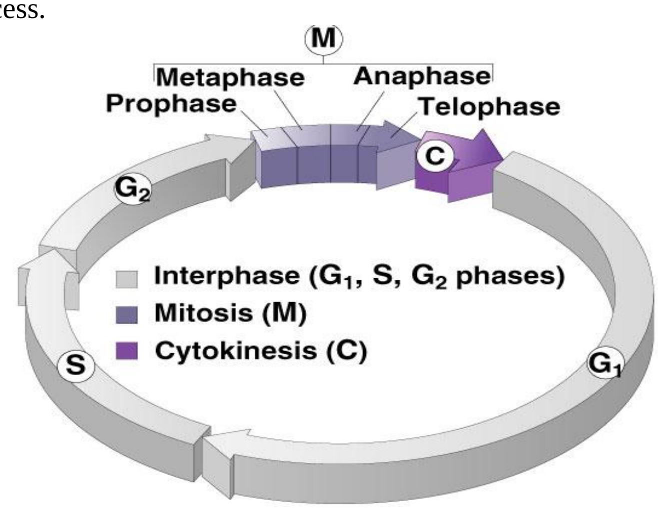
Cell Division and Reproduction

Mitosis

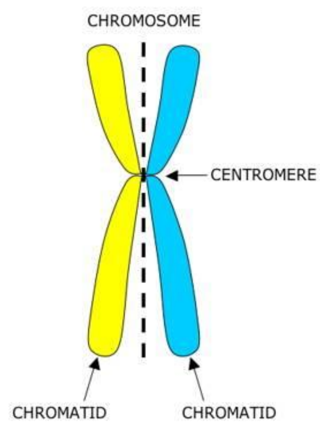
The ability of all life to replicate itself for future generations originates in reproduction of the cell. As stated in the cell theory, all cells arise from previous cells. This is true for one-celled organisms replicating their entire body, to multicellular organisms generating more cells within their larger, more complex bodies.

How long a cell lives and the amount of time the cell spends in each different stage can vary for each cell type, but some general statements can apply to the process. All cells spend about 90% of the cell cycle in interphase. Interphase is divided into three parts: G1, S, and G2. In G1, the cell experiences normal growth in volume and carries on normal processes of life (cell matures). In the S phase, the genetic information (DNA) is copied, providing the correct amount of this material for equal distribution during cell division. In G2 phase, the cell is chemically preparing for cell division by replicating organelles and creating chemicals, and enzymes needed for the actual division process.



Mitosis, also called karyokinesis, is division of the nucleus and its chromosomes. This process ensures that equal amounts of genetic material goes to each new cell that is formed in the cell division. It is followed by division of the cytoplasm known as cytokinesis. Both mitosis and cytokinesis are parts of the life of a cell called the Cell Cycle. Mitosis has 4 major stages --- Prophase, Metaphase, Anaphase, and Telophase. When a living organism needs new cells to repair damage, grow, or just maintain its condition, cells undergo mitosis.

During **Prophase,** the DNA and proteins start to condense (coil, thicken, and shorten to compact form) so it is moved more easily during division. Once the chromatin, or genetic material has condensed, it can then be visible under a microscope. The chromatin is called chromosomes now. A chromosome in prophase is made of two sister chromatids joined at a centromere.

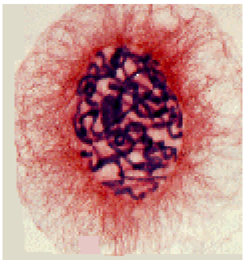


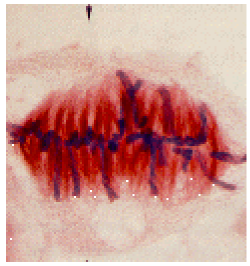
The two small centrioles move toward the opposite end of the cell (poles) in animals or microtubules are assembled in plants to form a spindle. Centrioles line up long, thin wire-like structures called spindle fibers across the length of the cell from pole to pole. These spindle fibers help line up the chromosomes during the next phase of mitosis. The nuclear envelope and nucleolus also start to break up. Prophase is the longest part of mitosis.

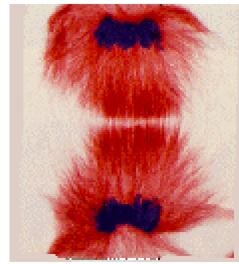
During **Metaphase**, the spindle apparatus attaches to sister chromatids of each chromosome. All the chromosomes are line up at the equator of the spindle. They are now in their most tightly condensed form.

During **Anaphase**, the spindle fibers attached to the two sister chromatids of each chromosome contract and separate chromosomes which move to opposite poles of the cell.

In **Telophase**, as the 2 new cells pinch in half (animal cells) or a cell plate forms (plant cells), the chromosomes become less condensed again and reappear as chromatin. New membrane forms nuclear envelopes and the nucleolus is reformed.



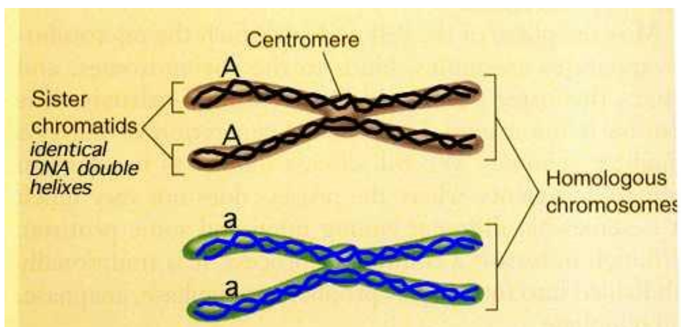




Prophase **Metaphase** **Anaphase** **Telophase**

Cytokinesis is the name given to the division of the cytoplasm of one cell into two new cells. In animal cells cytokinesis is conducted by the cell membrane pinching in at the equator until it eventually forms two new cells. In plant cells, cytokinesis is performed by a structure called a cell plate, which forms down the center to create two new cells. All one-celled organisms reproduce by mitosis. Mitosis is used by multicellular organisms for the growth and repair of all the cells in their bodies except cells called gametes (sex cells).

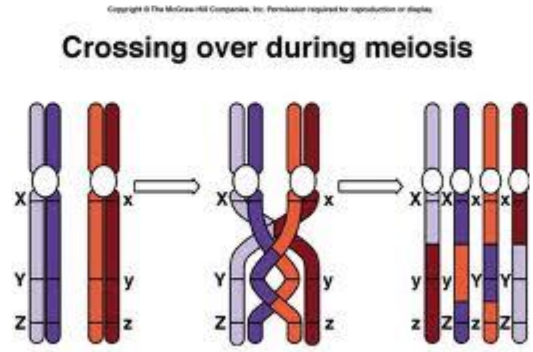
Meiosis



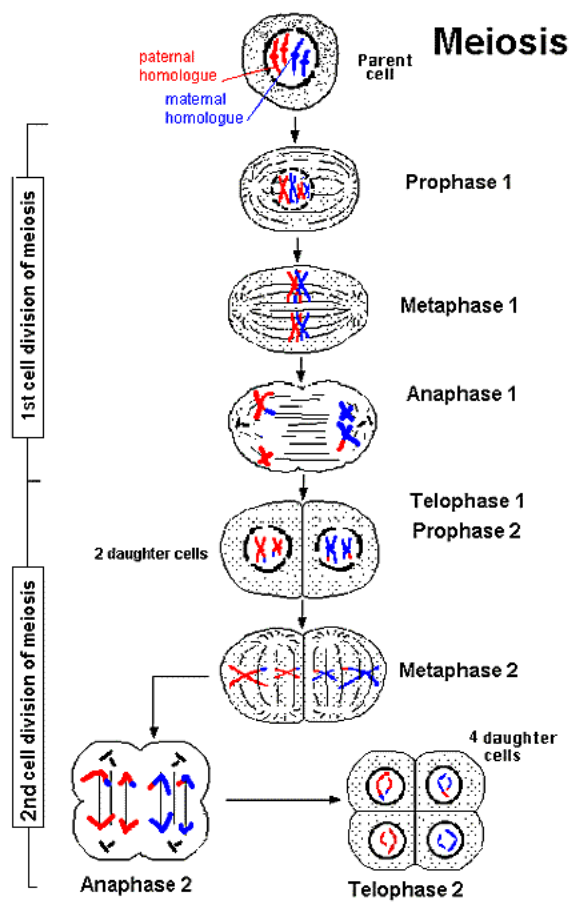
Gametes are the sex cells found in the bodies of multicellular organisms. All human cells are produced by mitosis except the sperm and egg which are the human sex cells, or gametes. Sex cells divide in a special process called meiosis. Meiosis is a process of cellular division where the genetic information is reduced in half for the newly created cells. In sexual reproduction, genetic information from the male and female are put together to produce a new organism. The new organism must have the same number of chromosomes as each of the parents. Meiosis ensures that each parent donates only half of the needed chromosomes, as seen in the sex cell, to the offspring. When each parent donates half of the needed chromosomes, the offspring will have the full number of chromosomes after fertilization (the two gametes join together) occurs. All body cells that have a full number of chromosomes are said to be **diploid** (2n----1n from each parent). Sex cells have half the number of chromosomes as diploid cells and so are called **haploid** (1n or half the full number). To achieve half of the number, the sex cells have to go through two divisions once the DNA is copied.

The actions of interphase, during the cell cycle, are basically the same for sex cells and body cells. It is when the sex cell begins the process of cell division or meiosis that some significant differences occur compared to mitosis of body cells. Meiosis is subdivided into stages that show the division and reduction of genetic information. In the first stage called Prophase I, the cell begins to coil and thicken its doubled genetic information. Then in a step unique to meiosis, each pair of sister chromatids matches up with another set of sister chromatids. This action forms a four-part structure called a **tetrad**, which are actually 2 homologous sets of sister chromatids. One pair is a copy of the mother parent DNA and the other pair is a copy of the male parent DNA.

When these sets of sister chromatids join together to form tetrads, some genetic information is exchanged between the chromatids. This exchange of genetic information is called crossing over. The process of crossing over makes the chromosomes more genetically diverse, which leads to more genetically diverse offspring.



The tetrads line up at the center of the cell preparing for division during the second stage of meiosis called Metaphase I. This is a difference from metaphase in mitosis where just the sister chromatids line up at the center of the cell. In the third stage of meiosis, Anaphase I, the tetrads separate into pairs of sister chromatids and move toward the poles of the cell. In Telophase I, the sister chromatids uncoil and the cell begins to go though cytokinesis and pinch into two new cells. At the end of this phase, there are two new daughter cells with a normal number of chromosomes, but they will divide again in order to achieve the half number which they need to become sex cells. The two new cells do NOT go through another interphase so that no additional copy of the DNA is made. Going through another division of genetic information is done by going through the four phases again—Prophase II, Metaphase II, Anaphase II, and Telophase II. These four stages ensure that each of the four cells created has a single copy of each chromosome.



Spermatogenesis and Oogenesis

The process in human males where the sex cells divide and mature into haploid sperm cells is called spermatogenesis. A human male will produce millions of sperm in this fashion from puberty almost until death. One mature male sex cell will produce four viable, fully functioning sperm.

The process in human females where the sex cells divide and mature into haploid egg cells is called oogenesis. A human female will normally produce one mature egg cell about every month from puberty until menopause when the menstrual cycle ends. The development of one female sex cell will produce only one mature egg cell and three polar bodies which are not viable due to lack of cytoplasm which went to the one mature egg cell to aid it in the future development of offspring when fertilized.