Medical Biology

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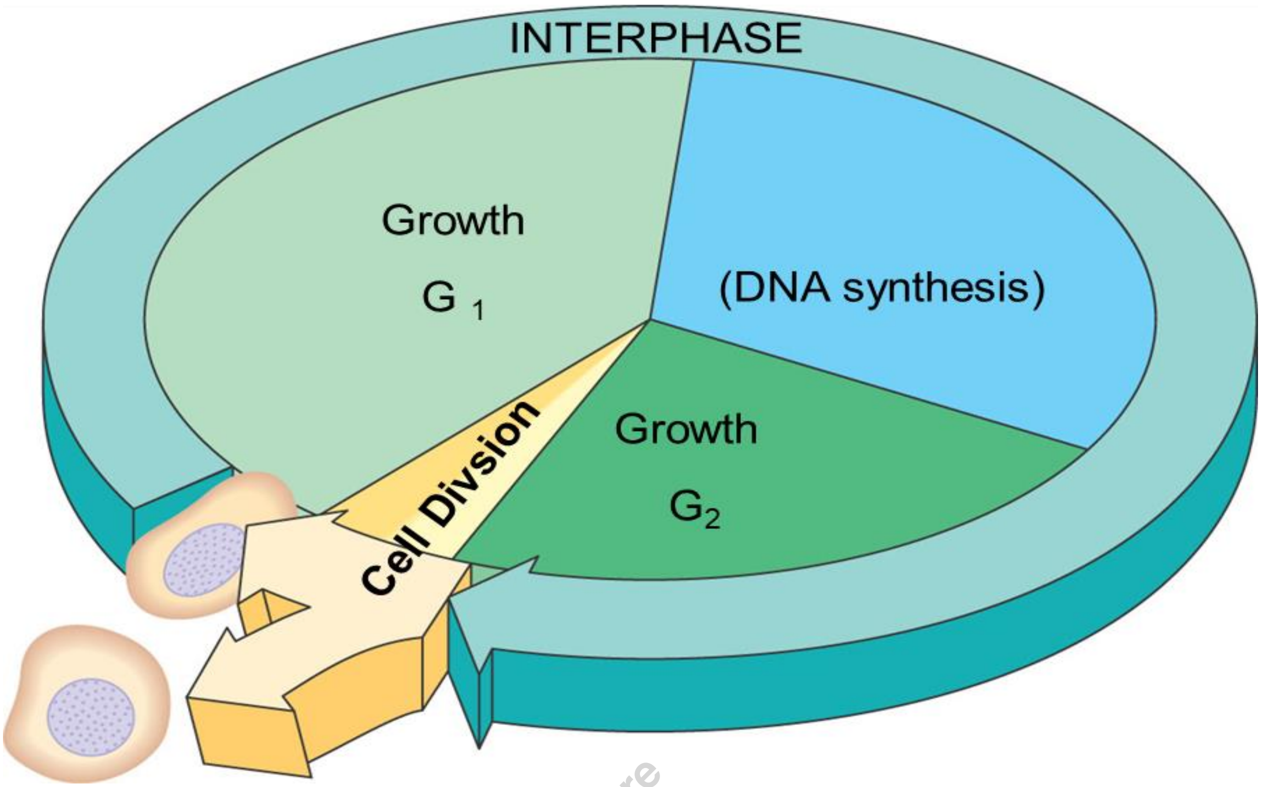
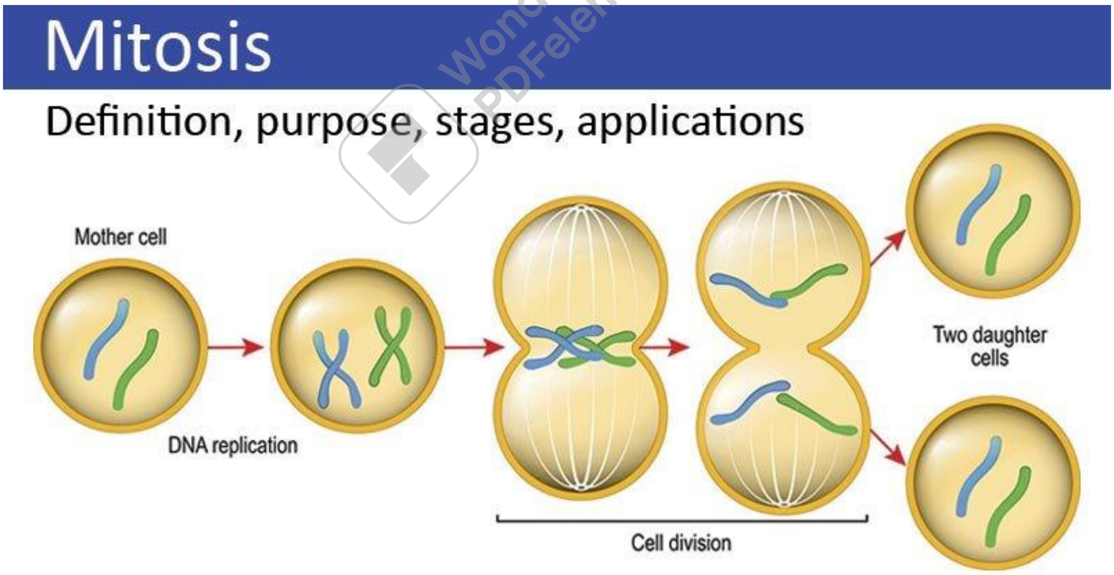
Cytology

cell cycle

A cell cycle is a series of events that takes place in a cell as it grows and divides. A cell spends most of its time in what is called interphase, and during this time it grows, replicates its chromosomes, and prepares for cell division. The cell then leaves interphase, undergoes mitosis, and completes its division. The resulting cells, known as daughter cells, each enter their own interphase and begin a new round of the cell cycle. Cell cycle has different stages called G1, S, G2, and M. G1 is the stage where the cell is preparing to divide. To do this, it then moves into the S phase where the cell copies all the DNA. So, S stands for DNA synthesis. After the DNA is copied and there's a complete extra set of all the genetic material, the cell moves into the G2 stage, where it organizes and condenses the genetic material, or starts to condense the genetic material, and prepares to divide. The next stage is M. M stands for mitosis. This is where the cell actually partitions the two copies of the genetic material into the two daughter cells. After M phase completes, cell division occurs and two cells are left, and the cell cycle can begin again.


INTERPHASE
Growth
G 1
(DNA synthesis)
Growth
G_2
Cell Division


Mitosis
Definition, purpose, stages, applications
Mother cell
DNA replication
Cell division
Two daughter cells

mitosis

Prophase

Mitosis begins with prophase, during which chromosomes recruit condensin and begin to undergo a condensation process that will continue until metaphase. In most species, cohesin is largely removed from the arms of the sister chromatids during prophase, allowing the individual sister chromatids to be resolved. Cohesin is retained, however, at the most constricted part of the chromosome, the centromere . During prophase, the spindle also begins to form as the two pairs of centrioles move to opposite poles and microtubules begin to polymerize from the duplicated centrosomes.

Prometaphase

Prometaphase begins with the abrupt fragmentation of the nuclear envelope into many small vesicles that will eventually be divided between the future daughter cells. The breakdown of the nuclear membrane is an essential step for spindle assembly. Because the centrosomes are located outside the nucleus in animal cells, the microtubules of the developing spindle do not have access to the chromosomes until the nuclear membrane breaks apart.

Prometaphase is an extremely dynamic part of the cell cycle. Microtubules rapidly assemble and disassemble as they grow out of the centrosomes, seeking out attachment sites at chromosome kinetochores, which are complex platelike structures that assemble during prometaphase on one face of each sister chromatid at its centromere. As prometaphase ensues, chromosomes are pulled and tugged in opposite directions by microtubules growing out from both poles of the spindle, until the pole-directed forces are finally balanced. Sister chromatids do not break apart during this tug-of-war because they are firmly attached to each other by the cohesin remaining at their centromeres. At the end of prometaphase, chromosomes have a bi-orientation, meaning that the kinetochores on sister chromatids are connected by microtubules to opposite poles of the spindle.

Metaphase

Next, chromosomes assume their most compacted state during metaphase, when the centromeres of all the cell's chromosomes line up at the equator of the spindle. Metaphase is particularly useful in cytogenetics, because chromosomes can be most easily visualized at this stage. Furthermore, cells can be experimentally arrested at metaphase with mitotic poisons such as colchicine. Video microscopy shows that chromosomes temporarily stop moving during metaphase. A complex checkpoint mechanism determines whether the spindle is properly assembled, and for the most part, only cells with correctly assembled spindles enter anaphase.

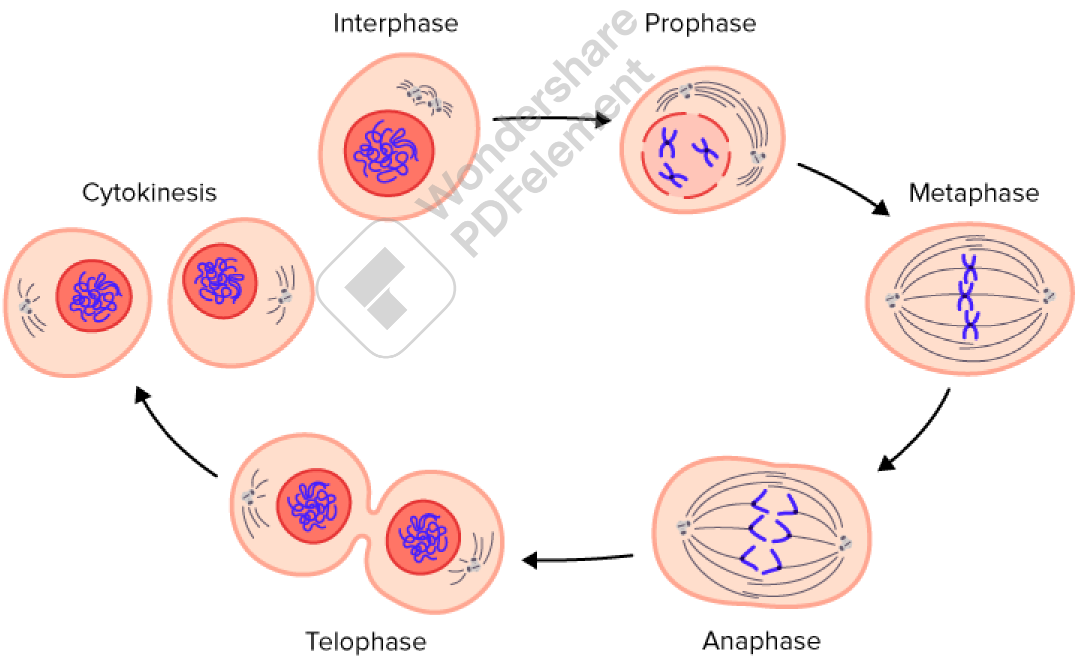
Anaphase

The progression of cells from metaphase into anaphase is marked by the abrupt separation of sister chromatids. A major reason for chromatid separation is the precipitous degradation of the cohesin molecules joining the sister chromatids by the protease separase (Figure 10.(

Two separate classes of movements occur during anaphase. During the first part of anaphase, the kinetochore microtubules shorten, and the chromosomes move toward the spindle poles. During the second part of anaphase, the spindle poles separate as the non-kinetochore microtubules move past each other. These latter movements are currently thought to be catalyzed by motor proteins that connect microtubules with opposite polarity and then "walk" toward the end of the microtubules.

Telophase and Cytokinesis

Mitosis ends with telophase, or the stage at which the chromosomes reach the poles. The nuclear membrane then reforms, and the chromosomes begin to decondense into their interphase conformations. Telophase is followed by cytokinesis, or the division of the cytoplasm into two daughter cells. The daughter cells that result from this process have identical genetic compositions.



Meiosis

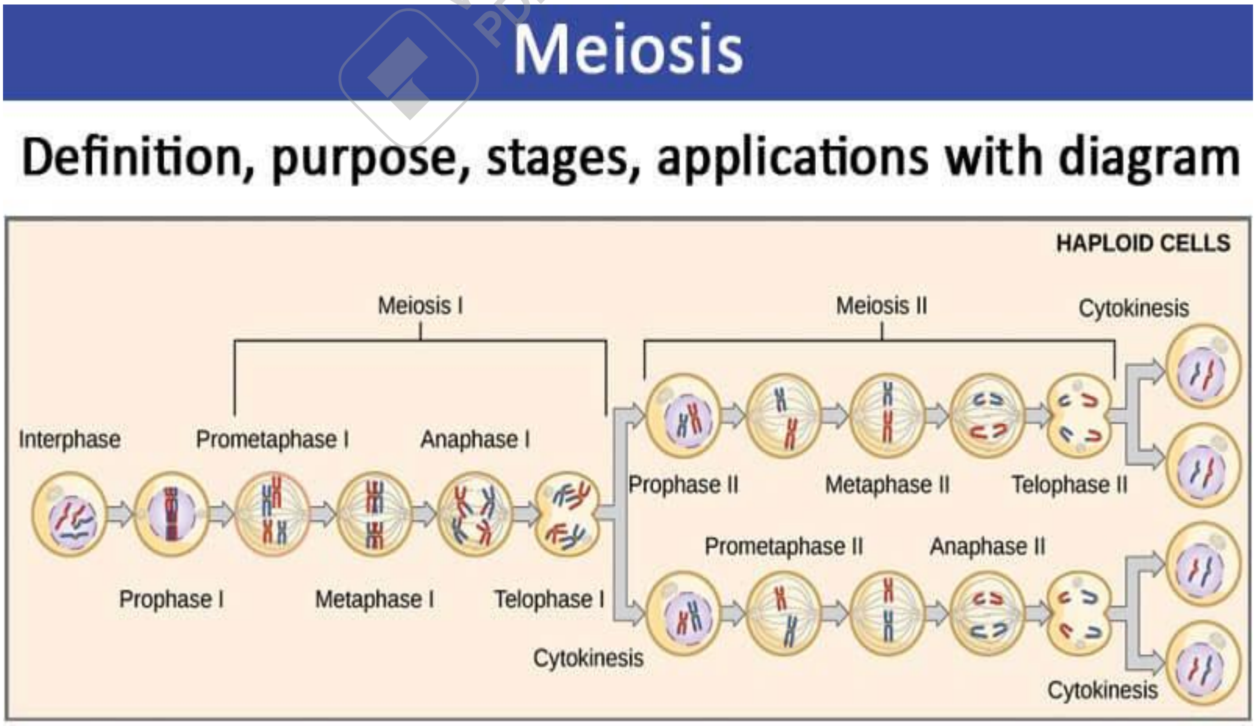
A special form of cell division needed to produce sex cells - for example, sperm and eggs with only one copy of each chromosome. Fusion of the sex cells creates a new individual with two copies of each chromosome. This process is required to produce egg and sperm cells for sexual reproduction. During reproduction, when the sperm and egg unite to form a single cell, the number of chromosomes is restored in the offspring.

Meiosis begins with a parent cell that is diploid, meaning it has two copies of each chromosome. The parent cell undergoes one round of DNA replication followed by two separate cycles of nuclear division. The process results in four daughter cells that are haploid, which means they contain half the number of chromosomes of the diploid parent cell.

Meiosis has both similarities to and differences from mitosis, which is a cell division process in which a parent cell produces two identical daughter cells. Meiosis begins following one round of DNA replication in cells in the male or female sex organs. The process is split into meiosis I and meiosis II, and both meiotic divisions have multiple phases. Meiosis I is a type of cell division unique to germ cells, while meiosis II is similar to mitosis.

Meiosis I, the first meiotic division, begins with prophase I. During prophase I, the complex of DNA and protein known as chromatin condenses to form chromosomes. The pairs of replicated chromosomes are known as sister chromatids, and they remain joined at a central point called the centromere. A large structure called the meiotic spindle also forms from long proteins called microtubules on each side, or pole, of the cell. Between prophase I and metaphase I, the pairs of homologous chromosome form tetrads. Within the tetrad, any pair of chromatid arms can overlap and fuse in a process called crossing-over or recombination. Recombination is a process that breaks, recombines and rejoins sections of DNA to produce new combinations of genes. In metaphase I, the homologous pairs of chromosomes align on either side of the equatorial plate. Then, in anaphase I, the spindle fibers contract and pull the homologous pairs, each with two chromatids, away from each other and toward each pole of the cell. During telophase I, the chromosomes are enclosed in nuclei. The cell now undergoes a process called cytokinesis that divides the cytoplasm of the original cell into two daughter cells. Each daughter cell is haploid and has only one set of chromosomes, or half the total number of chromosomes of the original cell.

Meiosis II is a mitotic division of each of the haploid cells produced in meiosis I. During prophase II, the chromosomes condense, and a new set of spindle fibers forms. The chromosomes begin moving toward the equator of the cell. During metaphase II, the centromeres of the paired chromatids align along the equatorial plate in both cells. Then in anaphase II, the chromosomes separate at the centromeres. The spindle fibers pull the separated chromosomes toward each pole of the cell. Finally, during telophase II, the chromosomes are enclosed in nuclear membranes. Cytokinesis follows, dividing the cytoplasm of the two cells. At the conclusion of meiosis, there are four haploid daughter cells that go on to develop into either sperm or egg cells.



Gametogenesis:-The production of gametes , in human ovum in female and sperms in male .

Oogenesis: The development of eggs within the ovaries.

At birth each ovary contains many thousands of follicles and each follicle contains one dormant primary oocyte (2n).

A primary oocyte can be triggered to develop further by FSH (follicle stimulating hormone)secreted by anterior pituitary gland .After puberty and until menopause about every 28 days FSH stimulates one of the dormant follicles to develop. The follicle enlarges and the primary oocyte within it completes meiosisI and begins meiosisII. The division of the cytoplasm in mieosisI is unequal , with a single secondary oocyte(n) receiving almost all of it . The smaller of the two daughter cells called the first polar body receives almost no cytoplasm . About the time the secondary oocyte forms , the pituitary gland secrets LH (lutenizing hormone) wich causes ovulation. The ripening follicle bursts releasing its secondary oocyte from the ovary .The ruptured follicle then develops into a corpus luteum . The secondary oocyte completes meiosisII which is unequal too , and forming ootid (n) and second polar body .1st and 2nd polar bodies are degenerated and ootid differentiated into ovum.

Spermatogenesis :-The formation of sperms.

Sperm cells develop inside the testes in seminiferous tubules . cells near the outer walls of the tubules multiply constantly by mitosis . Each day about 3 million of them differentiate into primary spermatocytes (2n) , the cells that undergo meiosis .MeiosisI of primary spermatocyte produces 2 secondary spermatocytes(n) and 4 haploid immature spermatids form as a result of meiosisII . The spermatids differentiate into immature sperms that are gradually pushed toward the center of the tubules , the sperms pass into the epididymis where they mature,become motile, and stored until ejaculation .

Both oogenesis and spermatogenesis produce haploid gametes , but there are several important differences between them :-

One obvious difference is location , testes in male and ovaries in female . Furthermore ,human males create new sperms every day from puberty through old age human females on the other hand, create primary oocytes only during fetal development; a woman is born with all the primary oocytes she will ever has.

Another difference four gametes result from each diploid parent cell during spermatogenesis, whereas oogenesis result in only one gamete from each parent cell. Moreover, there are significant differences in the cells produced by meiosis: sperms are small and motile and contain relatively few nutrients; eggs are large, non-motile, and well stocked with nutrients. Finally, oogenesis is not actually completed without stimulation from a sperm cell, whereas males complete spermatogenesis before the sperm leave the testis.