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Eukaryotic cells, which are all the cells that do not belong to the prokaryotic organisms in the bacteria and archaea domains, make copies of themselves by replicating their genetic material and then splitting in two from the inside out.This, however, is unlike the simple division of cell contents called _binary fission_ seen in prokaryotes. It comes in one of two forms: **mitosis** and **meiosis**. Mitosis is the simpler of these two related cell-division processes and is similar to binary fission in that it is a single division that results in the formation of two genetically identical daughter cells with the same diploid number of chromosomes as the parent cell (46 in humans).Meiosis, however, encompasses two successive divisions, resulting in four daughter cells with a haploid chromosome number (23 in humans); these daughter cells are genetically distinct from the parent cell and from each other. Both mitosis and meiosis start with a diploid parent cell that splits into daughter cells. The diploid number results from the fact that each cell includes one copy of each chromosome (numbered one through 22 in humans, plus one sex chromosome) from the organism's mother and one from the father. These copies of each chromosome are known as homologous chromosomes and are found only in the domain of sexual reproduction.Because the cell has replicated its chromosomes earlier in the cell cycle, the genetic material at the onset of mitosis or meiosis includes 92 individual chromatids, arranged in identical pairs of sister chromatids joined at a structure called a centromere to create a duplicated chromosome.Sister chromatidsare nothomologous chromosomes.In addition, both processes can be divided into four substages, or phases: prophase, metaphase, anaphase and telophase, with mitosis finishing after one round of this scheme and meiosis proceeding through a second. The essential characteristics of the respective phases of both mitosis and meiosis in humans are:**Prophase:**Chromatin condenses into 46 chromosomes.**Metaphase:**Chromosomes are aligned on the cell midline, or equator.**Anaphase:**Sister chromatidsare pulled toopposite polesof the cell.**Telophase:**Nuclear envelope forms around each set of daughter nuclei.After this separation of the nucleus and its contents, **cytokinesis**, the division of the entire parent cell, follows in short order.Because meiosis includes two rounds of this, these are neatly termed meiosis I and meiosis II. Meiosis I thus includes prophase I, metaphase I and so on and accordingly for meiosis II. It is during prophase I and metaphase I of meiosis that the events that ensure genetic diversity in offspring occur. These are called crossing over (or recombination) and independent assortment respectively. Mitosis is the process by which an organism's cells are continually replenished after they die as a result of physical trauma from the outside or natural aging from within. It therefore occurs in every eukaryotic cell, although turnover rates differ markedly between tissue types (e.g., muscle cell and skin cell turnover are typically very high, while heart cell turnover is not).Meiosis, on the other hand, occurs only in specialized glands called the gonads (testicles in males, ovaries in females).Also, as noted, mitosis has one round of phases that gives rise to two daughter cells, whereas meiosis has two phases and gives rise to four daughter cells. It helps to organize these schemes if you keep in mind that meiosis II is simply a mitotic division. Also, neither phase of meiosis involves the replication of any new genetic material. DNA replication is a result of the one-two punch recombination of and independent assortment.\(csv-tableMitosis MeiosisDefinition Diploid parent/mother cell divides into two identical diploid daughter cells Diploid parent/mother cell undergoes two separatedivision events to create 4 haploid daughter cellswith increased genetic variationFunction Growth, repair, and maintenance of organism/cells For creation of cells used in sexual reproductionNumber of Parent Cells One OneNumber of Division Events One Two (Meiosis I and Meiosis II)Chromosome Number in Parent/Mother Cell Diploid DiploidDaughter Cells Produced Two diploid cells 4 haploid cells (chromosome number halved).Males: 4 haploid sperm cellsFemales: 1 haploid egg cell, 3 polar bodiesCrossover Events Do not occur Do occurType of Reproduction Asexual SexualSteps of the Process Interphase, Prophase, Metaphase, Anaphase, Telophase/Cytokinesis Interphase, Meiosis I (Prophase I, Metaphase I, Anaphase I, Telophase I),Meiosis II (Prophase II, Metaphase II, Anaphase II, Telophase II)Homologous Pairs Present No YesWhere It Occurs All somatic cells In gonads only\) The daughter cells that result from meiosis are called gametes. Males produce gametes called sperm (spermatocytes), whereas females produce gametes known as egg cells (oocytes). Human males have one X sex chromosome and one Y sex chromosome, so sperm cells contain either a single X or a single Y chromosome. Human females have two X chromosomes and thus all of their egg cells have a single X chromosome.In the end, each daughter cell of meiosis is genetically "half-identical" to its parent no matter the result, yet is distinct from not only the parent cell but other daughter cells as well. In prophase I, not only do chromosomes become more condensed, but homologous chromosomes line up side by side to form tetrads, or bivalents. A single bivalent thus contains the sister chromatids of a given labeled chromosome (1, 2, 3 and so on up to 22) along with those of its homologous chromosome.Crossing over involves the swapping of lengths of DNA between adjoining non-sister chromatids in the middle of the bivalent. Although errors occur in this process, they are quite rare. The result is chromosomes that are very similar to the originals yet clearly distinct in their DNA composition. In metaphase I of meiosis, the tetrads line up along the metaphase plate, preparing to be pulled apart in anaphase I. But whether the female contribution to the tetrad winds up on a given side of the metaphase plate or whether the male contribution winds up in its place instead is purely a matter of chance.If humans had only one chromosome, then a gamete would wind up with either the derivative of the female homolog or the derivative of the male homolog (both of which are likely to have been modified by crossing over). So there would be two possible combinations of chromosomes in a given gamete.If humans had two chromosomes, the number of possible gametes would be four. Since humans have 23 chromosomes, a given cell can give rise to 223 = almost 8.4 million distinct gametes as a result of independent assortment in meiosis 1 alone. While meiosis is the engine driving genetic diversity in eukaryotic reproduction, mitosis is the force that allows everyday, moment-to-moment survival and growth. The human body contains trillions of somatic cells (that is, cells outside the gonads that cannot undergo meiosis) that must be able to respond to changing environmental conditions through various repair mechanisms.Without mitosis to give the body new cells to work with, this would all be moot.Mitosis unfolds at vastly different rates throughout the body. In the brain, for example, adult cells almost never divide. The epithelial cells on the surface of the skin, on the other hand, typically "turn over" every few days.When the cells divides, it may then differentiate into more specialized cells as a result of specific intracellular signals, or it may continue to divide in a way that retains its original composition but the capacity for differentiation on command. In bone marrow, for example, stem cell mitosis yields daughter cells that can develop into red blood cells, white blood cells and other kinds of blood cells.The "differentiable" but not-yet-specialized cells are known as stem cells, and they are vital in medical research as scientists continue to discover new techniques to prod cells to divide into specifically determined tissues rather than persist along their "natural" course.Related topics:Why Is Mitosis a Form of Asexual Reproduction? Beck, Kevin. "Mitosis Vs Meiosis: What Are The Similarities & Differences?" sciencing.com, . 17 July 2019. APA Beck, Kevin. (2019, July 17). Mitosis Vs Meiosis: What Are The Similarities & Differences?. sciencing.com. Retrieved from Chicago Beck, Kevin. Mitosis Vs Meiosis: What Are The Similarities & Differences? last modified August 30, 2022. Cell division producing haploid gametesFor the figure of speech, see Meiosis (figure of speech). For the process whereby cell nuclei divide to produce two copies of themselves, see Mitosis. For excessive constriction of the pupils, see Miosis. For the parasitic infestation, see Myiasis. For muscle inflammation, see Myositis.This article needs additional citations for verification. Please help improve this article by adding citations to reliable sources. Unsourced material may be challenged and removed.Find sources:"Meiosis"news newspapers books scholar JSTOR (February 2023) (Learn how and when to remove this message)In meiosis, the chromosomes duplicate (during interphase) and homologous chromosomes exchange genetic information (chromosomal crossover) during the first division, called meiosis I. The daughter cells divide again in meiosis II, splitting up sister chromatids to form haploid gametes. Two gametes fuse during fertilization, forming a diploid cell (zygote) with a complete set of paired chromosomes.Meiosis (/maoss/)[a] is a special type of cell division of germ cells in sexually-reproducing organisms that produces the gametes, the sperm or egg cells. It involves two rounds of division that ultimately result in four cells, each with only one copy of each chromosome (haploid). Additionally, prior to the division, genetic material from the paternal and maternal copies of each chromosome is crossed over, creating new combinations of code on each chromosome.[3] Later on, during fertilisation, the haploid cells produced by meiosis from a male and a female will fuse to create a zygote, a cell with two copies of each chromosome.Errors in meiosis resulting in aneuploidy (an abnormal number of chromosomes) are the leading known cause of miscarriage and the most frequent genetic cause of developmental disabilities.[4]In meiosis, DNA replication is followed by two rounds of cell division to produce four daughter cells, each with half the number of chromosomes as the original parent cell.[3] The two meiotic divisions are known as meiosis I and meiosis II. Before meiosis begins, during S phase of the cell cycle, the DNA of each chromosome is replicated so that it consists of two identical sister chromatids, which remain held together through sister chromatid cohesion. This S-phase can be referred to as "premeiotic S-phase" or "meiotic S-phase". Immediately following DNA replication, meiotic cells enter a prolonged G2-like stage known as meiotic prophase. During this time, homologous chromosomes pair with each other and undergo genetic recombination, a programmed process in which DNA may be cut and then repaired, which allows them to exchange some of their genetic information. A subset of recombination events results in crossovers, which create physical links known as chiasmata (singular: chiasma, for the Greek letter Chi,) between the homologous chromosomes. In most organisms, these links can help direct each pair of homologous chromosomes to segregate away from each other during meiosis I, resulting in two haploid cells that have half the number of chromosomes as the parent cell.During meiosis II, the cohesion between sister chromatids is released and they segregate from one another, as during mitosis. In some cases, all four of the meiotic products form gametes such as sperm, spores or pollen. In female animals, three of the four meiotic products are typically eliminated by extrusion into polar bodies, and only one cell develops to produce an ovum. Because the number of chromosomes is halved during meiosis, gametes can fuse (i.e. fertilization) to form a diploid zygote that contains two copies of each chromosome, one from each parent. Thus, alternating cycles of meiosis and fertilization enable sexual reproduction, with successive generations maintaining the same number of chromosomes. For example, diploid human cells contain 23 pairs of chromosomes including 1 pair of sex chromosomes (46 total), half of maternal origin and half of paternal origin. Meiosis produces haploid gametes (ova or sperm) that contain one set of 23 chromosomes. When two gametes (an egg and a sperm) fuse, the resulting zygote is once again diploid, with the mother and father each contributing 23 chromosomes. This same pattern, but not the same number of chromosomes, occurs in all organisms that utilize meiosis.Meiosis occurs in all sexually reproducing single-celled and multicellular organisms (which are all eukaryotes), including animals, plants, and fungi.[5][6][7] It is an essential process for oogenesis and spermatogenesis.Although the process of meiosis is related to the more general cell division process of mitosis, it differs in two important respects:RecombinationMeiosisShuffles the genes between the two chromosomes in each pair (one received from each parent), producing lots of recombinant chromosomes with unique genetic combinations in every gameteMitosisOccurs only if needed to repair DNA damage;Usually occurs between identical sister chromatids and does not result in genetic changesChromosome number (ploidy)MeiosisProduces four genetically unique cells, each with half the number of chromosomes as in the parentMitosisProduces two genetically identical cells, each with the same number of chromosomes as in the parentMeiosis begins with a diploid cell, which contains two copies of each chromosome, termed homologs. First, the cell undergoes DNA replication, so each homolog now consists of two identical sister chromatids. Then each set of homologs pair with each other and exchange genetic information by homologous recombination often leading to physical connections (crossovers) between the homologs. In the first meiotic division, the homologs are segregated to separate daughter cells by the spindle apparatus. The cells then proceed to a second division without an intervening round of DNA replication. The sister chromatids are segregated to separate daughter cells to produce a total of four haploid cells. Female animals employ a slight variation on this pattern and produce one large ovum and three small polar bodies. Because of recombination, an individual chromatid can consist of a new combination of maternal and paternal genetic information, resulting in offspring that are genetically distinct from either parent. Furthermore, an individual gamete can include an assortment of maternal, paternal, and recombinant chromatids. This genetic diversity resulting from sexual reproduction contributes to the variation in traits upon which natural selection can act.Meiosis uses many of the same mechanisms as mitosis, the type of cell division used by eukaryotes to divide one cell into two identical daughter cells. In some plants, fungi, and protists meiosis results in the formation of spores: haploid cells that can divide vegetatively without undergoing fertilization. Some eukaryotes, like bdelloid rotifers, do not have the ability to carry out meiosis and have acquired the ability to reproduce by parthenogenesis.Meiosis does not occur in archaea or bacteria, which generally reproduce asexually via binary fission. However, a "sexual" process known as horizontal gene transfer involves the transfer of DNA from one bacterium or archaeon to another and recombination of these DNA molecules of different parental origin.Meiosis was discovered and described for the first time in sea urchin eggs in 1876 by the German biologist Oscar Hertwig. It was described again in 1883, at the level of chromosomes, by the Belgian zoologist Edouard Van Beneden, in Ascaris roundworm eggs. The significance of meiosis for reproduction and inheritance, however, was described only in 1890 by German biologist August Weismann, who noted that two cell divisions were necessary to transform one diploid cell into four haploid cells if the number of chromosomes had to be maintained. In 1911, the American geneticist Thomas Hunt Morgan detected crossovers in meiosis in the fruit fly Drosophila melanogaster, which helped to establish that genetic traits are transmitted on chromosomes.The term "meiosis" is derived from the Greek word , meaning 'lessening'. It was introduced to biology by J.B. Farmer and J.E.S. Moore in 1905, using the idiosyncratic rendering "maiosis":We propose to apply the terms Maiosis or Maiotic phase to cover the whole series of nuclear changes included in the two divisions that were designated as Heterotype and Homotype by Flemming.[8]The spelling was changed to "meiosis" by Koernicke (1905) and by Pantel and De Sinety (1906) to follow the usual conventions for transliterating Greek.[9]Meiosis is divided into meiosis I and meiosis II which are further divided into Karyokinesis I, Cytokinesis I, Karyokinesis II, and Cytokinesis II, respectively. The preparatory steps that lead up to meiosis are identical in pattern and name to interphase of the mitotic cell cycle.[10] Interphase is divided into three phases:Growth 1 (G1) phase: In this very active phase, the cell synthesizes its vast array of proteins, including the enzymes and structural proteins it will need for growth. In G1, each of the chromosomes consists of a single linear molecule of DNA.Synthesis (S) phase: The genetic material is replicated; each of the cell's chromosomes duplicates to become two identical sister chromatids attached at a centromere. This replication does not change the ploidy of the cell since the centromere number remains the same. The identical sister chromatids have not yet condensed into the densely packaged chromosomes visible with the light microscope. This will take place during prophase I in meiosis.Growth 2 (G2) phase: G2 phase as seen before mitosis is not present in meiosis. Meiotic prophase corresponds most closely to the G2 phase of the mitotic cell cycle.Interphase is followed by meiosis I and then meiosis II. Meiosis I separates replicated homologous chromosomes, each still made up of two sister chromatids, into two daughter cells, thus reducing the chromosome number by half. During meiosis II, sister chromatids decouple, and the resultant daughter chromosomes are segregated into four daughter cells. For diploid organisms, the daughter cells resulting from meiosis are haploid and contain only one copy of each chromosome. In some species, cells enter a resting phase known as interkinesis between meiosis I and meiosis II.Meiosis I and II are each divided into prophase, metaphase, anaphase, and telophase stages, similar in purpose to their analogous subphases in the mitotic cell cycle. Therefore, meiosis includes the stages of meiosis I (prophase I, metaphase I, anaphase I, telophase I) and meiosis II (prophase II, metaphase II, anaphase II, telophase II). Diagram of the meiotic phasesDuring meiosis, specific genes are more highly transcribed.[11][12] In addition to strong meiotic stage-specific expression of mRNA, there are also pervasive translational controls (e.g. selective usage of preformed mRNA), regulating the ultimate meiotic stage-specific protein expression of genes during meiosis.[13] Thus, both transcriptional and translational controls determine the broad restructuring of meiotic cells needed to carry out meiosis.Meiosis I segregates homologous chromosomes, which are joined as tetrads (2n, 4c), producing two haploid cells (n chromosomes, 23 in humans) which each contain chromatid pairs (1n, 2c). Because the ploidy is reduced from diploid to haploid, meiosis I is referred to as a reductional division. Meiosis II is an equational division analogous to mitosis, in which the sister chromatids are segregated, creating four haploid daughter cells (1n, 1c).[14]Meiosis Prophase I in mice. In Leptotene (L), the axial elements (stained by SYCP3) begin to form. In Zygotene (Z), the transverse elements (SYCP1) and central elements of the synaptonemal complex are partially installed (appearing as yellow as they overlap with SYCP3). In Pachytene (P), it is fully installed except on the sex chromosomes. In Diplotene (D), it disassembles revealing chiasmata. CREST marks the centromeres.Schematic of the synaptonemal complex at different stages of prophase I and the chromosomes arranged as a linear array of loops.Prophase I is by far the longest phase of meiosis (lasting 13 out of 14 days in mice[15]). During prophase I, homologous maternal and paternal chromosomes pair, synapse, and exchange genetic information (by homologous recombination), forming at least one crossover per chromosome.[16] These crossovers become visible as chiasmata (plural; singular chiasma).[17] This process facilitates stable pairing between homologous chromosomes and hence enables accurate segregation of the chromosomes at the first meiotic division. The paired and replicated chromosomes are called bivalents (two chromosomes) or tetrads (four chromatids), with one chromosome coming from each parent. Prophase I is divided into a series of substages which are named according to the appearance of chromosomes.Main article: Leptotene stageThe first stage of prophase I is the leptotene stage, also known as leptonema, from Greek words meaning "thin threads".[18]:27 In this stage of prophase I, individual chromosomeseach consisting of two replicated sister chromatidsbecome "individualized" to form visible strands within the nucleus.[18]:27[19]:353 The chromosomes each form a linear array of loops mediated by cohesin, and the lateral elements of the synaptonemal complex assemble forming an "axial element" from which the loops emanate.[20] Recombination is initiated in this stage by the enzyme SPO11 which creates programmed double strand breaks (around 300 per meiosis in mice).[21] This process generates single stranded DNA filaments coated by RAD51 and DMC1 which invade the homologous chromosomes, forming inter-axis bridges, and resulting in the pairing/co-alignment of homologues (to a distance of ~400nm in mice).[20][22]Main article: ZygoteneLeptotene is followed by the zygotene stage, also known as zygonema, from Greek words meaning "paired threads",[18]:27 which in some organisms is also called the bouquet stage because of the way the telomeres cluster at one end of the nucleus.[23] In this stage the homologous chromosomes become much more closely (~100nm) and stably paired (a process called synapsis) mediated by the installation of the transverse and central elements of the synaptonemal complex.[20] Synapsis is thought to occur in a zipper-like fashion starting from a recombination nodule. The paired chromosomes are called bivalent or tetrad chromosomes.Main article: PachyteneThe pachytene stage (/pktin/ PAK-i-teen), also known as pachynema, from Greek words meaning "thick threads".[18]:27 is the stage at which all autosomal chromosomes have synapsed. In this stage homologous recombination, including chromosomal crossover (crossing over), is completed through the repair of the double strand breaks formed in leptotene.[20] Most breaks are repaired without forming crossovers resulting in gene conversion.[24] However, a subset of breaks (at least one per chromosome) form crossovers between non-sister (homologous) chromosomes resulting in the exchange of genetic information.[25] The exchange of information between the homologous chromatids results in a recombination of information; each chromosome has the complete set of information it had before, and there are no gaps formed as a result of the process. Because the chromosomes cannot be distinguished in the synaptonemal complex, the actual act of crossing over is not perceivable through an ordinary light microscope, and chiasmata are not visible until the next stage.During the diplotene stage, also known as diplonema, from Greek words meaning "two threads",[18]:30 the synaptonemal complex disassembles and homologous chromosomes separate from one another a little. However, the homologous chromosomes of each bivalent remain tightly bound at chiasmata, the regions where crossing-over occurred. The chiasmata remain on the chromosomes until they are severed at the transition to anaphase I to allow homologous chromosomes to move to opposite poles of the cell.In human fetal oogenesis, all developing oocytes develop to this stage and are arrested in prophase I before birth.[26] This suspended state is referred to as the dictyotene stage or dictyate. It lasts until meiosis is resumed to prepare the oocyte for ovulation, which happens at puberty or even later.Chromosomes condense further during the diakinesis stage, from Greek words meaning "moving through".[18]:30 This is the first point in meiosis where the four parts of the tetrads are actually visible. Sites of crossing over entangle together, effectively overlapping, making chiasmata clearly visible. Other than this observation, the rest of the stage closely resembles prometaphase of mitosis; the nucleoli disappear, the nuclear membrane disintegrates into vesicles, and the meiotic spindle begins to form.Unlike mitotic cells, human and mouse oocytes do not have centrosomes to produce the meiotic spindle. In mice, approximately 80 MicroTubule Organizing Centers (MTOCs) form a sphere in the ooplasm and begin to nucleate microtubules that reach out towards chromosomes, attaching to the chromosomes at the kinetochore. Over time, the MTOCs merge until two poles have formed, generating a barrel shaped spindle.[27] In human oocytes spindle microtubule nucleation begins on the chromosomes, forming an aster that eventually expands to surround the chromosomes.[28] Chromosomes then slide along the microtubules towards the equator of the spindle, at which point the chromosome kinetochores form end-on attachments to microtubules.[29]Homologous pairs move together along the metaphase plate: As kinetochore microtubules from both spindle poles attach to their respective kinetochores, the paired homologous chromosomes align along an equatorial plane that bisects the spindle, due to continuous counterbalancing forces exerted on the bivalents by the microtubules emanating from the two kinetochores of homologous chromosomes. This attachment is referred to as a bipolar attachment. The physical basis of the independent assortment of chromosomes is the random orientation of each bivalent along with the metaphase plate, with respect to the orientation of the other bivalents along the same equatorial line.[17] The protein complex cohesin holds sister chromatids together from the time of their replication until anaphase I. In mitosis, the force of kinetochore microtubules pulling in opposite directions creates tension. The cell senses this tension and does not progress with anaphase until all the chromosomes are properly bi-oriented. In meiosis, establishing tension ordinarily requires at least one crossover per chromosome pair in addition to cohesin between sister chromatids. (see Chromosome segregation)Kinetochore microtubules shorten, pulling homologous chromosomes (which each consist of a pair of sister chromatids) to opposite poles. Non-kinetochore microtubules lengthen, pushing the centrosomes farther apart. The cell elongates in preparation for division down the center.[17] Unlike in mitosis, only the cohesin from the chromosome arms is degraded while the cohesin surrounding the centromere remains protected by a protein named Shugoshin (Japanese for "guardian spirit"), what prevents the sister chromatids from separating.[30] This allows the sister chromatids to remain together while homologs are segregated.The first meiotic division effectively ends when the chromosomes arrive at the poles. Each daughter cell now has half the number of chromosomes but each chromosome consists of a pair of chromatids. The microtubules that make up the spindle network disappear, and a new nuclear membrane surrounds each haploid set. Cytokinesis, the pinching of the cell membrane in animal cells or the formation of the cell wall in plant cells, occurs, completing the creation of two daughter cells. However, cytokinesis does not fully complete resulting in "cytoplasmic bridges" which enable the cytoplasm to be shared between daughter cells until the end of meiosis II.[31] Sister chromatids remain attached during telophase I.Cells may enter a period of rest known as interkinesis or interphase II. No DNA replication occurs during this stage.Meiosis II is the second meiotic division, and usually involves equational segregation, or separation of sister chromatids. Mechanically, the process is similar to mitosis, though its genetic results are fundamentally different. The result is the production of four haploid cells (n chromosomes; 23 in humans) from the two haploid cells (with n chromosomes, each consisting of two sister chromatids)[clarification needed] produced in meiosis I. The four main steps of meiosis II are: prophase II, metaphase II, anaphase II, and telophase II.In prophase II, the disappearance of the nucleoli and the nuclear envelope is seen again as well as the shortening and thickening of the chromatids. Centrosomes move to the polar regions and arrange spindle fibers for the second meiotic division.In metaphase II, the centromeres contain two kinetochores that attach to spindle fibers from the centrosomes at opposite poles. The new equatorial metaphase plate is rotated by 90 degrees when compared to meiosis I, perpendicular to the previous plate.[32]This is followed by anaphase II, in which the remaining centromeric cohesin, not protected by Shugoshin anymore, is cleaved, allowing the sister chromatids to segregate. The sister chromatids by convention are now called sister chromosomes as they move toward opposing poles.[30]The process ends with telophase II, which is similar to telophase I, and is marked by decondensation and lengthening of the chromosomes and the disassembly of the spindle. Nuclear envelopes re-form and cleavage or cell plate formation eventually produces a total of four daughter cells, each with a haploid set of chromosomes.Meiosis is now complete and ends up with four new daughter cells.Meiosis appears to be a fundamental characteristic of eukaryotic organisms and to have been present early in eukaryotic evolution. Eukaryotes that were once thought to lack meiotic sex have recently been shown to likely have, or once have had, this capability. As one example, Giardia intestinalis, a common intestinal parasite, was previously considered to have descended from a lineage that predated the emergence of meiosis and sex. However, G. intestinalis has now been found to possess a core set of meiotic genes, including five meiosis specific genes.[33] Also evidence for meiotic recombination, indicative of sexual reproduction, was found in G. intestinalis.[34] Another example of organisms previously thought to be asexual are parasitic protozoa of the genus Leishmania, which cause human disease. However, these organisms were shown to have a sexual cycle consistent with a meiotic process.[35] Although amoeba were once generally regarded as asexual, evidence has been presented that most lineages are anciently sexual and that the majority of asexual groups probably arose recently and independently.[36] Dacks and Rogers[37] proposed, based on a phylogenetic analysis, that facultative sex was likely present in the common ancestor of eukaryotes.The new combinations of DNA created during meiosis are a significant source of genetic variation alongside mutation, resulting in new combinations of alleles, which may be beneficial. Meiosis generates gamete genetic diversity in two ways: (1) Law of Independent Assortment. The independent orientation of homologous chromosome pairs along the metaphase plate during metaphase I and orientation of sister chromatids in metaphase II, this is the subsequent separation of homologs and sister chromatids during anaphase I and II, it allows a random and independent distribution of chromosomes to each daughter cell (and ultimately to gametes);[38] and (2) Crossing Over. The physical exchange of homologous chromosomal regions by homologous recombination during prophase I results in new combinations of genetic information within chromosomes.[39] However, such physical exchange does not always occur during meiosis. In the oocytes of the silkworm Bombyx mori, meiosis is completely achiasmate (lacking crossovers).[40] Although synaptonemal complexes are present during the pachytene stage of meiosis in B. mori, crossing-over homologous recombination is absent between the paired chromosomes.[41]Female mammals and birds are born possessing all the oocytes needed for future ovulations, and these oocytes are arrested at the prophase I stage of meiosis.[42] In humans, as an example, oocytes are formed between three and four months of gestation within the fetus and are therefore present at birth. During this prophase I arrested stage (dictyate), which may last for decades, four copies of the genome are present in the oocytes. The arrest of oocytes at the four genome copy stage was proposed to provide the informational redundancy needed to repair damage in the DNA of the germline.[42] The repair process used appears to involve homologous recombinational repair[42][43] Prophase I arrested oocytes have a high capability for efficient repair of DNA damage, particularly exogenously induced double-strand breaks.[43] DNA repair capability appears to be a key quality control mechanism in the female germ line and a critical determinant of fertility.[43]Genetic recombination can be viewed as fundamentally a DNA repair process, and that when it occurs during meiosis it is an adaptation for repairing the genomic DNA that is passed on to progeny.[44][45] Experimental findings indicate that a substantial benefit of meiosis is recombinational repair of DNA damage in the germline, as indicated by the following examples. Hydrogen peroxide is an agent that causes oxidative stress leading to oxidative DNA damage.[46] Treatment of the yeast Schizosaccharomyces pombe with hydrogen peroxide increased the frequency of mating and the formation of meiotic spores by 4 to 18-fold.[47] Volvox carteri, a haploid multicellular, facultatively sexual green algae, can be induced by heat shock to reproduce by meiotic sex.[48] This induction can be inhibited by antioxidants indicating that the induction of meiotic sex by heat shock is likely mediated by oxidative stress leading to increased DNA damage.[49]Diplontic life cycleHaplontic life cycle.Main article: Biological life cycleSee also: Alternation of generationsMeiosis occurs in eukaryotic life cycles involving sexual reproduction, consisting of the cyclical process of growth and development by mitotic cell division, production of gametes by meiosis and fertilization. At certain stages of the life cycle, germ cells produce gametes. Somatic cells make up the body of the organism and are not involved in gamete production.Cycling meiosis and fertilization events results in alternation between haploid and diploid states. The organism phase of the life cycle can occur either during the diploid state (diplontic life cycle), during the haploid state (haplontic life cycle), or both (haplodiplontic life cycle), in which there are two distinct organism phases, one with haploid cells and the other with diploid cells.In the diplontic life cycle (with pre-gametic meiosis), as in humans, the organism is multicellular and diploid, grown by mitosis from a diploid cell called the zygote. The organism's diploid germ-line stem cells undergo meiosis to make haploid gametes (the spermatozoa in males and ova in females), which fertilize to form the zygote. The diploid zygote undergoes repeated cellular division by mitosis to grow into the organism.In the haplontic life cycle (with post-zygotic meiosis), the organism is haploid, by the proliferation and differentiation of a single haploid cell called the gamete. Two organisms of opposing sex contribute their haploid gametes to form a diploid zygote. The zygote undergoes meiosis immediately, creating four haploid cells. These cells undergo mitosis to create the organism. Many fungi and many protozoa utilize the haplontic life cycle. [citation needed]In the haplodiplontic life cycle (with sporic or intermediate meiosis), the living organism alternates between haploid and diploid states. Consequently, this cycle is also known as the alternation of generations. The diploid organism's germ-line cells undergo meiosis to produce spores. The spores proliferate by mitosis, growing into a haploid organism. The haploid organism's gamete then combines with another haploid organism's gamete, creating the zygote. The zygote undergoes repeated mitosis and differentiation to produce a new diploid organism. The haplodiplontic life cycle can be considered a fusion of the diplontic and haplontic life cycles.[50][citation needed]Overview of chromatides' and chromosomes' distribution within the mitotic and meiotic cycle of a male human cellMeiosis occurs in all animals and plants. The result, the production of gametes with half the number of chromosomes as the parent cell, is the same, but the detailed process is different. In animals, meiosis produces gametes directly. In land plants and some algae, there is an alternation of generations such that meiosis in the diploid sporophyte generation produces haploid spores instead of gametes. When they germinate, these spores undergo repeated cell division by mitosis, developing into a multicellular haploid gametophyte generation, which then produces gametes directly (i.e. without further meiosis).In both animals and plants, the final stage is for the gametes to fuse to form a zygote in which the original number of chromosomes is restored.[51]In females, meiosis occurs in cells known as oocytes (singular: oocyte). Each primary oocyte divides twice in meiosis, unequally in each case. The first division produces a daughter cell, and a much smaller polar body which may or may not undergo a second division. In meiosis II, division of the daughter cell produces a second polar body, and a single haploid cell, which enlarges to become an ovum. Therefore, in females each primary oocyte that undergoes meiosis results in one mature ovum and two or three polar bodies.There are pauses during meiosis in females. Maturing oocytes are arrested in prophase I of meiosis I and lie dormant within a protective shell of somatic cells called the follicle. At this stage, the oocyte nucleus is called the germinal vesicle.[52] At the beginning of each menstrual cycle, FSH secretion from the anterior pituitary stimulates a few follicles to mature in a process known as folliculogenesis. During this process, the maturing oocytes resume meiosis and continue until metaphase II of meiosis II, where they are again arrested just before ovulation. The breakdown of the germinal vesicle, condensation of chromosomes, and assembly of the bipolar metaphase I spindle are all clear indications that meiosis has resumed.[52] If these oocytes are fertilized by sperm, they will resume and complete meiosis. During folliculogenesis in humans, usually one follicle becomes dominant while the others undergo atresia. The process of meiosis in females occurs during oogenesis, and differs from the typical meiosis in that it features a long period of meiotic arrest known as the dictyate stage and lacks the assistance of centrosomes.[53][54]In males, meiosis occurs during spermatogenesis in the seminiferous tubules of the testicles. Meiosis during spermatogenesis is specific to a type of cell called spermatocytes, which will later mature to become spermatozoa. Meiosis of primordial germ cells happens at the time of puberty, much later than in females. Tissues of the male testis suppress meiosis by degrading retinoic acid, proposed to be a stimulator of meiosis. This is overcome at puberty when cells within seminiferous tubules called Sertoli cells start making their own retinoic acid. Sensitivity to retinoic acid is also adjusted by proteins called nanos and DAZL.[55][56] Genetic loss-of-function studies on retinoic acid-generating enzymes have shown that retinoic acid is required postnatally to stimulate spermatogonia differentiation which results several days later in spermatocytes undergoing meiosis, however retinoic acid is not required during the time when meiosis initiates.[57]In female mammals, meiosis begins immediately after primordial germ cells migrate to the ovary in the embryo. Some studies suggest that retinoic acid derived from the primitive kidney (mesonephros) stimulates meiosis in embryonic ovarian oogonia and that tissues of the embryonic male testis suppress meiosis by degrading retinoic acid.[58] However, genetic loss-of-function studies on retinoic acid-generating enzymes have shown that retinoic acid is not required for initiation of either female meiosis which occurs during embryogenesis[59] or male meiosis which initiates postnatally.[57]While the majority of eukaryotes have a two-divisional meiosis (though sometimes achiasmatic), a very rare form, one-divisional meiosis, occurs in some flagellates (parabasalids and oxymonads) from the gut of the wood-feeding cockroach Cryptocercus.[60]Recombination among the 23 pairs of human chromosomes is responsible for redistributing not just the actual chromosomes, but also pieces of each of them. There is also an estimated 1.6-fold more recombination in females relative to males. In addition, average, female recombination is higher at the centromeres and male recombination is higher at the telomeres. On average, 1 million bp (1 Mb) correspond to 1 cMorgan (cm = 1% recombination frequency).[61] The frequency of cross-overs remain uncertain. In yeast, mouse and human, it has been estimated that 200 double-strand breaks (DSBs) are formed per meiotic cell. However, only a subset of DSBs (~530% depending on the organism), go on to produce crossovers,[62] which would result in only 1-2 cross-overs per human chromosome.In humans, recombination rates differ between maternal and paternal DNA:Maternal DNA: Recombines approximately 42 times on average.Paternal DNA: Recombines approximately 27 times on average.Main article: NondisjunctionA diagram depicting nondisjunction in the maternal cell during the Meiosis I phase, resulting in gametes with an extra chromosome. Through fertilization of this egg, an offspring with the condition trisomy 21 is produced.The normal separation of chromosomes in meiosis I or sister chromatids in meiosis II is termed disjunction. When the segregation is not normal, it is called nondisjunction. This results in the production of gametes which have either too many or too few of a particular chromosome, and is a common mechanism for trisomy or monosomy. Nondisjunction can occur in the meiosis I or meiosis II, phases of cellular reproduction, or during mitosis.Most monosomic and trisomic human embryos are not viable, but some aneuploidies can be tolerated, such as trisomy for the smallest chromosome, chromosome 21. Phenotypes of these aneuploidies range from severe developmental disorders to asymptomatic. Medical conditions include but are not limited to:Down syndrome trisomy of chromosome 21Patau syndrome trisomy of chromosome 13Edwards syndrome trisomy of chromosome 18Klinefelter syndrome extra X chromosomes in males i.e. XXY, XXXY, XXXXY, etc.Turner syndrome lacking of one X chromosome in females i.e. X0Triple X syndrome an extra X chromosome in femalesJacobs syndrome an extra Y chromosome in males.The probability of nondisjunction in human oocytes increases with increasing maternal age,[63] presumably due to loss of cohesin over time.[64]In order to understand meiosis, a comparison to mitosis is helpful. The table below shows the differences between meiosis and mitosis.[65]MeiosisMitosisEnd resultNormally four cells, each with half the number of chromosomes as the parentTwo cells, having the same number of chromosomes as the parentFunctionProduction of gametes (sex cells) in sexually reproducing eukaryotes with diplont life cycleCellular reproduction, growth, repair, asexual reproductionWhere does it happen?Almost all eukaryotes (animals, plants, fungi, and protists);[66][60] In gonads, before gametes (in diplontic life cycles); After zygotes (in haplontic); Before spores (in haplodiplontic)All proliferating cells in all eukaryotesStepsProphase I, Metaphase I, Anaphase I, Telophase I, Prophase II, Metaphase II, Anaphase II, Telophase IIProphase, Prometaphase, Metaphase, Anaphase, TelophaseGenetically same as parent?NoYesCrossing over happens?Yes, normally occurs between each pair of homologous chromosomesVery rarelyPairing of homologous chromosomes?YesNoCytokinesisOccurs in Telophase I and Telophase IIOccurs in TelophaseCentromeres splitDoes not occur in Anaphase I, but occurs in Anaphase IIOccurs in AnaphaseThis section needs expansion. You can help by adding to it. (August 2020)Maturation promoting factor (MPF) seems to have a role in meiosis based on experiments with Xenopus laevis oocytes. Mammalian oocyte MPF induced germinal vesicle breakdown (GVB) in starfish and Xenopus laevis oocytes.[67] MPF is active prior to GVB but falls off toward the end of meiosis I.[68] CDK1 and cyclin B levels are correlated with oocyte GVB competence and are likely under translational rather than transcriptional control.[52] In meiosis II, MPF reappears ahead of metaphase II, and its activity remains high up to fertilization.[68][69]In mammals, meiotic arrest begins with natriuretic peptide type C (NPPC) from mural granulosa cells, which activates production of cyclic guanosine 3,5-monophosphate (cGMP) in concert with natriuretic peptide receptor 2 (NPR2) on cumulus cells.[70] cGMP diffuses into oocytes and halts meiosis by inhibiting phosphodiesterase 3A (PDE3A) and cyclic adenosine 3,5-monophosphate (cAMP) hydrolysis.[70] In the oocyte, G-protein-coupled receptor GPR3/12 activates adenylyl cyclase to generate cAMP.[70] cAMP stimulates protein kinase A (PKA) to activate the nuclear kinase WEE2 by phosphorylation.[71] PKA also assists in phosphorylation of the CDK1 phosphatase CDC25B to keep it in the cytoplasm; in its unphosphorylated form, CDC25B migrates to the nucleus.[52][71] Protein kinase C (PKC) may also have a role in inhibiting meiotic progression to metaphase II.[52] Overall, CDK1 activity is suppressed to prevent resumption of meiosis.[71] Oocytes further promote expression of NPR2 and inosine monophosphate dehydrogenase (and thereby the production of cGMP) in cumulus cells.[70] Follicle-stimulating hormone and estradiol likewise promote expression of NPPC and NPR2.[70] Hypoxanthine, a purine apparently originating in the follicle, also inhibits in vitro oocyte meiosis.[72] A spike in luteinizing hormone (LH) spurs oocyte maturation,[70] in which oocytes are released from meiotic arrest and progress from prophase I through metaphase II.[72] LH-induced epidermal growth factor-like factors like amphiregulin and epiregulin[72] synthesized in mural granulosa cells reduce levels of cGMP in oocytes by restricting cGMP transport through cumulus cell-oocyte gap junctions and lowering NPPC levels and NPR2 activity.[71][70] In fact, LH-induced epidermal growth factor-like factors may cause the destabilization and breakdown of gap junctions altogether.[72] LH-induced epidermal growth factor-like factors may trigger production of additional oocyte maturation factors like steroids and follicular fluid-derived meiosis-activating sterol (FF-MAS) in cumulus cells.[72] FF-MAS promotes progression from metaphase I to metaphase II, and it may help stabilize metaphase II arrest.[72] Meiosis resumption is reinforced by the exit of WEE2 from the nucleus due to CDK1 activation.[71] Phosphodiesterases (PDEs) metabolize cAMP and may be temporarily activated by PKA-mediated phosphorylation.[72] Longer-term regulation of phosphodiesterases may require modulation of protein expression.[72] For example, hypoxanthine is a PDE inhibitor that may stymie cAMP metabolism.[72] Kinases like protein kinase B, Aurora kinase A, and polo-like kinase 1 contribute to the resumption of meiosis.[71] There are similarities between the mechanisms of meiotic prophase I arrest and resumption and the mitotic G2 DNA damage checkpoint: CDC14B-based activation of APC-CDH1 in arrest and CDC25B-based resumption.[71] Meiotic arrest requires inhibitory phosphorylation of CDK1 at amino acid residues Thr-14 and Tyr-15 by MYT1 and WEE1[52] as well as regulation of cyclin B levels facilitated by the anaphase-promoting complex (APC).[71] CDK1 is regulated by cyclin B, whose synthesis peaks at the end of meiosis I.[52] At anaphase I, cyclin B is degraded by an ubiquitin-dependent pathway.[52] Cyclin B synthesis and CDK1 activation prompt oocytes to enter metaphase, while entry into anaphase follows ubiquitin-mediated cyclin B degradation, which brings down CDK1 activity.[52] Proteolysis of adhesion proteins between homologous chromosomes is involved in anaphase I, while proteolysis of adhesion proteins between sister chromatids is involved in anaphase II.[52] Meiosis II arrest is effected by cytostatic factor (CSF), whose elements include the MOS protein, mitogen-activated protein kinase kinase (MAPKK/MEK1), and MAPK.[52] The protein kinase p90 (RSK) is one critical target of MAPK and may help block entry into S-phase between meiosis I and II by reactivating CDK1.[52] There's evidence that RSK aids entry into meiosis I by inhibiting MYT1, which activates CDK1.[52] CSF arrest might take place through regulation of the APC as part of the spindle assembly checkpoint.[52]In the budding yeast S. cerevisiae, Clb1 is the main meiotic regulatory cyclin, though Clb3 and Clb4 are also expressed during meiosis and activate a p34cdc28-associated kinase immediately prior to the first meiotic division.[73] The IME1 transcription factor drives entry into meiotic S-phase and is regulated according to inputs like nutrition.[74] a1/2 represses a repressor of IME1, initiating meiosis.[74] Numerous S. cerevisiae meiotic regulatory genes have been identified. A few are presented here. IME1 enables sporulation of non-a/ diploids.[75] IME2/SME1 enables sporulation when nitrogen is present, supports recombination in a/ cells expressing RME1, an inhibitor of meiosis, and encodes a protein kinase homolog.[75] MCK1 (meiosis and centromere regulatory kinase) also supports recombination in a/ cells expressing RME1 and encodes a protein kinase homolog.[75] SME2 enables sporulation when ammonia or glucose are present.[75] UME1-5 enable expression of certain early meiotic genes in vegetative, non-a/ cells.[75]In the fission yeast S. pombe, the Cdc2 kinase and Cig2 cyclin together initiate the premeiotic S phase, while cyclin Cdc13 and the CDK activator Cdc25 are necessary for both meiotic divisions.[76] However, the Pat1-Mei2 system is at the heart of S. pombe meiotic regulation. Mei2 is the major meiotic regulator.[76] It moves between the nucleus and cytoplasm and works with meiRNA to promote meiosis I.[76] Moreover, Mei2 is implicated in exit from mitosis and induction of premeiotic S phase.[76] Mei2 may inactivate the DSR-Mmi1 system through sequestration of Mmi1 to stabilize meiosis-specific transcript expression.[76] Mei2 may stall growth and bring about G1 arrest.[76] Pat1 is a Ser/Thr protein kinase that phosphorylates Mei2, an RNA-binding protein, on residues Ser438 and Thr527.[76] This phosphorylation may decrease the half-life of Mei2 by making it more likely to be destroyed by a proteasome working with E2 Ubc2 and E3 Ubr1.[76] The Mei4 transcription factor is necessary to transcriptionally activate cdc25 in meiosis, and the mei4 mutant experiences cell cycle arrest.[76] Mes1 inhibits the APC/C activator Slp1 such that the Cdc2-Cdc13 MPF activity can drive the second meiotic division.[76]It has been suggested that Yeast CEP1 gene product, that binds centromeric region CDE1, may play a role in chromosome pairing during meiosis-I.[77]Meiotic recombination is mediated through double stranded break, which is catalyzed by Spo11 protein. Also Mre11, Sae2 and Exo1 play role in breakage and recombination. After the breakage happen, recombination take place which is typically homologous. The recombination may go through either a double Holliday junction (dHJ) pathway or synthesis-dependent strand annealing (SDSA). (The second one gives to noncrossover product).[78]Seemingly there are checkpoints for meiotic cell division too. In S. pombe, Rad proteins, S. pombe Mek1 (with FHA kinase domain), Cdc25, Cdc2 and unknown factor is thought to form a checkpoint.[79]In vertebrate oogenesis, maintained by cytostatic factor (CSF) has role in switching into meiosis-II.[77]FertilisationCoefficient of coincidenceDNA repairOxidative stressSynizesis (biology)Biological life cycleApomixisParthenogenesisAlternation of generationsBrachymeiosisMitotic recombinationDikaryonMating of yeast

^ from Ancient Greek mesis'lessening', since it is a reductional division.[1][2]^ "4.1: Meiosis". Biology LibreTexts. 2019-10-01. Retrieved 2021-05-29.^ "Definition of Reduction division". MedicineNet. Retrieved 2021-05-29.^ a b Freeman S (2011). Biological Science (6thed.). Hoboken, NY: Pearson. p.210.^ Hassold T, Hunt P (April 2001). "To err (meiotically) is human: the genesis of human aneuploidy". Nature Reviews Genetics. 2 (4): 28091. doi:10.1038/35066065. PMID11283700. S2CID22264575.^ Letunic I, Bork P (2006). "Interactive Tree of Life". Archived from the original on 29 January 2018. Retrieved 23 July 2011.^ Bernstein H, Bernstein C (2010). "Evolutionary origin of recombination during meiosis". BioScience. 60 (7): 498505. doi:10.1525/bio.2010.60.7.5. S2CID86663600.^ Lod T (June 2011). "Sex is not a solution for reproduction: the libertine bubble theory". BioEssays. 33 (6): 41922. doi:10.1002/bies.201000125. PMID21472739.^ Farmer, J.B.; Moore, J.E.S. (February 1904). 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Upper Saddle River, NJ: Pearson Prentice Hall. ISBN978-0-13-140941-5.Wikimedia Commons has media related to Meiosis.Meiosis Flash Animation Archived 2010-08-23 at the Wayback MachineAnimations from the U. of Arizona Biology Dept.Meiosis at Kimball's Biology PagesKhan Academy, video lectureCCO The Cell-Cycle OntologyStages of Meiosis animation"Abby Dernburg Seminar: Chromosome Dynamics During Meiosis"Retrieved from " and meiosis are both types of cell division. Mitosis is the process by which most cells in the body divide, involves a single round of cell division, and produces two identical, diploid daughter cells.Meiosis is the process by which gametes are produced. Meiosis involves two rounds of cell division and produces four non-identical haploid daughter cells.Cell divisionWhat are Mitosis and Meiosis? Mitosis and meiosis are both types of cell division. Though there are similarities between mitosis and meiosis, there are some key differences between these two processes.Mitosis is how new body cells are produced, whereas meiosis is used to produce gametes (i.e. sperm and egg cells). One cell divisionTwo cell divisionsProduces two daughter cellsProduces four daughter cellsProduces diploid cellsProduces haploid cellsDaughter cells are genetically identicalDaughter cells are non-identicalProduces body cellsProduces sex cellsNo crossing-over occursCrossing-over occursHomologous chromosomes do not pair upHomologous chromosomes do not pair upMitosisMitosis is how the cells of your body reproduce. During mitosis, a diploid parent cell (i.e. a cell with two sets of chromosomes) makes a complete copy of its DNA before splitting in two. This process produces two genetically identical daughter cellsand takes place across five phases.The phases of mitosis are prophase, prometaphase, metaphase, anaphase, and telophase.Before mitosis can begin, however, the cell must replicate its DNA. This happens during interphase, which happens over stages G1, S, and G2 of the cell cycle, and is not technically part of mitosis.Phases of mitosisThe Phases of MitosisProphase The first phase of mitosis is prophase. During prophase, the cells chromosomes condense and become visible under a light microscope. The nucleolus (the part of the nucleus where ribosomes are made) disappears, and the mitotic spindle (a cell structure made of microtubules) begins to form.PrometaphaseThe nuclear membrane breaks down. The microtubules attach themselves to the chromosomes and begin to move them around.MetaphaseThe microtubules move the chromosomes until they are lined up along the middle of the cell. This line of chromosomes is called the metaphase plate.AnaphaseThe chromosomes are pulled apart by the microtubules. Each chromosome is separated into two, genetically identical sister chromatids, which are pulled to opposite ends of the cell.TelophaseThe sister chromatids arrive at opposite ends of the cell. A new nuclear membrane begins to form around each set of chromosomes. The chromosomes decondense, so they are no longer visible under a light microscope. The nucleolus reappears, and the mitotic spindle disappears. Finally, the cytoplasm of the cell splits, and two new, genetically identical daughter cells are formed. This process is called cytokinesis and usually takes place during telophase.MeiosisAlmost all of your bodys cells divide by mitosis. Meiosis is used to produce only one type of cell, and those are the gametes. During meiosis, a diploid cell divides to produce four, non-identical haploid daughter cells, each containing a single set of chromosomes. In humans, these are sperm and egg cells.Unlike mitosis, meiosis involves two rounds of cell division. These happen across two stages: Meiosis I, and Meiosis II. Each stage of meiosis can be further divided into five phases:prophase, prometaphase, metaphase, anaphase, and telophase.Egg and sperm cellsThe Stages of MeiosisMeiosis ILike mitosis, meiosis I takes place across five stages.Before this first round of cell division begins, the cells DNA is replicated during the interphase of the cell cycle.Phases of meiosis IProphase IDuring prophase I, the chromosomes condense and form homologous pairs. Each homologous pair of chromosomes lines up carefully so their genes are aligned. Next, the chromosomes swap genetic material with one another, in a process known as crossing over. This ensures that each sister chromatid is no longer genetically identical.Prometaphase IDuring prometaphase I, the nuclear envelope breaks down and microtubules attach themselves to the chromosomes.Metaphase IThe homologous chromosome pairs line up along the metaphase plate in the middle of the cell.Anaphase IThe homologous pairs are separated by the microtubules and are pulled to opposite ends of the cell. The homologous pairs line up and are separated at random in a process known as independent segregation. This is done to further increase genetic diversity among daughter cells.Telophase IThe chromosomes arrive at opposite ends of the cell, and the cytoplasm is split by cytokinesis.The first round of cell division is complete. The two non-identical, haploid daughter cells now enter the second stage of meiosis.Meiosis IIMeiosis II is very similar to the process of mitosis, except it involves two haploid cells rather than one diploid cell.Phases of meiosis IIProphase IIDuring prophase II, the chromosomes condense.Prometaphase IIThe nuclear envelopes are broken down and microtubules attach themselves to the chromosomes.Metaphase IIThe chromosomes line up along the metaphase plates.Anaphase IIThe chromosomes are pulled apart by microtubules. The non-identical sister chromatids are pulled to opposite ends of the cells.Telophase IIThe sister chromatids reach opposite ends of the cells. The cells are divided by cytokinesis, and four non-identical, haploid daughter cells are produced.Mitosis vs. Meiosis: Differences and SimilaritiesMitosis and meiosis are similar processes, but there are key differences between the two.Mitosis vs. meiosisProducts of Mitosis vs. MeiosisMitosis produces two genetically identical diploid cells, whereas meiosis produces four non-identical haploid cells.Cell Types Involved in Mitosis vs. MeiosisMitosis involves the replication of somatic cells (i.e. any cells of the body that arent gametes), whereas meiosis is the process by which sperm and egg cells are produced.Cell Division in Mitosis vs. MeiosisMitosis involves one round of cell division, whereas meiosis involves two.Genetic Diversity in Mitosis vs. MeiosisMitosis produces genetically identical daughter cells, each containing a complete copy of the parent cells DNA. Meiosis produces four genetically non-identical daughter cells, which increases genetic variation among gametes (and, therefore, genetic diversity in the population).BySagar Dhande Have you ever thought about two special words: Mitosis and Meiosis? They may seem similar, but they are actually very different! Today, we will explore them together and learn how to use them properly. So, let's check the major difference between Mitosis and Meiosis in simple words!Here below a PDF document provides a detailed explanation of the differences between mitosis and meiosis, often including diagrams and examples to illustrate the distinctions.Mitosis is a type of cell division that results in two identical daughter cells with the same number of chromosomes as the parent cell.Meiosis is a special type of cell division that produces four genetically different daughter cells with half the number of chromosomes as the parent cell.Both mitosis and meiosis are processes of cell division.Both processes are preceded by a phase of cell growth and DNA replication called interphase.Both processes involve the segregation of chromosomes into daughter cells.Both mitosis and meiosis have similar stages including prophase, metaphase, anaphase, and telophase.Both processes are followed by cytokinesis, where the cytoplasm divides, forming two separate daughter cells.Both mitosis and meiosis occur in eukaryotic cells.Both mitosis and meiosis are essential for growth, development, and reproduction in multicellular organisms.Mitosis is a type of cell division that results in two identical daughter cells with the same number of chromosomes as the parent cell.Meiosis is a special type of cell division that produces four genetically different daughter cells with half the number of chromosomes as the parent cell.Mitosis is involved in growth, tissue repair, and asexual reproduction, while meiosis is involved in sexual reproduction to ensure genetic diversity. Mitosis Meiosis Mitosis discovered by Walther Flemming Meiosis was discovered by Oscar hertwig Mitosis occurs in all organisms, except for viruses Meiosis occurs only in animals, plant and fungi Mitosis creates body / somatic cells Meiosis crests germ/sex cells Mitosis involves one-cell division Meiosis involves two successive cell division Mitosis performs general growth repairs, Cell reproduction. Meiosis performs genetic diversity through sexual reproduction Mitosis is the process where the division of cells occur by asexual reproduction Meiosis is the process Where the division of cells occur by sexual reproduction In mitosis number of chromosomes remain the same In meiosis, the number of chromosomes is reduced by half In mitosis, Tetrad formation does not occur. In meiosis, tetrad formation Occurs and it's Consists of two sets of sister chromatids In mitosis sister chromatids separate In meiosis, sister chromatids do not separate In mitosis length of prophase is short. In meiosis length of prophase I is long and it's consist of five stages leptotene, zygotene, pachytene, Diplotene and diakinesis. List the main differences between mitosis and meiosis1. What are the 5 differences between mitosis and meiosis?Answer: Mitosis is a type of cell division that produces two identical daughter cells with the same number of chromosomes as the parent cell, while meiosis is a special type of cell division that produces gametes (sperm and egg cells) with half the number of chromosomes as the parent cell.The five main differences between mitosis and meiosis are:Mitosis produces two identical daughter cells, whereas meiosis produces four genetically different daughter cells.Mitosis occurs in somatic cells, while meiosis occurs in germ cells to produce gametes.Mitosis involves one round of cell division, while meiosis involves two rounds of cell division.Mitosis results in diploid daughter cells (having the same number of chromosomes as the parent cell), while meiosis results in haploid daughter cells (having half the number of chromosomes as the parent cell).Mitosis is involved in growth, tissue repair, and asexual reproduction, while meiosis is involved in sexual reproduction to ensure genetic diversity.2. What is the difference between mitosis and meiosis Class 10 Ncert?Answer: In Class 10 NCERT, the main difference between mitosis and meiosis is highlighted as mitosis is a type of cell division that produces two identical daughter cells with the same number of chromosomes, while meiosis is a process of cell division that produces four genetically different daughter cells with half the number of chromosomes.3. What are two major differences between mitosis and meiosis?Answer: Two major differences between mitosis and meiosis are:a. Mitosis produces two daughter cells, while meiosis produces four daughter cells.b. Mitosis results in genetically identical daughter cells, while meiosis results in genetically diverse daughter cells.4. What are the similarities between mitosis and meiosis?Answer: Some similarities between mitosis and meiosis include:a. Both processes involve the division of a parent cell's nucleus.b. Both processes involve the separation of chromosomes into daughter cells.c. Both processes occur in eukaryotic cells.5. How do you remember the difference between mitosis and meiosis?Answer: To remember the difference between mitosis and meiosis, one can use memory aids like mnemonic devices, such as "MITOSIS: Makes Identical Twins; MEIOSIS: Makes Eggs (and) Sperm." Getting mitosis and meiosis confused on a biology exam can cost you a lot of points, so it's important to keep these two cellular processes straight. In this guide, we break down mitosis vs meiosis, explain each of the processes, and lay out their similarities and differences so that youll be able to easily explain what each process does and how the two differ. What Is Mitosis? What Is Meiosis? Mitosis and meiosis are both processes of cell division. Organisms are constantly replenishing their cell supply and creating new cells to replace those that are old or damaged, as well as making cells to be used to create new organisms during sexual reproduction.Mitosis is when a cell divides to create two identical daughter cells. Mitosis occurs in somatic cells (all the cells that arent sex cells), and its a process critical for producing new cells and keeping the organism alive and healthy. Most cells in the human body only last a few days to a few weeks (an exception is brain cells, which typically last your whole life), so your body must constantly be making new cells through mitosis.All cells go through a process of formation, growth, division, and eventual death. During mitosis, the parent cells nucleus is split to form two sets of chromosomes for each of the new daughter cells. You can learn more about this process by reading our in-depth guide to mitosis.Meiosis also involves cell division, however, it occurs in far fewer cells in your body. The only cells that go through meiosis are gametes, or sex cells (sperm in men and eggs in women). Meiosis is needed for sexual reproduction, and each cycle of meiosis creates four daughter cells with exactly half the number of chromosomes as the parent cell. During fertilization, two daughter cells (one from each organism reproducing) will combine to create an embryo with a full set of chromosomes. How Are Mitosis and Meiosis Similar? As youll see in the next section, mitosis and meiosis have many differences, but they follow the same general pattern to complete the cell division process.The biggest similarity between the two is that they both produce new cells. While the cells they create have some key differences, the end goal is the creation of daughter cells that can be used to either keep the organism alive (mitosis) or help create a new organism during sexual reproduction (meiosis).Both mitosis and meiosis begin with a single parent cell which eventually splits to form new daughter cells. They also both are preceded by interphase, a period of growth (sometimes lasting up to 90% of the cells life) when DNA is synthesized.During cell replication, mitosis and meiosis follow the same phases: prophase, metaphase, anaphase, and telophase (although meiosis goes through each step twice, while mitosis only goes through each step once). Heres what happens in each phase: Prophase:Chromosomes condense into X-shaped structures made up of two identical chromatidsChromosomes/chromatids pair upMembrane around the cell nucleus dissolves Metaphase:Chromosomes/homologous pairs of chromosomes line up along the center of the cellMitotic spindle fibers attach to each of the chromosomes Anaphase:Chromosome pairs/sister chromatids are pulled apart by the spindle fibers and move to opposite ends of the cell Telophase:A set of chromosomes gather together at each end of the cellMembrane forms around each chromosome set to create new nuclei Both processes also end with cytokinesis, which is when the cytoplasm of the cell splits when the cell pinches in the middle and eventually separates, forming two new cells. From left to right: interphase, prophase, metaphase, anaphase, telophase, cytokinesis What Is the Difference Between Mitosis and Meiosis? Although mitosis and meiosis follow the same basic steps, they have more differences than similarities. Most of these differences relate back to the fact that, although both are needed for cell replication, mitosis and meiosis have different purposes: mitosis replaces body cells with identical copies, while meiosis creates genetically different sex cells that will be used to create an entirely new organism.Another difference between mitosis and meiosis is that, during mitosis, there is only one cell division, so the cell goes through the steps of prophase, metaphase, anaphase, and telophase once. However, during meiosis there are two cell divisions, and the cell goes through each phase twice (so theres prophase I, prophase II, etc.).Additionally, because increasing genetic diversity is a goal of meiosis but not mitosis (where all the daughter cells are identical), during prophase in meiosis, a process called recombination/crossing over occurs. This is when non-sister chromatids of homologous pairs exchange genetic material so that the daughter cells are more genetically diverse from each other.Heres a chart summarizing the key differences for mitosis vs meiosis: MitosisMeiosisWhere it occursOccurs in all organisms, except virusesOnly occurs in animals, plants, and fungiCells it producesCreates body/somatic cellsCreates germ/sex cellsNumber of cell divisionsOne cell division (4 stages total)Two cell divisions (8 stages total)Prophase lengthProphase is shortProphase I is longerRecombination/crossing overNo recombination/crossing over in prophaseRecombination/crossing over of chromosomes during prophase IMetaphaseDuring metaphase, individual chromosomes line up on cells equatorDuring metaphase I, pairs of chromosomes line up on cells equatorAnaphaseDuring anaphase, sister chromatids move to opposite ends of the cellDuring anaphase I, sister chromatids move together to the same cell pole. During anaphase II, sister chromatids are separated to opposite ends of the cellNumber of cells createdEnd result: two daughter cellsEnd result: four daughter cellsPloidyCreates diploid daughter cellsCreates haploid daughter cellsGeneticsDaughter cells are genetically identicalDaughter cells are genetically different Summary: Compare and Contrast Mitosis and MeiosisBelow is a mitosis and meiosis Venn Diagram that summarizes all the key mitosis vs meiosis similarities and differences. On the left side of the diagram, you can see the key features of mitosis, on the right are the key features of meiosis, and where the two circles overlap is where their similarities are listed. What's Next?If you want to better understand what DNA is, you need to know about nucleotides.In our guide to nucleotides, we explain what they are and how they make up DNA.Vacuoles are a key organelle in cells.Learn everything you need to know about vacuoles,as well as why they're so different in plant vs animal cells, by reading our guide to vacuoles.Are you fine with memorizing details, but struggling with grasping larger bio concepts? Follow along as we walk you through the differences between incomplete dominance vs. codominance and homologous vs. analogous structures. If you learn best through examples, you'll also love our break-down of commensalism.What are the most important science classes to take in high school? Check out our guide to learn all the high school classes you should be taking. By the end of this lesson you will:Understand how meiosis starts with one diploid cell and results in four haploid cells.Know how meiosis produces gametes that are genetically diverse.Be able to model the stages of meiosis.Be able tompare the similarities and differences in the mechanics of mitosis and meiosis.Review of sexual and asexual propagationAs seen earlier, there are two broad categories of plant propagation: sexual and asexual. When new plants are produced from existing plant parts, like pieces of leaf, stem, or root, reproduction is asexual and the only type of cell division that has taken place is mitosis, where one diploid cell produces two identical diploid cells.If new plants are instead produced from seeds, this is a strong indication (but not a certaintyoptionally read about apomixis) that reproduction was sexual. Plants that practice sexual reproduction use mitotic cell division when increasing the diploid vegetative parts of the plant like stem, leaf, and root, but use meiotic cell division to initiate the haploid stage of the plant that ultimately results in production of egg and sperm cells central to sexual reproduction. Instead of two diploid cells from one diploid cell (the outcome of mitosis), the outcome of meiosis is four haploid cells from one diploid cell.Sexual reproduction of an angiosperm. LadyofHats, Public domain, via Wikimedia Commons.Plant growth is divided into two generations that are diploid (2n) and haploid (1n). Higher plants (angiosperms) have a long-lived sporophytic generation that is the diploid sporophyte. The sporophyte is the growth you would easily recognize as a plant. Through the process of meiosis, the sporophyte produces haploid spores in the flower. The spores are the gametophytic generation. Meiosis occurs in the male flower parts to produce pollen (represented by the green circle) and the female floral organs produce egg cells (represented by the white circle). Spores grow by mitosis producing more haploid cells, this is the gametophytic generation. We get a brief glimpse of the gametophytic generation when pollen is released from the flower, the female gametes are hidden from direct view in the ovary. When the haploid gametes (male pollen and female egg cells) unite they reform the sporophytic generation producing a diploid (2n) zygote. The zygote grows into the embryo of the seed and eventually into the plant we see. Lower plants, mosses and ferns that are not flowering plants, also alternate generations, but the gametophytic generation is longer lived and separate from the sporophytic generation. Mitosis/meiosis cycle. Menchi. CC BY-SA 3.0The plant doesnt magically transition to being haploid, but instead particular parts of the flower in the androecium and gynoecium develop and protect a limited number of haploid cells, called the male gametophyte and female gametophyte. A later chapter addresses how the male and female gametophyte include the haploid egg and sperm cells that must unite to form the diploid embryo in seeds. For now, know that meiosis is the gateway into the haploid phase. Meiosis is the type of cell division that starts with diploid cells and results in haploid cells. Without meiosis there is no egg and sperm, and thus no sexual reproduction.Propagation and natural selectionFrom the natural selection perspective, how do asexual and sexual reproduction differ?In asexual reproduction, the plants are genetic copies of the parent plant. Cell division is strictly mitosis. Except for rare mutations, the resulting progeny are identical to the parents. The fitness of the progeny will mirror the fitness of the parent. The downside of this type of propagation is that there is no genetic variance among progeny that might result in selection for plants that have greater fitness than the parent for characteristics such as increased cold hardiness, drought tolerance, or disease resistance. The upside is that if the parent has high fitness to begin with (and it must have had reasonable fitness to reach reproductive age), all progeny will also have that high level of fitness. If the environment remains the same as it was for the parent, the progeny will stand a good chance of reproductive success. But if the environment changes, the fitness of the progeny may no longer be optimum.In sexual reproduction, since one gamete comes from the male parent and one from the female, and because in a population of cross-pollinating wild plants there are many potential parents, each with different genotypes, there are many potential genetic combinations of male and female gametes. Not only are the plants producing the gametes each genetically different, but each gamete from each plant is potentially unique. The many combinations of male and female gametes, and the uniqueness of gametes from the same plant, result in a substantial genetic variation among the progeny of plants that sexually reproduce. Some of these progeny will have greater fitness than others, and will be favored by natural selection some will survive to reproductive age and have more progeny than other plants, while the rest will either not survive to reproduce or, if they do reproduce, it will be with low frequency. The DNA of the fittest plants will thus be represented more frequently in the next generation of plants than the DNA of the least fit plants, which may never survive to reproduce and pass on their DNA. This is the process of natural selection. The DNA of reproductively successful parents is passed on the next generation, while the DNA of reproductively unsuccessful parents is not.Sex generates genetic variation. Genetic variation, generated by meiosis and sexual reproduction, is the fuel for the engine of natural selection.Ploidy reviewTo review: if you count the number of chromosomes in a somatic cell, for instance a root tip cell, you will find that there is always an even number. These are diploid 2n cells that arose from mitotic cell divisions tracking all the way back to the zygote that formed the embryo of the seed. Listed below are the numbers of chromosomes found in somatic, diploid, 2n cells of a few commonly grown plants. Note that the number of chromosomes is even, never odd, and that it doesnt imply anything about the size or type of plant:Corn = 20Rice = 24Soybean = 40Green bean = 22Tomato = 24Potato = 48Apple = 34Rose = 14Diploid cells always contain an even number of chromosomes because there are two copies of each chromosome, one contributed by the male sperm and one by the female egg. If you number each type of corn chromosome 1 through 10, there would be two 1s (a maternal and a paternal), two 2s, etc. Recall that the two (donated from the male and female) versions of the same chromosome in a diploid cell are called homologous chromosomes or homologs. In a diploid cell like corn where 2n=20, there are 10 pairs of homologous chromosomes.Also recall that the number of chromosomes in a gamete is half the number of chromosomes found in a somatic cell of the same plant. The gamete cells are haploid, abbreviated n. There may be an even or odd number of haploid chromosomes, depending on the diploid chromosome number. Beans have a diploid number of 22, so the gametes have an odd number of chromosomes (11). Tomato has a diploid number of 24, so the gametes have an even number of chromosomes (12).When two gametes fuse and form a zygote, the zygote has the 2n chromosome number restored. From then on, the cell divisions that allow a plant to grow from zygote to full size are all mitosis, and all the cells are copies of the zygote formed by fusion of the two gametes. In what sense is meiosis the gateway into the haploid or gametophytic stage of alternation of generations?Why does a diploid plant cell always have an even number of chromosomes?A diploid rose cell has 14 chromosomes. How many pairs of homologous chromosomes will you find in that diploid cell? Meiosis mechanicsMeiosis. Emily TepeMeiosis starts with a diploid cell and results in haploid (n) cells that we could correctly call spores. In the illustration above, note that starting with one diploid cell and meiosis yields four haploid cells.Below are the stages of meiosis. It wont be difficult to memorize them because you already know the stages of mitosis, and meiosis builds on mitosis. The illustration shows a hypothetical species with two pairs of chromosomes (2n=4) in the starting cell and n=2 in the resulting gamete cells. Meiosis has two chromosome divisions, so the stages are labeled I for those stages associated with the first division (e.g., Metaphase I) and II for those associated with the second division (e.g., Metaphase II).Stages of meiosis. Boumphreyfr. CC BY-SA 3.0As in mitosis, the cell division process starts when the chromosomes replicate in the S phase of interphase.Prophase I the nuclear membrane disintegrates, and we see that the chromosomes have already replicated (in S of interphase) so that the now condensed chromosomes are made up of two sister chromatids attached at the centromere. New, however, is that in this stage the homologous chromosomes pair up and form structures called tetrads because they are groupings of four sister chromatids (two sister chromatids per homolog). This process of pairing and tetrad formation promotes chiasma (seen under the microscope as the point where sister chromatids of homologs lay over each other, forming an X shape) and crossing over between sister chromatids of homologous chromosomes. Crossing over results in an exchange of DNA between homologs and is another contributor to genetic variation in the gametes and resulting organisms.Reread the preceding paragraph, making sure you understand how homologs pair, form chiasma, and cross over between sister chromatids. This type of pairing of homologs and subsequent chiasma formation doesnt happen in mitosis a very important and essential difference between the two types of cell division.Metaphase I the tetrads are lining up on the metaphase plate, ready to divide. Recall that they are called tetrads because they are made up of four sister chromatids.Anaphase I the tetrads divide and homologs go to opposite poles. Note that sister chromatids stay intact and the centromeres do not divide yet. It is the homologous chromosomes that separate at Anaphase I. The sister chromatids may differ in some places along their arms due to crossing over that causes exchange of DNA between homologs.Telophase I the nuclear membrane reappears to separate the products of the first division.The DNA relaxes in Interphase I, but no replication occurs. DNA condenses again in Prophase II, and we can see the chromosomes.Metaphase II the chromosomes (which are in the form of sister chromatids still connected at the centromere) line up at the metaphase plate, as in metaphase of mitosis.Anaphase II also like anaphase in mitosis, the centromeres split and sister chromatids are pulled to opposite poles.Telophase II nuclear membrane reforms, cytokinesis takes place, just like the telophase of mitosis. Note that the II stages of meiosis are just like the corresponding stages of mitosis, making them easy to remember. Do the chromosomes replicate prior to meiosis?What happens during crossing over?The illustration above shows that some of the sister chromatids are combinations of red and blue rather than being all red or all blue. What does that represent?What separates in Anaphase I?What separates in Anaphase II? DivisionWatch this video for a detailed explanation of division (8:19) Memorizing this process helps you focus on clearly understanding the mechanics of the process, and recognize how it is that meiosis results in four haploid cells instead of the two 2n cells that result from mitosis. You get four haploid cells because the initial cell undergoes two divisions. The cell first divides into two nuclei, then those two divide again into four. The chromosome number drops from 2n in the original cell to n in each of the four haploid cells because the number of sets of chromosomes is reduced from 2 to 1 (that is, homologs separated to opposite poles) in the first meiotic division, and then the sister chromatids separated in the mitosis-like second meiotic division. There was chromosome replication before the first division, but no replication before the second division.Heres a summary of what is dividing and when:Two divisions:Homologs separate in Anaphase I. Centromeres holding the chromatids do not split. Anaphase I. Boumphreyfr. CC BY-SA 3.0Chromatids separate in Anaphase II. Centromeres holding the chromatids do split.Anaphase II. Boumphreyfr. CC BY-SA 3.0Genetic variation among gametesWatch this video to see how meiosis contributes to genetic variation. (9:26)Each gamete ends up with one of the homologs of the pair, not both.Imagine that there are two or three or even 30 pairs of homologous chromosomes. Each homolog pair making up the tetrad in Metaphase I separates in Anaphase I. One homolog from the pair heads to one pole and the other heads to the opposite pole. Each pair of homologs moves independently of all the other homolog pairs that are also separating. That is, all the paternal-source chromosomes making up the homologous pairs dont go to one pole and all the maternal-source go to the other pole (this is possible, but since it would be by chance the probability is very low). Instead, paternal-source homologs of some chromosomes and maternal-source homologs of the other chromosomes are pulled to the poles, so that eventually there is a mix of maternal- and paternal-source chromosomes in the gametes, and that mix of maternal and paternal is generally thought to be random.This principle, where homologs move to poles independently, is called independent assortment, and leads to differences in the genotype of the gametes one source of genetic variation among gametes.Crossing over and exchange of DNA between homologous sister chromatids in Prophase I is another source of variation in gametes. If two cells in the sporangia are undergoing meiosis, the crossing over in each cell will probably happen in different places on the chromosome in each cell, resulting in exchanges taking place at different locations on the DNA backbone so that the gametes resulting from different cells going through meiosis will all be unique.What is crossing over?Crossing over. OpenStax. CC BY 4.0The illustration above shows a tetrad where the red and blue homologous chromosomes of the same chromosome type are pairing. Each homolog here consists of two sister chromatids joined at the centromere. Note that the chromosomes have already replicated in interphase prior to the start of Prophase I.In Prophase I, homologous chromosome pairs come together (synapsis).Arms of sister chromatids from different homologs overlap (chiasma) and exchange DNA (crossing over).Note that all four of the resulting sister chromatids are now genetically different, with each potentially having a different DNA sequence.SummaryMeiosis is a type of cell division that starts with a diploid, 2n cell.The process includes two chromosome divisions and produces four haploid, n cells.The haploid cells are genetically different from each other due to crossing over in Prophase I and independent assortment in Anaphase I.Homologs separate in Anaphase I while sister chromatids separate (the centromeres divide) in Anaphase II. Why does independent assortment during meiosis contribute to genetic variability of gametes?Why does crossing over contribute to genetic variability of gametes?definitionHaploid single cell produced by meiosis in the sporangium of a diploid sporophyte.Groupings of four sister chromatids.Point where sister chromatids of homologs lay over each other forming an "X" shape.Exchange of arms of DNA between sister chromatids of homologous chromosomes that can take place at the point of chiasma formation.Structures in the androecium and gynoecium where meiosis takes place and the gametophyte generation develops. From an academic perspective, understanding the difference between mitosis and meiosis is crucial. Read on to explorewhat is mitosis and meiosis, significant similarities and differences between the two: Meiosis is a type of cell division that results in the formation of four daughter cells each with half the number of chromosomes as the parent cell. Mitosis is the type of cell division that results in the formation of two daughter cells each with the same number and kind of chromosomes as the parent cell.Table of Contents Difference Between Mitosis And MeiosisIntroduction In single-celled organisms, cell reproduction gives rise to the next generation. In multicellular organisms,cell division occurs not just to produce a whole new organism but for growth and replacement of worn-out cells within the organisms.Cell division is always highly regulated and follows a highly orchestrated series of steps. The term cytokinesis refers to the division of a cells cytoplasm, while mitosis and meiosis refer to two different forms of nuclear division.Mitosis results in two nuclei that are identical to the original nucleus. Meiosis, on the other hand, results in four nuclei, each havinghalf the number of chromosomes of the original cell. In animals, meiosis only occurs in the cells that give rise to the sex cells (gametes), i.e., the egg and the sperm.Also read:Cell CycleDifferences Between Mitosis and Meiosis The important difference between mitosis and meiosis are mentioned below:MitosisMeiosisEach chromosome replicates during the S phase of the interphase. The result is two genetically identical sister chromatids (However, do note that interphase is technically not a part of mitosis because it takes place between one mitotic phase and the next).Chromosomes not yet visible but DNA has been duplicated or replicated.Prophase Each of the duplicated chromosomes appears as two identical or equal sister chromatids. The mitotic spindle begins to form. Chromosomes condense and thicken.Prophase I crossing-over and recombination Homologous chromosomes (each consists of two sister chromatids) appear together as pairs. Tetrad or bivalent is the structure that is formed. Segments of chromosomes are exchanged between non-sister chromatids at crossover points known as chiasmata (crossing-over).Metaphase -The chromosomes assemble at the equator at the metaphase plate.Metaphase I Chromosomes adjust on the metaphase plate. Chromosomes are still intact and arranged as pairs of homologues(bivalent).Anaphase The spindle fibres begin to contract. This starts to pull the sister chromatids apart. At the end of anaphase, a complete set of daughter chromosomes is found on each pole.Anaphase I Sister chromatids stay intact. However, homologous chromosomes drift to the opposite or reverse poles. Asexual ReproductionSexual ReproductionAll the cellsReproductive cellsGeneral growth and repair, Cell reproductionGenetic diversity through sexual reproductionOccurs in TelophaseOccurs in Telophase I and in Telophase IIWalther FlemmingOscar HertwigMitosis Overview Mitosis is a continuous process of cell division which occurs in all types of living cells. Mitosisinvolvesfour basic phases prophase, metaphase, anaphase and telophase.Mitosis is the process where the division of cell occurs by asexual reproduction.In mitosis, the nuclear membrane is broken down, spindle fibres (microtubules) attach to the chromatids at the centromere and pull apart the chromatids.When the chromatids reach separate ends of the cells, the spindle fibres disintegrate and a nuclear membrane rebuilds around the chromosomes making two nuclei.Each nucleus is identical to the original nucleus as it was in G1 phase.Also read:Difference between haploid and diploidMeiosis Overview Meiosis is the form of nuclear cell division that results in daughter cells that have one-half the chromosome numbers as the original cell.In organisms that are diploid, the end result is cells that are haploid. Each daughter cell gets one complete set of chromosomes, i.e., one of each homologous pair of chromosomes.In humans, this means the chromosome number is reduced from 46 to 23.The germ cells undergo meiosis to give rise to sperm and eggs.The joining together of a sperm and egg during fertilisation returns the number of the chromosomes to 46.Cells that undergo meiosis go through the cell cycle, including the S phase, so the process begins with chromosomes that consist of two chromatids just as in mitosis.Meiosis consists of meiosis I and meiosis II. In meiosis I, homologous chromosomes are separated into different nuclei.This is the reduction division; chromosome number is divided in half. Meiosis II is very similar to mitosis; chromatids are separated into separate nuclei.As in mitosis, it is spindle fibres that pull the chromosomes and chromatids apart in meiosis.The end result of meiosis is four cells, each with one complete set of chromosomes instead of two sets of chromosomes.Also read: Significance ofMeiosisSimilarities Between Mitosis and Meiosis Both mitosis and meiosis take place in the cell nuclei, which can be observed under a microscope.Both mitosis and meiosis involve celldivision.Both the processes occur in the M-phase of the cell cycle. In both cycles, the typical stages areprophase, metaphase, anaphase and telophase.In both cycles, synthesis of DNA takes place.Also Read: Conclusion The difference between Mitosis and Meiosis is quite apparent. They are two very different processes that have two different functions. Meiosis is required for genetic variation and continuity of all living organisms. Mitosis, on the other hand, is focused on the growth and development of cells. Meiosis also plays an important role in the repair of genetic defects in germline cells.Mitosis is a form of cell division where the cell splits into two, each identical to the original cell.Meiosis is a type of cell division that results in four cells, each having half the number of chromosomes of the original cell.The difference between mitosis and meiosis are as follows:Mitosis was discovered by Walther Flamming, while meiosis was discovered by Oscar Hertwig.Cytokinesis occurs only in telophase during mitosis, while it occurs in Telophase 1 and telophase 2 during meiosis.The primary function of mitosis is general growth and repair. It is also used for cell reproduction.Tetrad formation is not observed in mitosis. Tetrad formation is observed in meiosis.Meiosis, on the other hand, aims to provide genetic diversity through sexual reproduction.Asexual mode of reproduction is observed for mitosis. Sexual mode of reproduction is observed for meiosis.The similarities between mitosis and meiosis are as follows:Mitosis and meiosis take place in the cell nuclei.Both involve cell division.Both the processes occur in the M-phase of the cell cycle.In both cycles, the stages are common prophase, metaphase, anaphase and telophase.Synthesis of DNA occurs in both.To know more about mitosis and meiosis, what is mitosis and meiosis, the difference between mitosis and meiosis, or any other topic in Biology, keep visiting BYJUS website or download the BYJUS app for further reference. Put your understanding of this concept to test by answering a few MCQs. Click Start Quiz to begin! Select the correct answer and click on the Finish buttonCheck your score and answers at the end of the quiz Visit BYJUS for all Biology related queries and study materials 0 out of 0 arewrong 0 out of 0 are correct 0 out of 0 are Unattempted View Quiz Answers and Analysis The advantage of sexual reproduction is that it generates genetic diversity, which makes a population of mating organisms better able to survive environmental pressures. Meiosis is the process of producing gametes, which are sperm cells and egg cells. Gametes have only half the number of chromosomes that normal cells have, because a sperm and an egg fuse to form a cell that has the full number of chromosomes. Genetic diversity arises due to the shuffling of chromosomes during meiosis. A man produces sperm and a woman produces eggs because their reproductive cells undergo meiosis. Meiosis starts with one cell that has the full number of chromosomes specific to each organism human cells have 46 chromosomes. It ends with four cells, called gametes, that each have half the full number of chromosomes. Meiosis is a multi-step process in which a cell makes a copy of each strand of DNA, called a chromosome, and then divides twice. Each time it divides, it cuts its DNA content in half. In humans, a cell goes from having 46 strands of DNA, and then 96 after each is copied. The first division of meiosis cuts 96 in half into 46. The second division cuts 46 into 23, which is the number of chromosomes in a sperm or an egg. At the beginning of meiosis, the chromosomes condense from long strands into short, thick finger-like structures. In humans, condensed chromosomes look like an X. Half of the 46 chromosomes in a human cell came from the mother, while the other 23 are similar but came from the father they form 23 pairs, like 23 pairs of non-identical twins. Chromosomes that form a pair are called homologous chromosomes. During the early part of meiosis, the homologous chromosomes pair up with their non-identical twins and exchange regions of DNA. This process is called crossing over, and results in a shuffling of DNA regions between two homologous chromosomes. Chromosomes are purposely broken and rejoined in new combinations. Meiosis not only shuffles regions of DNA between homologous chromosomes, it shuffles whole chromosomes among the four gametes that result at the end. The distribution of chromosomes among four gametes is called random segregation. If the process of "crossing over" is like tearing blue cards and red cards apart, and then taping the pieces together to get striped cards, then "random segregation" is combining a red deck and a blue deck, shuffling them, and then randomly dividing them into four decks. Random segregation produces four decks of cards that contain different combinations of blue and red cards. The third way that meiosis generates genetic diversity is through the separation of homologous chromosomes into the gametes. As described above, homologous chromosomes are like pairs of non-identical twins. One chromosome of the pair came from mom, the other from dad. Each homologous chromosome can contain the same genes, or slightly different versions of the same gene which is why they are like non-identical twins and not identical twins. Independent assortment describes the process in which the two homologous chromosomes of a pair must go into separate gametes. This ensures that each gamete can have only one of two homologous chromosomes, meaning each can have only one version of a gene, though the original cell might have had two slightly different versions of a gene. Ph.D., David H. Nguyen,. "Three Ways That Genetic Diversity Occurs During Meiosis" sciencing.com, . 5 April 2018. APA Ph.D., David H. Nguyen,. (2018, April 5). Three Ways That Genetic Diversity Occurs During Meiosis. sciencing.com. Retrieved from Chicago Ph.D., David H. Nguyen,. Three Ways That Genetic Diversity Occurs During Meiosis last modified August 30, 2022. Cells divide and reproduce in two ways: mitosis and meiosis. Mitosis is a process of cell division that results in two genetically identical daughter cells developing from a single parent cell. Mitosis is used by single-celled organisms to reproduce; it is also used for the organic growth of tissues, fibers, and membranes. Meiosis, on the other hand, is the division of a germ cell involving two fissions of the nucleus and giving rise to four gametes, or sex cells, each possessing half the number of chromosomes of the original cell. Meiosis plays a role in sexual reproduction of organisms. The male and female sex cells (i.e., egg and sperm) are the end result of meiosis; they combine to create new, genetically different offspring. What is the role and purpose of mitosis and meiosis?Though both types of cell division are found in many animals, plants, and fungi, mitosis is more common than meiosis and has a wider variety of functions. Not only is mitosis responsible for asexual reproduction in single-celled organisms, but it is also what enables cellular growth and repair in multicellular organisms, such as humans. In mitosis, a cell makes an exact clone of itself. This process is what is behind the growth of children into adults, the healing of cuts and bruises, and even the regrowth of skin, limbs, and appendages in animals like geckos and lizards.Meiosis is a more specific type of cell division (of germ cells, in particular) that results in gametes, either eggs or sperm, that contain half of the chromosomes found in a parent cell. Unlike mitosis with its many functions, meiosis has a narrow but significant purpose: assisting sexual reproduction. It is the process that enables children to be related but still different from their two parents. Meiosis and Genetic DiversitySexual reproduction uses the process of meiosis to increase genetic diversity. Offspring created through asexual reproduction (mitosis) are genetically identical to their parent, but the germ cells created during meiosis are different from their parent cells. Some mutations frequently occur during meiosis. Further, germ cells have only one set of chromosomes, so two germ cells are required to make a complete set of genetic material for the offspring. The offspring is therefore able to inherit genes from both parents and both sets of grandparents.Genetic diversity makes a population more resilient and adaptable to the environment, which increases chances of survival and evolution for the long term.Mitosis as a form of reproduction for single-cell organisms originated with life itself, around 3.8 billion years ago. Meiosis is thought to have appeared around 1.4 billion years ago.Mitosis and Meiosis StagesCells spend about 90% of their existence in a stage known as interphase. Because cells function more efficiently and reliably when small, most cells carry out regular metabolic tasks, divide, or die, rather than simply grow larger in the interphase. Cells "prepare" for division by replicating DNA and duplicating protein-based centrioles. When cell division begins, the cells enter into either mitotic or meiotic phases. In mitosis, the end product is two cells: the original parent cell and a new, genetically identical daughter cell. Meiosis is more complex and goes through additional phases to create four genetically different haploid cells which then have the potential to combine and form a new, genetically diverse diploid offspring. A diagram showing the differences between meiosis and mitosis. Image from OpenStax College.Stages of MitosisWhat are the four stages of mitosis?There are four mitotic phases: prophase, metaphase, anaphase, and telophase. Plant cells have an additional phase, preprophase, that occurs before prophase. During the mitotic prophase, the nuclear membrane (sometimes called "envelope") dissolves. Interphase's chromatin tightly coils and condenses until it becomes chromosomes. These chromosomes are made up of two genetically identical sister chromatids that are joined together by a centromere. Centrosomes move away from the nucleus in opposite directions, leaving behind a spindle apparatus. In metaphase, motor proteins found on either side of the chromosomes' centromeres help move the chromosomes according to the pull of the opposing centrosomes, eventually placing them in a vertical line down the center of the cell; this is sometimes known as the metaphase plate or spindle equator. The spindle fibers begin to shorten during anaphase, pulling the sister chromatids apart at their centromeres. These split chromosomes are dragged toward the centrosomes found at opposite ends of the cell, making many of the chromatids briefly appear "V" shaped. The two split portions of the cell are officially known as "daughter chromosomes" at this point in the cell cycle. Telophase is the final phase of mitotic cell division. During telophase, the daughter chromosomes attach to their respective ends of the parent cell. Previous phases are repeated, only in reverse. The spindle apparatus dissolves, and nuclear membranes form around the separated daughter chromosomes. Within these newly formed nuclei, the chromosomes uncoil and return to a chromatin state. One final processcytokinesisis required for the daughter chromosomes to become daughter cells. Cytokinesis is not part of the cell division process, but it marks the end of the cell cycle and is the process by which the daughter chromosomes separate into two new, unique cells. Thanks to mitosis, these two new cells are genetically identical to each other and to their original parent cell; they now enter their own individual interphases.Stages of MeiosisThere are two primary meiosis stages in which cell division occurs: meiosis 1 and meiosis 2. Both primary stages have four stages of their own. Meiosis 1 has prophase 1, metaphase 1, anaphase 1, and telophase 1, while meiosis 2 has prophase 2, metaphase 2, anaphase 2, and telophase 2. Cytokinesis plays a role in meiosis, too; however, as in mitosis, it is a separate process from meiosis itself, and cytokinesis shows up at a different point in the division.Meiosis I vs. Meiosis IISee a detailed comparison of Meiosis I and Meiosis II.In meiosis 1, a germ cell divides into two haploid cells (halving the number of chromosomes in the process), and the main focus is on the exchange of similar genetic material (e.g., a hair gene; see also genotype vs phenotype). In meiosis 2, which is quite similar to mitosis, the two diploid cells further divide into four haploid cells.Stages of Meiosis I The first meiotic phase is prophase 1. As in mitosis, the nuclear membrane dissolves, chromosomes develop from the chromatin, and the centrosomes push apart, creating the spindle apparatus. Homologous (similar) chromosomes from both parents pair up and exchange DNA in a process known as crossing over. This results in genetic diversity. These paired up chromosomestwo from each parentare called tetrads. In metaphase 1, some of the spindle fibers attach to the chromosomes' centromeres. The fibers pull the tetrads into a vertical line along the center of the cell. Anaphase 1 is when the tetrads are pulled apart from each other, with half the pairs going to one side of the cell and the other half going to the opposite side. It is important to understand that whole chromosomes are moving in this process, not chromatids, as is the case in mitosis. At some point between the end of anaphase 1 and the developments of telophase 1, cytokinesis begins splitting the cell into two daughter cells. In telophase 1, The spindle apparatus dissolves, and nuclear membranes develop around the chromosomes that are now found at opposite sides of the parent cell / new cells.Stages of Meiosis II In prophase 2, centrosomes form and push apart in the two new cells. A spindle apparatus develops, and the cells' nuclear membranes dissolve. Spindle fibers connect to chromosome centromeres in metaphase 2 and line the chromosomes up along the cell equator. During anaphase 2, the chromosomes' centromeres break, and the spindle fibers pull the chromatids apart. The two split portions of the cells are officially known as "sister chromosomes" at this point. As in telophase 1, telophase 2 is aided by cytokinesis, which splits both cells yet again, resulting in four haploid cells called gametes. Nuclear membranes develop in these cells, which again enter their own interphases.References Share this comparison via: If you read this far, you should follow us: "Meiosis vs Mitosis." Diffen.com. Diffen LLC, n.d. Web. 27 Jun 2025. < > Difference Between Mitosis And Meiosis: Meiosis and Mitosis cell division is crucial for sustaining life processes. Mitosis cell division produces two identical daughter cells with the same chromosome number, while meiosis produces four genetically different haploid cells for sexual reproduction. Mitosis takes part in growth, repair, and asexual reproduction, on the other hand, meiosis is essential for sexual reproduction, producing sperm and egg cells for genetic diversity. This article provides a difference between mitosis and meiosis, a brief introduction to cell division, an overview of mitosis and meiosis, and their significance. Differences Between Mitosis and MeiosisThe difference between mitosis and meiosis are as follows: FeatureMitosisMeiosisDiscovered By Walther Flemming Oscar Hertwig Type of DivisionEquational division Reductional division Number of NucleiTwo nuclei with the same chromosomes Four nuclei with half the chromosomes Similarity to ParentDaughter nuclei are identical Daughter nuclei are not identical PhasesProphase, Metaphase, Anaphase, Telophase Meiosis I and Meiosis II, each with four phases Cell TypeOccurs in both haploid and diploid cells Occurs in diploid cells only Genetic VariationProduces genetically identical cells Produces genetically non-identical cells Occurs in Telophase Occurs in Telophase I and in Telophase II Asexual Reproduction Sexual Reproduction RoleHelp in growth and repair Help in reproduction by maintaining chromosome numbers, promotes variation What is Mitosis?Mitosis cell division is a type of karyokinesis in which the nucleus divides to form two nuclei having the same number and kind of chromosomes as the parent cell. It is an equational division. The daughter nuclei formed are exactly identical to the parent cell. The mitosis stages are: Interphase:G1 Phase: Growth of cell take place.S Phase: DNA replicationG2 Phase: Preparation for mitosis.Prophase:Condensation of Chromosomes take place.Formtion of spindle fibre.Nuclear envelope breaks down.Metaphase:Chromosomes align at the metaphase plate.Spindle fibers attach to centromeres.Anaphase:Sister chromatids separate and move to opposite poles.Telophase:Chromatids reach poles and de-condense.Nuclear envelopes reform.Cytokinesis:Cell divides and forms two daughter cell. What is Meiosis?Meiosis is a type of Karyokinesis in which the nucleus divides to form four nuclei having half the number of chromosomes of the parent cell. It is a reductional division. Daughter nuclei formed are not identical to parent cells. Meiosis I is a reductional division because homologous chromosomes are segregated and thus chromosome number is reduced to half. Meiosis II is equational division and is very much similar to mitosis, chromatids of a chromosome are separated. Between meiosis, I and meiosis II, a phase known as 'interkinesis' is present where centrosome replication occurs. Meiosis I involves the pairing of homologous chromosomes, crossing over between them, and their separation, leading to a reduction in chromosome number. Meiosis II is similar to mitosis, where sister chromatids are separated, resulting in the formation of four genetically non Identical haploid cells. Similarities Between Mitosis and MeiosisSimilarities Between Mitosis and Meiosis are as follows: Both mitosis and meiosis are types of cell division.Both the processes take place in the nucleus of cell.During the preceding interphase, replication of DNA take place in both the processes.Both processes starts with a diploid cell having homologous chromosomes.During cell division both use spindle fibers to move chromosomes.Conclusion - Difference Between Mitosis And MeiosisMitosis and meiosis are two different processes, each having different function. The difference between mitosis and meiosis table is described above. In Mitosis nucleus divides to form two nuclei having the same number of chromosomes as the parent cell. In Meiosis the nucleus divides to form four nuclei having half the number of chromosomes of the parent cell. Meiosis help in the continuity of life and promotion of genetic diversity. Mitosis, on the other hand, takes part in the growth and development of cells.Meiosis also repair the genetic defects in germline cells. Also Read: The primary goal of all living organisms on earth is to reproduce in order to survive and evolve, generation after generation. In multi-celled organisms (eukaryotes), the cells grow and reproduce using two different cell division processes mitosis and meiosis. Mitosis vs Meiosis Diagram Chart Mitosis is the process by which somatic cells duplicate and divide their genetic material, forming two identical daughter cells. Meiosis, on the other hand, allows reproductive cells to divide twice to produce four non-identical daughter cells, each having half the genetic material of the parent cell. The former is used in eukaryotes mainly for cell growth and repair, while the latter is necessary for reproduction. Although both are similar in some ways, there are also many differences in their basic processes, steps, and the outcome. The important ones are listed below. Mitosis and Meiosis Venn Diagram BasisMitosisMeiosis1. End ResultProduces two daughter cells.Produces four daughter cells2. Chromosome NumberThe daughter cells are diploid (2n).The daughter cells are haploid (n).3. Genetic CompositionDaughter cells are genetically identical.Daughter cells are genetically different.4.

Main Purposea) Growth, repair, and replacement of old, damaged cells in higher organisms; a form of asexual reproduction in lower organisms (prokaryotes).b) Not involved in maintaining the chromosome number in organisms.c) Helps in cell multiplication during the early period of growth. a) Formation of sex cells or gametes, necessary for reproduction in higher organisms.b) Maintains the chromosome number in the organism.c) Helps to maintain genetic diversity in the population.5. Takes place inAll organisms except viruses.Only in animals, plants, and fungi.6. Number of Cell divisionsInvolves one cell division. Steps: Prophase, Metaphase, Anaphase, Telophase.Involves two cell divisions. Steps: (Meiosis 1) Prophase I, Metaphase I, Anaphase I, Telophase I; (Meiosis 2) Prophase II, Metaphase II, Anaphase II, and Telophase II.7. Cells it ProducesCreates all body (somatic) cells such as blood, liver, and skin cells except the germ cells.Creates sex (germ) cells eggs and sperms.8. Length of ProphaseProphase is shorter than prophase I in meiosis.Prophase I is longer than the prophase of mitosis.9. Formation of Synapsis and Crossing OverBoth are absent.Both take place during prophase I.10. Formation of TetradAbsentOccurs during prophase I.11. Number of Chromatids and CentromereEach chromosome contains two chromatids and a single centromere.Each chromosome contains four chromatids and two centromeres.12. Chromosome AlignmentSister chromatids align along the center of the cell during metaphase.Sister chromatids align along the center of the cell during metaphase I.13. Chromosome SeparationSister chromatids separate during anaphase.Sister chromatids do not separate during anaphase I.14. CytokinesisOccurs once at the end of telophase.Occurs twice at the end of telophase I and telophase II. Start with a diploid parent cell.Are preceded by an initial growth period called interphase of the cell cycle, during which the DNA is duplicated. Thus the number of chromosomal duplication is the same in both the processes.Go through the same basic phases; prophase, metaphase, anaphase, and telophase.Involve lining the duplicated chromosome (sister chromatids) along the center of the cell during the metaphase.Involve separation of sister chromatids forming daughter chromosomes during anaphase of mitosis and meiosis IIEnd with the division of cytoplasm called the cytokinesis that produces new cells. Considering the differences and the similarities, the basic significance of mitosis and meiosis is that they both involve cells to divide and form new cells. This makes them vital for the survival of organisms that reproduce sexually. Q1. Who discovered mitosis and meiosis? Ans. Walther Flemming discovered the process of mitosis in 1879, while meiosis was discovered by Oscar Hertwig in 1876. Q2. Do prokaryotes undergo mitosis? Ans. Cell division in prokaryotes does not occur through mitosis but undergoes a similar process known as binary fission. Q3. Which of the two processes occurs more frequently? Ans. Mitosis is the more common of the two processes in all living cells since it helps grow, repair, and replace the old and damaged cells. In contrast, meiosis occurs only in reproductive cells during the formation of gametes. Q4. What is evaluated at the G2 checkpoint in mitosis and meiosis? Ans. At the G2 checkpoint in both, it is evaluated whether any DNA is damaged in the cell to decide whether the cell should progress further in the cell cycle. Q5. Why do some species employ both mitosis and meiosis? Ans. Some species employ both mitosis and meiosis because the former helps in the initial growth of the organism while the later is needed in carrying out their reproduction. Q6. When is DNA replicated in mitosis and meiosis? Ans. DNA is replicated during the S phase of interphase before the start of both mitosis and meiosis. Q7. Why is meiosis better than mitosis? Ans. Although both are essential in higher organisms, meiosis has an advantage over mitosis in that the former helps create genetic variation within the population such that every individual is different from the other. Q8. What do spindle fibers do during mitosis and meiosis? Ans. Spindle fibers help divide the DNA of the parent cell equally among the two resulting daughter cells both during mitosis and meiosis. Article was last reviewed on Thursday, February 2, 2023 Organisms grow and reproduce through cell division. In eukaryotic cells, the production of new cells occurs as a result of mitosis and meiosis. These two nuclear division processes are similar but distinct. Both processes involve the division of a diploid cell, or a cell containing two sets of chromosomes (one chromosome donated from each parent). However, mitosis involves the division of body cells, while meiosis involves the division of sex cells. Additionally, in mitosis, cell division results in two daughter cells, while meiosis yields four daughter cells through two rounds of division.Mitosis and meiosis are nuclear division processes that occur during cell division.The division of a cell occurs once in mitosis but twice in meiosis. As a result, two daughter cells are produced after mitosis and cytoplasmic division, while four daughter cells are produced after meiosis.Daughter cells resulting from mitosis are diploid, while those resulting from meiosis are haploid. Additionally, daughter cells that are the product of mitosis are genetically identical. Daughter cells produced after meiosis are genetically diverse.Tetrad formation occurs in meiosis but not mitosis. In mitosis, the genetic material (DNA) in a cell is duplicated and divided equally between two cells. The dividing cell goes through an ordered series of events called the cell cycle. The mitotic cell cycle is initiated by the presence of certain growth factors or other signals that indicate the production of new cells is needed. Somatic cells of the body replicate by mitosis. Examples of somatic cells include fat cells, blood cells, skin cells, or any body cell that is not a sex cell. Mitosis is necessary to replace dead cells, damaged cells, or cells that have short life spans. Meiosis is the process by which gametes (sex cells) are generated in organisms that reproduce sexually. Gametes are produced in male and female gonadsandcontain one-half the number of chromosomes as the original cell. New gene combinations are introduced in a population through the genetic recombination that occurs during meiosis. Thus, unlike the two genetically identical cells produced in mitosis, the meiotic cell cycle produces four cells that are genetically different. Lily Anther Microsporocyte in Telophase II of Meiosis.Ed Reschke/Photolibrary/Getty ImagesMitosis: Two daughter cells are produced. Each cell is diploid containing the same number of chromosomes.Meiosis: Four daughter cells are produced. Each cell is haploid containing one-half the number of chromosomes as the original cell.Mitosis: The resulting daughter cells in mitosis are genetic clones (they are genetically identical). No recombination or crossing over occurs.Meiosis: The resulting daughter cells contain different combinations of genes. Genetic recombination occurs as a result of the random segregation of homologous chromosomes into different cells and by the process of crossing over (transfer of genes between homologous chromosomes).Mitosis: During the first mitotic stage, known as prophase, chromatin condenses into discrete chromosomes, the nuclear envelope breaks down, and spindle fibers form at opposite poles of the cell. A cell spends less time in the prophase of mitosis thana cellin prophase I of meiosis.Meiosis: Prophase I consists of five stages and lasts longer than the prophase of mitosis. The five stages of meiotic prophase I are leptotene, zygotene, pachytene, diplotene, and diakinesis. These five stages do not occur in mitosis. Genetic recombination and crossing over take place during prophase I.Mitosis: Tetrad formation does not occur.Meiosis: In prophase I, pairs of homologous chromosomes line up closely together forming what is called a tetrad. A tetrad consists of four chromatids (two sets of sister chromatids).Mitosis: Sister chromatids (duplicated chromosomes comprised of two identical chromosomes connected at the centromere region) align at the metaphase plate (a plane that is equally distant from the two cell poles).Meiosis: Tetrads (homologous chromosome pairs) align at the metaphase plate in metaphase I.Mitosis: During anaphase, sister chromatids separate and begin migrating centromere first toward opposite poles of the cell. A separated sister chromatid becomes known as a daughter chromosome and is considered a full chromosome.Meiosis: Homologous chromosomes migrate toward opposite poles of the cell during anaphase I. Sister chromatids do not separate in anaphase I. Plant cell in Interphase. In interphase, the cell is not undergoing cell division. The nucleus and chromatin are evident.Ed Reschke/Getty Images While the processes of mitosis and meiosis contain several differences, they are also similar in many ways. Both processes have a growth period called interphase, in which a cell replicates its genetic material and organelles in preparation for division. Both mitosis and meiosis involve phases: prophase, metaphase, anaphase, and telophase. However, in meiosis, a cell goes through these cell cycle phases twice. Both processes also involve the lining up of individual duplicated chromosomes, known as sister chromatids, along the metaphase plate. This happens in the metaphase of mitosis and metaphase II of meiosis. In addition, both mitosis and meiosis involve the separation of sister chromatids and the formation of daughter chromosomes. This event occurs in the anaphase of mitosis and anaphase II of meiosis. Finally, both processes end with the division of the cytoplasm that produces individual cells.While there is only one way for mitosis to go right, there are many ways for it to go wrong. For example, in early mitosis, if there are incorrect contacts between microtubules and chromosomes, chromosomes can become misaligned, which can lead to incorrect segregation of sister chromatids. In late mitosis, how is the cell certain that the time is right to perform cytokinesis? The chromosome passenger complex (CPC) is a molecular guardian angel that acts at many stages of mitosis to safeguard the fidelity of the process. At the start of mitosis, the CPC localizes all over the chromosomes and acts to modify chromatin, during mitosis it moves to the chromosome centromeres to prevent incorrect microtubule attachments and before cytokinesis the CPC finds its way to the central spindle. Therefore, a question of ongoing research is how does the CPC elegantly re-localize throughout mitosis to save the day?Vader, G., Medema, R. H., & Lens, S. M. (2006). The chromosomal passenger complex: guiding Aurora-B through mitosis. The Journal of cell biology, 173(6), 833-837.Kabeche, L., Nguyen, H. D., Buisson, R., & Zou, L. (2018). A mitosis-specific and R loopdriven ATR pathway promotes faithful chromosome segregation. Science, 359(6371), 108-114.You might remember from above that it is the protein cohesin that holds together sister chromatids in metaphase of mitosis and metaphase II of meiosis. However, in meiosis I homologous chromosomes must be held together in metaphase I, before these ties are swiftly broken during anaphase I. This feat is performed by a miraculous cellular zipper called the synaptonemal complex (SC). This zipper must be strong enough to hold chromosomes together, but it must also be disassembled equally efficiently, otherwise homologous chromosomes will not accurately segregate in anaphase I, leading to a potentially disastrous genetic inequality in the daughter cells. How exactly this zipper disassembles is a hot topic of research.Argunhan, B., Tsubouchi, T., & Tsubouchi, H. (2018). Polo is not solo in meiosis. Cell Cycle, 17(3), 273-274.Gao, J., & Colaicovo, M. P. (2017). Zipping and unzipping: protein modifications regulating synaptonemal complex dynamics. Trends in Genetics.References (Click to expand)1)Bennett, M. D. (1977). The time and duration of meiosis. Phil. Trans. R. Soc. Lond. B, 277(955), 201-226.2)Jett, J. H. (2015). How long does it take a cell to divide? Cytometry Part A, 87(5), 383-384.3)Brewer, B. J., Chlebowicz-Sledziewska, E., & Fangman, W. L. (1984). Cell cycle phases in the unequal mother/daughter cell cycles of Saccharomyces cerevisiae. Molecular and cellular biology, 4(11), 2529-2531.4)Clift, D., & Schuh, M. (2013). Restarting life: fertilization and the transition from meiosis to mitosis. Nature reviews Molecular cell biology, 14(9), 549.5)Paweletz, N. (2001). Walther Flemming: pioneer of mitosis research. Nature Reviews Molecular Cell Biology, 2(1), 72.6)Nurse, P. M. (2002). Nobel Lecture: Cyclin dependent kinases and cell cycle control. Bioscience reports, 22(5), 487-499.Mitosis and meiosis are both types of cell division. Mitosis is the process by which most cells in the body divide, involves a single round of cell division, and produces two identical, diploid daughter cells.Meiosis is the process by which gametes are produced. Meiosis involves two rounds of cell division and produces four non-identical haploid daughter cells.Cell divisionWhat are Mitosis and Meiosis? Mitosis and meiosis are both types of cell division. Though there are similarities between mitosis and meiosis, there are some key differences between these two processes.Mitosis is how new body cells are produced, whereas meiosis is used to produce gametes (i.e. sperm and egg cells). One cell divisionTwo cell divisionsProduces two daughter cellsProduces four daughter cellsProduces diploid cellsProduces haploid cellsDaughter cells are genetically identicalDaughter cells are non-identicalProduces body cellsProduces sex cellsNo crossing-over occursCrossing-over occursHomologous chromosomes do not pair upHomologous chromosomes do not pair upMitosisMitosis is how the cells of your body reproduce. During mitosis, a diploid parent cell (i.e. a cell with two sets of chromosomes) makes a complete copy of its DNA before splitting in two. This process produces two genetically identical daughter cellsand takes place across five phases.The phases of mitosis are prophase, prometaphase, metaphase, anaphase, and telophase.Before mitosis can begin, however, the cell must replicate its DNA. This happens during interphase, which happens over stages G1, S, and G2 of the cell cycle, and is not technically part of mitosis.Phases of mitosisThe Phases of MitosisProphase The first phase of mitosis is prophase. During prophase, the cells chromosomes condense and become visible under a light microscope. The nucleolus (the part of the nucleus where ribosomes are made) disappears, and the mitotic spindle (a cell structure made of microtubules) begins to form.PrometaphaseThe nuclear membrane breaks down. The microtubules attach themselves to the chromosomes and begin to move them around.MetaphaseThe microtubules move the chromosomes until they are lined up along the middle of the cell. This line of chromosomes is called the metaphase plate.AnaphaseThe chromosomes are pulled apart by the microtubules. Each chromosome is separated into two, genetically identical sister chromatids, which are pulled to opposite ends of the cell.TelophaseThe sister chromatids arrive at opposite ends of the cell. A new nuclear membrane begins to form around each set of chromosomes. The chromosomes decondense, so they are no longer visible under a light microscope. The nucleolus reappears, and the mitotic spindle disappears. Finally, the cytoplasm of the cell splits, and two new, genetically identical daughter cells are formed. This process is called cytokinesis and usually takes place during telophase.MeiosisAlmost all of your bodys cells divide by mitosis. Meiosis is used to produce only one type of cell, and those are the gametes. During meiosis, a diploid cell divides to produce four, non-identical haploid daughter cells, each containing a single set of chromosomes. In humans, these are sperm and egg cells.Unlike mitosis, meiosis involves two rounds of cell division. 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The two non-identical, haploid daughter cells now enter the second stage of meiosis.Meiosis IIMeiosis II is very similar to the process of mitosis, except it involves two haploid cells rather than one diploid cell.Phases of meiosis IIProphase IIDuring prophase II, the chromosomes condense.Prometaphase IIThe nuclear envelopes are broken down and microtubules attach themselves to the chromosomes.Metaphase IIThe chromosomes line up along the metaphase plates.Anaphase IIThe chromosomes are pulled apart by microtubules. The non-identical sister chromatids are pulled to opposite ends of the cells.Telophase IIThe sister chromatids reach opposite ends of the cells. 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Meiosis produces four genetically non-identical daughter cells, which increases genetic variation among gametes (and, therefore, genetic diversity in the population).Mitosis and meiosis are two fundamental processes of cell division that play crucial roles in the growth, development, and reproduction of organisms. While both involve the division of a single parent cell into two or more daughter cells, they serve distinct functions and follow different mechanisms. Understanding the differences between mitosis and meiosis is key to grasping the complexities of biology, particularly in the areas of genetics, reproduction, and evolution.In this article, well delve deep into these two processes, exploring their key differences, the stages involved, and the outcomes of each. By the end of our exploration, youll have a clear understanding of how these processes contribute to life as we know it.Mitosis is a type of cell division that results in two genetically identical daughter cells, each with the same number of chromosomes as the parent cell. Mitosis occurs in somatic (body) cells and is responsible for growth, development, tissue repair, and asexual reproduction in organisms. For instance, when you get a cut, your skin cells undergo mitosis to regenerate and heal the wound.Mitosis involves several phases that work like a well-orchestrated dance, ensuring the accurate division of the cells genetic material. These stages include:Interphase (Preparation Phase): Before mitosis even begins, the cell prepares. Interphase consists of three subphases:G1 phase: The cell grows and performs its normal functions.S phase: The DNA is replicated, ensuring that the daughter cells will have identical genetic information.G2 phase: The cell continues to grow and prepares for mitosis.Prophase: In prophase, the chromatin (the uncoiled form of DNA) condenses into visible chromosomes. Each chromosome consists of two sister chromatids joined at a centromere. The nuclear membrane begins to break down, and the mitotic spindle begins to form.Metaphase: During this phase, the chromosomes align at the cells equatorial plane, known as the metaphase plate. The spindle fibers attach to the centromeres of the chromosomes.Anaphase: Anaphase is characterized by the separation of the sister chromatids. The centromere splits, and the chromatids are pulled to opposite sides of the cell by the spindle fibers.Telophase: In telophase, the separated chromatids, now individual chromosomes, begin to de-condense back into chromatin. The nuclear membrane reforms around the two sets of chromosomes, marking the near end of the division process.Cytokinesis: Cytokinesis is the final step, in which the cytoplasm divides, and the cell splits into two daughter cells, each genetically identical to the parent cell.Meiosis, on the other hand, is a type of cell division that reduces the chromosome number by half, resulting in four genetically diverse daughter cells. These cells are gametes (sperm or egg cells in animals, and pollen or ovules in plants) and are crucial for sexual reproduction. When two gametes combine during fertilization, they restore the original chromosome number in the resulting zygote, ensuring genetic diversity.Meiosis consists of two rounds of division: meiosis I and meiosis II. Each round contains stages similar to those in mitosis, but the outcomes and mechanisms differ.Meiosis I is the reductional division because it reduces the chromosome number by half. It involves the following phases:Prophase I: Prophase I is a lengthy and critical phase. Homologous chromosomes (chromosomes that are similar in shape and size and carry the same genes) pair up and undergo crossing over, where they exchange genetic material. This process is crucial for genetic diversity. The chromosomes then condense, and the nuclear envelope dissolves. Spindle fibers begin to form.Metaphase I: The homologous chromosomes align at the metaphase plate. Unlike mitosis, where individual chromosomes line up, homologous chromosome pairs line up in meiosis I. Spindle fibers attach to the centromeres of each chromosome.Anaphase I: In anaphase I, the homologous chromosomes are pulled to opposite poles of the cell. Note that the sister chromatids remain attached at this stage.Telophase I: The chromosomes arrive at opposite poles, and the cell begins to divide. A nuclear envelope reforms around each set of chromosomes, resulting in two haploid cells (each with half the number of chromosomes).Cytokinesis: Cytokinesis splits the cytoplasm, resulting in two daughter cells, each with half the chromosome number of the original cell.Meiosis II is similar to mitosis but involves the division of haploid cells, not diploid ones. The goal is to separate the sister chromatids. Meiosis II consists of the following stages:Prophase II: Chromosomes condense, and a new spindle apparatus forms in each of the two haploid cells. The nuclear envelope dissolves, and the chromosomes are free to move toward the metaphase plate.Metaphase II: The chromosomes align at the metaphase plate. Unlike meiosis I, the chromosomes are individual, not in homologous pairs.Anaphase II: The centromeres split, and the sister chromatids are pulled apart toward opposite poles of the cell.Telophase II: Chromatids arrive at opposite poles, and nuclear envelopes form around the chromosomes.Cytokinesis: Cytokinesis occurs, and the result is four genetically unique haploid cells, each containing half the number of chromosomes as the original cell.While both mitosis and meiosis are essential forms of cell division, they differ significantly in their purpose, process, and outcomes.Mitosis is responsible for growth, repair, and asexual reproduction. It produces two genetically identical daughter cells.Meiosis, on the other hand, is responsible for producing gametes (sperm and egg cells in animals, pollen and ovules in plants) for sexual reproduction. It results in four genetically diverse haploid cells.Mitosis involves one round of division.Meiosis involves two rounds of division: meiosis I and meiosis II.In mitosis, the chromosome number remains the same. The parent cell is diploid (2n), and the two daughter cells are also diploid (2n).In meiosis, the chromosome number is halved. The parent cell is diploid (2n), but the four daughter cells are haploid (n), containing half the chromosome number.Mitosis produces genetically identical daughter cells, meaning there is no genetic diversity between them.Meiosis promotes genetic diversity through processes like crossing over and the random assortment of chromosomes during metaphase I.Mitosis produces somatic (body) cells that are identical to the parent cell.Meiosis produces gametes, which are specialized for sexual reproduction.Mitosis does not involve crossing over. The genetic material is replicated and divided directly without exchange between chromosomes.Meiosis features crossing over during prophase I, where homologous chromosomes exchange genetic material, leading to new genetic combinations.The outcome of mitosis is two identical diploid cells.The outcome of meiosis is four non-identical haploid cells.The differences between mitosis and meiosis are crucial for the functioning of living organisms. Mitosis is essential for maintaining the bodys structure and function, allowing cells to proliferate and repair tissues. On the other hand, meiosis introduces genetic variation, which is vital for the process of evolution and adaptation. Sexual reproduction, powered by meiosis, ensures that each new generation has a unique combination of traits, increasing the chances of survival in a constantly changing environment.Mitosis and meiosis are two extraordinary processes that enable life to thrive and evolve. While mitosis is the engine of growth, repair, and asexual reproduction, meiosis serves as the cornerstone of sexual reproduction and genetic diversity. By understanding the intricacies of these processes, we can better appreciate the delicate mechanisms that drive life on Earth.Love this? Share it and help us spark curiosity about science! Mitosis and meiosis serve different functions and produce different types of daughter cells.Mitosis and meiosis are the two mechanisms of cell division in eukaryotes. These cellular events ensure growth, development, and genetic diversity in organisms. However, they are fundamentally different in their functions and outcomes.In mitosis, a diploid (2n) cell yields two diploid daughter cells. The function is for growth and repair.In meiosis, a diploid (2n) cells yields two haploid (n) daughter cells. The function is for making sex cells.Mitosis is the process of cell division that produces two genetically identical daughter cells from a single parent cell. This form of cell division functions in growth, tissue repair, and asexual reproduction in some organisms. Mitosis is part of the cell cycle.Meiosis, on the other hand, produces gametes (sperm and egg cells in animals, and spores in plants and fungi). It results in four non-identical daughter cells, each with half the number of chromosomes of the parent cell. This process is crucial for sexual reproduction and genetic diversity.The names of the steps in mitosis and meiosis are the same. However, they dont work exactly the same way. Specifically, crossing over occurs in meiosis I, so the chromosomes that separate into daughter cells are not identical to parent cells. Also, the division of chromosome in metaphase differs. In mitosis metaphase and anaphase II in meiosis, sister chromatids separate. In anaphase I of meiosis, homologous chromosomes (not chromatids) separate.Interphase: DNA replication occurs, preparing the cell for division.Prophase: Chromosomes condense, and the nuclear envelope dissolves.Metaphase: Chromosomes align at the equatorial plane.Anaphase: Sister chromatids separate and move to opposite poles.Telophase: New nuclear envelopes form around each set of chromosomes.Cytokinesis: Cytoplasm divides, creating two identical daughter cells.There are two rounds of cell division in meiosis: Meiosis I and Meiosis II.Interphase: Similar to mitosis, DNA replication occurs.Prophase I: Chromosomes pair up in homologous pairs, and crossing-over occurs.Metaphase I: Homologous pairs align at the equatorial plane.Anaphase I: Homologous chromosomes separate to opposite poles.Telophase I: Nuclear membranes reform, followed by cytokinesis.Prophase II: Chromosomes condense; nuclear envelope dissolves.Metaphase II: Chromosomes align at the equatorial plane.Anaphase II: Sister chromatids separate.Telophase II: Nuclear membranes reform, followed by cytokinesis, resulting in four non-identical daughter cells.Both mitosis and meiosis begin with a single parent cell.Both processes have an interphase stage where DNA replication occurs.Fundamental stages such as prophase, metaphase, anaphase, and telophase are present in both.Mitosis and meiosis have different numbers of cell division cycles, events in the stages of division, outcomes, and functions in organisms.While both mitosis and meiosis are forms of cell division, they have different outcomes.Both mitosis and meiosis start out with DNA replication, but with different ultimate goals.Mitosis: DNA replication produces identical sister chromatids.Meiosis: DNA replication also occurs, but crossing-over in Prophase I will create genetic diversity.Mitosis: Chromosomes condense, but theres no formation of homologous pairs or crossing-over.Meiosis: Prophase I includes crossing-over, creating genetic diversity.Mitosis: Individual chromosomes align at the metaphase plate.Meiosis: In Metaphase I, homologous pairs align, not individual chromosomes.Mitosis: Sister chromatids separate, ensuring each daughter cell gets identical sets of chromosomes.Meiosis: In Anaphase I, homologous chromosomes separate. In Anaphase II, sister chromatids separate, similar to mitosis, but the chromatids may not be identical due to crossing-over.Mitosis has one round of cell division, while meiosis has two rounds. In both cases, the steps involve prophase, metaphase, anaphase, telophase, and cytokinesis.Mitosis: One round of cell division.Meiosis: Two rounds of cell division.While mitosis yields two daughter cells that are genetically identical (2n) to the parent cell, meiosis produces four haploid (n) cells that are genetically different from the parent cell.Mitosis: Two identical daughter cells.Meiosis: Four non-identical daughter cells with half the chromosome number.This table summarizes the key differences between mitosis and meiosis.CriteriaMitosisMeiosisFunctionGrowth, repairReproductionNo. of DivisionsOneTwoDaughter CellsTwo, identicalFour, non-identicalChromosome NumberSame as parentHalf of parentInterphaseDNA replicationDNA replicationProphaseNo crossing-overCrossing-over occursMetaphaseChromosomes alignHomologous pairs alignAnaphaseSister chromatidsHomologues, then chromatidsMaton, A.; Hopkins, J.J.; et al. (1997). Cells: Building Blocks of Life. New Jersey: Prentice Hall. 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