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Minnesota Undergraduate Research & Academic Journal MURAJ engages undergraduate students across the University of Minnesota - Twin Cities in the collaborative and educational process of assembling an academic journal that celebrates the breadth and depth of innovative thinking among undergraduate students. Open Rivers: Rethinking Water, Place & Community is an interdisciplinary online journal that recognizes rivers in general, and the Mississippi River in particular, as space for timely and critical conversations about the intersections between biophysical systems and human systems. Panorama is a peer-reviewed, open-access, online publication dedicated to American art and visual culture. Our vision is to make health equity possible for everyone in every community - so we provide students, alumni, and professionals from any discipline or affiliation the opportunity to publish public health-related material in a peer-reviewed journal. Reconsidering Development Reconsidering Development is an international, open access, and peer reviewed e-journal that aims to create an equitable space for dialogue and discussion concerning the theory and practice of international development. A non-partisan political news site publishing original, data-driven reporting and analysis. Teaching Media Quarterly is an online, open-access journal dedicated to circulating practical and timely approaches to media concepts and topics. Essential topics, readings, and multimedia that provide historical context to current debates over immigration reform, integration, and citizenship. The #PurpleSyllabus presents essential topics, readings, and multimedia related to Prince. This syllabus is an offshoot of the “Reparations, Repatriation, and Redress” symposium at the University of Minnesota and presents an archive of scholarly and popular sources on themes related to reparations. 2019 Kidney Tumor Segmentation Challenge The 2019 Kidney Tumor Segmentation Challenge (KiTS19) was one of several "grand challenges" associated with the 2019 International Conference on Medical Image Computing and Computer Assisted Intervention (MICCAI19) held in in Shenzhen, China. Advances in Pharmacy: Journal of Student Solutions to Pharmacy Problems (AiP) was an open access, online publication dedicated to disseminating student research relevant to pharmacy practice. The aim of this publication was to provide an accessible outlet and a learning environment to encourage student participation in rigorous research. Dream of the Red Chamber: Afterlives Dream of the Red Chamber: Afterlives is a companion to the English-language opera co-produced by the San Francisco Opera and the Hong Kong Arts Festival. News and trends in election and voting technology, registration and turnout, and election administration. A comprehensive history of Medicinal Chemistry beginning with the founding of the University of Minnesota’s College of Pharmacy in 1892 until today. Journal of Opinions, Ideas, & Essays JOIE provides a venue for a wide variety of articles submitted by retired or active faculty, staff and civil service colleagues of the University. Dr. Wilson challenges readers to think about their own experience of nostalgia and how it may (or may not) fit with the ideas presented here. Ong for Everybody includes an accessible introduction and annotations to the works of Walter J. Ong, S.J. (1912-2003), an American cultural historian and philosopher. Share — copy and redistribute the material in any medium or format for any purpose, even commercially. Adapt — remix, transform, and build upon the material for any purpose, even commercially. The licensor cannot revoke these freedoms as long as you follow the license terms. Attribution — You must give appropriate credit , provide a link to the license, and indicate if changes were made . You may do so in any reasonable manner, but not in any way that suggests the licensor endorses you or your use. ShareAlike — If you remix, transform, or build upon the material, you must distribute your contributions under the same license as the original. No additional restrictions — You may not apply legal terms or technological measures that legally restrict others from doing anything the license permits. You do not have to comply with the license for elements of the material in the public domain or where your use is permitted by an applicable exception or limitation . No warranties are given. The license may not give you all of the permissions necessary for your intended use. For example, other rights such as publicity, privacy, or moral rights may limit how you use the material. Most students find understanding cell division challenging, yet it is necessary for grasping how life functions at a cellular level. Exploring mitosis and meiosis through interactive worksheets can significantly enhance your comprehension and retention of these processes. Engaging with these educational tools not only prepares you for exams but also consolidates your knowledge of genetic variation and reproduction. For a dynamic learning experience, check out the Cell Division Match-Up: Mitosis & Meiosis Worksheets - 3 ... that offers a variety of exercises tailored to cell division. Key Takeaways: Mitosis is the process of cell division that produces two identical daughter cells, maintaining the same chromosome number as the original cell. Meiosis involves two rounds of division, resulting in four non-identical gametes, which have half the chromosome number of the parent cell, facilitating genetic diversity. Worksheets on cell division help reinforce understanding of these processes through diagrams, comparison charts, and practice questions, enhancing overall comprehension. Mitosis Worksheets Overview of Mitosis At the core of understanding cell division is a thorough grasp of mitosis. Mitosis is the process by which a single cell divides to produce two genetically identical daughter cells. This process is vital for growth, development, and tissue repair in multicellular organisms. Through a series of organized steps, mitosis ensures that each daughter cell receives the same set of chromosomes as the original cell, thus maintaining genetic continuity. You will find that the importance of mitosis extends beyond mere cellular replication; it plays a key role in facilitating the proper functioning of organisms. At the same time, an appreciation for the different phases of mitosis—prophase, metaphase, anaphase, and telophase—enhances your understanding of how cell division occurs. Each phase involves distinct processes and structural changes that can be illustrated effectively through educational worksheets. These resources can assist you in visualizing and differentiating between the stages, leading to a deeper comprehension of how cells progress through their life cycle and respond to various signals. Mitosis Stages Worksheets Worksheets focused on the stages of mitosis can be an invaluable tool for your learning journey. By engaging with diagrammatic representations and guided activities, you can solidify your grasp of each stage's key characteristics. This section of worksheets typically provides scenario-based questions that challenge you to identify phases based on visual cues and descriptive prompts. These interactive tasks can greatly enhance your ability to analyze and differentiate between prophase, metaphase, anaphase, and telophase. To maximize your learning experience, incorporate hands-on activities along with theoretical knowledge. By completing these worksheets, you will gain insight into the remarkable precision of the mitotic process, as well as the significance of each stage in cellular reproduction. These worksheets not only promote retention but also help you grasp the importance of mitosis in maintaining genetic stability and facilitating cellular growth. Thus, as you explore these resources, you will undoubtedly develop a more comprehensive understanding of this necessary biological process. Meiosis Worksheets Overview of Meiosis Now that you have a solid foundation in cell division, it's time to explore the intricacies of meiosis. This type of cell division is necessary for sexual reproduction and results in the formation of gametes—sperm and eggs—each containing half the genetic material of a typical body cell. By engaging with meiosis worksheets, you can deepen your understanding of this process, including the importance of genetic variation that meiosis promotes through processes like crossing over. Such variations contribute significantly to the adaptability and evolution of species. Before submerging into the specifics of each phase, it's important to note that meiosis consists of two sequential divisions: meiosis I and meiosis II. During these stages, the number of chromosomes is halved, resulting in four non-identical daughter cells. This reduction is vital in maintaining the correct chromosome number across generations. Meiosis also introduces diversity through independent assortment and other genetic recombination strategies, allowing you to grasp the fundamental mechanisms that drive evolution and heredity. Meiosis Stages Worksheets Behind every significant biological process lies a series of carefully orchestrated stages. Meiosis is no exception, comprising several key phases that can be effectively illustrated through numerous worksheets. Engaging with these resources can help you visually and conceptually break down the stages of meiosis, such as prophase I, metaphase I, anaphase I, and the subsequent stages until telophase II. Worksheets can enhance your learning experience by allowing you to label diagrams, answer questions, and engage in exercises that reinforce your understanding of these stages. Due to the complexity of meiosis, worksheets often provide scenarios for you to analyze and apply your knowledge practically. By focusing on phase differentiation, such as distinguishing between the events of meiosis I and meiosis II, or identifying the significance of independent assortment and crossing over, you can unlock a deeper understanding of how genetic diversity is achieved. These worksheets empower you to test your knowledge and visualize the intricate changes that occur during each stage, leading to a more profound grasp of this pivotal biological process. Comparing Mitosis and Meiosis Once again, understanding the fundamental processes of cell division is pivotal for grasping the complexities of biological life. While both mitosis and meiosis are vital forms of cell division, they serve distinct purposes and have unique outcomes. Mitosis is responsible for growth and repair in somatic cells, resulting in two identical daughter cells, whereas meiosis is imperative for the formation of gametes in reproductive cells, leading to four genetically varied daughter cells. You can dive deeper into these processes with resources like the Cell Cycle Mitosis Meiosis Worksheet - Name. Both processes undergo similar phases, including prophase, metaphase, anaphase, and telophase, but they differ significantly in function and result. The comparison can be broken down into distinct categories. Below, you will find a summary of the key differences and similarities that define mitosis and meiosis. Key Differences Mitosis Meiosis Results in two identical diploid cells Results in four genetically varied haploid cells Occurs in somatic cells Occurs in germ cells One round of cell division Two rounds of cell division No exchange of genetic material Crossing over occurs, increasing genetic diversity Similarities in Processes An interesting aspect of both mitosis and meiosis lies in their operational similarities, despite their divergent outcomes. Both processes begin with a single parent cell and involve a series of stages that ensure genetic material is accurately distributed. During the initial phases, DNA replication occurs, preparing the cells for division. An understanding of these shared stages can enhance your knowledge, especially when distinguishing between the two processes. Meiosis also shares fundamental mechanisms with mitosis, such as the segregation of chromosomes during anaphase. This ensures that each resulting gamete or daughter cell receives the correct number of chromosomes. Moreover, both processes are guided by checkpoints that monitor the cell's readiness to progress to subsequent phases, ensuring fidelity in cellular reproduction. The interplay of similarity and difference offers you a clearer insight into how various division processes contribute to life's complexity. Gametogenesis Worksheets Despite the complexities of human reproduction, gametogenesis is a fascinating process that you can easily explore with worksheets designed specifically for this purpose. Gametogenesis refers to the formation of gametes, which are imperative for sexual reproduction. In humans, this involves two distinct processes: spermatogenesis, the development of sperm cells, and oogenesis, the development of egg cells. Through worksheets, you can visualize the stages of these processes, making it easier to understand how each cell undergoes meiosis to ultimately produce your reproductive cells. This exploration not only enriches your knowledge but also underscores the significance of genetic diversity in offspring. As you probe into gametogenesis worksheets, you'll uncover the intricacies involved in producing viable gametes. In males, spermatogenesis results in four functional sperm cells from one precursor cell, which is fundamental for fertilization. In contrast, oogenesis produces just one functional egg cell and three polar bodies that eventually degenerate. This difference highlights the complexities of female gamete production, where resource allocation is primarily directed toward producing a single high-quality egg. Engaging with these worksheets will enlighten you about both the potential benefits, such as genetic variation and evolution, and the inherent risks of errors that can lead to conditions like infertility or genetic disorders. Cell Division Worksheets Many educators and students find cell division worksheets to be valuable tools for understanding the complex processes of mitosis and meiosis. These worksheets can enhance your grasp of how cells replicate and divide, facilitating a deeper comprehension of the mechanisms that underpin growth, repair, and reproduction in living organisms. Engaging with these materials will enable you to visualize the stages of cell division, from the intricate phases of mitosis—where one cell divides to form two identical daughter cells—to the more complex process of meiosis, which results in the formation of gametes with half the chromosome number. Moreover, utilizing interactive worksheets can promote retention of important concepts, making the learning process enjoyable and informative. You may find that activities involving labeling diagrams, solving quizzes, or completing fill-in-the-blank sections deepen your understanding and spark your interest in cell biology. By actively working through these exercises, you will not only reinforce your knowledge but also develop vital skills in analyzing and interpreting biological data, equipping you for further studies or careers in the life sciences. Application of Worksheets in Education Keep in mind that integrating worksheets on mitosis and meiosis into your educational strategies can significantly enhance student comprehension. These worksheets serve as practical tools for visualizing and reinforcing complex concepts associated with cell division. By engaging with these materials, you allow your students to actively participate in their learning journey, promoting a deeper understanding of how cells divide and the key differences between mitosis and meiosis. With a range of activities, from labeling diagrams to solving problems, these worksheets cater to various learning styles, helping you address the unique needs within your classroom. Furthermore, using Mitosis and meiosis worksheets can foster collaboration among students. Group activities involving these worksheets encourage discussion and peer learning, allowing students to clarify doubts and share insights. Incorporating these worksheets into your lesson plans not only makes the learning process engaging but also ensures that your students develop a solid foundation in cell biology. By doing so, you prepare them for more advanced topics in their academic journey, ultimately leading to a more comprehensive understanding of life sciences. To wrap up Following this exploration of mitosis and meiosis worksheets, you should have a deeper understanding of the fundamental processes that drive cell division in living organisms. These worksheets serve as excellent tools for reinforcing the concepts of how cells replicate and divide, with mitosis being imperative for growth and repair, while meiosis is vital for sexual reproduction. As you work through the material, you will appreciate not only the similarities but also the distinct differences between these two types of division, which are pivotal in maintaining genetic diversity and stability in biological systems. Utilizing these worksheets can enhance your comprehension of complex biological processes and aid in your academic pursuits. You can effectively increase your retention of information through exercises that challenge your understanding and encourage active engagement with the topic. By mastering the concepts of mitosis and meiosis, you equip yourself with the knowledge to interpret scientific studies and apply these principles in a variety of contexts within biology and related fields. FAQ Q: What are the primary differences between mitosis and meiosis? A: Mitosis is the process of cell division that results in two genetically identical daughter cells, maintaining the original cell's chromosome number. It occurs in somatic cells for growth and repair. In contrast, meiosis results in four genetically diverse daughter cells, each with half the chromosome number of the original cell, and is important for the production of gametes (sperm and eggs) for sexual reproduction. Q: How can worksheets help students understand mitosis and meiosis? A: Worksheets can provide structured activities that reinforce key concepts of mitosis and meiosis, such as the stages of each process, the importance of division for growth and reproduction, and the differences between the two. They can include diagrams, labeling exercises, and comparisons that enhance visual learning and retention of information. Q: What types of activities are commonly found in mitosis and meiosis worksheets? A: Common activities include diagrams for students to label the stages of mitosis and meiosis, matching terms with definitions, fill-in-the-blank exercises related to key processes, and questions that promote critical thinking about the importance of each type of cell division. These activities can also involve case studies or applications of the concepts in real-life scenarios. Q: Are there specific learning outcomes associated with using these worksheets? A: Yes, using mitosis and meiosis worksheets can help students achieve several learning outcomes, including the ability to accurately describe the stages of each process, differentiate between mitosis and meiosis, understand the significance of cell division in growth and reproduction, and apply their knowledge to predict outcomes in genetic variation and inheritance patterns. Q: How can teachers effectively incorporate these worksheets into their curriculum? A: Teachers can integrate these worksheets into their lesson plans by using them as part of interactive lectures, group activities, or assessments. They can also assign worksheets for homework or as review material before tests. Utilizing a variety of worksheets allows for differentiation in instruction to cater to diverse learning styles and paces among students. Thank you for visiting our website. We hope you find what you are looking for about Mitosis and Meiosis Worksheets: Explore Cell Division. Using Word Search Maker for Creating Printable Word Search By employing the delightful tool of Word Search Maker, you can effortlessly craft engaging and personalized printable word searches tailored to your specific needs. This user-friendly platform allows you to choose themes, input your own words, and customize layouts, making it perfect for classrooms, events, or personal enjoyment. In this tutorial, you will discover step-by-step instructions to maximize your creativity and efficiency while creating captivating word searches that are sure to challenge and entertain your audience. Let's dive in and unlock the possibilities together! Understanding Word Search Puzzles The word search puzzle is a fantastic tool for enhancing your vocabulary and pattern recognition skills. These puzzles consist of a grid of letters where words are hidden in various directions, and your task is to locate them. Using a Word Search Worksheet Generator, you can create custom puzzles tailored to your interests or educational needs. This engaging activity is not only entertaining but also an effective way to improve spelling and cognitive skills. Features of Word Search Maker Word Search Maker To create engaging and unique word searches, Word Search Maker offers a variety of features tailored to meet your needs. You can easily customize the grid size, choose from different word orientations, and select themed categories that resonate with your audience. Additionally, the platform allows you to input your own words or utilize pre-loaded lists, giving you the flexibility to design a personalized puzzle. With a user-friendly interface, generating printable word searches becomes quick and efficient, making it an excellent tool for teachers, parents, and puzzle enthusiasts alike. Step-by-Step Guide to Creating a Word Search Now, you can easily create a custom word search that's perfect for your needs in WordSearchMaker.net. Follow these simple steps to ensure your word search is engaging and fun for everyone. Step Action 1 Select a theme or topic for your word search. 2 Input your chosen words into the Word Search Maker. 3 Customize the grid size and layout to suit your audience. 4 Generate your word search and review for any adjustments. 5 Print your completed word search for distribution. Customizing Your Word Search If you want your word search to stand out, customization is key. The Word Search Maker allows you to choose the grid size, word list, and even the orientation of the words, whether they are placed horizontally, vertically, or diagonally. You can also select various themes and colors, which can enhance the visual appeal and make it more engaging for your audience. Tailoring these elements to suit your preferences can transform a standard word search into a unique activity that reflects your style or the theme of an event. Tips for Educators and Parents Any educator or parent can enhance the learning experience by integrating word searches into their activities. Here are some strategies to maximize the effectiveness of using a Word Search Maker: Customize puzzles to align with current lesson topics. Incorporate vocabulary words to reinforce language skills. Encourage collaboration by having students create their own puzzles. Utilize printable formats for easy distribution, making it accessible for home or classroom use. Perceiving word searches as a fun learning tool will not only engage your students or children but also foster a deeper understanding of the material at hand. Printing and Sharing Your Word Search Even after creating your word search with Word Search Maker, the fun continues with printing and sharing. You can easily print your custom design directly from the platform, ensuring that your puzzle is crisp and clear. Consider offering physical copies at events or sharing the digital version via email or social media for friends and family to enjoy. This not only engages your loved ones but also adds a personal touch to gatherings or educational activities. Your creativity can now be experienced by everyone! Final Words To wrap up, using a Word Search Maker for creating printable word searches is an efficient and enjoyable way to enhance your educational or recreational activities. With customizable options, you can easily tailor puzzles to suit your audience's interests or skill levels. Whether you're planning a classroom activity, a family gathering, or just want to challenge your friends, these tools provide a simple solution for generating engaging and fun content. Embrace the creative possibilities and enjoy the satisfaction of crafting your own word puzzles that everyone can appreciate. 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. Number the following stages of mitosis in order and label each stage properly. The diagrams below show the stages of cell division in animal cells. Provide the label for each of these phases with the proper number and name. The diagrams below show the stages of the first meiotic division. Provide the label for each of these with the proper number and name of each stage. Place check marks in the appropriate column(s) to indicate whether the listed items apply to mitosis, meiosis or both. Describe the events that take place for during each phase of body cell division below. The human body is an amazing thing; it contains trillions of cells which all replace themselves by dividing into two duplicates. Our bodies create slightly different sex cells to create eggs and sperm, each containing exactly half of our genetic information. But how exactly does this complicated process work? Mitosis and meiosis are the two different types of cell division. Mitosis is the process used in most cells and results in two diploid (46 chromosome) daughters. Meiosis is used in the sex organs and results in four haploid (23 chromosome) sex cells. Mitosis produces most of your body’s cells, your bones, organs, and muscles; meiosis only produces eggs in women and sperm in males. The primary difference between the two is how the chromosomes are separated and recombined, an essential part of human reproduction. Keep reading to learn more about how both of these processes work. All body cells have a short life span. To make sure organisms can continue to survive, they constantly need to make new copies of them. To do this they undergo a process of duplicating themselves. There are five phases associated with this process. The first phase is named Prophase. This is where the cell duplicates its DNA. The second phase is called Metaphase this is where the DNA lines up in the middle of it. The third phase is where the chromosomes (DNA) begins to split and move itself into two cells. During the Telophase, it actually pinch off into two separate beings. The final stage is really when nothing is going on and that phase is called Interphase. I refer to it as the in between phase. This process of self-replication of body cells is called mitosis. If this process takes place in a sex cell (sperm or egg) it is called meiosis. In mitosis the division only occurs once which creates two cells from one. As a result, both new cells are identical copies of the original (parent). In meiosis the division occurs twice. So that single egg or sperm cell create four new cells that have only part of the original gametes genetic information. Therefore, sex cells are genetically diverse. This is also why the babies that sex cells form as genetic diverse too. Mitosis, Meiosis, and Chromosomes Mitosis and meiosis are types of cell division. The primary purpose of this is the duplication and recombination of chromosomes. Before mitosis or meiosis occurs, the cell duplicates its own DNA, a process called interphase. In the first part of both mitosis and meiosis, the pairs of chromosomes line in the center of it. The chromosomes are pulled apart by microtubules during the first part of prophase. Prophase takes place in both meiosis and mitosis. After prophase and metaphase, during which the chromosomes separate, the cells move into telophase, which ends the first stage of division. The purpose of cell division in both cases is the duplication and separation of the chromosomes, which is critical for genetic diversity. What Is Mitosis? During mitosis, the chromosomes are pulled apart, and a new cellular membrane forms between the two bundles. The chromosome bundles disassociate, and two new cells, which are identical to each other, have now formed. Mitosis is essential for the health of cells. Your body’s cells have a limited life span and are replaced periodically. Fortunately, your body also makes new copies of them constantly to keep up with the demand. Mitosis also helps ensure genetic health in your cells by constantly replicating healthy cells faster than any flawed cells. What Is Meiosis? A slightly different process is used to create a new human being. Meiosis divides the chromosomes into four separate strands. After the first prophase, the chromosomes are carefully lined up so that all “homologous” or nearly identical chromosomes are aligned. In the second prophase, the two homologous strands are separated so that there are now four identical strands of DNA. The cell divides and becomes four sex cells with 23 chromosomes. The purpose of meiosis is to create these haploid, or 23-chromosome cells so that they can combine with other haploid cells and then combine into a 46-chromosome cell following fertilization. Combining DNA like this is how humans have maintained our genetic diversity over thousands of years. Important Differences Between Mitosis and Meiosis The primary difference between mitosis and meiosis is the second division and the final type of cells produced during meiosis. Meiosis is the specialized version of cell division intended to create unique DNA types. Unlock the potential of engaging education with our comprehensive collection of Mitosis Worksheets 2025 worksheets for students and teachers. Explore a diverse range of Mitosis Worksheets 2025’s topics, tailored to various grade levels. Our educational resources empower teachers and inspire students to excel academically. Access a wealth of interactive and printable Mitosis Worksheets 2025 worksheets designed to enhance learning experiences. Elevate your classroom with our user-friendly platform, fostering a dynamic and effective educational environment for all. 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 propagation As 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 certainty…optionally 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 3.0 The plant doesn’t 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 selection From 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 review To 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 doesn’t imply anything about the size or type of plant: Corn = 20 Rice = 24 Soybean = 40 Green bean = 22 Tomato = 24 Potato = 48 Apple = 34 Rose = 14 Diploid 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 mechanics Meiosis. Emily Tepe Meiosis 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 won’t 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 3.0 As 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 doesn’t 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? Division Watch 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 n haploid cells instead of the two 2n cells that result from mitosis. You get four n 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. Here’s 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 3.0 Chromatids separate in Anaphase II. Centromeres holding the chromatids do split. Anaphase II. Boumphreyfr. CC BY-SA 3.0 Genetic variation among gametes Watch 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 don’t 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.