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Author: Chris Palmer A new study led by researchers at University of Utah Health tracing the development of human sperm stem cells to mature sperm cells has yielded the most comprehensive view of this process to date. The results, published in the journal Cell Stem Cell, expand the understanding of human testis development and point to potential treatments for male infertility. Spermatogenesis—the production of sperm cells—involves the differentiation of spermatogonial stem cells into mature sperm through a complex process. Disruptions to this process are a common cause of male infertility, which affects one in every six couples. Most of what scientists know about spermatogenesis comes from studies in mice. A few years ago, though, Bradley Cairns, Ph.D., professor and chair of oncological sciences at U of U Health and chief academic officer at Huntsman Cancer Institute led research that used genome analysis tools to track this multistage process in human sperm stem cells. His group identified four distinct cellular phases of sperm stem cell maturation, revealing how the stem cells progress from a “quiescent” state, to a “proliferation” state during which stem cells divide, to a final “differentiation” state when stem cells mature to become sperm. In the current study, Cairns and colleagues used single-cell RNA sequencing analysis to build an atlas of all the genes expressed in human fetal and postnatal testes. This analysis revealed that it takes just about 14 weeks after fertilization for fetal primordial germ cells, the precursors of all germ cells (including sperm cells), to transition to a cell state highly similar to the quiescent state of adult cells the researchers identified in their previous study. “The identity of these cells is laid down early in fetal development, and is then maintained, mostly unchanged, until puberty,” says Cairns. In addition, the researchers discovered that somatic cells responsible for producing testosterone and creating various support structures within the testis, including the seminiferous tubules where spermatogenesis takes place, derive from a common pool of undifferentiated progenitor cells at around 7 weeks post-fertilization. “As we learn more about human testis development, our efforts to grow those cells in vitro—or in a dish—can become more sophisticated,” says lead author Jingtao Guo, Ph.D., assistant professor of surgery. “And once we develop an accurate in vitro model of this process, we can potentially grow the stem cells we’ve identified and hopefully drive their development all the way to functional sperm. That is the path toward achieving spermatogenesis in the lab as a possible treatment for infertile individuals.” Researchers have successfully grown sperm cells from stem cells derived from mice, but replicating the process in humans has been challenging. “The [human] stem cells either die or they differentiate into somatic cells. It’s been a complete failure in the past, but we plan to use our data to explore paths forward,” Cairns says. One notable difference in mouse and human brought to light by the researchers’ findings is that only humans exhibit an approximately eight-week gap between when cells that support the primordial germ cells differentiate and when primordial germ cells themselves transition into sperm stem cells. “In humans, it appears that the somatic support cells differentiate first so that they can guide the primordial germ cells to further transition into sperm stem cells.” Guo says. Cairns says that the changes that occur during this gap, and the signals sent to the stem cells by the support cells, could be critical for successfully recapitulating stem cell survival and spermatogenesis in the lab. “We need to continue studying human sperm stem cells directly and recognize the differences between mice and humans, then exploit those differences to facilitate in vitro growth of human sperm stem cells,” he says. “This study helps lay the groundwork for being able to do that kind of work.” # # # The research publishes as “Single-cell analysis of the developing human testis reveals somatic niche cell specification and fetal germline stem cell establishment” and was supported by the Howard Hughes Medical Institute, National Institutes of Health, Swedish Childhood Cancer Foundation, Swedish Research Council, Magnus Bergvall Foundation, and the Birgitta and Carl-Axel Rydbeck research Grant for Pediatric Research. How can financial brands set themselves apart through visual storytelling? Our experts explain how Learn MoreThe Motorsport Images Collections captures events from 1895 to today’s most recent coverage.Discover The CollectionCurated, compelling, and worth your time. Explore our latest gallery of Editors’ Picks.Browse Editors’ FavoritesHow can financial brands set themselves apart through visual storytelling? Our experts explain how Learn MoreThe Motorsport Images Collections captures events from 1895 to today’s most recent coverage.Discover The CollectionCurated, compelling, and worth your time. Explore our latest gallery of Editors’ Picks.Browse Editors’ FavoritesHow can financial brands set themselves apart through visual storytelling? Our experts explain how Learn MoreThe Motorsport Images Collections captures events from 1895 to today’s most recent coverage.Discover The CollectionCurated, compelling, and worth your time. Explore our latest gallery of Editors’ Picks.Browse Editors’ FavoritesThe difference between spermatogenesis and oogenesis is mainly due to the following factors like the process, occurrence and the product formed after gametogenesis. Process: The process of spermatogenesis and oogenesis is different, in which a former produce sperm cells from a spermatogonium and the latter produce ovum from an oogonium. Occurrence: Spermatogenesis occurs inside the seminiferous tubules of a testis, whereas oogenesis occurs inside the ovary. The sperm cells are the product formed in the spermatogenesis, which is flagellated, i.e. motile. On the contrary, ova is the product produced from the oogonia, which are non-motile. Therefore, both sperm cells and ova are structurally and functionally different from each other. The product formed after gametogenesis: Spermatogenesis and oogenesis are the two phenomena called gametogenesis. Gametogenesis is the process of formation of both male and female gametes, i.e. sperms and ova. The formation of sperm and ovum takes place inside the male and female gonads, i.e. testis and ovary, respectively. Content: Spermatogenesis Vs Oogenesis Comparison Chart PropertiesSpermatogenesisOogenesisOccurs in maleOccurs in female FormationSeminiferous tubules of testisIn ovaries ProcessProduction of sperms from spermatogoniaProduction of ovum from oogonia Continuous, occurs after the puberty till deathDiscontinuous, occurs after the puberty until menopause StagesAll stages occur inside the testisExcept the last stage which occurs in oviduct, all stages occur inside the ovary Sertoli cellsFound in germinal epitheliumAbsent Nuclear condensationFoundAbsent ReleasingSperms are released from the testisOocytes are released from the ovary which matures later Growth phaseToo shortProlonged Food reserveSperm contains less food reserveOvum contain a lot of food reserve CytokinesisEqualUnequal ResultForms four motile male gametes i.e. spermsForms one non-motile female gamete i.e. ovum Meaning of Spermatogenesis It is the reproductive stage where the formation of haploid sperms or spermatozoa occurs from a diploid stem cell called spermatogonium with a male gonad, i.e. seminiferous tubules of a testis. Meaning of Oogenesis It is the reproductive stage where the formation of haploid ovum occurs from a diploid stem cell called oogonium within the female gonad, i.e. ovaries. Stages of Spermatogenesis and Oogenesis Both the process of gametogenesis differs in their three phases, namely multiplication, growth and differentiation. Spermatogenesis: It involves the following steps: First, a spermatogonium develops from the germinal epithelial lining of the seminiferous tubules that are diploid stem-cell having totipotency, i.e. self-renewing capacity. Spermatogonium then undergoes mitosis cell division and differentiates into the primary spermatocytes through a process called spermatocytogenesis. Then primary spermatocytes undergo meiosis cell division-1 and form two secondary spermatocytes. Secondary spermatocytes further undergo meiosis cell division-2 and form two spermatids that connect to the border of testis lumen through the cytoplasmic bridges. Spermatids are round, unflagellated cells that undergo maturation and form motile, haploid spermatozoa or sperms. Here, the process of formation of sperms forms spermatids is called spermiogenesis. Oogenesis: It involves the following steps: First, oogonium develops from the germinal epithelium overlying the ovary that is a diploid stem-cell also having the self-renewing capacity. Oogonium then undergoes mitosis cell division-1, which arrest at diplotene stage in the childhood and puberty onwards these forms secondary oocyte and one polar body. Secondary oocytes further undergo meiosis cell division-2, which arrest at metaphase stage and later form ootids. At last, ootid when undergoes the process of fertilization it forms a non-motile, large and spherical ovum and second polar body that degenerates. Facts about Spermatogenesis and Oogenesis There are some facts that we must know about both the processes. So, let us discuss a few points that we should remember to know more about spermatogenesis and oogenesis. Points to remember in Spermatogenesis: Spermatogenesis takes 70 days to form sperm from spermatogonium. A spermatogonium forms four spermatozoa or sperms. One primary spermatocyte will produce two secondary spermatocytes. The number of chromosomes is 46 in human. Therefore, there is no meiosis division in the spermatogonium, the chromosomal number will be same, i.e. 46 in primary spermatocyte. But when primary spermatocyte undergoes meiosis cell division 1 and 2, the chromosomal number will become half, i.e. 23 in secondary spermatocytes, spermatids and sperms. In one ejaculation, 200-300 million sperms produce, in which 60% are non-motile and 40% are motile. If there is 20million/ml of semen, then the condition will be termed as oligospermia, which causes infertility because the normal range should be within 100million/ml of semen in a male. Points to remember in Oogenesis: An Oogonium produces a single ovum. One primary oocyte will produce one secondary oocyte and one polar body which degenerates from the ovary. The number of chromosomes is 46 in human, and if no meiosis division occurs in the oogonium, the chromosomal number will be the same, i.e. 46 in the primary oocyte. But, when the primary oocytes undergo meiosis cell division 1 and 2, the chromosomal number will become half, i.e. 23 in the secondary oocyte, one polar body and ovum. In oogenesis, 7 million primary oocytes form in the ovary of a female foetus, which regresses to 2-4 million at the time of birth. By puberty, only 40,000 primary oocytes left out and regress to 480 in number after the division in a reproductive phase of 11-50 years in females. Difference Between Sperm and Ovum Male gametes (sperms) and female gametes (ova) are produced after the cycle of spermatogenesis and oogenesis, respectively. Both sperm and ovum differ in many ways like their structure, motility, shape, size etc. Structure of Sperm Sperm is yolkless. The size of the sperm is smaller than the spermatocytes. It contains less amount of cytoplasm. Sperm is surrounded by only one plasma membrane. It consists of four parts head, neck, middle piece and tail, i.e. sperm is differentiated. Head: It consists of acrosome and nucleus. The acrosome is present at the tip and formed by the Golgi body and contains an enzyme called sperm lysins (digest the membrane of ovum). A non-condensed nucleus is present having no nucleoplasm. Neck: It consists of proximal and distal centrioles. A proximal centriole is required for the first cleavage. Distal centriole maintains the axial filament. Middle piece: It possesses an axial filament and mitochondria. Axial filament consists of compactly arranged mitochondria, which are approximately 25 in number and provides energy for the flagellar movement. Tail: It is elongated, motile and encircled by a flagellar sheath. Structure of Ovum It lacks a head, neck and tail, i.e. an ovum is not differentiated. A nucleus of an ovum is eccentric and in this nuclear condensation is present. It is bloated with nucleoplasm and called as germinal vesicles. Ovum lacks centrioles. In this, mitochondria are scattered in the cytoplasm. It is alecithal, i.e. an ovum will have little or no yolk. The size of an ovum is larger than the oocyte. It contains a large amount of cytoplasm. Ovum is encircled by the two layers, namely granulosa cells and zona pellucida. Spermatogenesis is the production of sperms from spermatogonia in the seminiferous tubules of the testis in a male. Oogenesis is the production of the ovum from oogonia inside the ovary of a female. Spermatogenesis is a continuous process that occurs after the puberty till death, whereas oogenesis is a discontinuous process that occurs after the puberty till menopause. All stages of spermatogenesis occur inside the testis of a male, whereas the stages of oogenesis occur inside the ovaries expect for the last stage (occurs in the oviduct). In spermatogenesis, sperms release out from the testis, while oocytes release from the ovary that further develops in the process of oogenesis. Spermatogenesis results in four motile male gametes (sperms) from a spermatogonium and oogenesis results in a single non-motile female gamete (ovum) from an oogonium. Conclusion We can conclude that both spermatogenesis and oogenesis are the reproductive phases, which basically includes three phases like multiplication, maturation and differentiation. Multiplication is a stage, where spermatogonium and oogonium multiply by mitosis to form germ cells, i.e. spermatocytes and oocytes, respectively whose number increases after further cell divisions. Maturation is a phase where both the germ cells grow in size. Maturation takes place when germ cells undergo meiosis, after which they form spermatids and ootids that later undergo differentiation to produce male and female gametes, respectively. MeSH Heading Spermatogenesis Tree Numbers) G04.152.650.624 G08.686.784.310.760 Unique IDDD013091 RDF Unique Identifier Scope NoteThe process of germ cell development in the male from the primordial germ cells, through SPERMATOGONIA, SPERMATOCYTES, SPERMATIDS, to the mature haploid SPERMATOZOA. Entry Term(s) Spermatocytogenesis Spermatogenesis NLM Classification # OU 385 Previous Indexing Spermatozoa (1966-1970) See Also Antispermatic Agents Spermatogenesis-Blocking Agents Public MeSH Note73 History Note(73/71) Date Established 1973/01/01 Date of Entry 1999/01/01 Revision Date 2016/06/17 Home > Difference Between Image created with biorender.com Spermatogenesis is the process of formation of mature sperm cells through a series of mitotic and meiotic divisions along with metamorphic changes in the immature sperm cell. It is the male version of gametogenesis which results in the formation of mature male gametes. Spermatogenesis requires optimal conditions to occur and is essential for sexual reproduction. The complete process of spermatogenesis occurs in different stages that take place in different structures within the male reproductive system. It begins in the seminiferous tubules within testes and then continues into the epididymis where maturation of the male gamete occurs, and they are further stored under ejaculation. Spermatogenesis begins in males after puberty, and it is continued throughout life. Even though sperms are continuously being formed in the testes, not all areas of testes can form sperm at the same time. Sperms in different stages of their development can be found in the testes. It begins with a primary spermatocyte that undergoes multiple changes to develop into a motile and matured sperm cell. It takes as long as 74 days for an immature germ cell to develop into a mature male gamete, and during that time, there are many intermittent resting stages. One primary spermatocyte results in four functional spermatozoa after the process of meiosis, each of which develops separately into a sperm cell. The process of spermatogenesis is completed through the following three stages; spermatocytogenesis, spermatidogenesis, and spermiogenesis. All of these stages are performed within the testes until the spermatozoa formed finally reach the epididymis and gain motility. Human sperm is a motile cell divided into a head, body, and a long tail. The head consists of acrosomes that secrete enzymes and helps in the entry of sperm inside an ovum. The overall process of spermatogenesis is regulated by various glands and their products. The luteinizing hormone by the pituitary gland regulates the formation of sperm and the production of testosterone in the male reproductive system. The follicle-stimulating hormone, secreted by the pituitary and the testes together regulate the overall process of spermatogenesis. The hormone testosterone is responsible for the activation of genes coding for the male gametes, and it also provides nutrients to the sperm cell during its development. The process of spermatogenesis is the basis for sexual reproduction which permits genetic recombination, resulting in genetic variation among the species. Oogenesis Definition Oogenesis is the process of formation of female gamete or ovum through a series of mitotic and meiotic divisions occurring in the female reproductive system. It is the female version of gametogenesis which results in the formation of mature female gametes. The process of oogenesis starts pre-natally, i.e. before the birth of the female child. It begins about 8-20 weeks after the fetus has begun to grow and goes on until the birth of the child. Thus, a newborn female child already has all the egg cells that are to be released from the ovaries during the reproductive life of the female. These cells are termed primary ova. The primary ova remain dormant until ovulation and become matured afterward. Some of these cells take as long as 40 years to mature while some never reach maturation. The reproductive life of a female is characterized by the monthly periodic changes that occur in the release of sexual hormones as well as changes in the structure of ovaries as well as other sexual organs, called the menstrual cycle. The process of oogenesis is described by the ovarian cycle, which is involved in the formation and maturation of female gamete. The overall process of oogenesis is divided into three stages; the follicular phase, the ovulation phase, and the luteal phase. It begins with the release of follicle-stimulating hormone and luteinizing hormone that causes the cells of the ovary to form primary follicles. These follicles then undergo mitotic and meiotic divisions, causing the cell to divide into two larger secondary oocytes and a smaller polar body. The secondary oocyte then releases the ovum that moves around the ovary until fertilization. If fertilization doesn't occur, the cell degenerates into a corpus luteum and is removed from the body during the menstrual cycle. The ovum formed is non-motile and remains in the fallopian tube to be fertilized by the sperm. An ovum is an oval structure that contains yolk or plasma that provides nutrients to the cell. The process of oogenesis only continues till menopause after which the ovary ceases to form primary oocytes. Like spermatogenesis, oogenesis is also controlled by the hormones of the pituitary gland. Besides, the corpus luteum also releases progesterone hormone to regulate the process of menstruation. Oogenesis is a biologically vital process that ensures sexual reproduction in animals. It is responsible for the transfer of half of the chromosomes to be introduced into the newborn. Key Differences (Spermatogenesis vs Oogenesis) Definition Spermatogenesis is the process of formation of mature sperm cells through a series of mitotic and meiotic divisions along with metamorphic changes in the immature sperm cell. Oogenesis is the process of formation of female gamete or ovum through a series of mitotic and meiotic divisions occurring in the female reproductive system. Nature of the process It is the male version of gametogenesis which results in the formation of mature male gametes. It is the female version of gametogenesis which results in the formation of mature female gametes. Stages The process of spermatogenesis is completed through the following three stages; spermatocytogenesis, spermatidogenesis, and spermiogenesis. The overall process of oogenesis is divided into three stages; the follicular phase, the ovulation phase, and the luteal phase. Occurs in The overall process of spermatogenesis occurs in the testes until the sperm moves to the epididymis and gains motility. The overall process of oogenesis occurs in the ovary until the mature ovum moves to the fallopian tube. Continuity of the process Spermatogenesis is a continuous process that begins with puberty and continuous until death. The early stages of oogenesis begin in the fetal stage while the rest continue after puberty till menopause. Occurrence Spermatogenesis occurs continuously, and all spermatogonia undergo meiosis, producing sperms all the time. Oogenesis occurs for one egg cell at a time, and some cells might require many years to reach maturation. Rate of production Spermatogenesis forms millions of sperms every day. Oogenesis releases one ovum per month. Develops from The male gamete develops from the germinal epithelium of the seminiferous tubules of the testes. The female gamete develops from the germinal epithelium lining the ovary. Starting cell The starting cell during spermatogenesis is the primary spermatocyte. The starting cell during oogenesis is the primary oocyte. Functional cell produced from division The meiotic division of primary spermatocyte results in four spermatids, each of which develops into a sperm cell. The meiotic division of primary oocyte only forms a single functional secondary oocyte. Cytogenesis Cytogenesis in spermatogenesis forms two equal cells. Cytogenesis in oogenesis forms two unequal cells; larger secondary oocyte and a smaller polar body. Sertoli cells Sertoli cells are found in the testes that provide nourishment to the developing male gamete. Sertoli cells are not found in the ovary, and the nourishment to the female gamete is provided by the yolk present around the ovum. Growth phase The growth phase during spermatogenesis is shorter than in oogenesis. The growth phase during oogenesis is longer than in spermatogenesis. Resting phase There is no resting phase during the spermatogenesis process. The resting phase occurs during oogenesis from the embryonic stage till puberty. Size of the gametes The male gametes formed after spermatogenesis are smaller in size than the female gametes. The female gametes formed after oogenesis are larger in size than the male gametes. Motility of the gamete The male gamete formed is motile. The female gamete formed is non-motile. Nuclear condensation Nuclear condensation can be seen in a male gamete. Nuclear condensation doesn't take place in the ovum. Food preservation The male gamete stores less amount of food within itself. The female gamete stores a lot more food within itself. References Hall JE and Guyton AC. (2011) Textbook of Medical Physiology. Twelfth Edition. Elsevier Saunders. Waugh A and Grant A. (2004) Anatomy and Physiology. Ninth Edition. Churchill Livingstone. Sources 2% - 3A Anatomy and Physiology (Boundless)/26%3A The Reproductive System/26.4%3A Physiology of the Male Reproductive System/26.4C%3A Spermatogenesis 1% - 1% - 1% - 1% - 1% - 1% - 1% - 1% - 1% - 1%