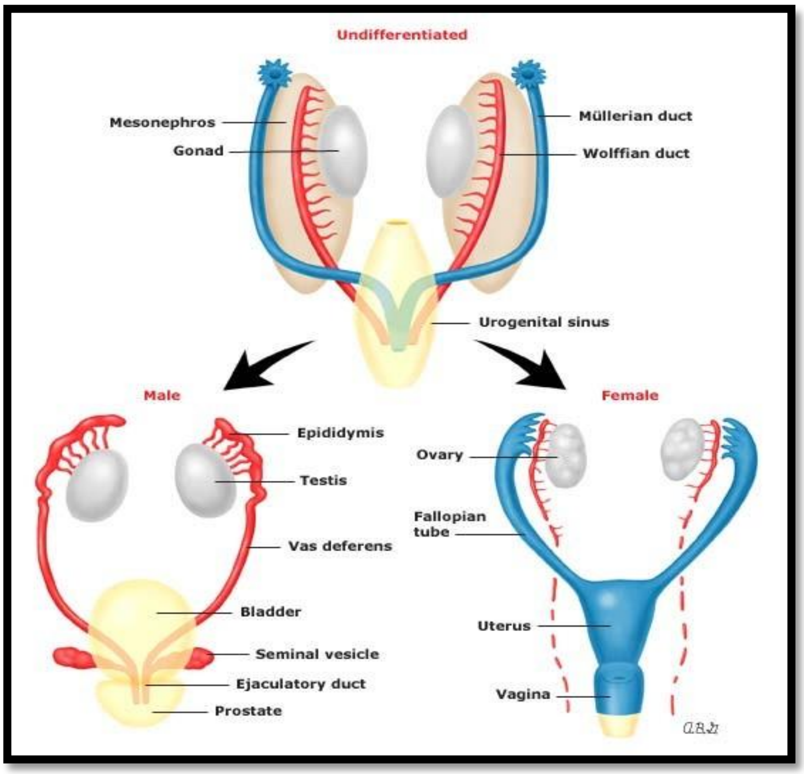
Male development

In early embryogenesis the gonads of XY and XX individuals do not have morphological differences. The gonads contain both male and female germ cells. Primordial germ cells colonize conadal cortex, where they can become oogonia, as well as the central medulla where they become spermatogenesis.



In XY embryos the gonads will develop to testis, the central medulla develops testis cords at puberty these cords will hollow to form the somniferous tubules in which the sperms are produce. the supporting cells differentiate to sertoli's cells these produce the hormonal anti-mullerian-duct factor (AMDF or called mullerian duct-inhibiting substance MIS), while the interstitial cells develop into leydig's cells that produce the male sex hormones (androgen) like testosterone.

Female development

The primordial germ cells in the cortex stop mitotic activity, become oocytes and inter meiosis. In contrast to male, where the meiosis in the spermatocytes is delayed until the puberty. In females meiosis begins in the ovaries at 12^{th}. Week of embryonic development. The supporting cells assume the function of follicle cells and surround the oocytes. The interstitial cells become theca cells which produce female sexual hormone (estradiol) and estrogen. Any additional gonadal development depends on presence or not testosterone. This hormone is trigger factor to male development; its absence allows female development to take over.

Gametogenesis

At fertilization, the maternal and paternal gametes are united forming the zygote. The maternal gamete, the oocyte is the largest non-motile cell of the body, while the paternal gamete, the spermatozoon has ability for motion and penetration of the oocyte. The cells which produce the gametes during the embryological period are called **the Primordial germ cells** (**PGCs**)

The gametogenesis is the process by which the maternal and paternal gametes are produced from the primordial germ cells to form mature sex cells called the gametes.

Gametogenesis includes both mitosis and meiosis to allow for recombination of genetic material and for reduction of the number of chromosomes from diploid to haploid cells.

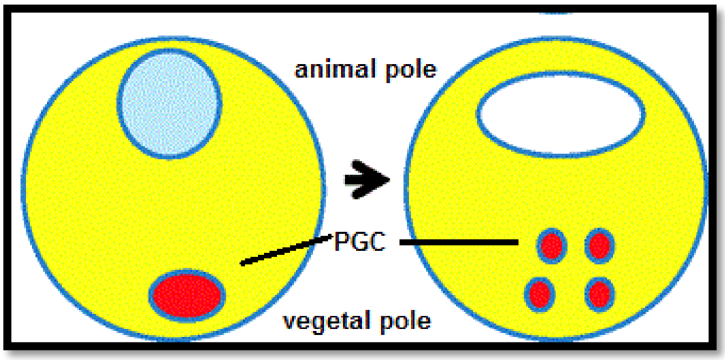
The gametogenesis includes two types of processes differs between male and female, in the male called, **Spermatogenesis**, and in the female called **Oogenesis**, and the two processes are also called **pre-embryonic development**.

Primordial Germ Cells (PGCs)

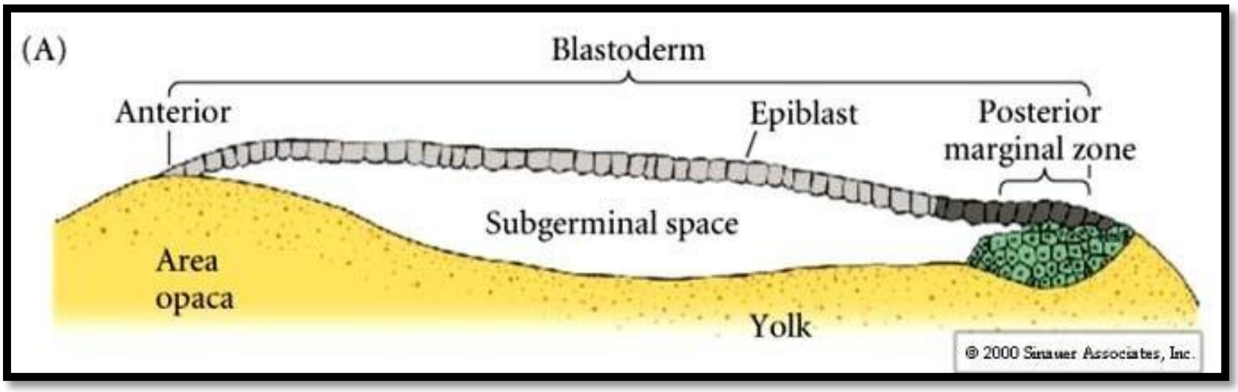
Although much of the early history of the germ cells is still unknown, the cells that give rise to the gametes are recognized at early stage in development.

PGC of birds, reptiles, and mammals arise in the epiblast of the embryo and then go temporary in extraembryonic tissues before return to the body of the embryo.

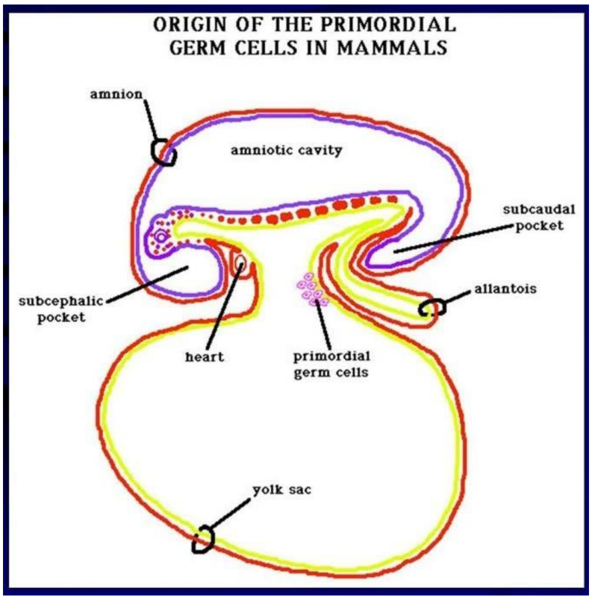
In frog and number of invertebrate species, germ cells can be recognized very early in the life of the animal around the vegetal pole cytoplasm of the zygote as specific cells during the cleavage stages. The PGCs of the birds are recognized in the germinal crescent which is located beyond the head region of the embryo, in the mammals the PGCs derived from yolk sac entoderm near caudal end of the body near the origin of the allantois. So many studies proved that the site of the PGCs in various reptiles, birds, and mammals is from **an extra-gonadal origin**.



PGC in frog



PGC in chick



PGC in human

In most vertebrates, mitosis in the PGC is arrested after their until reach the genital region, but this is differ in the mammals, there is no stop in the mitotic activity of the PGC during migration to the genital area.

Like all normal somatic cells (non-germ cells) the PGCs contain 23 pairs of chromosomes (46 chromosomes). One chromosome of each pair is obtained from the maternal gamete and the other from the paternal gamete, 22 pair consists of homologous chromosomes called **autosomes**, the remaining 2 chromosomes (1 pair) are called **sex chromosomes**.

In males, PGCs remain dormant in the testes from 6th.Week of human embryonic development until puberty. At puberty, seminiferous tubules mature by the male hormones that stimulate the differentiation of the PGCs into **spermatogonia** by mitosis. In contrast in the female, the PGCs, undergo a few more mitotic divisions and invested by some somatic cells from the stroma of the ovaries before 5th. Week of the human embryonic development the PGCs transform to the **oogonia**, and by the 5th month of the fetal development all oogonia inter **meiosis** I, they are called **primary oocytes**, the primary oocytes still arrest in the ovaries until sexual maturity.

Spermatogenesis

The process in which an animal produces spermatozoa from spermatogonial stem cells by way of mitosis and meiosis. The initial cells in this pathway are called spermatogonia, which yield primary spermatocytes by mitosis. The development of the spermatozoa takes place in the male gonads, the testes, in all vertebrates the testes are mixed gland; exocrine organ, produce sperms and endocrine gland, producing male hormones.

The spermatogenesis takes place continuously from puberty until death, At birth, the germ cells in the infant male can be recognized in the sex cords of the testis, as large, pale cells surrounded by supporting cells. The supporting cells called the **sertoli cells**; originate from the surface of epithelium of the seminiferous tubules, the sertoli cells have physical and chemical support to the spermatocytes.

At puberty, the testes begin to secret greatly increased amounts of the steroid hormones, testosterone, among effects of this hormone; the PGCs will resume the development and divide several times by mitosis, and then differentiate into

Spermatogonia. Spermatogonia locate under the basement membrane of the seminiferous tubule.

The spermatogenesis is a continuous process; it can be divided into two stages:

1- Spermatocytogenesis **2- Spermiogenesis**

1- Spermatocytogenesis: - the process which the primordial germ cells (PGCs) produce the spermatozoa during several stages of mitosis.
2- Spermiogenesis: - the process which includes the re-structuring of the spermatids to spermatozoa (sperms) without any cell division only morphological changes. Because a sperm or spermatozoon is very active and motile, therefore it requires a degree of specialization, head and tail of the sperm are formed in this process.

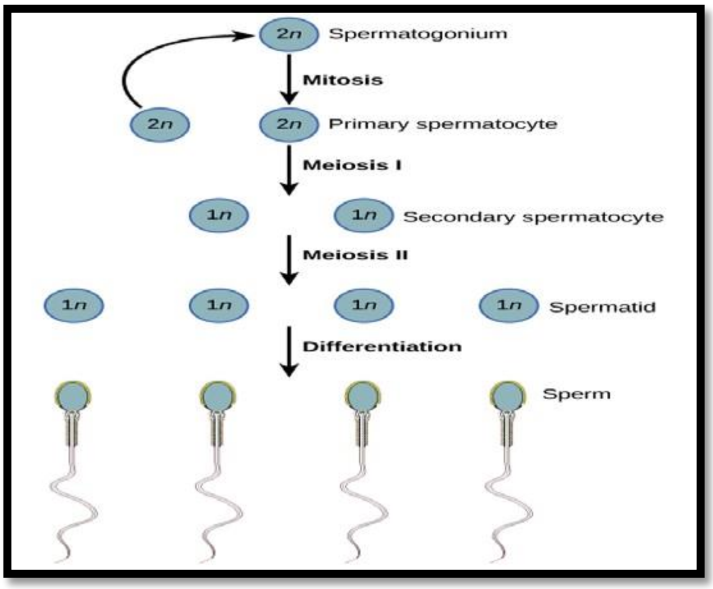
1- Spermatocytogenesis

PGCs (**46,2n**) move from the wall of the yolk sac arrive in the testes and remain dormant until birth, **at puberty** the testes differentiate during mitosis into Spermatogonia (**46,2n**) which are located peripherally in the seminiferous tubules, these cells are active mitotically all the life. The DNA replication is occur in mitosis convert the Spermatogonia from **2n** to **4n** the resultant cells called the Primary spermatocytes (**46, 4n**)

Primary spermatocytes (**46, 4n**) inter the **meiosis I** and divided into two daughter cells called **secondary spermatocytes** (**23, 2c**), each of the secondary spermatocytes inter the **meiosisII** to form **four haploid spermatids** (**23,1c**). Commonly in the human the **meiosis I** last for several weeks, whereas the **meiosis II** is completed in about 8 hours.

Through this series of division, cytokinesis is incomplete; leaving all cells still connected through thin cytoplasmic bridges, and connects with **sertoli cells**, which support them physically and metabolically.

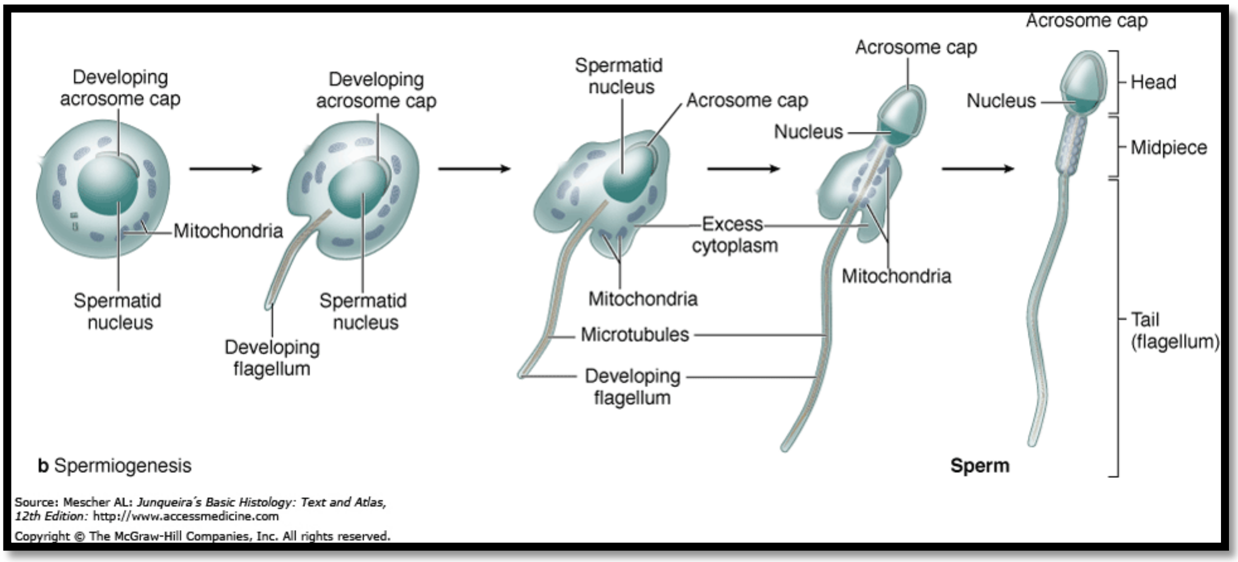
Although the spermatids no longer divide, they undergo a transformation to specialized spermatozoa; this is done by the spermiogenesis process.



2- <u>Spermeiogenesis</u>

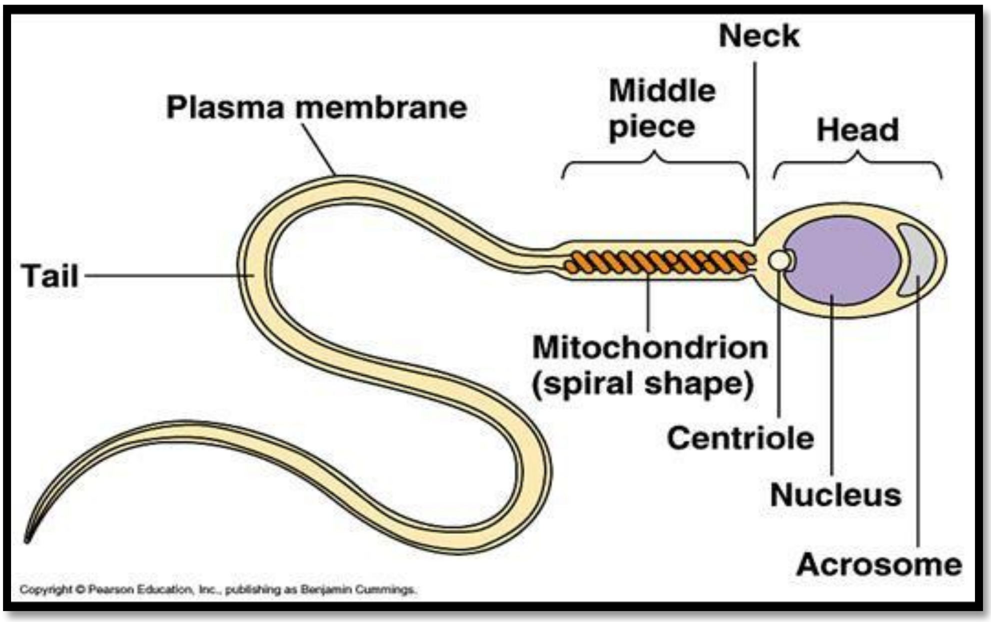
The Spermeiogenesis is the second process of the spermatogenesis mechanisms, it consists of series of morphological changes that responsible of transformation the spermatids into mature spermatozoa (sperms) (**23,1n**). Because the sperm or spermatozoon is very active and mobile cells, so it must be supported with great amount of energy and activation, therefore there is need to a high degree of specialization must occur in the sperm cells before release from the testes.

After the end of the meiosis II, the nucleus begins to lose fluid, decrease its size The nucleus loses its RNA molecules, nucleolus and most proteins, only the haploid copy of the DNA will remain, and the chromatin compress until forming the head of the sperm, at the apical end of the developing sperm head, there is a Golgi complex form the pro-acrosomal granules, contains hydrolytic enzymes that are released during fertilization. The centriole develop to be a point of the flagellum, after the meiosis II, the two centrioles move through the cytoplasm of the spermatid just behind the nucleus, these centrioles give rise to the axial filament of the flagellum of the sperms, which later differentiate into tail. mitochondria begin to form a spiral form called the mitochondria helix as a source of energy, during development the rest of the cytoplasm will sloughed off and phagocytized by the sertoli cells, all these events make the mature spermatozoa leaves all the non-essential parts,



at the end the mature spermatozoa will consists of :-

1- Head; containing nucleus and acrosome
2- A neck; containing the centriole
3- A middle piece; containing the proximal part of the flagellum and mitochondria helix
4- The tail, highly specialized flagellum


Neck
Middle piece
Head
Plasma membrane
Tail
Mitochondrion (spiral shape)
Centriole
Nucleus
Acrosome
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