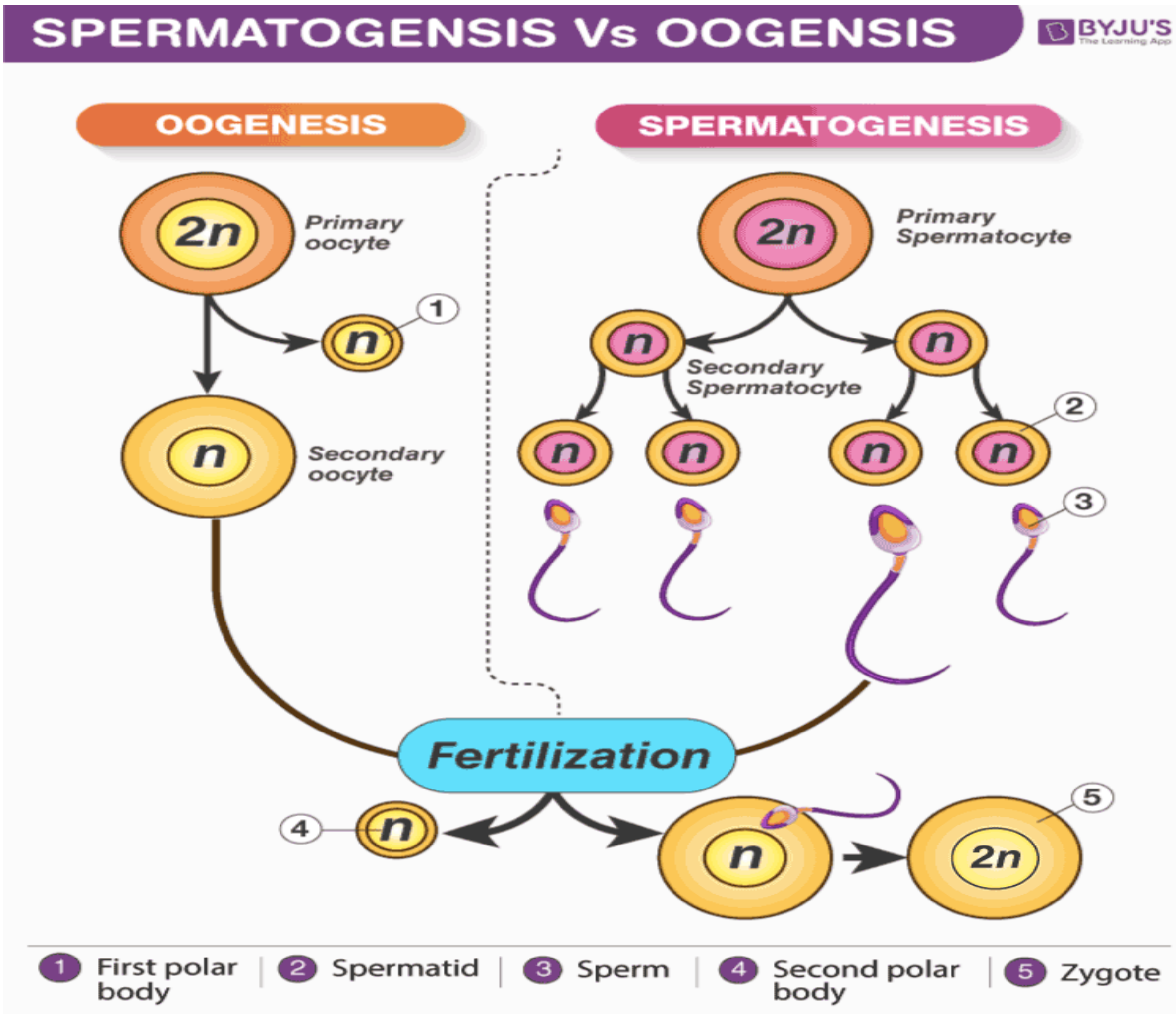
Gametogenesis (Spermatogenesis and Oogenesis)

An organism undergoes a series of changes throughout its life cycle. Gametogenesis (spermatogenesis and oogenesis), plays a crucial role in humans to support the continuance of generations.

Gametogenesis is the process of division of diploid cells to produce new haploid cells. In humans, two different types of gametes are present. Male gametes are called sperm and female gametes are called the ovum.

- **Spermatogenesis**: Sperm formation
- **Oogenesis**: Ovum formation



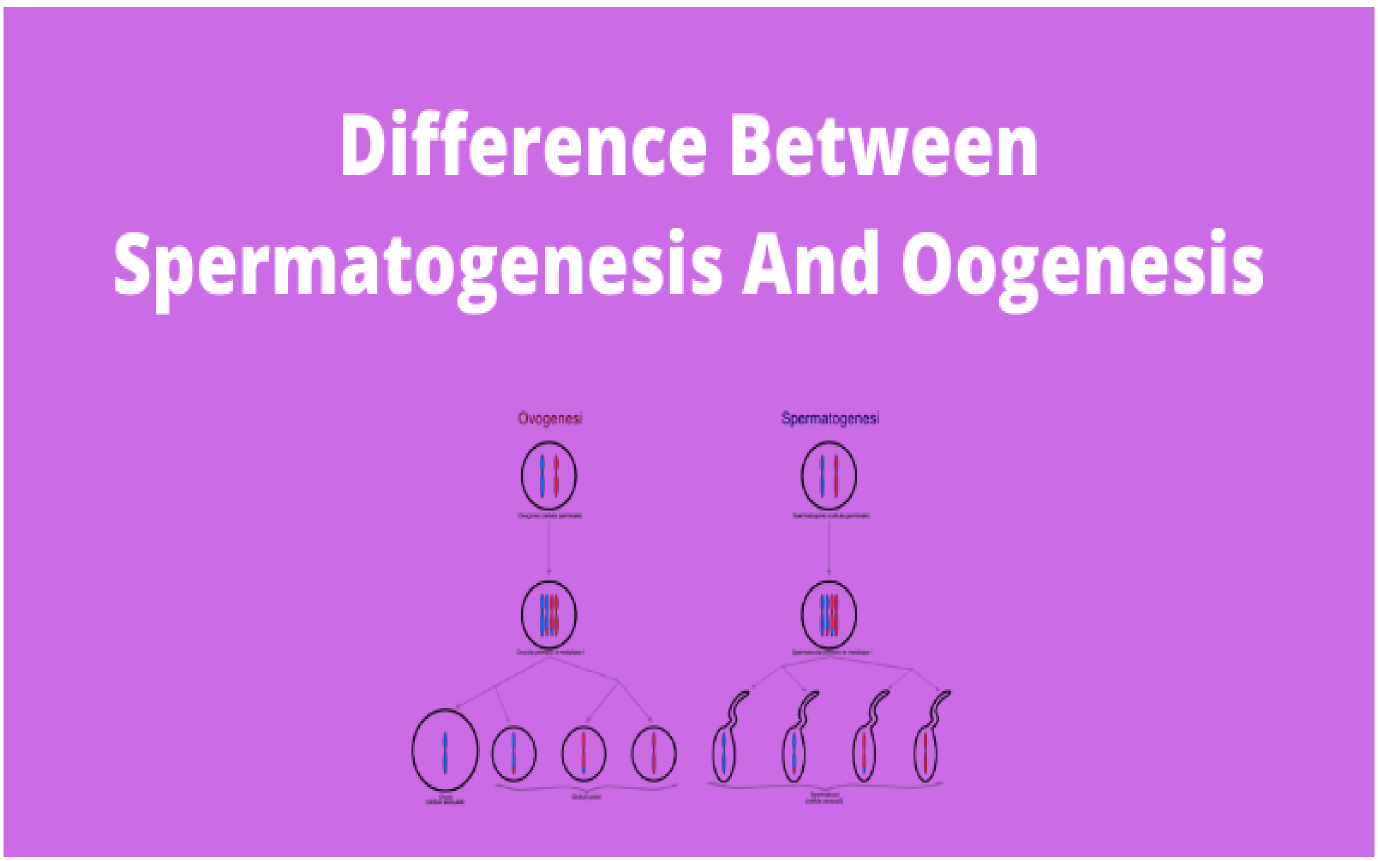
Difference between Spermatogenesis and Oogenesis

The major difference between spermatogenesis and oogenesis includes factors like the process, occurrence, product formation after gametogenesis. The difference in the process consists of the production of sperms from **spermatogonium** on the other side the **oogonium** is used for the production of the **ovum**.

The occurrence of Spermatogenesis is found inside the seminiferous tubules of a testis whereas oogenesis is present inside the ovary.

The product form in spermatogenesis is sperm which is motile and the product form in an oogonium is ovum which is non-motile. Thus there is the structural and functional difference between sperm and ovum.

Gametogenesis is the process in which the sperm and ovum are produced. This sperm and ovum are also known as male and female gametes. This production of sperm and ovum occurs inside the testis of the male and the ovary of the female.



Difference between Spermatogenesis and Oogenesis

Properties	Spermatogenesis	Oogenesis
Definition	The main feature is the production of the sperms from spermatogenesis.	The main feature is the production of the ovum from oogenesis.
Stages	All the stages take place in the testis.	Not all only the last stage of oogenesis takes place in the oviduct.
Location	Spermatogenesis is located in the testis of males.	Oogenesis is located in the ovary of females.
Growth	The growth phase is short.	The growth phase is extended.
Production rate	The production of sperms is in	Only one ovum is released once a month.

	millions every day.	
Release	The sperms are released from the testis.	The ova are released from the ovary.
Duration	It takes place every day.	It takes place once per month.
Cell division	The division is equal and helps in the formation of four haploid spermatids.	The division of the cell is unequal and helps in the formation of one haploid ovum and two polar bodies.
Nuclear Condensation	It takes place in the sperms.	No nuclear condensation is found in the ovum.
Mortality	The sperms are motile.	The ova are nonmotile.

Spermatogenesis:

Spermatogenesis is the reproductive stage where the production of haploid sperms takes place from "**spermatogonium**" in a male gonad, i.e. seminiferous tubules of a testis.

Process

The process in spermatogenesis includes the following steps:

1. Spermatogonium first develops from the germinal epithelial lining of the seminiferous tubules which are diploid stem-cell having totipotency.
2. It then goes through mitosis cell division and evolves into primary spermatocytes. This process is known as "Spermatocytogenesis".
3. This primary spermatocytes further goes through meiosis cell division-1 and result in the formation of two secondary spermatocytes.
4. Now, this secondary spermatocytes experience meiosis cell division-2 and form two spermatids which connect to the border of testis lumen through the cytoplasmic bridges.
5. Spermatids are round in shape and non-motile cells that undergo maturation and form motile, haploid sperms. This process of formation of sperms forms spermatids refers to "Spermiogenesis".

Facts

- The duration required for the formation of sperm from Spermatogonium is 70 days by spermatogenesis.
- A Spermatogonium forms four spermatozoa.
- One primary spermatocyte is responsible for the production of two secondary spermatocytes.
- In humans the number of chromosomes is 46, due to no meiosis division in the Spermatogonium, the chromosomal number will remain the same. But when primary spermatocyte further goes through meiosis cell division 1 and 2, then the chromosomal number becomes half i.e. 46 in the primary and 23 in the secondary spermatocytes, spermatids, and sperms.

- In one ejaculation, 200-300 million sperms are produced. It consists of 60% non-motile and 40% motile sperms.
- The normal range should be within 100million/ml of semen in a male. If there is less count then the "Oligospermia" condition occurs which causes infertility.

Oogenesis

Oogenesis is the reproductive stage where the formation of haploid ovum occurs from "Oogonium" in a female gonad, i.e. ovaries.

Process

The process in oogenesis includes the following steps:

1. Oogonium first develops from the germinal epithelium overlying the ovary having a self-renewing capacity.
2. Oogonium then goes through mitosis cell division and differentiates into primary oocytes.
3. This primary oocytes further goes through meiosis cell division-1 which seizes at the diplotene stage in childhood. When puberty occurs this helps in the formation of secondary oocyte and one polar body.
4. Secondary oocytes go through meiosis cell division-2 which stops at the metaphase stage forms ootid.
5. When this ootid experiences the process of fertilization it produces the non-motile, large and spherical ovum and second polar body that degenerates.

Facts

- An Oogonium forms a single ovum.
- One primary oocyte will produce one secondary oocyte and one polar body that degenerates from the ovary.
- In humans the number of chromosomes is 46, due to no meiosis division in the Oogonium, the chromosomal number will be the same. But when the primary oocyte undergoes meiosis cell division 1 and 2, the chromosomal number

becomes half i.e. 46 in the primary oocyte and 23 in the secondary oocyte and one polar body and ovum.

- In oogenesis, 7million primary oocytes forms in the ovary of a female fetus which reverts to 2-4millions at the time of birth. After puberty, only 40,000 primary oocytes left out and reverts to 480 after the division in a reproductive phase of 11-50 years in females.

Difference between Male and Female Gamete

The sperm and ovum can be distinguished in many ways like their structure, motility, shape, size, etc.

Structure of sperm

- It consists of three parts head, neck, and tail.

Head: It consists of acrosome present at the tip and is produced by the Golgi body. It contains an enzyme known as "Sperm lysins". It conducts an essential role that enters the ovum by digesting away its membrane. A non-condensed nucleus is also present with no nucleoplasm.

Neck: It consists of a proximal centriole that is required for the first cleavage and a Distal centriole which maintains the axial filament.

Middle piece: It comprises axial filament which consists of organized mitochondria. These mitochondria are approximately 25 in number that provides energy for the flagellar movement.

Tail: It is extended and motile surrounds by a flagellar sheath.

Sperm are smaller than most cells in the body; in fact, the volume of a sperm cell is 85,000 times less than that of the female gamete. Approximately 100 to 300 million sperm are produced each day, whereas women typically ovulate only one oocyte per month. As is true for most cells in the body, the structure of sperm cells speaks to their function. Sperm have a distinctive head, mid-piece, and tail region (Figure 22.3.122.3.1). The head of the sperm contains the extremely compact haploid nucleus with very little cytoplasm. These qualities contribute to the overall small size of the sperm (the head is only 5 μm long). A structure called the acrosome covers most of the head of the sperm cell as a "cap" that is filled with lysosomal enzymes important for preparing sperm to participate in fertilization. Tightly packed mitochondria fill the mid- piece of the sperm. ATP produced by these mitochondria will power the flagellum, which extends from the neck and the mid-piece through the tail of the sperm, enabling it to move the entire sperm cell. The central strand of the flagellum, the axial filament, is formed from one centriole inside the maturing sperm cell during the final stages of spermatogenesis.

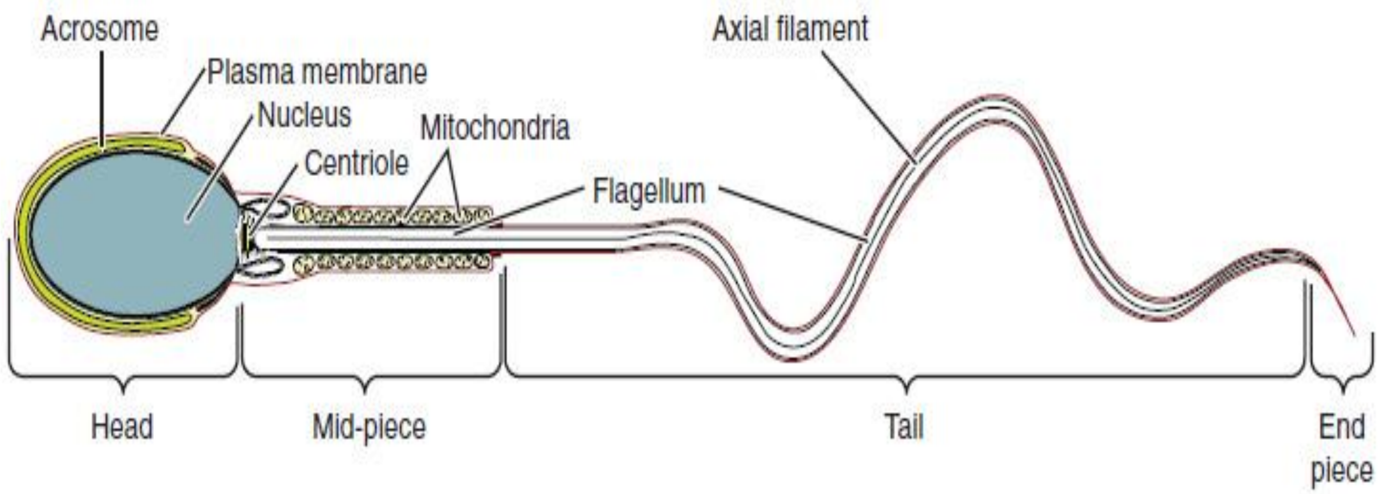


Figure : Structure of Sperm Sperm cells are divided into a head, containing DNA; a mid-piece, containing mitochondria; and a tail, providing motility. The acrosome is oval and somewhat flattened. (CC-BY-4.0, OpenStax, Human Anatomy)

Structure of ovum

- It does not consist of a head, neck, and tail.
- A nucleus of an ovum is uncommon. In this nuclear condensation is present where it is bloated with nucleoplasm and refers to germinal vesicles.
- Centrioles are absent in ovum.
- In the ovum, the mitochondria scatter in the cytoplasm.

- Ovum consists of little or no yolk.
- The size is larger than the oocytes.
- It consists of a large amount of cytoplasm.
- Ovum surrounds by two layers known as granulosa cells and zona pellucida.

Spermatogenesis and oogenesis are the reproductive phases that include the following – multiplication, growth, maturation and differentiation. The spermatogonium and oogonium multiply by mitosis to form spermatocytes and oocytes. The spermatocytes eventually lead to the formation of spermatids – and it contains only half of the genetic material present in the original primary spermatocyte as a result of meiosis. Oocytes (germ cells) undergo mitosis and maturation to form ootids that further differentiate to form ovum.

Spermatogenesis

In the male, immature germ cells are produced in the testes. At puberty, in males, these immature germ cells or spermatogonia are converted into sperms by the process of spermatogenesis. Spermatogonia are diploid cells that undergo mitotic division and their number increases. Primary spermatocytes undergo meiosis and produce haploid cells- secondary spermatocytes. These secondary spermatocytes undergo the second meiotic division to produce immature sperms or spermatids. These spermatids undergo spermiogenesis to transform into sperms. Various hormones like GnRH, LH, FSH and androgens are involved in stimulating spermatogenesis.

Oogenesis

In females, the oogonia are converted to the mature ovum. This process is called oogenesis. In the female ovary, millions of oogonia or mother cells are formed during fetal development. These mother cells undergo the meiotic cell division, the meiotic division rests at the prophase-I and lead to the production of primary oocytes. Primary oocytes are embedded within the primary follicles on the outer layer. Primary follicles get surrounded by more granulosa cell layer and forms secondary follicles. Secondary follicles then turn into the tertiary follicle. At the stage of female puberty, the primary oocytes present in the tertiary follicles complete meiosis and form secondary oocytes (haploid) and the polar body by unequal division. The tertiary follicle undergoes some structural and functional changes and produces mature Graafian follicle. Secondary oocyte undergoes second meiotic division to form an ovum. Ovum is released from the Graafian follicle during the menstrual cycle. The release of an ovum from the Graafian follicle is called ovulation. Ovulation is controlled by the female reproductive hormone which is stimulated by the pituitary gland.

Spermatogenesis and oogenesis are both forms of gametogenesis, in which a diploid gamete cell produces haploid sperm and egg cells, respectively.

Key Points

- Gametogenesis, the production of sperm (spermatogenesis) and eggs (oogenesis), takes place through the process of meiosis.
- In oogenesis, diploid oogonium go through mitosis until one develops into a primary oocyte, which will begin the first meiotic division, but then arrest; it will finish this division as it develops in the follicle, giving rise to a haploid secondary oocyte and a smaller polar body.
- The secondary oocyte begins the second meiotic division and then arrests again; it will not finish this division unless it is fertilized by a sperm; if this occurs, a mature ovum and another polar body is produced.
- In spermatogenesis, diploid spermatogonia go through mitosis until they begin to develop into gametes; eventually, one develops into a primary

spermatocyte that will go through the first meiotic division to form two haploid secondary spermatocytes.

- The secondary spermatocytes will go through a second meiotic division to each produce two spermatids; these cells will eventually develop flagella and become mature sperm.

Key Terms

- **spermatocyte**: a male gametocyte, from which a spermatozoon develops
- **oocyte**: a cell that develops into an egg or ovum; a female gametocyte
- **polar body**: one of the small cells that are by-products of the meiosis that forms an egg
- **mitosis**: the division of a cell nucleus in which the genome is copied and separated into two identical halves. It is normally followed by cell division
- **meiosis**: cell division of a diploid cell into four haploid cells, which develop to produce gametes

Gametogenesis (Spermatogenesis and Oogenesis)

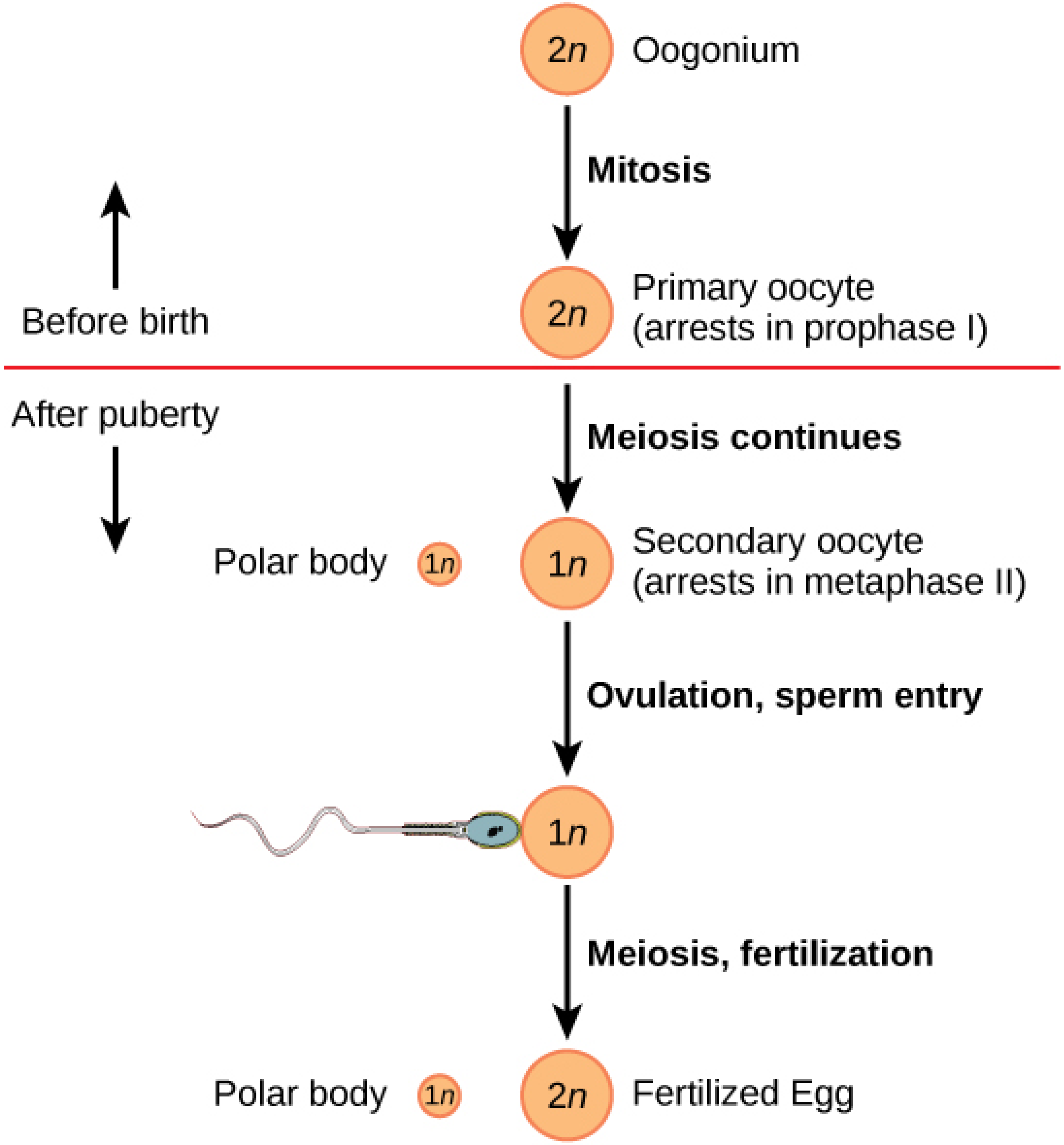
Gametogenesis, the production of sperm and eggs, takes place through the process of meiosis. During meiosis, two cell divisions separate the paired chromosomes in the nucleus and then separate the chromatids that were made during an earlier stage of the cell's life cycle, resulting in gametes that each contain half the number of chromosomes as the parent. The production of sperm is called spermatogenesis and the production of eggs is called oogenesis.

Oogenesis

Oogenesis occurs in the outermost layers of the ovaries. As with sperm production, oogenesis starts with a germ cell, called an oogonium (plural: oogonia), but this cell undergoes mitosis to increase in number, eventually resulting in up to one to two million cells in the embryo.

Figure : Oogenesis: The process of oogenesis occurs in the ovary's outermost layer. A primary oocyte begins the first meiotic division, but then arrests until later in life when it will finish this division in a developing follicle. This results in a secondary oocyte, which will complete meiosis if it is fertilized.

The cell starting meiosis is called a primary oocyte. This cell will begin the first meiotic division, but be arrested in its progress in the first prophase stage. At the time of birth, all future eggs are in the prophase stage. At adolescence, anterior pituitary hormones cause the development of a number of follicles in an ovary. This results in the primary oocyte finishing the first meiotic division. The cell divides unequally, with most of the cellular material and organelles going to one cell, called a secondary oocyte, and only one set of chromosomes and a small amount of cytoplasm going to the other cell. This second cell is called a polar body and usually dies. A secondary meiotic arrest occurs, this time at the metaphase II stage. At ovulation, this secondary oocyte will be released and travel toward the uterus through the oviduct. If the secondary oocyte is fertilized, the cell continues through the meiosis II, completing meiosis, producing a second polar body and a fertilized egg containing all 46 chromosomes of a human being, half of them coming from the sperm.



Spermatogenesis

Spermatogenesis occurs in the wall of the seminiferous tubules, with stem cells at the periphery of the tube and the spermatozoa at the lumen of the tube. Immediately under the capsule of the tubule are diploid, undifferentiated cells. These stem cells, called spermatogonia (singular: spermatagonium), go through mitosis with one offspring going on to differentiate into a sperm cell, while the other gives rise to the next generation of sperm.

Meiosis begins with a cell called a primary spermatocyte. At the end of the first meiotic division, a haploid cell is produced called a secondary spermatocyte. This haploid cell must go through another meiotic cell division. The cell produced at the end of meiosis is called a spermatid. When it reaches the lumen of the tubule and grows a flagellum (or "tail"), it is called a sperm cell. Four sperm result from each primary spermatocyte that goes through meiosis.

Stem cells are deposited during gestation and are present at birth through the beginning of adolescence, but in an inactive state. During adolescence, gonadotropic hormones from the anterior pituitary cause the activation of these cells and the production of viable sperm. This continues into old age.