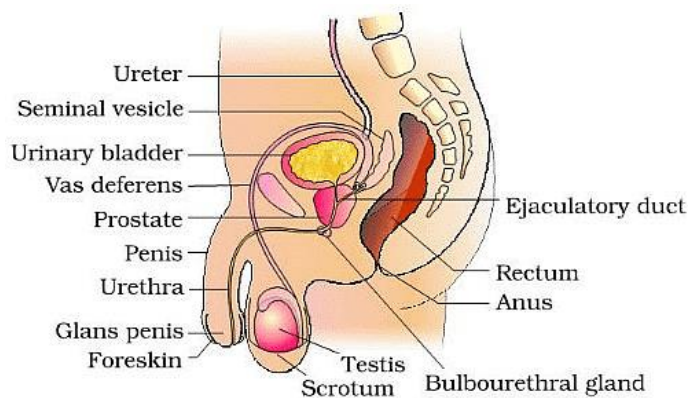


# Human Reproduction

Humans are sexually reproducing and viviparous. The reproductive events in humans include formation of gametes (**gametogenesis**), transfer of sperms into the female genital tract (**insemination**) and fusion of male and female gametes (**fertilisation**) leading to formation of zygote. This is followed by formation and development of blastocyst and its attachment to the uterine wall (**implantation**), embryonic development (**gestation**) and delivery of the baby (**parturition**). Based on these events, some important diagrams for NEET Examination are given below.

## 1. Male Pelvis

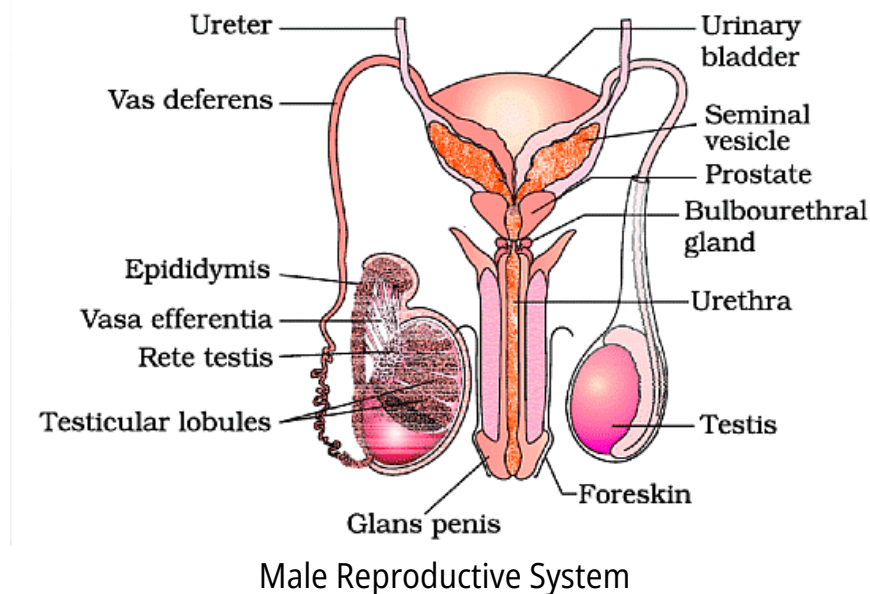
- The male reproductive system is located in the pelvis region. It includes **a pair of testes** alongwith **accessory ducts, glands and the external genitalia**.
- The testes are situated outside the abdominal cavity within a pouch called **scrotum**.
- The scrotum helps in maintaining the low temperature of the testes (**2- 2.5°C lower** than the normal internal body temperature) necessary for spermatogenesis.
- In adults, each testis is oval in shape, with a length of about 4 to 5 cm and a width of about 2 to 3cm.
- Each testis has about **250 compartments** called **testicular lobules**.



Structure of Male Pelvis

## 2. Male Reproductive System

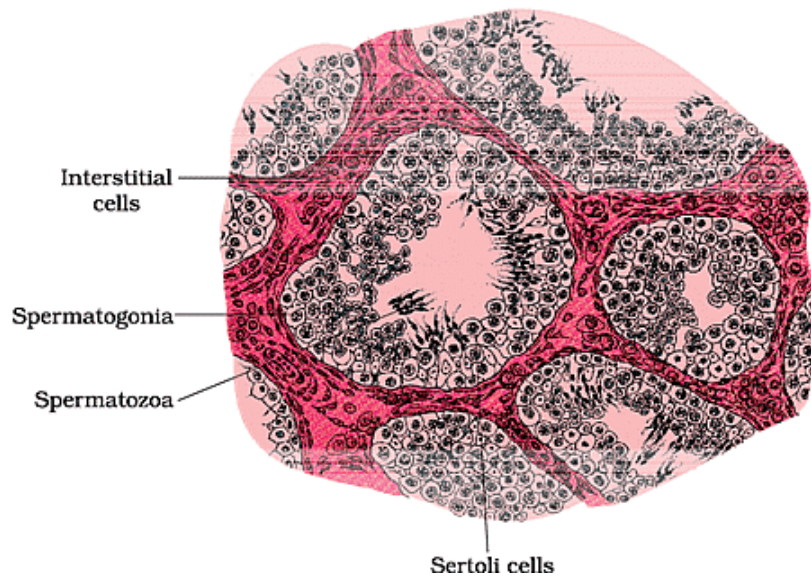
- The male sex accessory ducts include **rete testis**, **vasa efferentia**, **epididymis** and **vas deferens**.
- The **seminiferous tubules** of the testis open into the **vasa efferentia** through **rete testis**.
- The vasa efferentia leave the testis and open into **epididymis** located along the posterior surface of each testis.
- The **urethra** originates from the urinary bladder and extends through the penis to its external opening called **urethral meatus**.
- The **penis** is the male external genitalia.
- The enlarged end of penis called the **glans penis** is covered by a loose fold of skin called **foreskin**.



## 3. Seminiferous Tubule

- Each testicular lobule contains one **1-3 highly coiled seminiferous tubules** in which sperms are produced.
- Each seminiferous tubule is lined on its inside by two types of cells called **male germ cells (spermatogonia)** and **Sertoli cells**.

- The male germ cells undergo **meiotic divisions** finally leading to **sperm formation**.
- **Sertoli cells** provide nutrition to the germ cells.
- The regions outside the seminiferous tubules called **interstitial spaces**, contain small blood vessels and interstitial cells or **Leydig cells**.



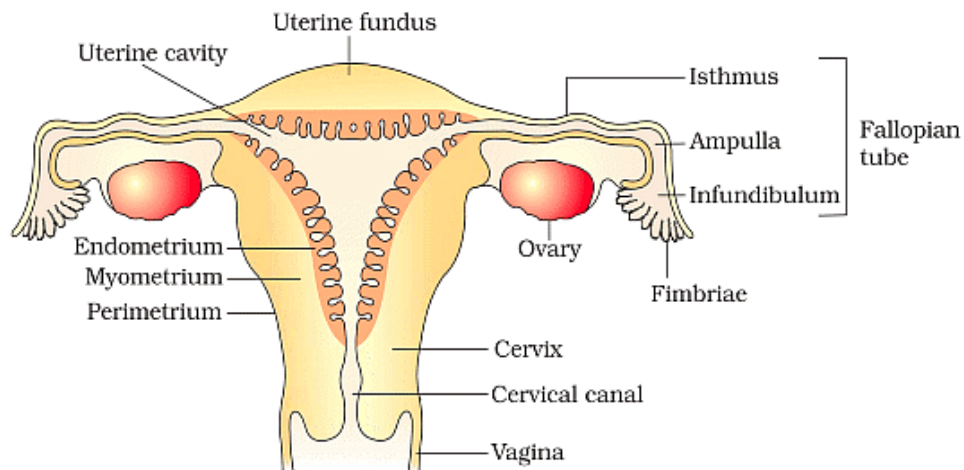
Sectional View of Seminiferous Tubule

#### 4. Female Reproductive System

Diagrammatic sectional view of female pelvis showing reproductive system

- The female reproductive system consists of a pair of ovaries along with a pair of **oviducts, uterus, cervix, vagina** and the **external genitalia** located in pelvic region.
- The **oviducts** (fallopian tubes), **uterus** and **vagina** constitute the **female accessory ducts**.
- The part closer to the ovary is the funnel-shaped **infundibulum**.
- The edges of the infundibulum possess **finger-like projections** called **fimbriae**, which help in collection of the ovum after ovulation.
- The infundibulum leads to a wider part of the oviduct called **ampulla**.

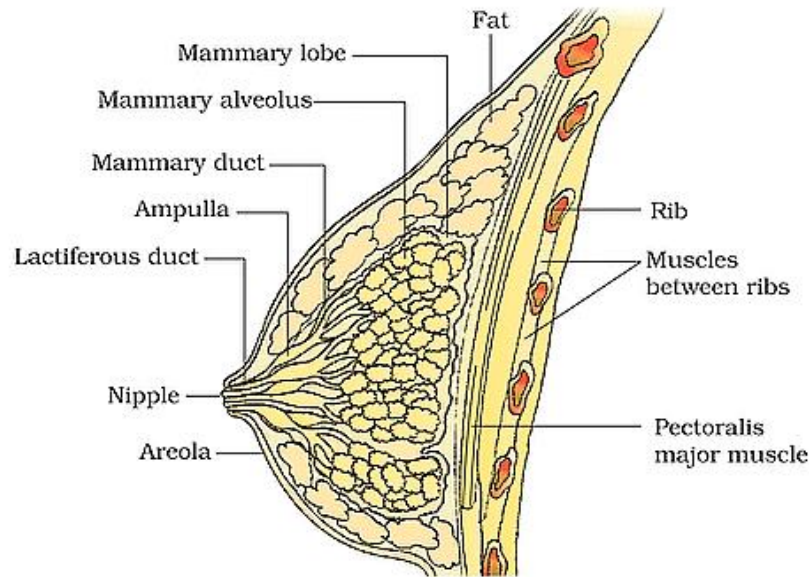
- The last part of the oviduct, **isthmus** has a narrow lumen and it joins the uterus.
- The cavity of the **cervix** is called **cervical canal** which along with **vagina** forms **the birth canal**.
- The wall of the uterus has three layers of tissue: The external thin membranous **perimetrium**, middle thick layer of smooth muscle (**myometrium**) and inner glandular layer (**endometrium**) that lines the uterine cavity.



Female Reproductive System

## 5. Mammary Glands

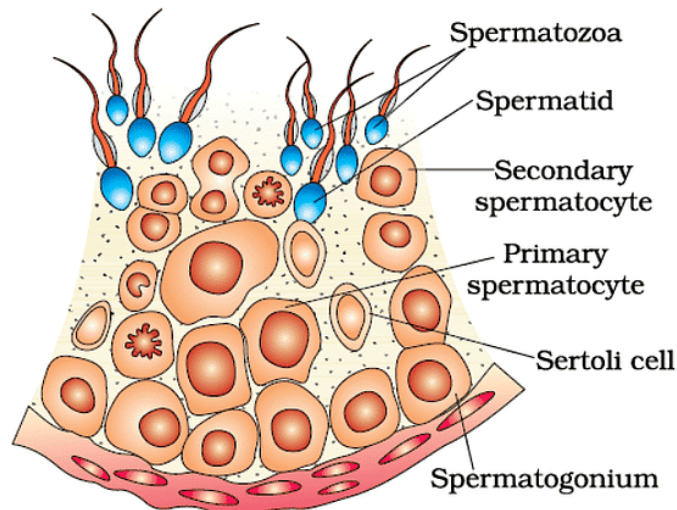
- A functional mammary gland is **characteristic of all female mammals**.
- The glandular tissue of each breast is divided into **15-20 mammary lobes** containing clusters of cells called **alveoli**.
- The cells of alveoli secrete milk, which is stored in the cavities (lumens) of alveoli.
- The alveoli open into **mammary tubules**.
- The tubules of each lobe join to form a **mammary duct**.
- Several mammary ducts join to form a wider **mammary ampulla** which is connected to **lactiferous duct** through which milk is sucked out.



Mammary Glands

## 6. Gametogenesis

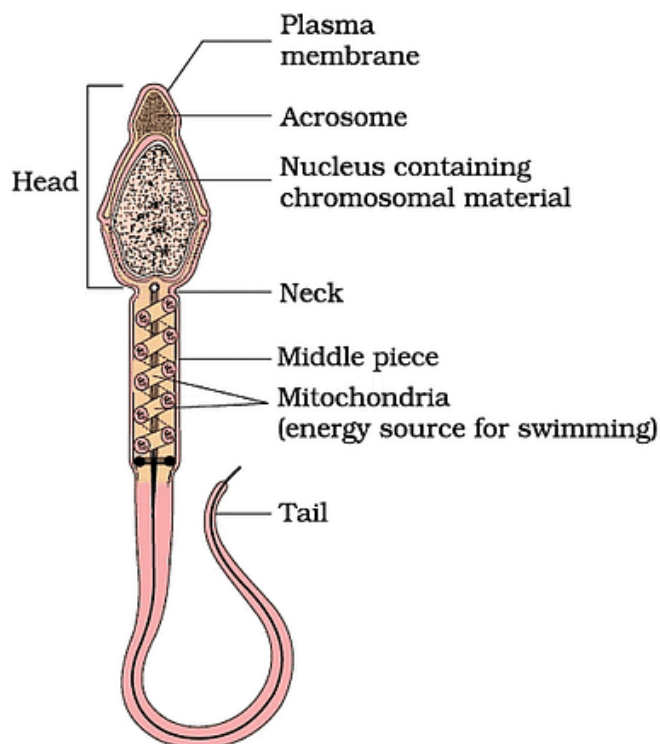
- Each **spermatogonium** is **diploid** and contains **46 chromosomes**.
- Some of the spermatogonia called **primary spermatocytes** periodically undergo **meiosis**.
- A primary spermatocyte completes the first meiotic division (reduction division) leading to formation of two equal, haploid cells called **secondary spermatocytes**, which have only **23 chromosomes** each.
- The secondary spermatocytes undergo the second meiotic division to produce **four equal, haploid spermatids**.
- The spermatids are transformed into **spermatozoa (sperms)** by the process called **spermiogenesis**.
- After spermiogenesis, sperm heads become embedded in the **Sertoli cells**, and are finally released from the seminiferous tubules by the process called **spermiation**.



Seminiferous Tubule depicting Spermatogenesis

## 7. Structure of a Sperm

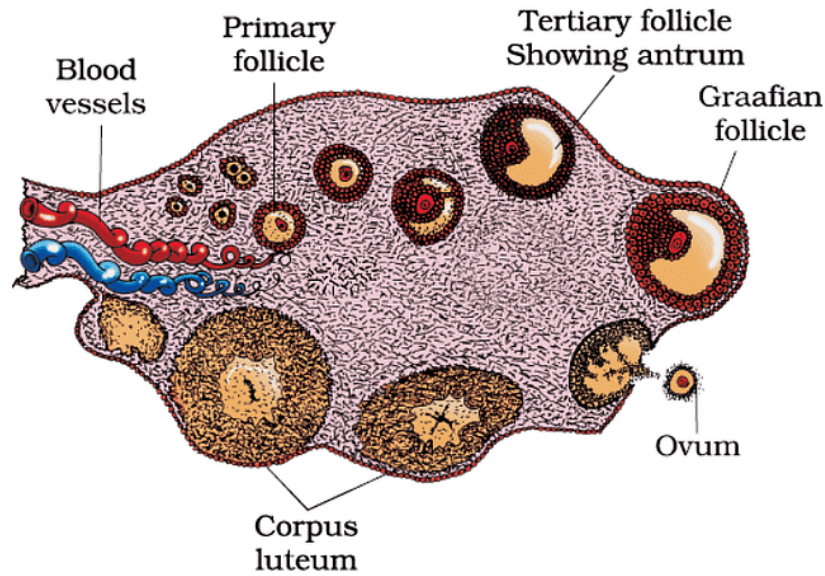
- It is a microscopic structure composed of a **head**, **neck**, a **middle piece** and a **tail**.
- A plasma membrane envelops the whole body of sperm.
- The sperm **head** contains an elongated haploid nucleus, the anterior portion of which is covered by a cap-like structure, **acrosome**.
- The acrosome is filled with enzymes that help fertilisation of the ovum.
- The **middle piece** possesses numerous **mitochondria**, which produce energy for the movement of tail that facilitate sperm motility essential for fertilisation.



Structure of a Sperm

## 8. Sectional View of an Ovary

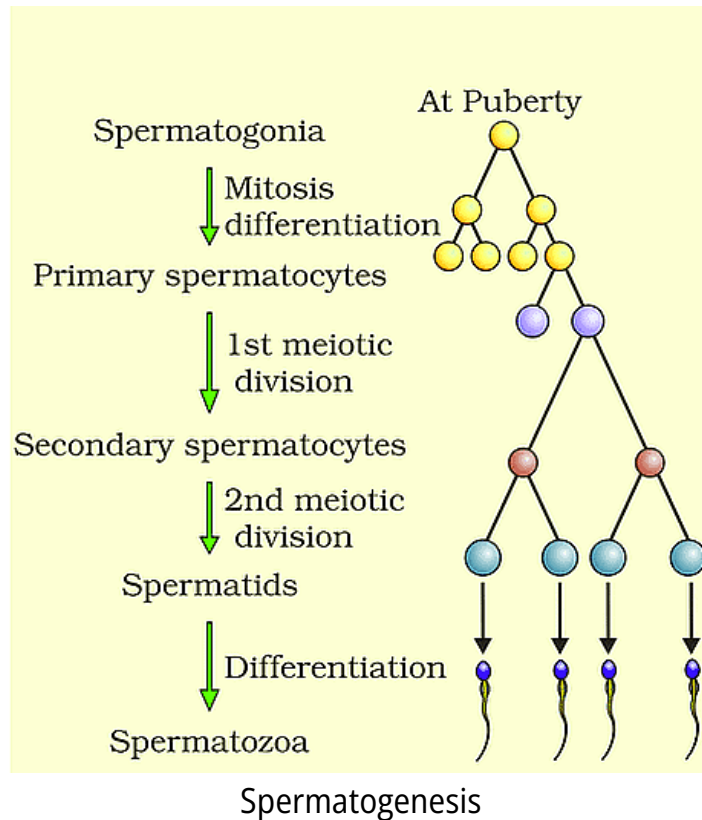
- Oogenesis is initiated during the embryonic development stage, **no more oogonia** are formed and added **after birth**.
- These cells start division and enter into prophase-I of the **meiotic division** called **primary oocytes**.
- Each primary oocyte then gets surrounded by a layer of granulosa cells and is called the **primary follicle**. The primary follicles get surrounded by more layers of granulosa cells and a new theca and are called **secondary follicles**.
- The secondary follicle soon transforms into a tertiary follicle which is characterised by a fluid filled cavity called **antrum**.
- The tertiary follicle further changes into the mature follicle or **Graafian follicle**.
- The Graafian follicle now ruptures to release the secondary oocyte (ovum) from the ovary by the process called **ovulation**.



Sectional View of an Ovary

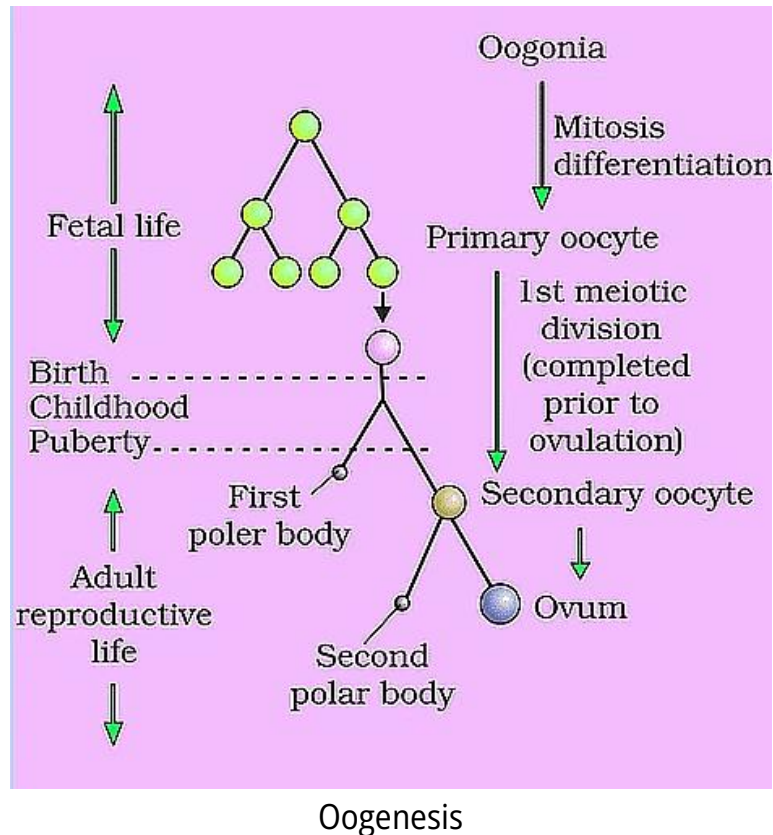
## 9. Spermatogenesis

- Spermatogenesis is the process of the production of sperms from the immature germ cells in males.
- During spermatogenesis, a diploid spermatogonium (male germ cell) increases its size to form a **diploid primary spermatocyte**.
- This diploid primary spermatocyte undergoes first meiotic division (**meiosis I**), which is a reductional division to form two equal **haploid secondary spermatocytes**.
- Each secondary spermatocyte then undergoes second meiotic division (**meiosis II**) to form two equal **haploid spermatids**.
- Hence, a diploid spermatogonium produces four haploid spermatids.
- These spermatids are transformed into **spermatozoa (sperm)** by the process called **spermiogenesis**.



## 10. Oogenesis

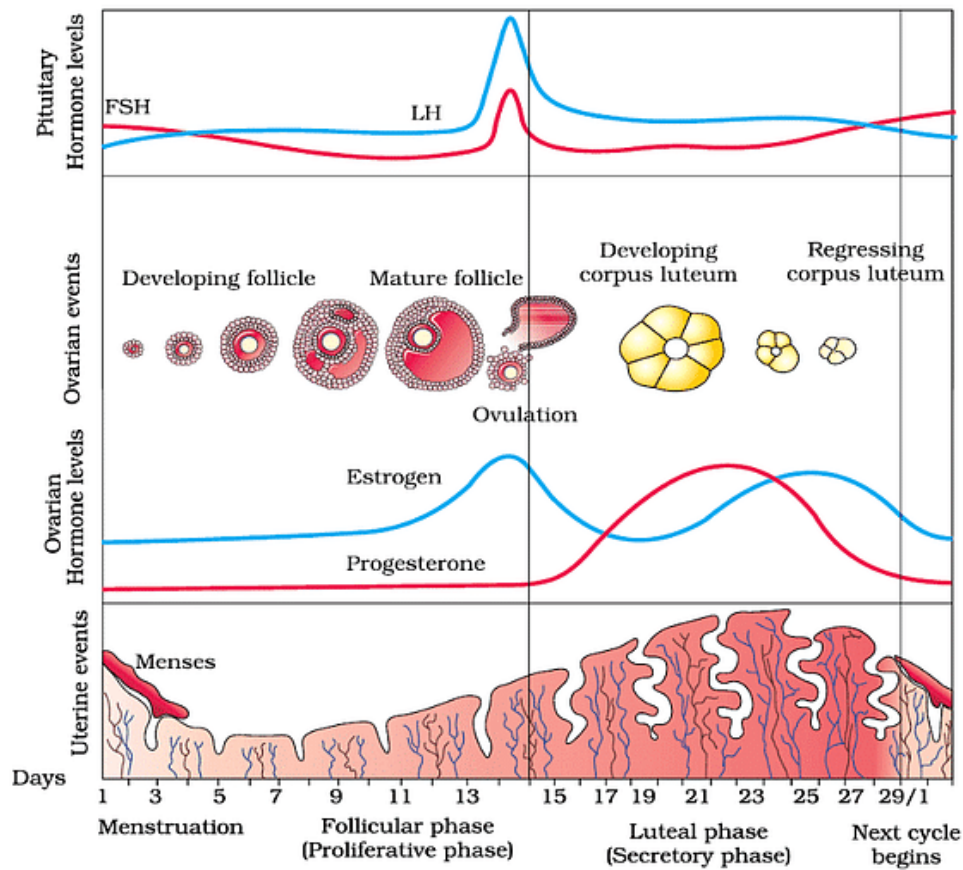
- Oogenesis is the process of the formation of a mature ovum from the oogonia in females. It takes place in the ovaries.
- During oogenesis, a **diploid oogonium** or **egg mother cell** increases in size and gets transformed into a **diploid primary oocyte**.
- This diploid primary oocyte undergoes first meiotic division i.e., **meiosis I** or reductional division to form **two unequal haploid cells**. The smaller cell is known as the **first polar body**, while the larger cell is known as the **secondary oocyte**.
- This secondary oocyte undergoes second meiotic division i.e., **meiosis II** or **equational division** and gives rise to a **second polar body** and an **ovum**.
- Hence, in the process of oogenesis, a diploid oogonium produces a **single haploid ovum** while **two or three polar bodies** are produced.



## 11. Menstrual Cycle

- One ovum is released (ovulation) during the **middle** of each **menstrual cycle**.
- The cycle starts with the **menstrual phase**, when menstrual flow occurs and it lasts for **3-5 days**.
- The menstrual phase is followed by the **follicular phase**. During this phase, the **primary follicles** in the ovary grow to become a fully mature **Graafian follicle** and simultaneously the endometrium of uterus regenerates through proliferation.
- The secretion of **gonadotropins (LH and FSH)** increases gradually during the follicular phase, and stimulates **follicular development** as well as **secretion of estrogens** by the growing follicles.
- Both **LH and FSH** attain a peak level in the middle of cycle (about 14th day). Rapid secretion of LH leading to its maximum level during the mid-cycle called **LH surge** induces rupture of Graafian follicle and thereby the release of ovum (**ovulation**).

- The ovulation (ovulatory phase) is followed by the **luteal phase** during which the remaining parts of the Graafian follicle transform as the **corpus luteum**.
- The corpus luteum secretes large amounts of **progesterone** which is essential for **maintenance of the endometrium**.

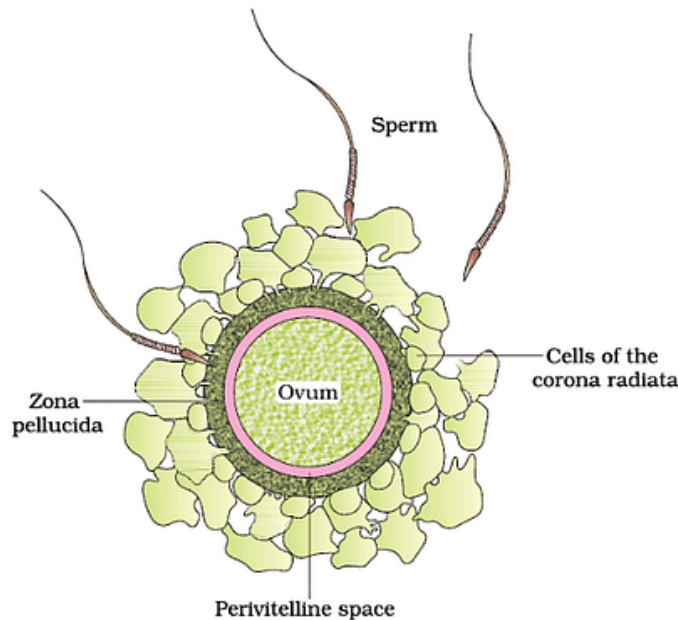


Various Events of Menstrual Cycle

## 12. Fertilisation

- The process of fusion of a sperm with an ovum is called fertilisation.
- During fertilisation, a sperm comes in contact with the **zona pellucida** layer of the ovum and induces changes in the **membrane that block the entry of additional sperms**, ensuring that only one sperm can fertilise an ovum.
- The **secretions of the acrosome** help the sperm enter into the cytoplasm of the ovum through the zona pellucida and the plasma membrane.
- This induces the **completion of the meiotic division of the secondary oocyte**.

- The second meiotic division is also unequal and results in the formation of a **second polar body** and a **haploid ovum (ootid)**.
- Soon the haploid nucleus of the sperms and that of the ovum fuse together to form a **diploid zygote**.

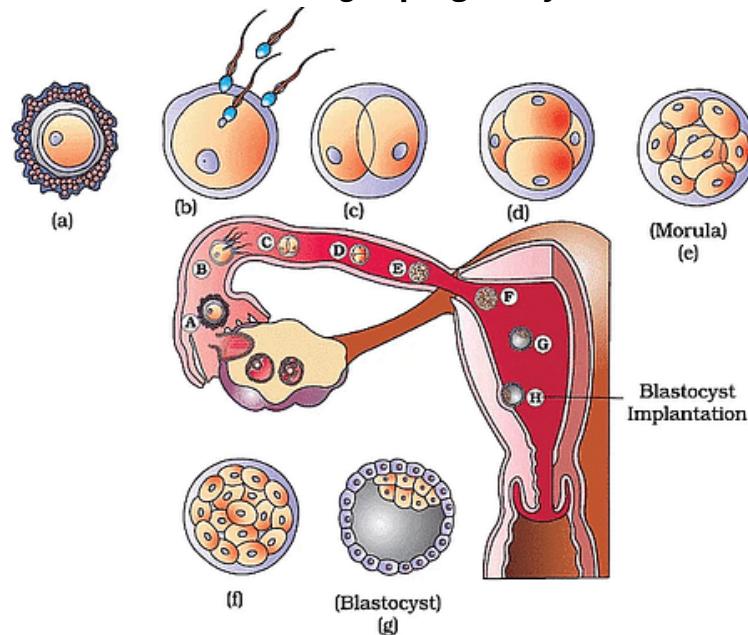


Ovum Surrounded by Sperms before Fertilisation

### 13. Different Stages of Growth of an Embryo

- The mitotic division of zygote (**cleavage**) starts and forms **2, 4, 8, 16 daughter cells** called **blastomeres**.
- The embryo with **8 to 16 blastomeres** is called a **morula**.
- The morula continues to divide and transforms into **blastocyst** as it moves further into the uterus.
- The blastomeres in the blastocyst are arranged into an outer layer called **trophoblast** and an inner group of cells attached to trophoblast called the **inner cell mass**.
- The trophoblast layer then gets attached to the endometrium and the inner cell mass gets differentiated as the embryo.

- After **implantation**, the uterine cells divide rapidly and covers the blastocyst. As a result, the blastocyst becomes embedded in the endometrium of the uterus leading to **pregnancy**.



Fertilisation and Passage of Growing Embryo in Fallopian Tube

## 14. Pregnancy and Embryonic Development

The human foetus within the uterus

### Placenta Formation:

- Chorionic Villi:** Finger-like projections from the trophoblast that interdigitate with uterine tissue.
- Function:** Forms the placenta, which supplies oxygen and nutrients to the embryo and removes waste products.
- Umbilical Cord:** Connects the placenta to the embryo for substance transport.
- Endocrine Function:** Produces hormones like human chorionic gonadotropin (hCG), human placental lactogen (hPL), estrogens, and progestogens, crucial for pregnancy maintenance.

### Hormonal Changes:

- **Increased Hormones:** During pregnancy, levels of hCG, hPL, estrogens, progesterone, cortisol, prolactin, and thyroxine rise significantly to support fetal growth and pregnancy maintenance.
- **Relaxin:** Secreted by the ovary in later pregnancy.

### Germ Layer Formation:

- **Post-Implantation:** Inner cell mass differentiates into:
  - **Ectoderm:** Outer layer.
  - **Endoderm:** Inner layer.
  - **Mesoderm:** Middle layer.

### Human Pregnancy Milestones:

- **1 Month:** Heart of the embryo forms; heartbeat may be detectable.
- **2 Months:** Development of limbs and digits.
- **12 Weeks (First Trimester):** Major organ systems formed; limbs and external genital organs well-developed.
- **5 Months:** First fetal movements and appearance of hair on the head.
- **24 Weeks (End of Second Trimester):** Body covered with fine hair, eyelids separate, eyelashes form.
- **9 Months:** Full development and readiness for delivery.

### Pregnancy Durations in Other Animals:

- **Dogs:** Approximately 2 months.
- **Elephants:** Around 22 months.
- **Cats:** Approximately 2 months.

### Diagram Based Previous Year Questions - NEET

**Q1: Given below are two statements: (NEET 2022)**

**Statement I:** The release of sperms into the seminiferous tubules is called spermiation.

**Statement II:** Spermiogenesis is the process of formation of sperms from spermatogonia.

In the light of the above statements, choose the most appropriate answer from the options given below :

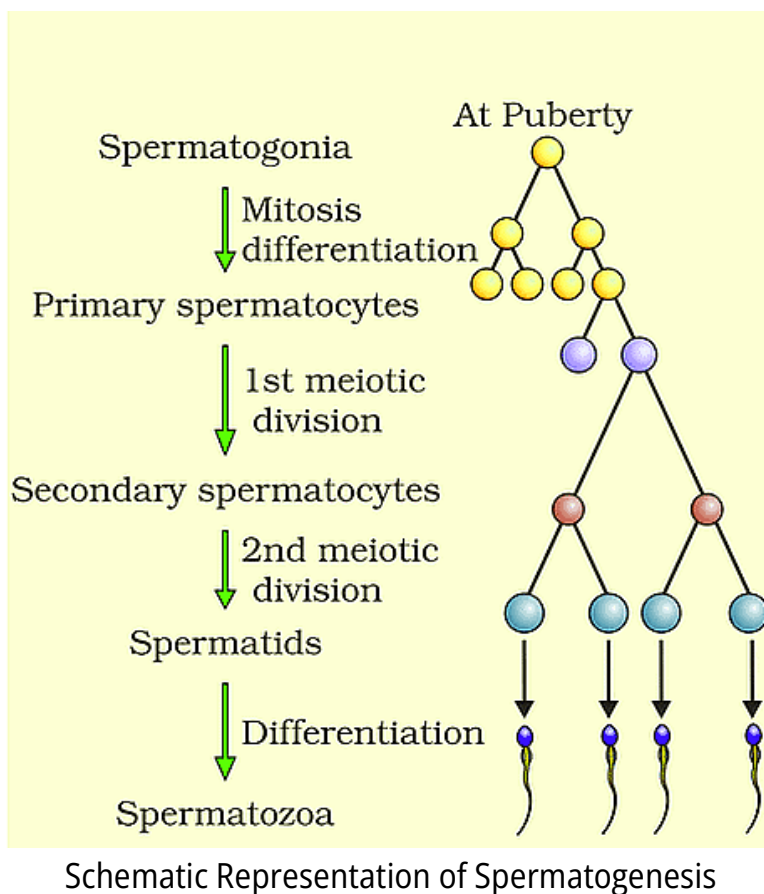
(a) Statement I is correct but Statement II is incorrect

(b) Statement I is incorrect but Statement II is correct

(c) Both Statement I and Statement II are correct

(d) Both Statement I and Statement II are incorrect

**Ans. (a)**



**Solution.**

- The process of spermatogenesis occurs in testis, in which the immature male germ cells or spermatogonia are converted to sperms.
- The spermatogonia present on the inside wall of seminiferous tubules undergoes mitosis.
- Some spermatogonia periodically undergo meiosis.
- These spermatogonia are called as primary spermatocytes ( $2n$ ).
- A primary spermatocyte completes the first meiotic division and forms secondary spermatocytes ( $n$ ). The secondary spermatocytes undergo the second meiotic division to produce spermatids.
- The spermatids are then, transformed into spermatozoa or sperms by the process called spermiogenesis.
- After spermiogenesis, sperm heads become embedded in the Sertoli cells.
- These spermatozoa are finally released from the seminiferous tubules by the process called spermiation.

**Q2: At which stage of life the oogenesis process is initiated? (NEET 2022)**

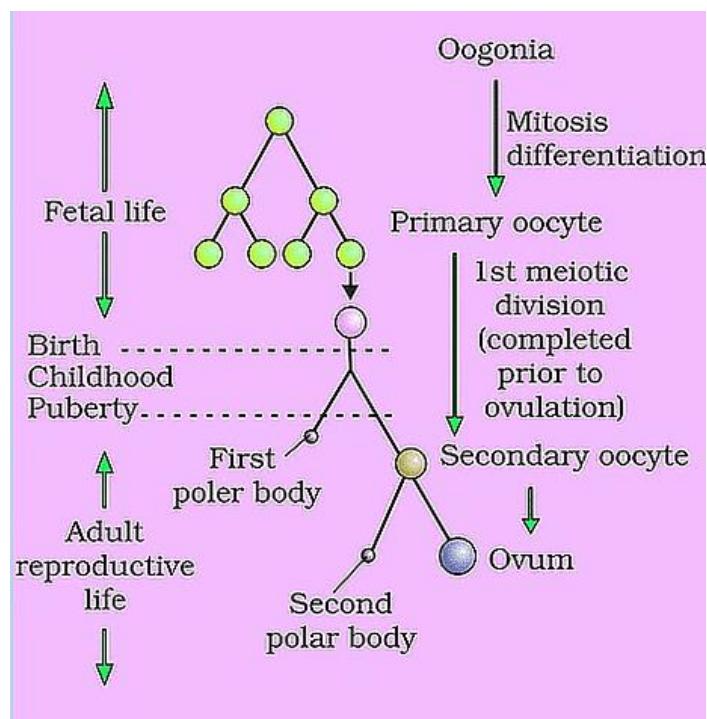
**(a) Birth**

**(b) Adult**

**(c) Puberty**

**(d) Embryonic development stage**

**Ans. (d)**



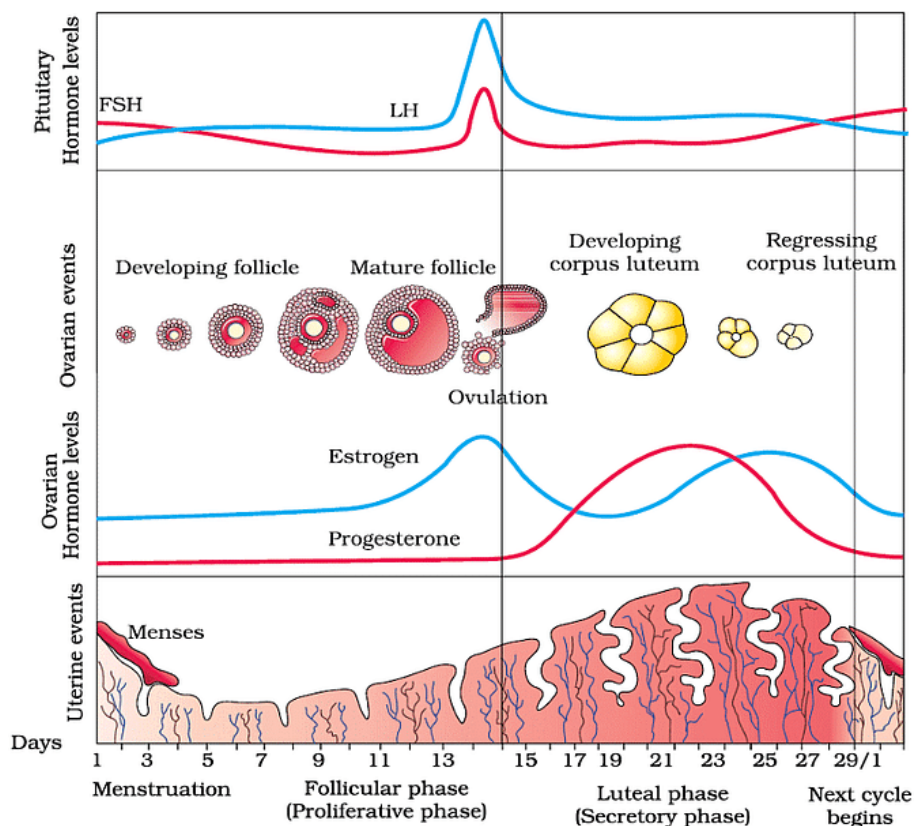
Schematic Representation of Oogenesis

**Solution.** Oogenesis starts at embryonic development stage in females.

**Q3: Which of the following hormone levels will cause release of ovum (ovulation) from the graffian follicle? (NEET 2020)**

- (a) Low concentration of LH
- (b) Low concentration of FSH
- (c) High concentration of Estrogen
- (d) High concentration of Progesterone

**Ans. (c)**



Various Events of Menstrual Cycle

**Solution.** LH (**Leutenizing hormone**) is produced by pituitary gland in the brain. It triggers **ovulation** & promotes the **development of corpus luteum** by rupture of graafian follicle. Which high concentration of estrogen is released by moture graafian follicle.

### Some Important Terms

#### The Male Reproductive System

- **Scrotum:** The testes are situated outside the abdominal cavity within a pouch called scrotum. The scrotum helps in maintaining the low temperature of the testes (2–2.5 degree celcius lower than the normal internal body temperature) necessary for spermatogenesis.
- **Testicular lobules:** The testis is covered by a dense covering. Each testis has about 250 compartments called testicular lobules.
- **Seminiferous tubules:** Each testicular lobule contains one to three highly coiled seminiferous tubules in which sperms are produced.

- **Male germ cells:** Each seminiferous tubule is lined on its inside by two types of cells called male germ cells (spermatogonia) and Sertoli cells. The male germ cells undergo meiotic divisions finally leading to sperm formation.
- **Sertoli Cells:** Sertoli cells provide nutrition to the germ cells.
- **Interstitial cells or Leydig cells:** Leydig cells synthesise and secrete testicular hormones called androgens.
- **Urethral meatus:** The urethra originates from the urinary bladder and extends through the penis to its external opening called urethral meatus.
- **Foreskin:** The enlarged end of penis called the glans penis is covered by a loose fold of skin called foreskin.

### The Female Reproductive System

- **Accessory ducts:** The oviducts (fallopian tubes), uterus and vagina constitute the female accessory ducts.
- **Womb:** Uterus is also called as womb.
- **Cervical canal:** The uterus opens into vagina through a narrow cervix. The cavity of the cervix is called cervical canal.
- **Mons pubis:** Mons pubis is a cushion of fatty tissue covered by skin and pubic hair in females.
- **Labia majora:** The labia majora are fleshy folds of tissue, which extend down from the mons pubis and surround the vaginal opening.
- **Labia Minora:** The labia minora are paired folds of tissue under the labia majora.
- **Hymen:** The opening of the vagina is often covered partially by a membrane called hymen.
- **Clitoris:** The clitoris is a tiny finger-like structure which lies at the upper junction of the two labia minora above the urethral opening.

### Gametogenesis



- **Spermatogenesis:** In testis, the immature male germ cells (spermatogonia) produce sperms by spermatogenesis that begins at puberty.
- **Spermatids:** The secondary spermatocytes undergo the second meiotic division to produce four equal, haploid spermatids.
- **Spermiogenesis:** The spermatids are transformed into spermatozoa (sperms) by the process called spermiogenesis.
- **Spermiation:** After spermiogenesis, sperm heads become embedded in the Sertoli cells, and are finally released from the seminiferous tubules by the process called spermiation.
- **Acrosome:** The sperm head contains an elongated haploid nucleus, the anterior portion of which is covered by a cap-like structure, acrosome. The acrosome is filled with enzymes that help fertilisation of the ovum.
- **Oogenesis:** The process of formation of a mature female gamete is called oogenesis.
- **Primary Follicle:** Each primary oocyte then gets surrounded by a layer of granulosa cells and is called the primary follicle.
- **Secondary follicle:** The primary follicles get surrounded by more layers of granulosa cells and a new theca and are called secondary follicles.
- **Antrum:** The secondary follicle soon transforms into a tertiary follicle which is characterised by a fluid filled cavity called antrum.
- **Ovulation:** The Graafian follicle ruptures to release the secondary oocyte (ovum) from the ovary by the process called ovulation.

### Menstrual Cycle

- **Menstrual Cycle:** The reproductive cycle in the female primates (e.g. monkeys, apes and human beings) is called menstrual cycle. In human females, menstruation is repeated at an average interval of about 28/29 days, and the cycle of events starting from one menstruation till the next one is called the menstrual cycle.



- **Menarche:** The first menstruation begins at puberty and is called menarche. In human beings, menstrual cycles cease around 50 years of age; that is termed as menopause.

### Fertilisation and Implantation

- **Fertilisation:** The process of fusion of a sperm with an ovum is called fertilisation.
- **Cleavage & Blastomeres:** The mitotic division starts as the zygote moves through the isthmus of the oviduct called cleavage towards the uterus and forms 2, 4, 8, 16 daughter cells called blastomeres.
- **Morula:** The embryo with 8 to 16 blastomeres is called a morula
- **Implantation:** When the blastocyst becomes embedded in the endometrium of the uterus. This is called implantation and it leads to pregnancy.

### Pregnancy and Embryonic Development

- **Chorionic villi:** After implantation, finger-like projections appear on the trophoblast called chorionic villi.
- **Placenta:** The chorionic villi and uterine tissue become interdigitated with each other and jointly form a structural and functional unit between developing embryo (foetus) and maternal body called placenta.
- **Stem cells:** Inner cell mass of embryo contains certain cells called stem cells which have the potency to give rise to all the tissues and organs.

### Parturition and Lactation

- **Gestation Period:** The average duration of human pregnancy is about 9 months which is called the gestation period.
- **Parturition:** Vigorous contraction of the uterus at the end of pregnancy causes expulsion/delivery of the foetus. This process of delivery of the foetus (childbirth) is called parturition.

- **Foetal ejection reflex:** The signals for parturition originate from the fully developed foetus and the placenta which induce mild uterine contractions called foetal ejection reflex.
- **Colostrum:** The milk produced during the initial few days of lactation is called colostrum which contains several antibodies absolutely essential to develop resistance for the new-born babies.

### Abbreviations

- **GnRH:** Gonadotropin releasing hormone
- **LH:** Luteinising hormone
- **FSH:** Follicle stimulating hormone

