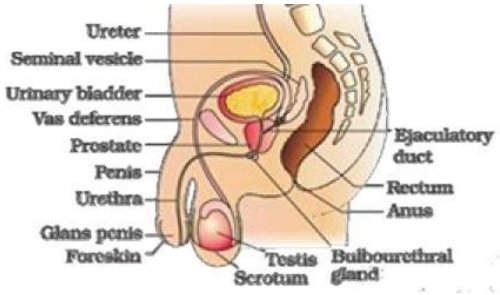
Human Reproduction

Reproduction is the production of young ones by an organism. Humans are sexually reproducing and viviparous.

HUMAN REPRODUCTIVE SYSTEM

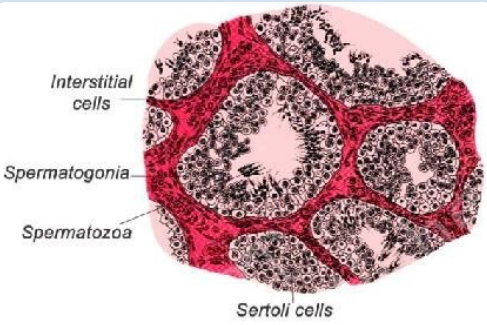
1. Male Reproductive System

- It consists of **paired testes, Accessory ducts, Accessory glands & external genitalia (penis).**



a. Paired testes

- **Primary sex organs** that produce **sperms & testosterone.**
- Testes are formed within the abdomen. Soon after the birth or at the 8th month of pregnancy they descent into the **scrotal sac (scrotum)** through **inguinal canal**.
- The low temperature (2-2.5^0 C less than the body temperature) of scrotum helps for proper functioning of testes and for **spermatogenesis.**
- Each testis is oval shaped. Length 4-5 cm, width: 2-3 cm.
- Each testis has about 250 **testicular lobules**.
- Each lobule contains 1-3 coiled **seminiferous tubules.**
- Seminiferous tubule is lined internally with **spermatogonia (male germ cells) & Sertoli cells (supporting cells)**.
- Sertoli cells give shape and nourishment to developing spermatogonia.
- The regions outside the seminiferous tubules (interstitial spaces) contain small blood vessels, **interstitial cells (Leydig cells)** and immunologically competent cells.
- Leydig cells secrete testicular hormones **(androgens).**



b. Accessory ducts (Duct system)

- Include **rete testis, vasa efferentia, epididymis & vas deferens.** They conduct sperms from testis as follows:
- Seminiferous tubules → **rete testis** (irregular cavities) → **vasa efferentia** (series of fine tubules) → **epididymis** (stores sperms temporarily) → **vas deferens** → join with duct of **seminal vesicle** to form **common ejaculatory duct** → **urethra** → **urethral meatus.**
- Urethra receives ducts of prostate and Cowper's glands.

c. Accessory glands

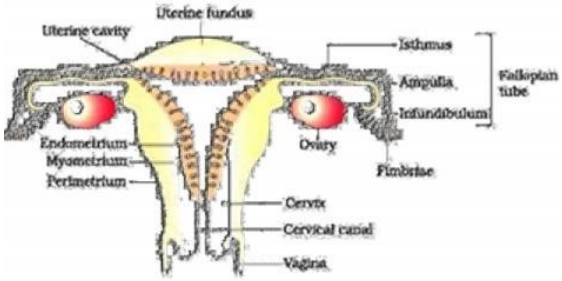
- Include a **prostate gland,** a pair of **seminal vesicles** and a pair of **Cowper's glands (bulbo-urethral glands).**
- Their collective secretion **(seminal plasma)** is rich in fructose, Ca and enzymes.
- Seminal plasma + sperms → **semen.**
- **Functions of seminal plasma:**
  - Helps for transporting sperms.
  - Supplies nutrients to sperms.
  - Provides alkalinity to counteract the acidity of uterus.
  - Secretions of Cowper's glands lubricate the penis.
- Secretions of epididymis, vas deferens, seminal vesicle & prostate help for maturation and motility of sperms.

d. Penis (external genitalia)

- It is a **copulatory organ** made of erectile **spongy tissue.**
- When spongy tissue is filled with blood, the penis erects. It facilitates **insemination**.
- The cone-shaped tip of the penis is called **glans penis.** It is covered by **prepuce (foreskin).**

2. Female Reproductive System

It includes **Ovaries, Accessory ducts** & **External genitalia.**



a. Paired ovaries

- Primary sex organs which produce **ova (female gamete)** & steroid **ovarian hormones (estrogen & progesterone).**
- Each ovary is **2-4 cm** in length.
- They are located on both side of the lower abdomen and connected to the pelvic wall and uterus by ligaments.
- Each ovary is covered by a thin epithelium which encloses the **ovarian stroma.**
- The stroma has outer **cortex** and inner **medulla.**
- Ovary contains groups of cells **(Ovarian follicles).** Each follicle carries a centrally placed **ovum.**

b. Accessory ducts (Duct system)

Include 2 **oviducts (Fallopian tubes), a uterus** & **vagina.**

➢ **Oviducts:** Each oviduct (10-12 cm long) has 3 parts:

- **Infundibulum:** Funnel-shaped opening provided with many finger-like **fimbriae.** It helps to collect the ovum.
- **Ampulla:** Wider part.
- **Isthmus:** Narrow part. It joins the uterus.

The **ciliated epithelium** lined the lumen of the oviduct drives the ovum towards the uterus.

➢ **Uterus (womb):** It is inverted pear shaped. It is supported by ligaments attached to the pelvic wall.

Uterus has 3 parts- Upper **fundus,** middle **body** and terminal **cervix.** Cervix opens to vagina.

The uterine wall has 3 layers:

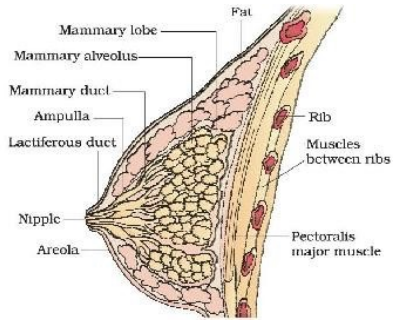
- **Perimetrium**: External thin membrane.
- **Myometrium**: Middle thick layer of smooth muscle.
- **Endometrium**: Inner glandular and vascular layer.

➢ **Vagina:** It opens to the exterior between **urethra** & **anus.** The lumen of vagina is lined by a glycogen-rich mucous membrane consisting of **sensitive papillae & Bartholin's glands.** Bartholin's glands secrete mucus that lubricates the penis during sexual act.

c. External genitalia (vulva or pudendum)

- Consist of **Mons pubis, vestibule, hymen & clitoris.**
- **Mons pubis:** A cushion of fatty tissue covered by pubic hair.
- **Vestibule:** A median channel. It includes
  - **Labia majora**: Large, fleshy, fatty and hairy outer folds. Surrounds vaginal opening.
  - **Labia minora**: Small, thin and hairless inner folds.
- **Hymen (Maiden head):** A membrane which partially cover the vaginal opening. It is often torn during the first coitus. It may also be broken by a sudden fall or jolt, insertion of a vaginal tampon; active participation in some sports items etc. In some women, hymen persists after coitus. So the hymen is not a reliable indicator of virginity.
- **Clitoris:** A highly sensitive organ lying just in front of the urethral opening.

Mammary glands (breasts)



- A pair of mammary glands contains glandular tissue & fat.
- Glandular tissue of each breast has 15-20 **mammary lobes** containing clusters of cells **(mammary alveoli).**
- Cells of alveoli secrete milk. It is stored in lumen 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.

GAMETOGENESIS

- It is the formation of gametes in the gonads.
- It is 2 types: **Spermatogenesis** and **Oogenesis.**

1. Spermatogenesis

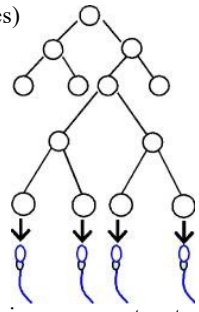
It is the process of formation of sperms (spermatozoa) in seminiferous tubules of testis. It has 2 stages:

a. Formation of spermatids: In this, Spermatogonia (Sperm mother cells or immature male germ cells) produce spermatids.

b. Spermiogenesis: Spermatids transform into **sperm.**

Schematic representation of spermatogenesis

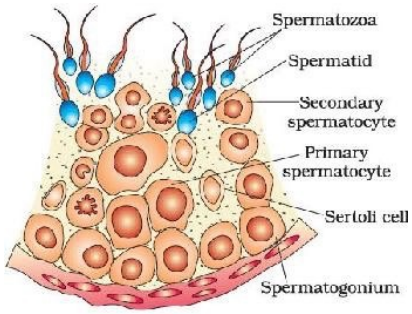
Spermatogonia -2n (46 chromosomes)
↓ *Mitosis differentiation*
Primary spermatocytes (2n)
↓ *1st meiotic division*
Sec. spermatocytes -n (23)
↓ *2nd meiotic division*
Spermatids (n)
↓ *Differentiation*
Spermatozoa (n)



- **4 spermatids** are formed from each primary spermatocyte.
- After spermiogenesis, sperm heads become embedded in the Sertoli cells. Then they are released to lumen of seminiferous tubules. It is called **spermiation.**

Role of Hormones in Spermatogenesis

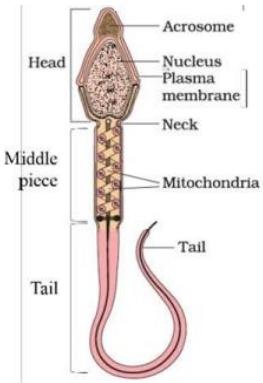
- Hypothalamus releases **Gonadotropin releasing hormone (GnRH).**
- GnRH stimulates the anterior pituitary gland to secrete 2 **gonadotropins** such as **Luteinizing hormone (LH)** and **follicle stimulating hormone (FSH).**
- LH acts on the **Leydig cells** and stimulates secretion of androgens. Androgens stimulate the spermatogenesis.
- FSH acts on the **Sertoli cells** and stimulates secretion of some factors for the spermiogenesis.



Diagrammatic sectional view of a seminiferous tubule

Structure of spermatozoa (Sperm)

- A mature sperm is about **60 µ (0.06 mm)** long.
- A plasma membrane envelops the whole body of sperm.
- A sperm has 3 regions:
  - **a. Head:** Oval shaped. Formed of **nucleus** and **acrosome.** Acrosome is formed from **Golgi complex.** It contains **lytic enzymes.** Behind the head is a neck.



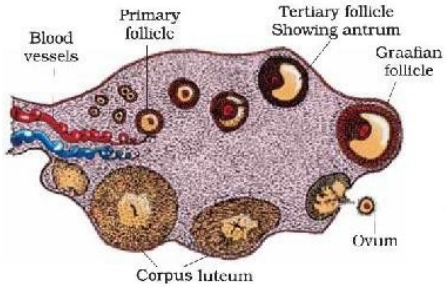
b. **Middle piece:** Composed of **axial filament** surrounded by **mitochondria** & **cytoplasm.** Mitochondria produce energy for the sperm motility.

c. **Tail:** Consists of a **central axial filament**. The sperm moves in fluid medium and female genital tract by the **undulating movement** of the tail.

- Man ejaculates **200-300 million sperms** during a coitus.
- For normal fertility, at least 60% sperms must have normal shape and size. 40% of them must show vigorous motility.

2. Oogenesis

- It is the process of formation and maturation of **ovum.**
- It takes place in **Graafian follicles.**



- Oogenesis is initiated in embryonic stage when millions of **egg mother cells (oogonia)** are formed within each ovary.
- No more oogonia are formed and added after birth.
- Oogonia multiply to form **primary oocytes.** They enter **prophase-I** of the meiosis and get temporarily arrested at that stage.
- Each primary oocyte gets surrounded by a layer of **granulosa cells** to form **primary follicle.**
- Many primary follicles degenerate during the phase from birth to puberty. Therefore, at puberty, only **60,000-80,000** primary follicles are left in each ovary.
- Primary follicles get surrounded by more layers of granulosa cells and a new **theca** to form **secondary follicles.**
- The secondary follicles transform into a **tertiary follicle.** It has a fluid filled cavity **(antrum).** The theca layer forms an inner **theca interna** and an outer **theca externa.**
- The primary oocyte in tertiary follicle grows and undergoes first unequal meiotic division to form a large **secondary oocyte (n)** & a tiny first **polar body (n).** So, secondary oocyte retains nutrient rich cytoplasm of primary oocyte.
- It is unknown that whether the first polar body divides further or degenerates.
- The tertiary follicle further changes into the **mature follicle (Graafian follicle).**
- Secondary oocyte forms a new membrane **(zona pellucida).**
- Graafian follicle now ruptures to release the **secondary oocyte (ovum)** from the ovary. This is called **ovulation.**

Schematic representation of oogenesis

Oogonia -2n (46 chromosomes)

↓ *Mitosis differentiation (at foetal stage)*

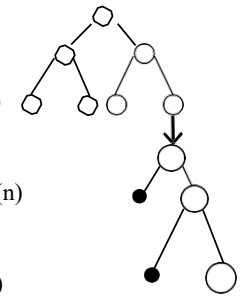
Primary oocyte- 2n (grows in size)

↓ *1st meiotic division (prior to ovulation)*

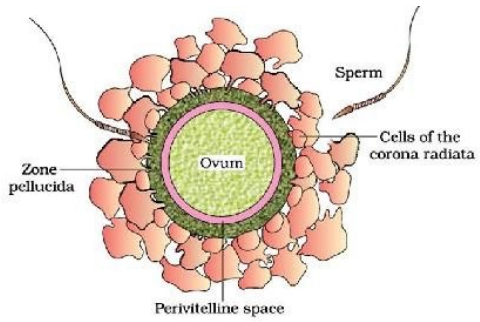
Sec. oocyte (n) & first polar body (n)

↓ *2nd meiotic division (during fertilization)*

Ovum (n) & second Polar body (n)



Structure of ovum (egg)



- Spherical and **non-motile.** About **0.2 mm** in diameter.
- Ovum has 3 membranes:
  a. **Plasma membrane:** Innermost layer.
  b. **Zona pellucida:** Outer to the plasma membrane.
  c. **Corona radiata:** Outer layer formed of follicle cells.

Spermatogenesis & Oogenesis- A comparison

Spermatogenesis	Oogenesis
Occurs in testis.	Occurs in ovary.
Limited grow th phase.	Elaborated grow th phase
Each primary spermatocyte gives 4 sperms.	Each primary oocyte gives one ovum.
No polar body formation.	Polar bodies are formed.
Begins at puberty and extends up to senility.	Begins at embryonic stage but suspends up to puberty. It ceases around the age of f if ty.

MENSTRUAL CYCLE (REPRODUCTIVE CYCLE)

- It is the cyclic events starting from one menstruation till the next during the **reproductive period** (from puberty to menopause) of a woman's life.
- Its duration is **28 or 29 days.**
- Menstrual cycle is also seen in other primates.
- Menstrual cycle includes **Ovarian cycle** (changes in ovary) & **Uterine cycle** (changes in uterus, oviduct & vagina).
- Menstrual cycle has the following phases:

I. Menstrual phase: 1-5th day

- The cycle starts with **menstrual flow (bleeding).**
- It lasts for **3-5 days.**
- Menstruation occurs if the released ovum is not fertilized. It results in breakdown of endometrial lining and uterine blood vessels that comes out through vagina.
- Lack of menstruation indicates pregnancy. It may also be caused due to stress, poor health etc.
- **Menarche:** The first menstruation during puberty.

II. Follicular (Proliferative) phase: 5-13th day

- It starts from **5th day** after menstruation and completed within **8-12 days.**

- In this phase, the action of gonadotropins **(FSH &LH)** from pituitary occurs. FSH stimulates
  - Development of primary follicles into **Graafian follicles.**
  - Secretion of **oestrogens** by **Graafian follicles.**
- Oestrogens stimulate
  - **Proliferation** of **ruptured uterine endometrium** and mucus lining of **oviduct & vagina**.
  - Development of secondary sexual characters.
  - Suppression of FSH secretion.
  - Secretion of LH (Luteinizing hormone).

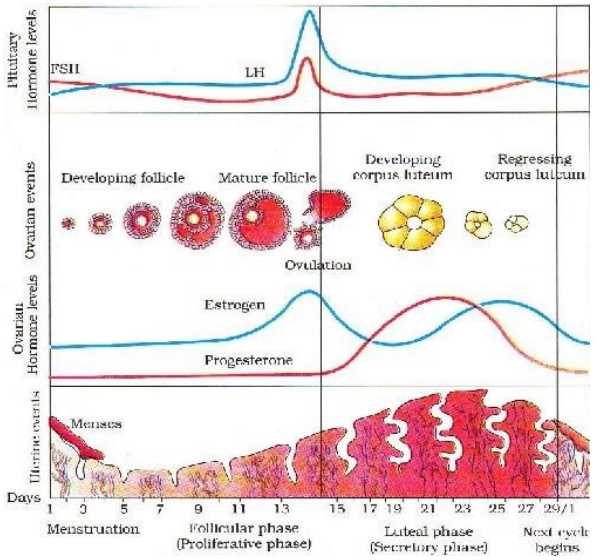
III. Ovulatory phase: 14th day

- LH & FSH attain a peak level in the middle of cycle.
- Rapid secretion of LH (**LH surge**) induces rupture of Graafian follicle and thereby **ovulation** (on 14th day).

IV. Secretory (Luteal) phase: 15-28th day

- After ovulation, **Graafian follicle** is transformed into a yellow endocrine mass called **Corpus luteum.** It secretes **progesterone.**
- **Functions of progesterone:**
  - Makes the endometrium **maximum vascular, thick** and **soft.** Thus, the uterus gets ready for implantation.
  - Inhibits the FSH secretion to prevent development of a second ovarian follicle.

- If fertilization does not occur, corpus luteum degenerates. It causes disintegration of endometrium. It leads to next **menstruation** and new cycle.
- If a woman becomes pregnant, all events of menstrual cycle stop and there is no menstruation.
- Menstrual cycle ceases around **50 years** of age. It is called **Menopause.**



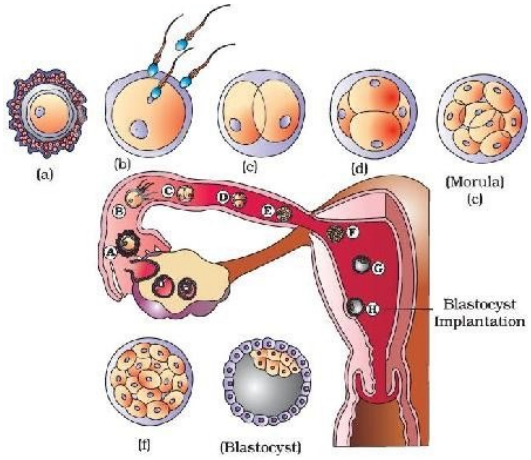
FERTILIZATION AND IMPLANTATION

- During copulation, semen is released by the penis into the vagina. It is called **insemination.**
- Fusion of a sperm with ovum is called **fertilization.** It occurs in **Ampullary-isthmic junction** of fallopian tube.

Sperms → vagina → cervical canal → uterus → isthmus
↓
Fertilization ← Ampullary-isthmic Junction
↑
Ovum (from ovary) → fimbriae → infundibulum → ampulla

- Fertilization happens only if ovum & sperms are transported simultaneously. So all copulations do not lead to fertilization & pregnancy.
- A sperm contacts with **zona pellucida.** It induces changes in the membrane that block entry of additional sperms.
- The secretions of the **acrosome** help sperm to enter the egg cytoplasm via zona pellucida & plasma membrane. This causes second meiotic division of secondary oocyte to form an **ovum (ootid)** and a **second polar body.**
- The haploid nuclei of the sperm and ovum fuse together to form a **diploid zygote.**
- Zygote undergoes mitotic division **(cleavage)** as it moves through the isthmus towards the uterus and forms 2, 4, 8, 16 daughter cells called **blastomeres.**
- The embryo with 8-16 blastomeres is called a **morula.**
- Morula continues to divide and transforms into **blastocyst.**

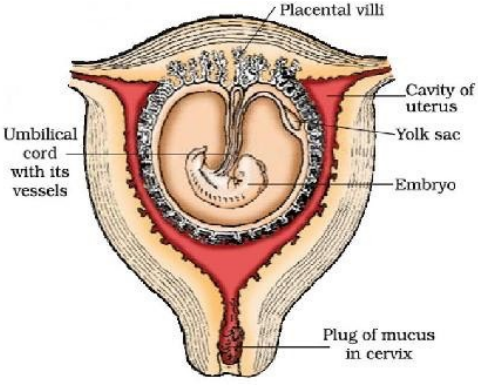
- In blastocyst, blastomeres are arranged into **trophoblast** (outer layer) and an **inner cell mass** attached to trophoblast.
- The trophoblast layer gives nourishment to inner cell mass. Also, it gets attached to endometrium.
- After attachment, uterine cells divide rapidly and cover the blastocyst. Thus, the blastocyst becomes embedded in the endometrium. This is called **implantation.**
- The inner cell mass gets differentiated to **3 germ layers** (outer **ectoderm,** middle **mesoderm** & inner **endoderm).** This 3-layered structure **(gastrula)** forms the embryo.



PREGNANCY AND EMBRYONIC DEVELOPMENT

- After implantation, finger-like projections **(chorionic villi)** appear on the trophoblast which is surrounded by the uterine tissue and maternal blood.
- The chorionic villi & uterine tissue are interdigitated to form **placenta.** It is a structural and functional unit b/w embryo (foetus) and maternal body.

- Placenta is connected to the embryo by an **umbilical cord.** It transports substances to and from the embryo.



Functions of placenta

- Acts as **barrier** between the foetus and mother.
- Supply **O_2, nutrients** etc. from mother to foetus.
- Remove **CO_2 and excretory wastes** from foetus.
- Acts as an endocrine gland. It secretes **Human chorionic gonadotropin (hCG), human placental lactogen (hPL), oestrogens, progesterone & relaxin.** Relaxin is also secreted by ovary.
- During pregnancy, levels of **estrogens, progestogens, cortisol, prolactin, thyroxin** etc. are also increased in maternal blood. They support the fetal growth, metabolic changes in the mother and maintain pregnancy.
- The germ layers give rise to all tissues (organs). The **stem cells** in inner cell mass have the potency to give rise to all the tissues and organs.
- Human pregnancy **(gestation period)** lasts 9 months (for cats: 2 months, dogs: 2 months, elephants: 21 months).

Changes in embryo during pregnancy

- **After one month:** Heart is formed.
- **End of second month:** Limbs and digits are developed.
- **End of 12 weeks (first trimester):** The major organs (limbs, external genital organs etc.) are well developed.
- **During 5th month:** First movement of foetus and appearance of hair on the head.
- **End of 24 weeks (secondtrimester):** Body is covered with fine hair, eyelids separate and eye lashes are formed.
- **End of 9 months:** Ready for delivery.

PARTURITION AND LACTATION

- **Parturition (labour):** Process of giving birth to young ones.
- Parturition is induced by **neuroendocrine mechanism.**
- The signals originating from the foetus and placenta induce mild uterine contractions **(fetal ejection reflex)**. This causes the release of **oxytocin** from **maternal pituitary.**
- Oxytocin causes stronger uterine muscle contractions which in turn stimulate further secretion of oxytocin. This process is continued leading to expulsion of the baby out of the uterus through the **birth canal.**
- After parturition, the **umbilical cord** is cut off.
- The placenta & remnants of umbilical cord are expelled from the maternal body after parturition. It is called **"after birth".**
- The mammary glands produce milk towards the end of pregnancy. It is called **lactation.**
- The yellowish milk produced during the initial few days of lactation is called **colostrum.** It contains several antibodies essential to develop resistance for the new born babies.