Human reproduction

Human beings are sexually reproducing organisms and are viviparous.

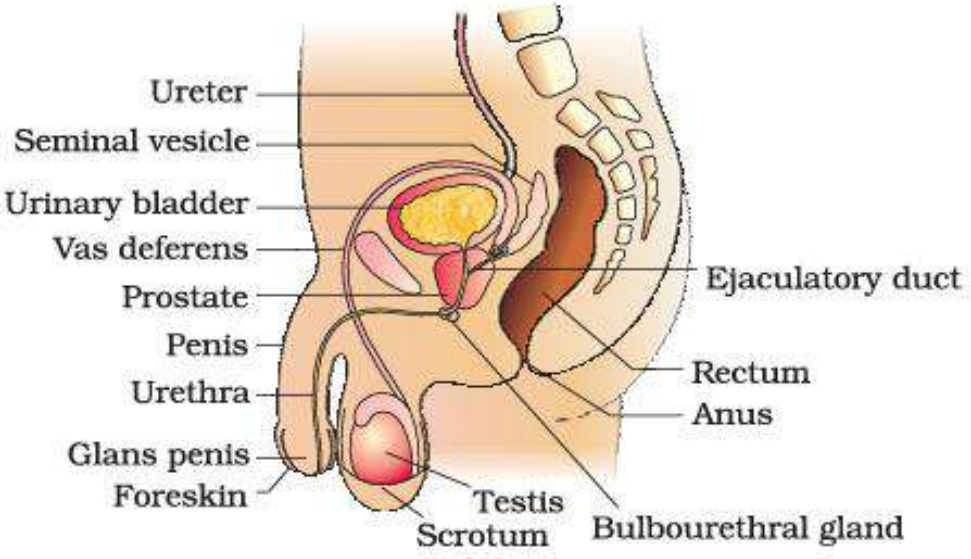
The events of sexual reproduction in human beings are–

- **Gametogenesis–** the process of formation of gametes is called as gametogenesis.
- **Insemination–** the process of transfer of sperms into the ovum is called insemination.
- **Fertilization–** the process of fusion of male and female gamete to form a single celled zygote is called fertilization.
- **Implantation–** the process of attachment of embryo to the endometrial wall of uterus of a female is called implantation.
- **Gestation–** the period of embryonic development is called gestation.
- **Parturition–** the process of delivery of the baby is called parturition.

Male reproductive system: Male reproductive system is located in the pelvis region. It Consists of a pair of testes, glands, accessory ducts, external genitalia.

➢ **Testes:** Smooth organ situated outside the abdominal cavity within a pouch called scrotum.

- The scrotum helps in maintaining the low temperature of the testis which is $2 - 2.5^0C$ which is below than the normal internal body temperature.



• Each testes is 4 to 5 cm in length and 2 to 3 cm in width in adults.

• Each testis contains about 250 compartments called testicular lobules.

• Each testicular lobule contains one to three highly coiled seminiferous tubules, in which sperms are produced.

• The wall of each seminiferous tubule is lined by two types of cells called male germ cells (spermatogonia) and Sertoli cells.

• The male germ cells undergo meiosis leading to sperm formation and 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.

• Leydig cells synthesise and secrete testicular hormones called androgens.

➢ **Accessory ducts:** The male accessory ducts include rete testis, vasa efferentia, epididymis and vas deferens.

• The seminiferous tubules of the testes open into the vasa efferentia through rete testis.

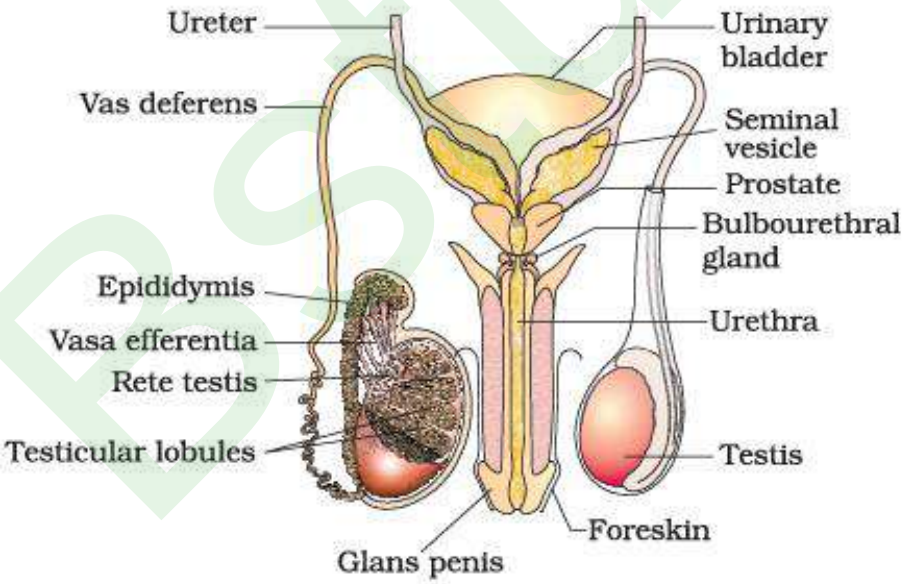
• The vasa efferentia leave the testis and open into epididymis located along the posterior surface of each testis.

• The epididymis leads to vas deferens that ascends to the abdomen and loops over the urinary bladder.

• Vas deferens receives a duct from the seminal vesicle and opens into the urethra as the ejaculatory duct.

• The urethra originates from the urinary bladder and extends through the penis to its external opening called urethral meatus.

➢ **Accessory glands:** The male accessory glands include paired seminal vesicles, prostate gland and paired bulbourethral glands.



• Accessory glands secrete seminal plasma which is rich in fructose, calcium and some enzymes

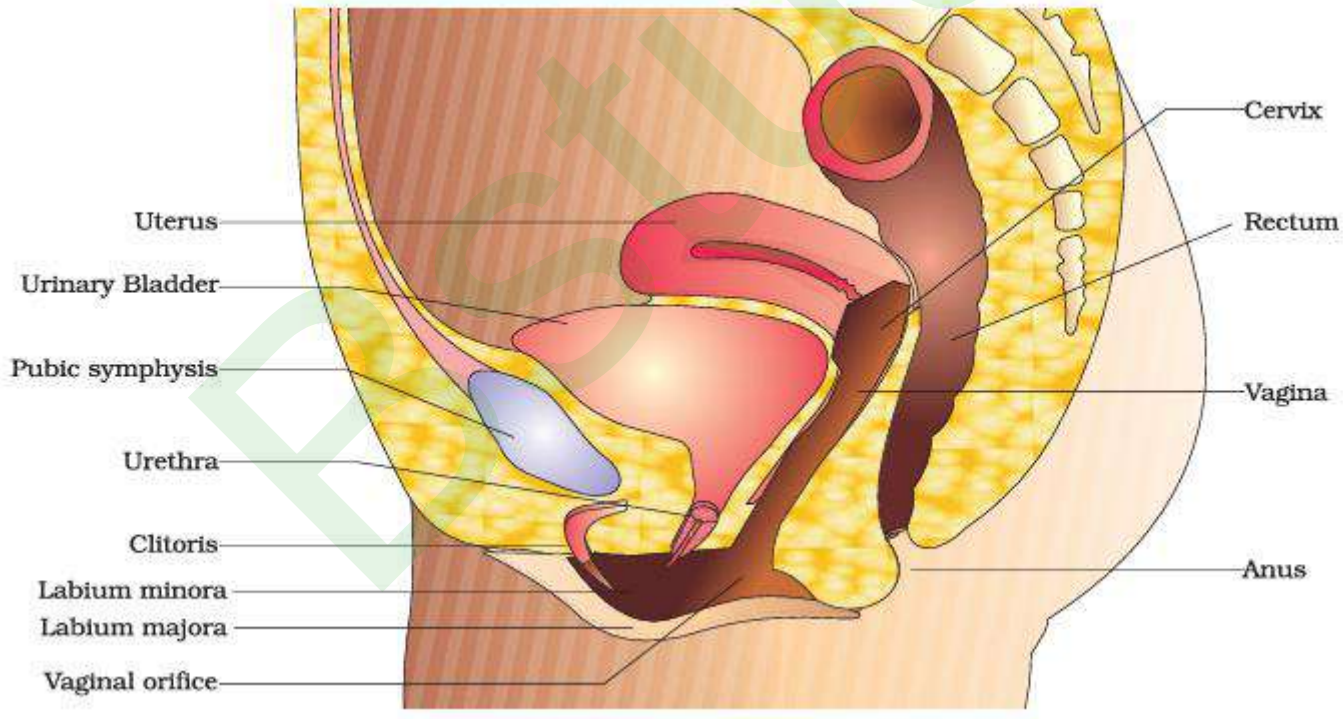
• Secretion of the bulbourethral gland also helps in lubricating the penis.

➢ **External genitalia:** The penis is the male external genitalia.

• Some special tissues make up the penis which helps in the erection of the penis.
• The enlarged end of penis is called the glans penis.
• Foreskin, a loose fold of tissue covers the glans penis.

Female reproductive system: Female reproductive system is located in the pelvic region. It consists of a pair of ovaries, a pair of oviducts, uterus, cervix, vagina and the external genitalia. A pair of mammary glands is also integrated structurally and functionally with the parts of the female reproductive system.

Ovaries: The primary female sex organs that produce the ovum and several ovarian hormones, steroid in nature.



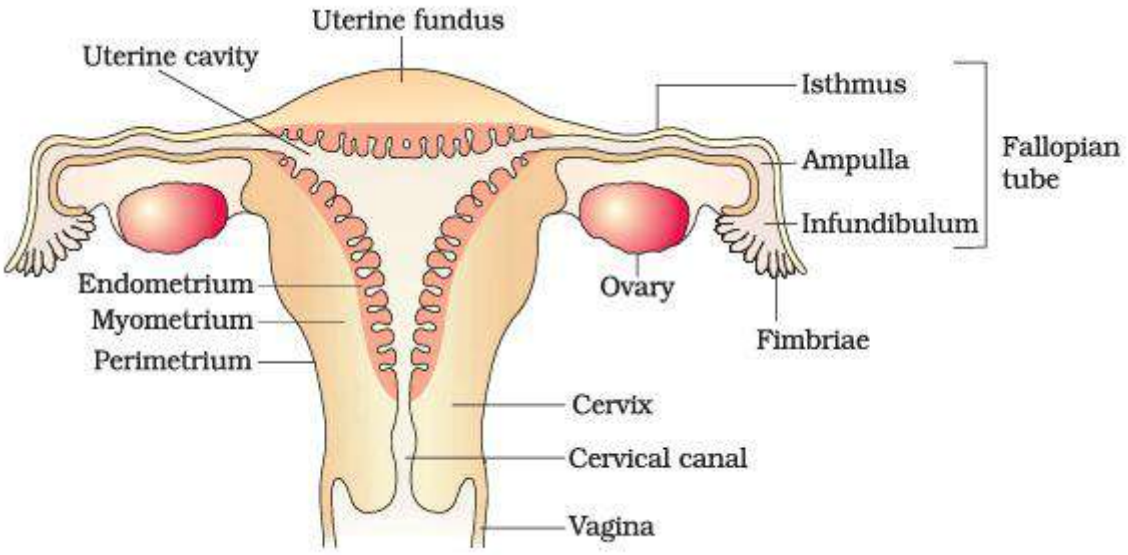
• Located one on each side of the lower abdomen.
• Each ovary is covered by a thin epithelium which encloses the ovarian stroma.
• The ovarian stroma is divided into two zones – a peripheral cortex and an inner medulla.

➢ **Oviduct (fallopian tube):** 10–12 cm in length.

- Extends from the periphery of each ovary to the uterus.
- Part closer to the ovary is the funnel shaped infundibulum.
- Fimbriae are the finger–like projections located on the edges of the infundibulum.
- Fimbriae help in collection of the ovum after ovulation.
- The infundibulum leads to the ampulla which is the wider part of the oviduct.
- The last part of the oviduct is isthmus which has a narrow lumen and it joins the uterus.

➢ **Uterus (womb):** The shape of the uterus is like an inverted pear.

- Ligaments attached to the pelvic wall support the uterus.
- The narrow cervix opens the uterus into the vagina.
- Cervical canal is the cavity of the cervix which forms the birth canal along with vagina.
- Three layers of tissues are present in the uterus wall– the outer thin membrane bound perimetrium, middle thick layer of smooth muscle called myometrium, inner glandular layer called endometrium.



• Endometrium lines the uterine cavity.
• During menstrual cycle, endometrium undergoes cyclical changes but the myometrium exhibits strong contraction during parturition.

➢ **External genitalia:** Vagina is the female external genitalia.
• Vagina includes mons pubis, labia majora (labia majus), labia minora (labia minora), hymen and clitoris.
• Mons pubis is a cushion of fatty tissue covered by skin and pubic hair.
• The labia majora are folds of tissue extending down from the mons pubis and surround the vaginal opening.
• Under the labia majora, there are paired tissues folded to form labia minora.
• Hymen is a membrane covering the opening of the vagina.
• A tiny finger–like structure which lies at the upper junction of the two labia minora above the urethral opening is called clitoris.

➢ **Mammary glands:** Paired structures containing glandular tissues and fats, the amount of fat varies from person to person.
• 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 called lumens of alveoli.
• The alveoli open into mammary tubules and the tubules of each lobe join to form a mammary duct which joins to form a wider mammary ampulla.

• Mammary ampulla is connected to a lactiferous duct through which milk is sucked out.

Gametogenesis: The process of formation of gametes in primary sex organs is called Gametogenesis.

• Gametogenesis includes spermatogenesis, spermatogenesis in males and oogenesis in females.

➢ **Spermatogenesis:** The process of formation of sperms is called spermatogenesis. It involves 3 phases– multiplication phase, growth phase, maturation phase.

1) **multiplication phase:** male germ cells also called spermatogonia undergo mitotic divisions to form a large number of spermatogonia.

2) **growth phase:** spermatogonia increases their size by accumulation of nutrition in the cytoplasm and are ready for meiotic division and the spermatocytes are called primary spermatocytes with 46 chromosomes.

3) **maturation phase:** A primary spermatocyte completes the first meiotic division leading formation of two equal, haploid cells called secondary spermatocytes, which have only 23 chromosomes each and the secondary spermatocytes undergo the second meiotic division to produce four equal, haploid spermatids

Hormonal control of spermatogenesis

• Spermatogenesis starts at the age of puberty due to significant increase in the secretion of gonadotropin releasing hormone (GnRH) from hypothalamus.

• The increased level of gonadotropin releasing hormone stimulates the anterior pituitary to secrete luteinizing hormone(LH) and follicle stimulating hormone(FSH).

• LH acts at the Leydig cells and stimulates synthesis and secretion of androgens.

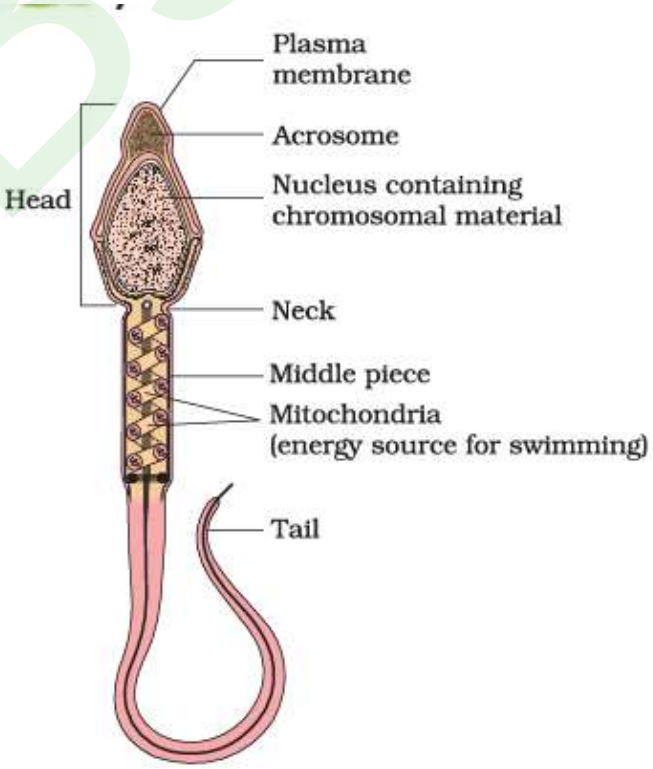
• Androgens stimulate the process of spermatogenesis.

• FSH acts on the Sertoli cells and secrete two factors– androgen binding protein (ABP) and inhibin which helps in spermiogenesis.

➢ **Spermiogenesis:** The spermatids are transformed into sperms, also called as spermatozoa by the process called spermiogenesis.

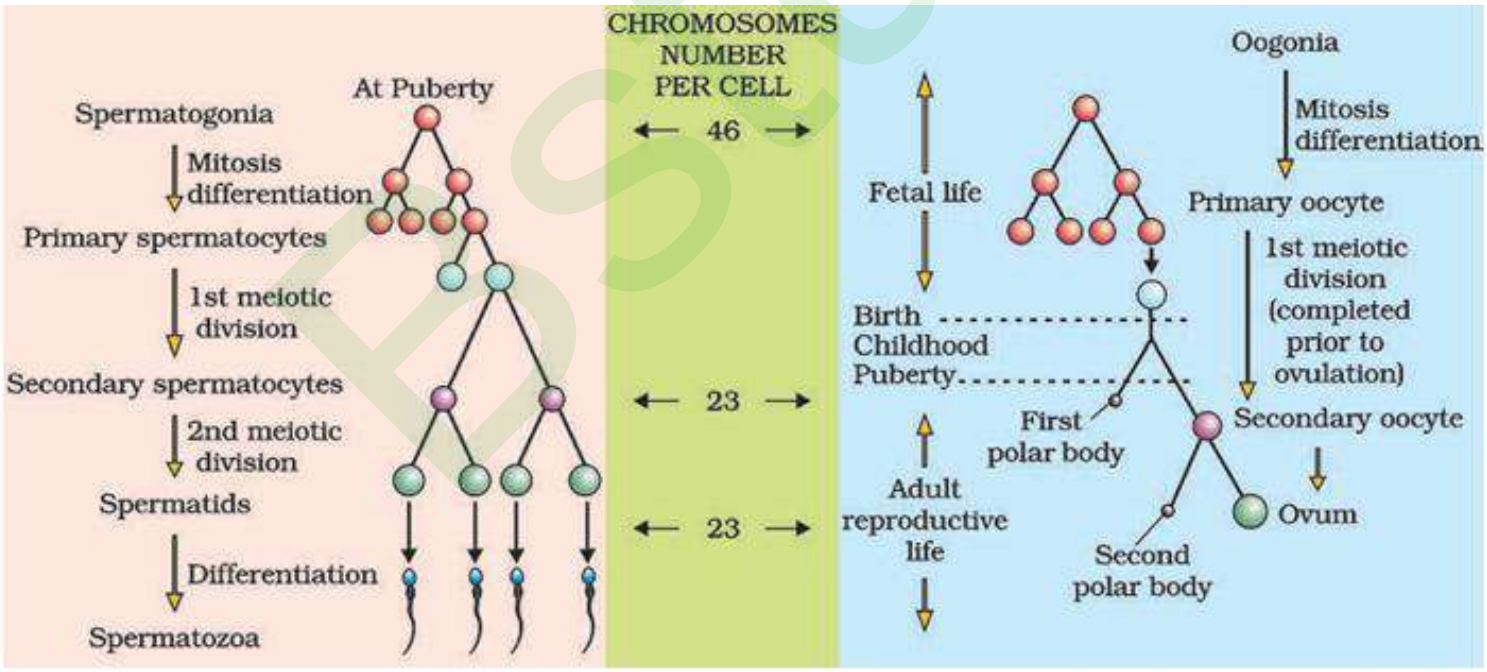
• After spermatogenesis, sperm heads become embedded in the Sertoli cells and are released from the seminiferous tubules by the process called spermiation.

Structure of a sperm: It is a microscopic, motile structure composed of a head, neck, a middle piece and a tail.



• Whole body is covered by plasma membranes.
• The sperm head contains an elongated haploid nucleus and the anterior portion is covered by a cap–like structure acrosome.
• The middle piece contains numerous mitochondria which produce energy for sperm motility needed for fertilization.
• Tail helps the sperm cell to swim to reach the egg cell.
• Seminal plasma along with sperm constitutes the semen.

➢ **Oogenesis:** The process of formation of a mature female gamete is called oogenesis.
• Some of the germinal epithelial cells divide by mitosis to produce a large number of gamete mother cells or oogonia Oogonia multiplies by mitosis and forms primary oocytes.



Menstrual cycle: The reproductive cycle starting from the one menstruation till the next one in the female primates is called menstrual cycle.
• The first menstruation which begins at puberty and is called menarche.

• The cycle is repeated at an interval of 28–29 days.
• Menstrual cycle involves three phases– menstrual phase, follicular phase and luteal phase.

1) Menstrual phase: Menstrual flow occurs and lasts for about 3–5 days.
• The endometrial lining of the uterus breaks along with the blood vessels which forms a red fluid and results in menstrual flow.
• If the ovum is fertilized by a sperm, menstrual flow does not occur and hence indicates pregnancy.

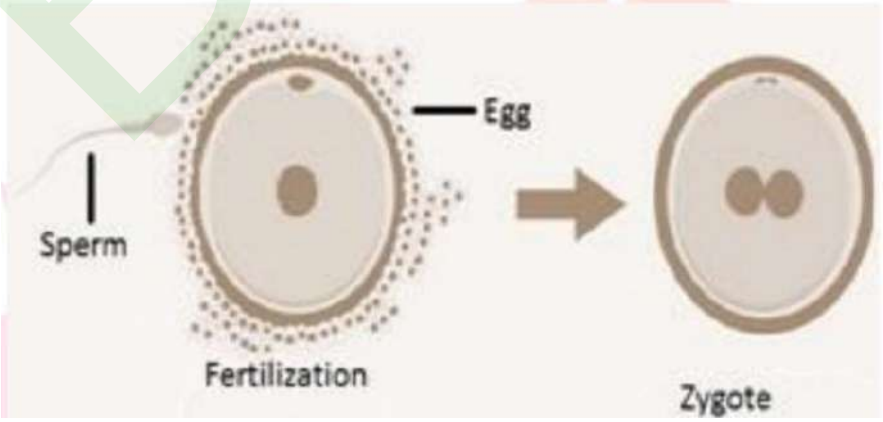
2) Follicular phase: the primary follicles in the ovary grow to become a fully matured graafian follicle.
• Endometrium regenerates through proliferation.
• Changes in Pituitary hormone and ovarian hormones induce the formation of graafian follicles and regeneration of endometrium.
• The secretion of gonadotropins like LH and FSH increases gradually during this 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 the cycle about the 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 known as ovulation

3) Luteal phase: In this phase, the ruptured part of Graafian follicle transforms into yellow body called Corpus luteum.

- The corpus luteum secretes large amounts of progesterone hormone which maintains the endometrium for implantation of the fertilized ovum.
- During pregnancy all events of the menstrual cycle stop and there is no menstruation.
- In the absence of fertilization, the corpus luteum degenerates hence causes disintegration of the endometrium leading to menstruation and a new cycle begins.
- In human beings, menstrual cycles cease around 50 years of age and are known as menopause.

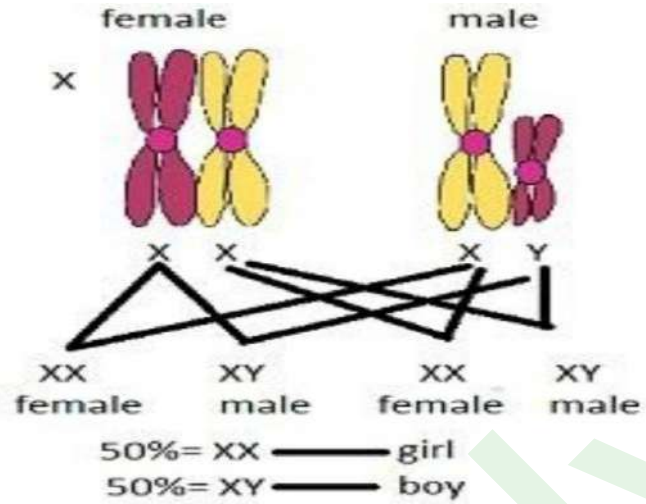
Fertilization: The fusion of haploid male gamete, sperm and haploid female gamete, ovum is called fertilization.

- During coitus, sperm is released by male partner into the vagina of the female partner and is called insemination.
- Fertilization takes place in the ampulla–isthmic junction.
- only one sperm fertilizes the ovum.



- The haploid nucleus of the sperm and ovum fuse together to form a zygote which develops into new individual.

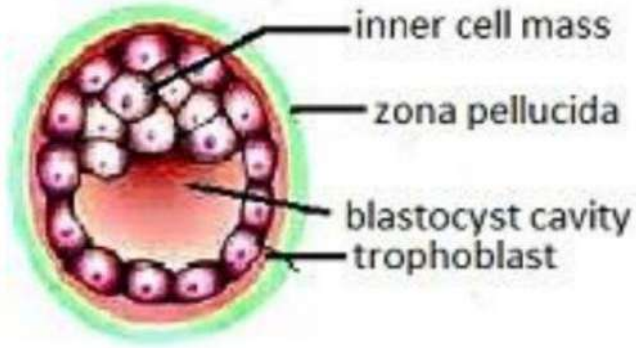
Sex determination in human: Male has two sex chromosomes X and Y hence male produces 50% of sperms carrying X and 50% carrying Y, while the female has two X chromosomes.



- After fusion of the male and female gametes the zygote would carry either XX or XY depending on whether the sperm carrying X or Y fertilized the ovum.
- The zygote carrying XX would develop into a female baby and XY would form a male.

Cleavage: Cleavage is the mitotic division which starts as the zygote moves through the isthmus of the oviduct towards the uterus and forms 2, 4, 8, 16 daughter cells called blastomeres.

- The embryo with 8 to 16 blastomeres is called a morula.
- The morula divides further as it moves further in to the uterus and transforms into blastocyst.
- The blastomeres in the blastocyst are arranged in to an the outer layer is called trophoblast and inner mass of cells attached to trophoblast is called inner cell mass.



• The trophoblast layer then gets attached to the endometrium of the uterus and the inner cell mass divides to cover the blastocyst, hence blastocyst becomes embedded in the endometrium of the uterus and the process is called implantation.

Pregnancy and embryonic development

• After implantation, finger like projections appear on the trophoblast called as chorionic villi.
• Uterine tissue and maternal blood surrounds the chorionic villi.
• The chorionic villi and uterine tissue together form a structural and functional organic structure between developing embryo and tissues of the mother called as placenta

Functions of placenta: The placenta facilitates the supply of oxygen and nutrients to the embryo.
• Help in the removal of carbon dioxide and excretory/waste materials produced by the embryo.
• The placenta is connected to the embryo through an umbilical cord which helps in the transport of substances to and from the embryo.

• Placenta also acts as an endocrine tissue and produces several hormones like human chorionic gonadotropin (hCG), human placental lactogen (hPL), estrogens, progestogen. etc.
• A hormone called relaxin is secreted by the ovary in the later phase of pregnancy.
• hCG, hPL and relaxin are produced in women only during pregnancy.
• Levels of other hormones like estrogens, progestogens, cortisol, prolactin, thyroxine, etc., are increased several folds in the maternal blood.

Parturition and lactation: The average duration of human pregnancy is about 9 months called the gestation period.
• Vigorous contraction of the uterus at the end of pregnancy causes expulsion/delivery of the foetus is called parturition.
• The signals for parturition originate from the fully developed fetus and the placenta which induced mild uterine contraction is called fetal ejection reflex.
• Production of milk at the end of pregnancy by the differentiation of mammary glands is called lactation.
• Milk produced during the first few days of lactation is called colostrum.
• Colostrum contains antibodies necessary to develop resistance against diseases of the new born baby.