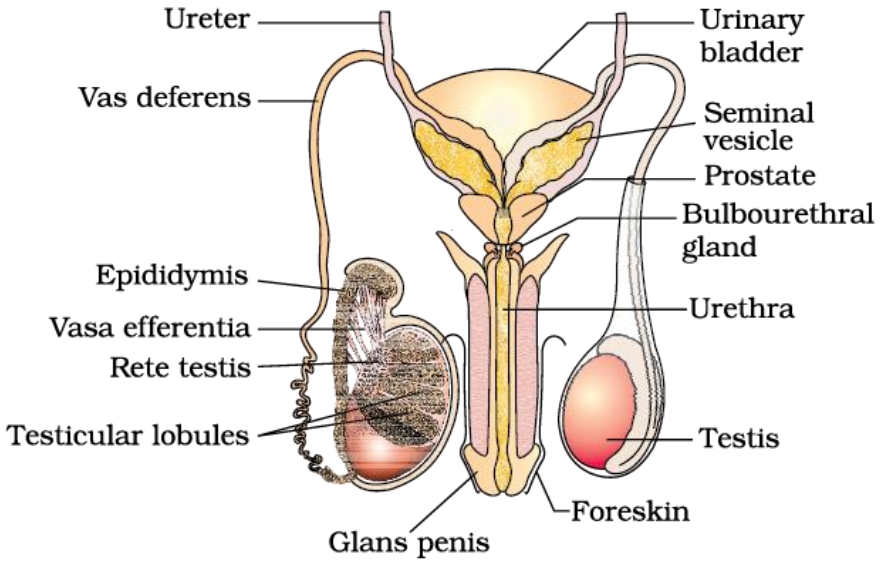
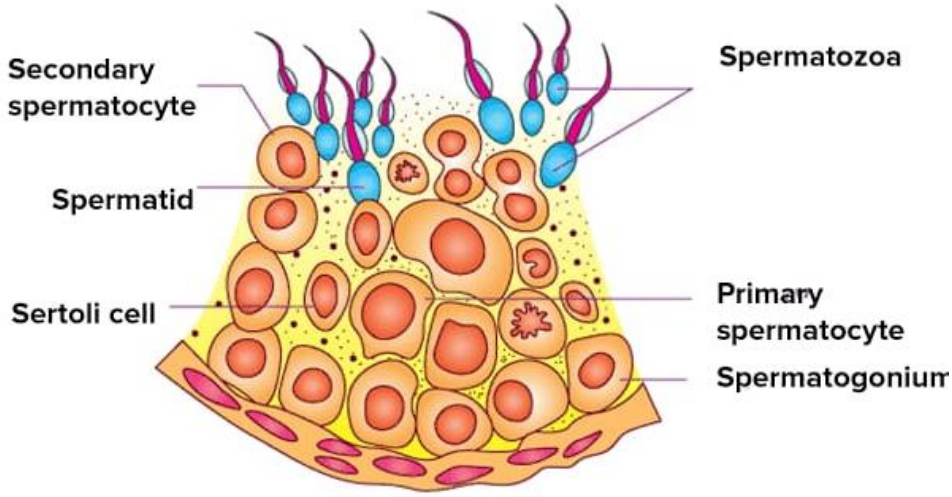
Human Reproduction

Human reproduction involves several key events such as gametogenesis, insemination, fertilization, blastocyst formation, implantation, gestation, and parturition. These reproductive events occur after puberty.
Significant anatomical and physiological differences exist between male and female reproductive systems, such as ongoing sperm formation in men and ovum formation ceasing in women around the age of fifty years.

Male reproductive system

- Located in pelvic region; includes testes, accessory ducts, glands, and the external genitalia
- **Testes are** located in **scrotum** (a pouch outside the abdominal cavity); maintain 2-2.5°C lower than the normal internal body temperature necessary for **spermatogenesis**; oval-shaped; contain around 250 compartments called **testicular lobules**
- **Testicular lobule -** 1-3 highly coiled **seminiferous tubules** for **sperm production**
- **Seminiferous tubules -** two types of cells are present: **male germ cells (spermatogonia)** and **Sertoli cells**
- **Male germ cells -** undergo meiotic divisions; produce sperm; **Sertoli cells** provide nutrition to germ cells
- Interstitial spaces outside seminiferous tubules contain **small blood vessels** and **Leydig cells (interstitial cells)**; produce **androgens**
- Accessory ducts: **rete testis**, **vasa efferentia**, **epididymis**, **vas deferens**, **ejaculatory duct**
- Seminiferous tubules connect to vasa efferentia via **rete testis**; **vasa efferentia** connect to **epididymis**; epididymis leads to **vas deferens**, ascends to abdomen and loops over the urinary bladder; vas deferens receives a duct from seminal vesicle, opens into the urethra as **ejaculatory duct**; ducts store and transport sperm from testis to outside through urethra; urethra originates from urinary bladder, extends through penis to external opening called **urethral meatus**
- **Penis -** male external genitalia, aids erection for insemination
- **Glans penis** - enlarged end of penis; covered by loose fold of skin, the **foreskin**
- **Male accessory glands -** paired **seminal vesicles**, a **prostate**, and paired **bulbourethral glands**; secretion of bulbourethral glands contribute to penis lubrication

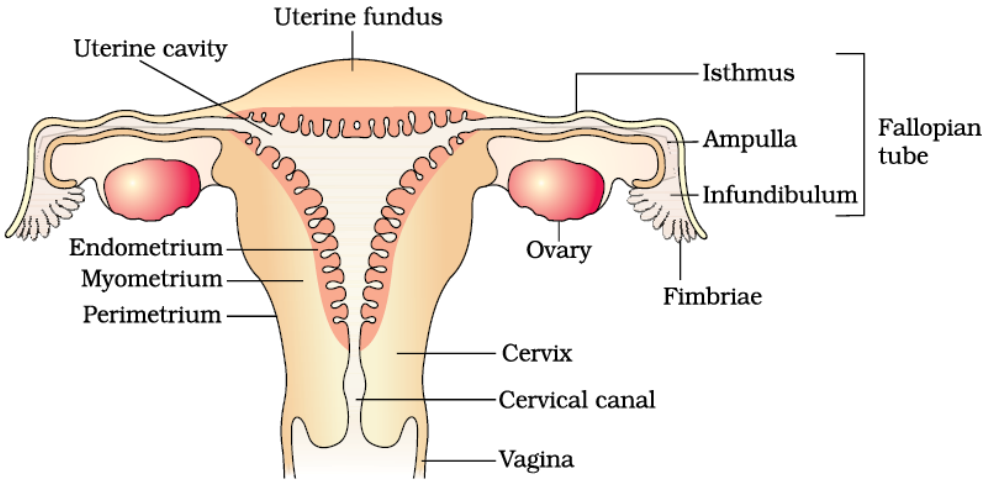




Female reproductive system

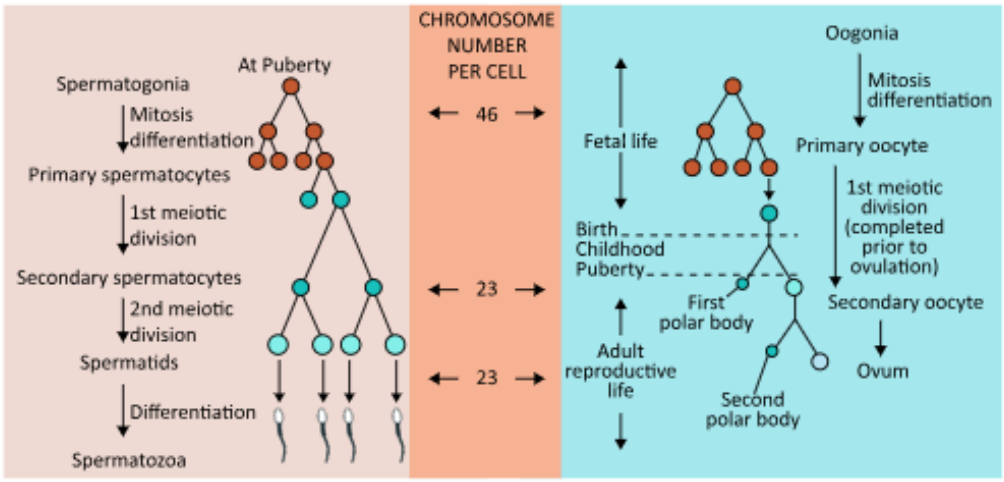
- Located in pelvic region; includes a pair of **ovaries**, a pair of **oviducts**, **uterus**, **cervix**, **vagina** and the **external genitalia**
- **Ovaries - primary female sex organ**; produce ovum and various ovarian hormones; located on each side of lower abdomen; connected to pelvic wall and uterus; covered by thin **epithelium**; contains ovarian stroma; divided into two zones **peripheral cortex** & **inner medulla**
- **Accessory ducts** - includes **oviducts (fallopian tubes), uterus, and vagina**
- **Fallopian tube** - approx 10-12 cm long; extends from periphery of ovary to uterus
- **Infundibulum** - funnel-shaped part of the fallopian tube; closer to ovary, with finger like projections - **fimbriae** for collecting the ovum; leads to wider **ampulla**, and **isthmus**, has a narrow lumen and joins the uterus

- **Uterus** - known as **womb**; inverted pear shape; ligaments provide support to the uterus; opens into vagina through narrow cervix and the cervical canal, along with the vagina forms the birth canal
- **Uterine wall** - three layers: external **perimetrium**, middle **myometrium** (smooth muscle) and inner **endometrium** (glandular layer)
- **Endometrium** - undergoes cyclical changes during menstrual cycle; **myometrium**- exhibits strong contractions during delivery of the baby
- **Female external genitalia** - include **mons pubis, labia majora, labia minora, hymen, and clitoris; mons pubis** - fatty tissue cushion covered by skin and pubic hair; **labia majora** - fleshy folds of tissue; extend from mons pubis; surround the vaginal opening; **labia minora** - paired folds of tissue located under the labia majora
- **Hymen** - membrane that partially covers the vaginal opening; can be torn during the first coitus or by other activities like sports or tampon use
- **Clitoris** - small finger-like structure located on labia minora above the urethral opening
- **Mammary glands** - characteristic of all female mammals; paired structures; referred as breasts; consist of glandular tissue and variable amount of fat; has 15-20 mammary lobes; contain cluster of cells called **alveoli**
- **Alveoli** - secrete milk, stored in its cavities; open into mammary tubules, which join to form **mammary ducts,** multiple mammary ducts converge to form **mammary ampulla**
- Mammary ampulla connects to **lactiferous duct**, from which milk is sucked out



Gametogenesis

- Process of gamete formation by testis and ovary



(a) Spermatogenesis (b) Oogenesis

Aspect	Spermatogenesis	Oogenesis
Location	occurs in the testis	occurs in the ovaries
Initiation	begins at puberty	initiates during embryonic development
Gamete mother cells	Spermatogonia (2n) multiply throughout life	oogonia (2n) are established in fetal ovaries and no new ones are formed after birth
Primary gamete	primary spermatocytes (2n)	primary oocytes (2n)
Meiotic divisions	two sequential divisions: Meiosis I and Meiosis II	meiosis I is completed during tertiary follicle stage, and Meiosis II is completed after fertilization
Final gametes	four equal, haploid spermatids	one large secondary oocyte (n) and one or more small polar bodies (n)
Cytoplasm retention	spermatids receive equal amounts of cytoplasm	secondary oocyte retains most of the nutrient-rich cytoplasm of the primary oocyte
Number of follicles	numerous p-spermatocytes are produced daily	a significant number of primary follicles degenerate before puberty, leaving a limited number
Follicular development	not applicable	sequential development from primary to secondary to tertiary follicles
Ovulation	not applicable	occurs when the *Graafian* follicle ruptures to release the secondary oocyte (ovum)
Release of gametes	sperm released continuously	ovum is released periodically during the menstrual cycle

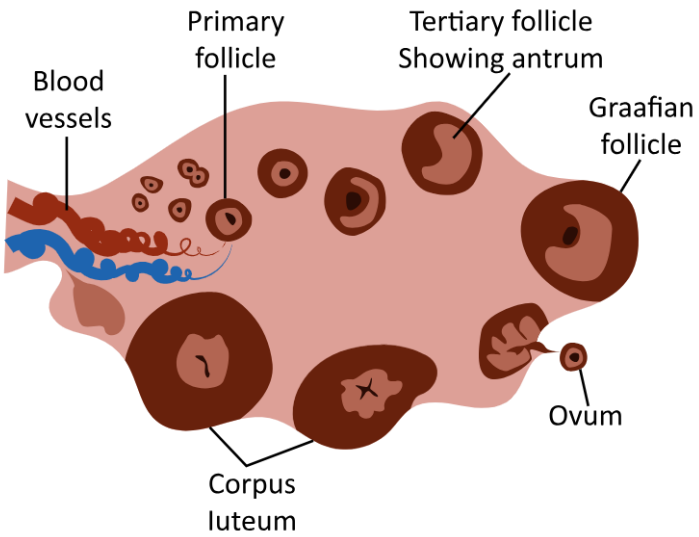
Spermatogenesis/ Oogenesis

Structure of sperm

- Microscopic structure with head, neck, middle piece, and tail
- **Head** - contains an elongated haploid nucleus; anterior portion - covered by the **acrosome**, filled with enzymes essential for fertilization of the ovum
- **Middle piece** - has numerous mitochondria producing energy for the movement sperm
- Among 200 to 300 million sperms for normal fertility at least 60% must have normal shape and size; at least 40% displaying vigorous motility
- Epididymis, vas deferens, seminal vesicle, and prostate involved in maturation and motility of sperms
- Seminal plasma + sperms = **semen**
- Functions of male sex accessory ducts and glands regulated by androgens

Menstrual cycle

- Reproductive cycle in female primates, including humans
- **Menarche** - first menstruation at puberty
- Menstruation occurs at an average interval of about 28/29 days; entire cycle from one menstruation to the next - **menstrual cycle**
- **Ovulation** - one ovum is released during the middle of each menstrual cycle
- Lasts for 3-5 days; menstrual flow due to the breakdown of the endometrial lining
- **Follicular phase** - growth of primary follicles in ovary and regeneration of endometrium; influenced by changes in pituitary and ovarian hormones like LH and FSH
- Ovulation marked by rupture of ***graafian*** **follicle** and release of the ovum; occurs in middle of the menstrual cycle, triggered by LH
- **Luteal phase** - remaining part of the *graafian* follicle transforms into the *corpus luteum* (secretes progesterone)
- **Progesterone** - maintain endometrium for possible implantation and pregnancy
- **Menopause** - cease menstrual cycle around 50 years of age



Developing ovarian follicles

Fertilization and implantation

- During copulation, semen released in vagina, motile sperm swim through the cervix, uterus, and ampullary region of the fallopian tube
- Fertilization occurs when ovum and sperm reach ampullary region simultaneously and fuse; not all copulations lead to fertilization
- Sperm meets zona pellucida layer of the ovum; induce changes that block entry of additional sperm
- **Acrosome** helps to enter ovum through **zona pellucida** and the plasma membrane; results in completion of the meiotic division of the secondary oocyte
- Result of fertilization is diploid **zygote**
- Mitotic division begins as the zygote moves through the isthmus of the oviduct, forming **blastomeres** and then **morula**, further into **blastocyst**
- Blastocyst consists of **trophoblast and inner cell mass**
- Trophoblast attaches to **endometrium**; inner cell mass **differentiates into embryo**
- Blastocyst becomes embedded in the endometrium called **implantation**

Pregnancy and embryonic development

- After implantation, chorionic villi and uterine tissue form the **placenta**
- **Placenta** - connected to the embryo via the **umbilical cord**; acts as an endocrine tissue; produce hormones like **hCG, hPL, oestrogens, progestogens,** and **relaxing**
- **Oestrogens, progestogens, cortisol, prolactin, thyroxine** increase during pregnancy; support foetal growth, maternal metabolic changes, and pregnancy maintenance
- Embryo's inner cell mass differentiates, give rise to all tissues and organs in adults
- After one month - embryo's **heart** formed; by the end of the second month - **limb and digit** development
- Major organ, well-developed **limbs and external genital organs** formed by the end of first trimester (12 weeks)
- Fifth month - **first foetal movements** and appearance of **hair on the head**

Parturition and lactation

- **Gestation period** - human pregnancy of around 9 months
- **Parturition** - process of delivering the foetus, initiated by signals from the fully developed foetus and placenta, causing uterine contractions and leading to the release of oxytocin
- **Oxytocin** - stimulates strong uterine contractions; results in the expulsion of baby from the uterus; doctors may inject oxytocin to induce delivery
- Mammary glands undergo differentiation during pregnancy; start producing milk, known as **lactation**
- **Colostrum** - **initial milk**; contains essential antibodies for new-borns, promotes immunity

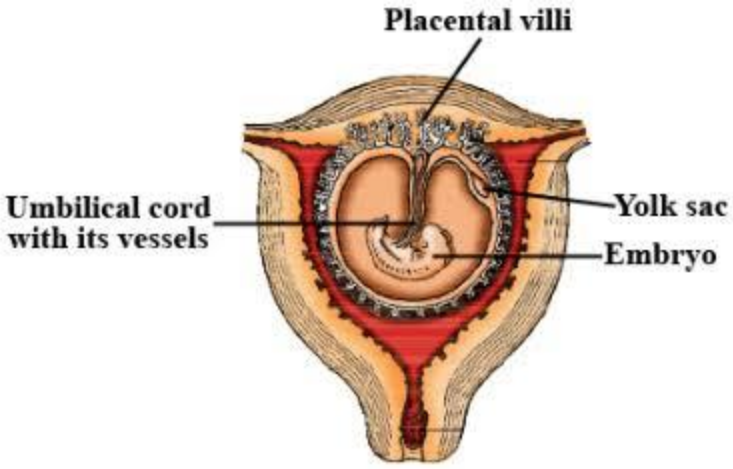


Figure: Human foetus within the uterus