REPRODUCTIVE SYSTEMS

Humans produce offspring by a process called **sexual reproduction**. Sexual reproduction involves the **fusion of two different sex cells (gametes)**. Haploid sperm cells produced by the testes of males fertilize the haploid secondary oocyte (ovum) produced by the ovaries of females. The resultant diploid cell formed is called a **zygote**, which contains one set of chromosomes from each parent.

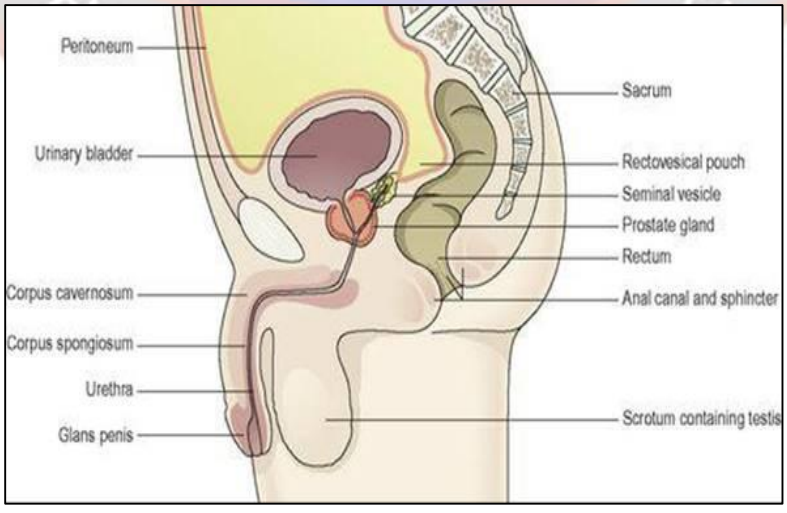
Male and female reproductive organs differ **anatomically and physiologically**. They produce, nourish, and transport haploid cells and facilitate fertilization. In females, the reproductive system also sustains the **growth of the embryo and fetus**.

COMPONENTS OF THE REPRODUCTIVE SYSTEM

The reproductive system consists of the following:

1. **Gonads**
   - Testes in males and ovaries in females
   - Produce gametes and secrete sex hormones
2. **Ducts**
   - Store and transport the gametes
3. **Accessory sex glands**
   - Produce substances that protect the gametes and facilitate their movement
4. **Supporting structures**
   - Penis in males and uterus in females
   - Assist in the delivery of gametes
   - Uterus serves as the site for growth of the embryo and fetus during pregnancy

MALE REPRODUCTIVE SYSTEM



The organs of the male reproductive system include:

- Testes
- System of ducts:
  - Epididymis
  - Ductus deferens
  - Ejaculatory ducts
  - Urethra
- Accessory sex glands:
  - Seminal vesicles
  - Prostate gland
  - Bulbourethral glands
- Supporting structures:
  - Scrotum
  - Penis

FUNCTIONS OF MALE REPRODUCTIVE SYSTEM

- Production of sperms and secretion of hormones by testes
- Transport, storage, and maturation of sperms by the duct system
- Delivery of sperms in semen into the female reproductive tract by the penis

Andrology is the branch of medicine that deals with male disorders, especially infertility and sexual dysfunction.
Urology deals with disorders of the urinary system.

SCROTUM

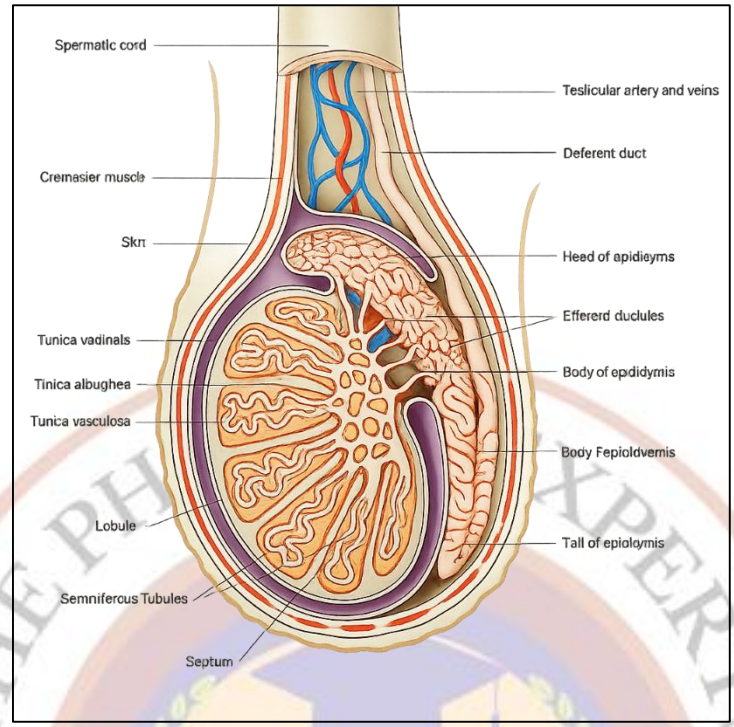
The scrotum is a pouch of loose pigmented skin and underlying subcutaneous layer that hangs from the root of the penis. It also consists of fibrous connective tissue and smooth muscle.

Internally, the **scrotal septum** divides the scrotum into two compartments. Each compartment contains one testis, one epididymis, and the testicular end of a spermatic cord. The septum is made of muscle tissue called the **dartos muscle**, which consists of bundles of smooth muscle fibers.

Each testis is associated with small bands of skeletal muscle called the **cremaster muscle**. The scrotum lies outside the pelvic cavity, below the pubic symphysis, in front of the upper parts of the thighs, and behind the penis.

TESTES

Testes or testicles are paired oval male reproductive glands suspended in the scrotum by spermatic cords. Each testis measures about **5 cm long, 2.5 cm wide, and 3 cm thick**. They develop near the kidneys and descend into the scrotum through the inguinal canals during the later half of the **7th month of fetal development**.



COVERINGS OF TESTES

Three layers of tissue surround the testes:

Tunica Vaginalis

A double serous membrane forming the outer covering of the testes. It is a downgrowth of the abdominal and pelvic peritoneum and partially covers the testes in the scrotum.

Tunica Albuginea

A fibrous capsular covering beneath the tunica vaginalis, composed of dense irregular connective tissue. It extends inward forming septa that divide the testis into internal compartments called **lobules**.

Tunica Vasculosa

Consists of a network of capillaries supported by delicate connective tissue. Blood and lymph vessels pass to the testes through the spermatic cords.

STRUCTURE OF TESTES

Each testis contains **200–300 lobules**. Each lobule contains **1–4 tightly coiled tubules** called **seminiferous tubules**, where sperm are produced.

Seminiferous tubules contain two types of cells:

- **Spermatogenic cells** – sperm-forming cells
- **Sustentacular (Sertoli) cells** – support and protect developing spermatogenic cells

Between the tubules are **interstitial (Leydig) cells**, which secrete testosterone after puberty.

SPERMATOGENESIS

Spermatogenesis is the process by which seminiferous tubules of the testes produce sperm and takes **65–75 days**.

In the embryo, primordial germ cells from the yolk sac differentiate into stem cells called **spermatogonia**. Spermatogonia are diploid cells that remain dormant during childhood and actively produce sperm at puberty.

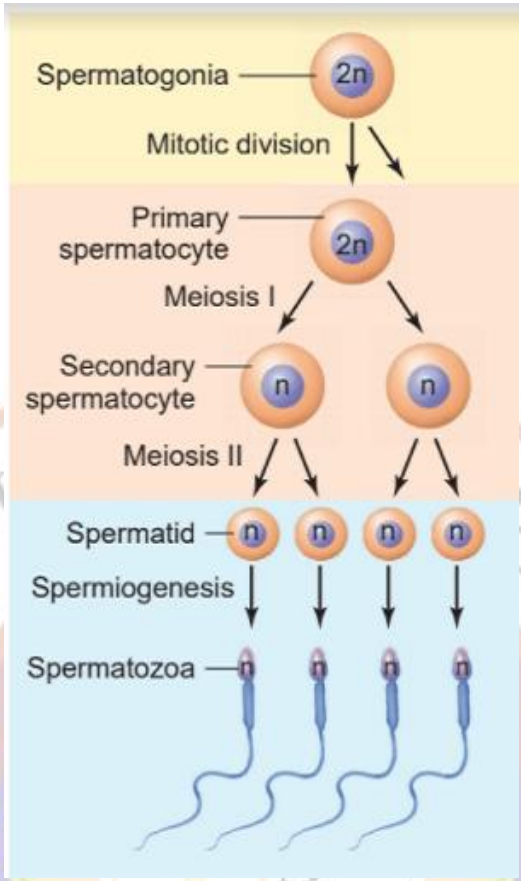
Spermatogonia undergo mitosis. Some remain undifferentiated near the basement membrane as reserve cells, while others differentiate into **primary spermatocytes (2n)**.

Primary spermatocytes undergo meiosis:

- Meiosis I produces two haploid **secondary spermatocytes**
- Meiosis II produces four haploid **spermatids**

The final stage of spermatogenesis is **spermiogenesis**, where spermatids develop into sperm without cell division. The release of sperm into the lumen of seminiferous tubules is called **spermiation**. Fluid from Sertoli cells pushes sperm toward the ducts.

Sperm mature as they pass through the **epididymis**, where they are stored.
FSH from the anterior pituitary stimulates sperm production, and LH stimulates interstitial cells to secrete testosterone.

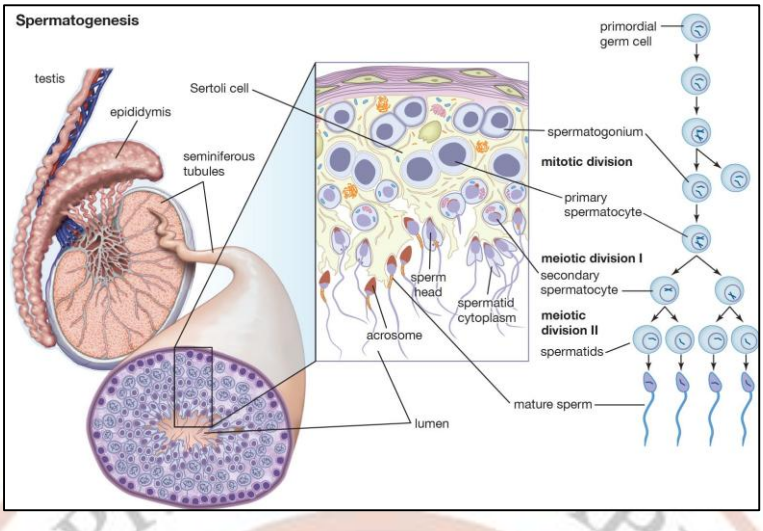


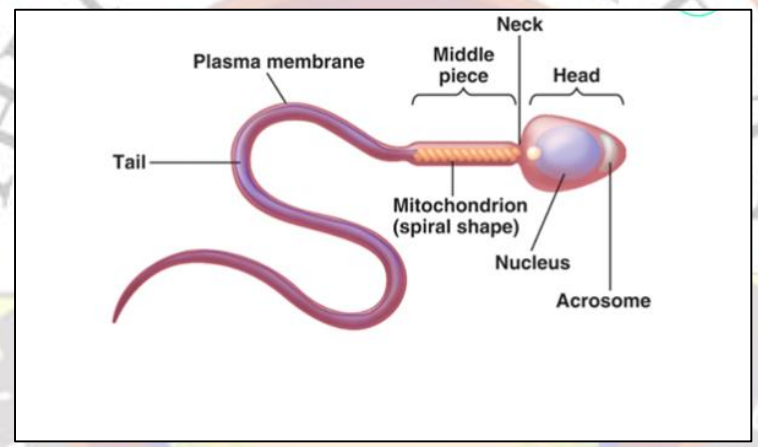
SPERM

A mature sperm is about **60 µm long** and consists of:

- **Head** – flattened and pointed, contains the nucleus with DNA; anterior two-thirds covered by acrosome containing enzymes to penetrate the ovum
- **Neck** – constricted region behind the head containing centrioles
- **Body** – packed with mitochondria to supply energy
- **Tail** – long whip-like structure with principal and end pieces for locomotion

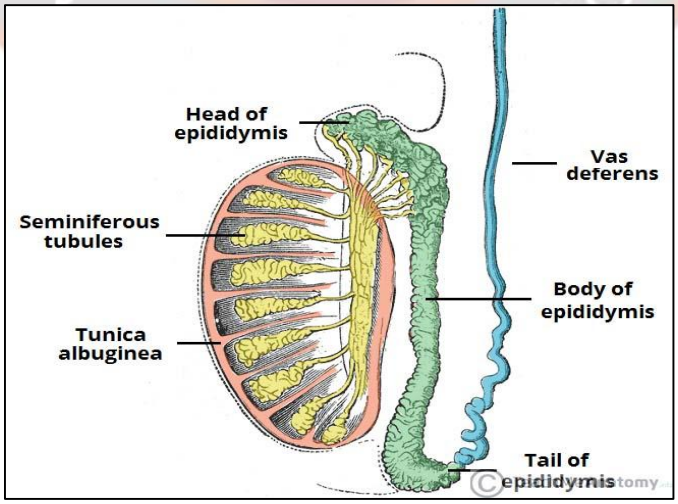
Most sperm do not survive more than **48 hours** in the female reproductive tract. Successful spermatogenesis requires a temperature **3°C below normal body temperature**. Unlike females, sperm production begins at puberty and continues throughout life.





SYSTEM OF DUCTS

Epididymis



- At the upper pole of testis, the seminiferous tubules combine to form a single tubule – 6 m in length, repeatedly folded and tightly packed into a mass called ***epididymis***
- Head, body & tail
- Tail – leaves the scrotum as ductus deferens (vas deferens) in the spermatic cord

Functions

- Site of maturation of sperm – acquire motility and ability to fertilize
- Helps propel sperm into vas deferens during sexual arousal
- Stores sperm

Ductus Deferens (Vas Deferens)

Continuation of the tail of the epididymis, about **45 cm long**. Passes through the inguinal canal and joins the duct of the seminal vesicle to form the ejaculatory duct.

Function:

- Conveys sperm from epididymis to urethra

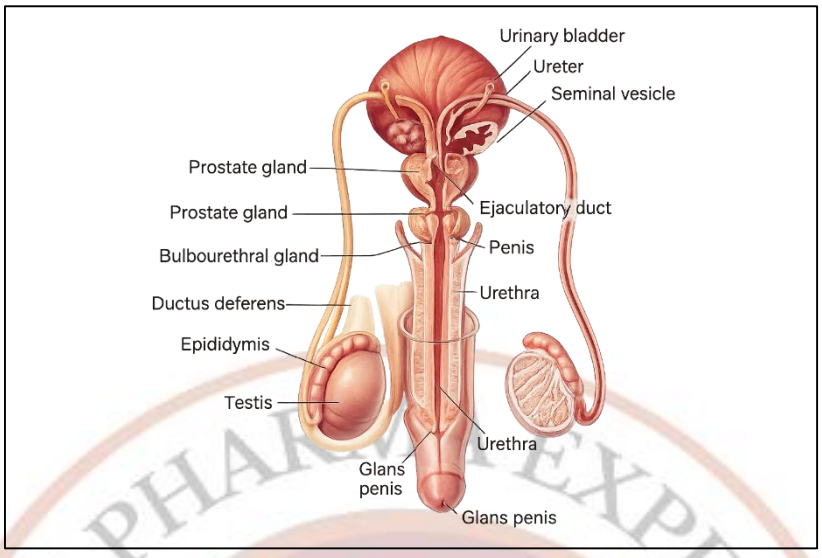
Spermatic Cord

- Supporting structure that suspends testes in the scrotum
- Each cord – vas deferens, testicular artery, testicular veins, nerves, lymphatic vessels and the cremaster muscle
- Covered by connective and fibrous tissues – extend through inguinal canal and attached to testis on the posterior wall

Ejaculatory Ducts

- Two tubes, each 2 cm long and formed by the union of duct from a seminal vesicle and a vas deferens
- Pass through prostate gland and join prostatic urethra – carry seminal fluid and sperm to urethra, thus ejected to exterior

ACCESSORY SEX GLANDS



Seminal Vesicles

- Paired small fibromuscular pouches, also called seminal glands
- Lie posterior to base of urinary bladder and anterior to rectum
- At lower end, each seminal vesicle opens into a short duct – joins with deferent duct to form ejaculatory duct
- Secretion called seminal fluid – constitutes 60% of volume of semen
- Seminal fluid – alkaline, viscous and contains fructose, prostaglandins, clotting proteins
- ***Function***
- Contract and expel seminal fluid during ejaculation
-

Prostate Gland

- Single doughnut-shaped gland, lies in pelvic cavity in front of rectum, behind pubic symphysis, inferior to urinary bladder and completely surrounds prostatic urethra
- Progressively enlarges with age

Functions

- Secretes a thin, slightly acidic milky fluid that makes up about 30% of volume of semen – gives milky appearance
- Contains a clotting enzyme, citric acid and seminal plasmin (antibiotic)

Bulbourethral (Cowper's) Glands

- Paired glands, about the size of peas – also called cowper's glands
- Located inferior to prostate on either side of urethra and their ducts open into urethra

Functions

- During sexual arousal – secrete an alkaline fluid and mucus (lubricates end of penis and urethra)

SEMEN

- Mixture of sperm and seminal fluid, a liquid that consists of secretions of seminiferous tubules, seminal vesicles, prostate and bulbourethral glands
- Volume in typical ejaculation – 2.5-5 ml, with 50-150 million sperm/ml
- Slightly alkaline – 7.2-7.7
- Milky white appearance due to prostatic secretions; sticky consistency due to fluids from seminal vesicles and bulbourethral glands
- Once ejaculated, coagulates within 5 min

URETHRA

- Common passageway for both semen and urine
- About 20 cm long and consists of three parts

1. ***Prostatic urethra*** – originates at urethral orifice of bladder and passes through prostate gland; 2-3 cm long
2. ***Membranous (intermediate) urethra*** – passes through deep muscles of perineum; shortest (1 cm) and narrowest part extending from prostate gland to bulb of penis
3. ***Spongy or penile urethra*** – lies within corpus spongiosum of penis and terminates at external urethral orifice in glans penis; 15 cm long

- External urethral orifice guarded by external urethral sphincter – a ring of skeletal muscle

PENIS

- Contains urethra and is passageway for ejaculation of semen and excretion of urine
- Cylindrical in shape and consists of root and body (shaft)
- Root – attached portion, anchors penis in the perineum
- Body – externally visible, movable portion

- Formed by three cylindrical masses of erectile tissue and smooth muscle
- Each surrounded by fibrous tissue called tunica albuginea and covered with skin, has rich blood supply
- Two lateral columns called ***corpora cavernosa*** and the column between them called ***corpus spongiosum*** – contains spongy urethra & keeps it open during ejaculation

- Erectile tissue is composed of numerous blood sinuses (vascular spaces) lined by endothelial cells and surrounded by smooth muscle
- Tip of the penis is expanded into triangular structure – glans penis
- Above glans penis, skin is folded on itself and forms movable double layer – foreskin or prepuce

- Distal urethra enlarges with glans penis & forms terminal slit like opening – external urethral orifice

Erection of penis

- Penis is supplied by autonomic and somatic nervous system
- Parasympathetic stimulation – relaxation/ dilation of smooth muscle in the wall of arterioles supplying erectile tissue – entry of large amounts of blood to erectile tissue – also relaxation of smooth muscle of erectile tissue
- Widening of blood sinuses – increased blood flow to penis – erection of penis, essential for intercourse (insertion of erect penis into vagina)

Ejaculation

- *It is the powerful release of semen from urethra*
- Mediated by sympathetic reflex
- Smooth muscle sphincter of urinary bladder closes – prevents expelling of urine during ejaculation & semen from entering the bladder
- Rhythmic contraction of smooth muscle of epipidymis, deferens duct, seminal vesicles, ejaculatory ducts and prostate gland – propel semen into penile urethra – emission through external urethral sphincter
- End of sexual stimulation – smooth muscle of arterioles contracts – blood sinuses smaller – relieve of pressure on the veins – penis returns to flaccid (relaxed) state

PUBERTY IN MALES

Occurs between **10–14 years**. Testosterone causes:

- Growth of muscles and bones
- Enlargement of larynx and deepening of voice
- Growth of facial, axillary, chest, abdominal, and pubic hair
- Enlargement of penis, scrotum, and prostate
- Maturation of seminiferous tubules and sperm production

FEMALE REPRODUCTIVE SYSTEM

The female reproductive system consists of a group of organs that function in the **production of ova**, **fertilization**, **pregnancy**, **childbirth**, and **lactation**.
It also secretes female sex hormones that regulate reproductive cycles and secondary sexual characteristics.

Organs of female reproductive system include –

- **External organs (genitalia)/ Vulva/ Pudendum**

- *Labia Majora*
- *Labia Minora*
- *Clitoris*
- *Vestibule*

- **Internal organs (genitalia)**

- *Ovaries (female gonads)*
- *Uterine (fallopian) tubes or oviducts*
- *Uterus*
- *Vagina*

- Perineum
- Mammary Glands – part of integumentary & female reproductive systems

The female reproductive system includes:

- Ovaries
- Uterine (fallopian) tubes
- Uterus
- Vagina
- External genital organs (vulva)
- Mammary glands

Gynecology is the branch of medicine concerned with the study and treatment of disorders of the female reproductive system.

FUNCTIONS OF THE FEMALE REPRODUCTIVE SYSTEM

1. Ovaries produce secondary oocytes (ova) and hormones, progesterone and estrogens (female sex hormones), inhibin and relaxin
2. Uterine tubes transport a secondary oocyte to the uterus and normally are the sites where fertilization occurs
3. Uterus is the site of implantation of a fertilized ovum, development of the fetus during pregnancy and labor
4. Vagina receives the penis during sexual intercourse and is a passageway for childbirth
5. Mammary glands synthesize, secrete, and eject milk for nourishment of the newborn

OVARIES

- Ovaries are female gonads – paired glands resemble unshelled almonds in size and shape
- Produce gametes and sex hormones
- Lie in a shallow fossa on the lateral walls of pelvis
- Each is 2.5-3.5 cm long, 2 cm wide and 1 cm thick

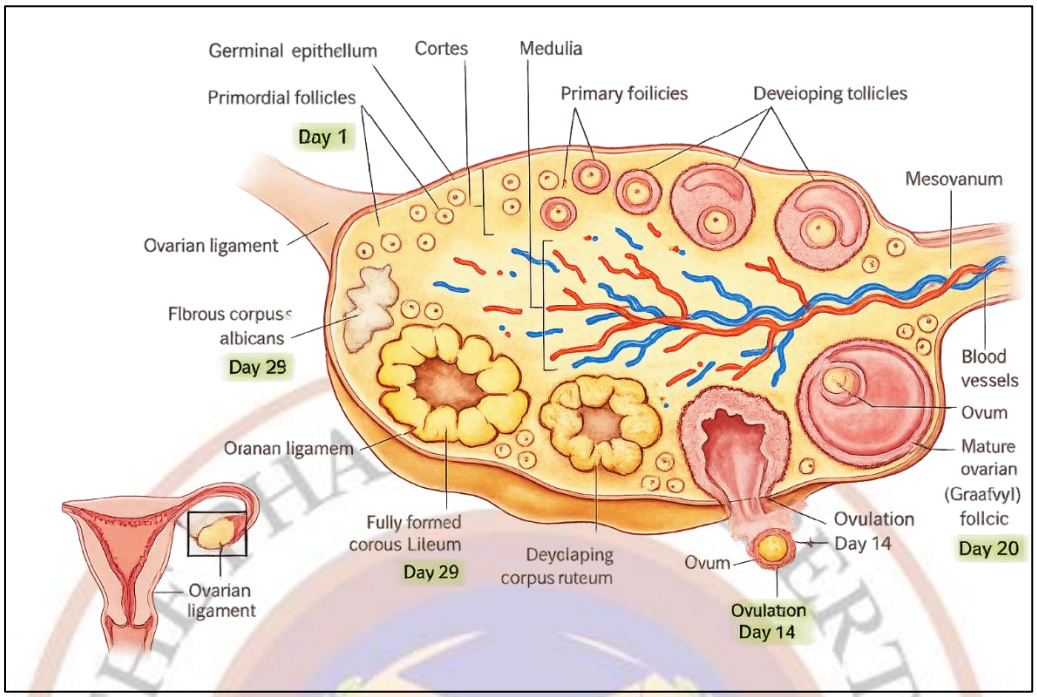
- A series of ligaments hold them in position

- Attached to upper part of uterus by ***ovarian ligament***
- The ***broad ligament*** of uterus attaches to ovaries by a double-layered fold of peritoneum called ***mesovarium***
- ***Suspensory ligament*** attaches ovaries to the pelvic wall
- Mesovarium – blood vessels and nerves pass to the ovary through the mesovarium

STRUCTURE OF OVARY

- Each ovary consists of following parts

- ***Ovarian mesothelium or surface epithelium or germinal epithelium*** – layer of simple epithelium (low cuboidal to squamous) that covers the surface of the ovary
- ***Tunica albuginea*** – whitish capsule of dense irregular connective tissue located immediately deep to ovarian mesothelium
- ***Ovarian cortex*** – region deep to tunica albuginea; consists of ovarian follicles in various stages of maturity, each of which contains ovum; surrounded by dense irregular connective tissue that contains collagen fibers and stromal cells
- ***Ovarian medulla*** – deep to cortex, consists of more loosely arranged connective tissue and contains blood vessels, lymphatic vessels and nerves
- ***Ovarian follicles*** – consists of oocytes in various stages of development + cells surrounding them
- - Surrounding cells form single layer – called follicular cells
- - Several layers – granulosa cells
- ***Mature or graafian follicle*** – large, fluid-filled follicle ready to rupture and expel its secondary oocyte by a process called ovulation (about every 28 days)
- ***Corpus luteum*** – yellow body; following ovulation, ruptured follicle develops into corpus luteum, leaves a small permanent scar of fibrous tissue on the surface of ovary called corpus albicans



OOGENESIS

- Formation of gametes in the ovaries is called *oogenesis*
- Begins in females before they are even born (contrast to spermatogenesis, which begins in males at puberty)
- During early fetal development, primordial germ cells differentiate within ovaries into *oogonia* (diploid stem cells)
- Oogonia undergo mitosis – give millions of germ cells – only few develop into *primary oocytes*
- Primary oocytes enter Prophase of Meiosis I during fetal development but do not complete the phase until puberty

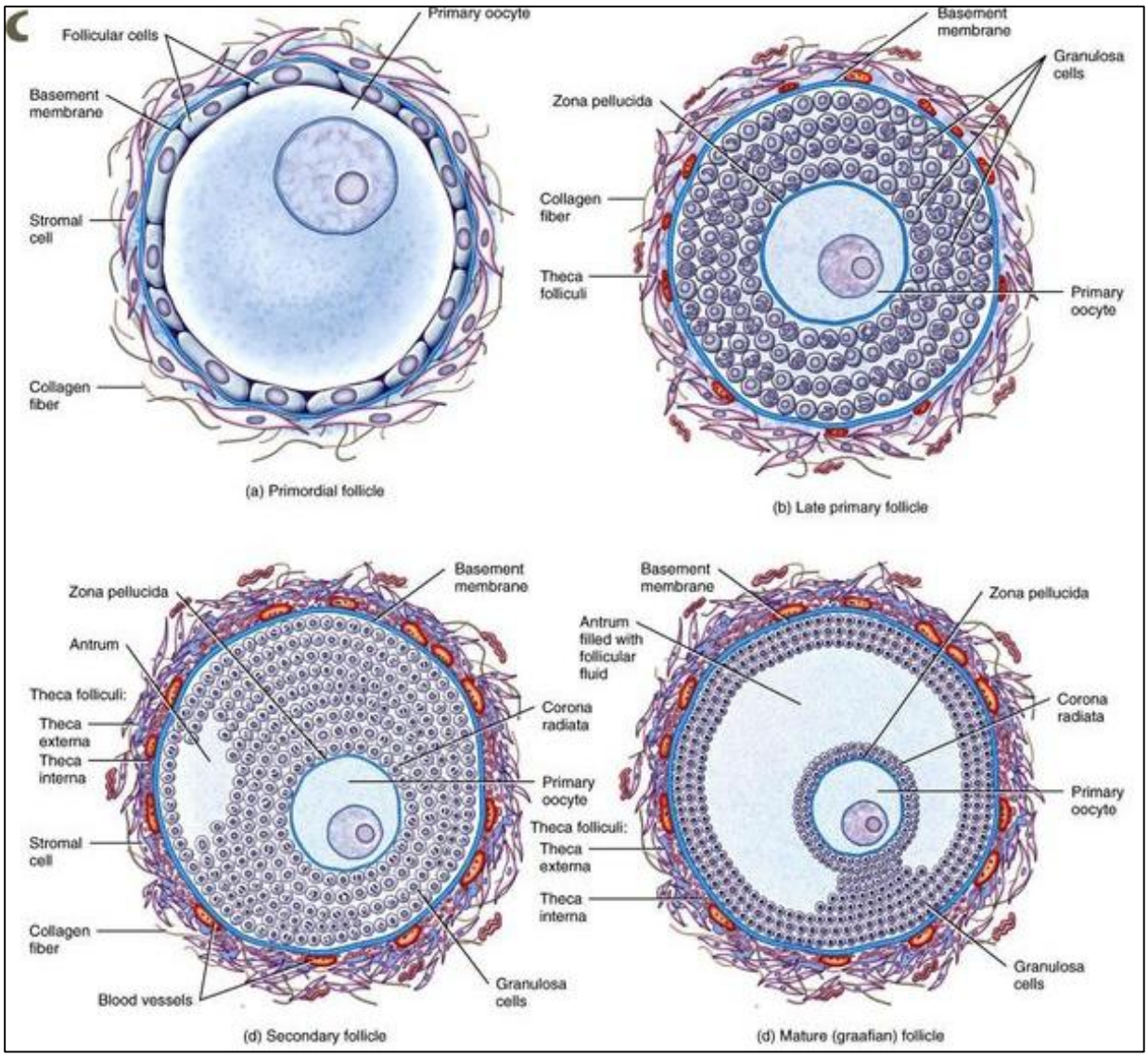
- During this phase, primary oocyte surrounded by a single layer of flat follicular cells – entire structure called *primordial follicle*
- At birth, 200,000 to 2,000,000 remain in each ovary – 40,000 at puberty – around 400 will mature and ovulate during woman's reproductive lifetime

- From puberty till menopause – LH & FSH by anterior pituitary – stimulate further development of primordial follicles
- Few primordial follicles start to grow – develop into *primary follicles* (late primary follicle)

- Consist of primary oocyte surrounded by several layers of cells, granulosa cells – outer most layer rests on basement membrane

- Growth of primary follicle – clear glycoprotein layer between primary oocyte and granulosa cells – Zona pellucida
- Stromal cells around basement membrane form an organized layer – Theca folliculi

- Primary follicle develops into *secondary follicle* with continued maturation



- Theca folliculi differentiates into 2 layers – theca interna & theca externa
- Theca interna – highly vascularized internal layer of cuboidal cells that secrete estrogens
- Theca externa – outer layer of stromal cells and collagen fibers
- Granulosa cells secrete follicular fluid – builds up in cavity called antrum in the center of secondary follicle (primary oocyte still in prophase I)
- Innermost layer of granulosa cells firmly attached to zona pellucida – corona radiata

- Secondary follicle eventually becomes larger & turn into *mature/ graafian follicle*

- Before ovulation, diploid primary oocyte completes Meiosis I – produce two haploid cells of unequal size – smaller cell called first polar body and larger cell called secondary oocyte
- Meiosis II begins in secondary oocyte and stops in metaphase
- Mature follicle ruptures and releases secondary oocyte by ***Ovulation***
- Secondary oocyte (with corona radiata) and first polar body swept into uterine tube
- If fertilization does not occur, these cells degenerate
- If sperm penetrates the secondary oocyte, meiosis-II resumes – splits into two haploid cells – smaller second polar body and the larger Ovum
- Nuclei of sperm cell and the ovum unite – a diploid zygote
- Primary oocyte ultimately give rise to single gamete, ovum (polar bodies degenerate)

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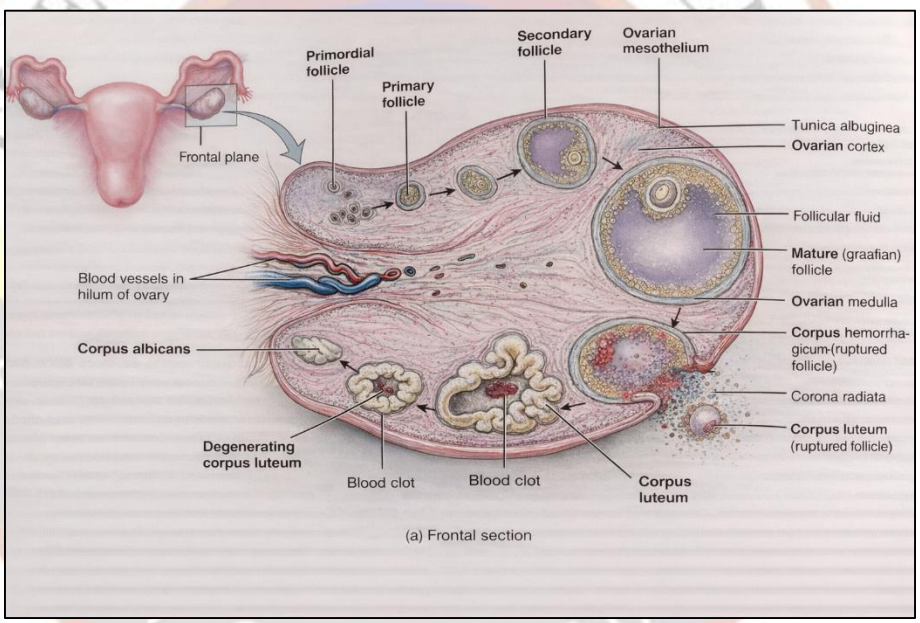


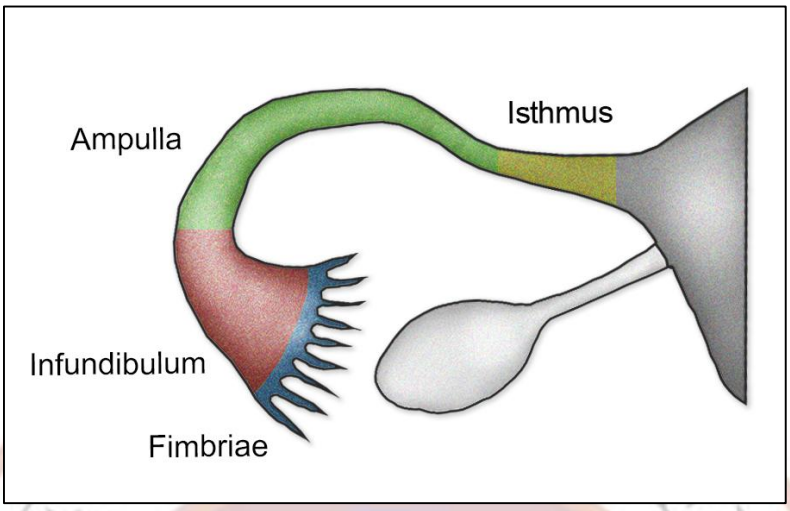
UTERINE (FALLOPIAN) TUBES

The uterine tubes are **paired muscular tubes**, about **10–12 cm long**, extending from the ovaries to the uterus.

Functions:

- Transport ova from ovaries to uterus
- Site of fertilization

PARTS OF UTERINE TUBE



Each tube has four parts:

1. **Infundibulum**
   - Funnel-shaped distal end
   - Has finger-like projections called **fimbriae** that capture the ovum
2. **Ampulla**
   - Widest and longest part
   - **Site of fertilization**
3. **Isthmus**
   - Narrow medial portion
   - Connects tube to uterus
4. **Intramural part**
   - Passes through uterine wall

UTERUS

- The uterus is a **hollow, muscular, pear-shaped organ** located between the urinary bladder and rectum. Lies in the pelvic cavity between the bladder and the rectum
- Present right angles to vagina
- When the body is upright, uterus lies almost horizontally
- About 7.5 cm long, 5 cm wide and 2.5 cm thick

Functions:

- Site of implantation
- Nourishment and development of embryo and fetus
- Expulsion of fetus during childbirth

PARTS OF UTERUS

- Three main parts of the uterus – *fundus, body and cervix*
- Fundus – dome shaped part of uterus above the openings of the uterine tubes
- Body – pear-shaped, tapering central portion
- Cervix ('neck' of uterus) – inferior narrow portion that opens into vagina, 2.5 cm long
- Isthmus – present between body and cervix

- Interior of body of uterus called ***uterine cavity***, and interior of cervix is called ***cervical canal***
- Cervical canal opens into uterine cavity at the ***internal os*** and into the vagina at the ***external os***

Supporting structures

Uterus is supported in the pelvic cavity by

- Surrounding organs
- Muscles of pelvic floor and
- Ligaments that suspend it from walls of pelvis

Broad ligaments

- Double folds of peritoneum attaching the uterus to either side of pelvic cavity

Round ligaments

- Bands of fibrous and muscular tissue between the layers of broad ligaments, one on each side of the uterus

Uterosacral ligaments

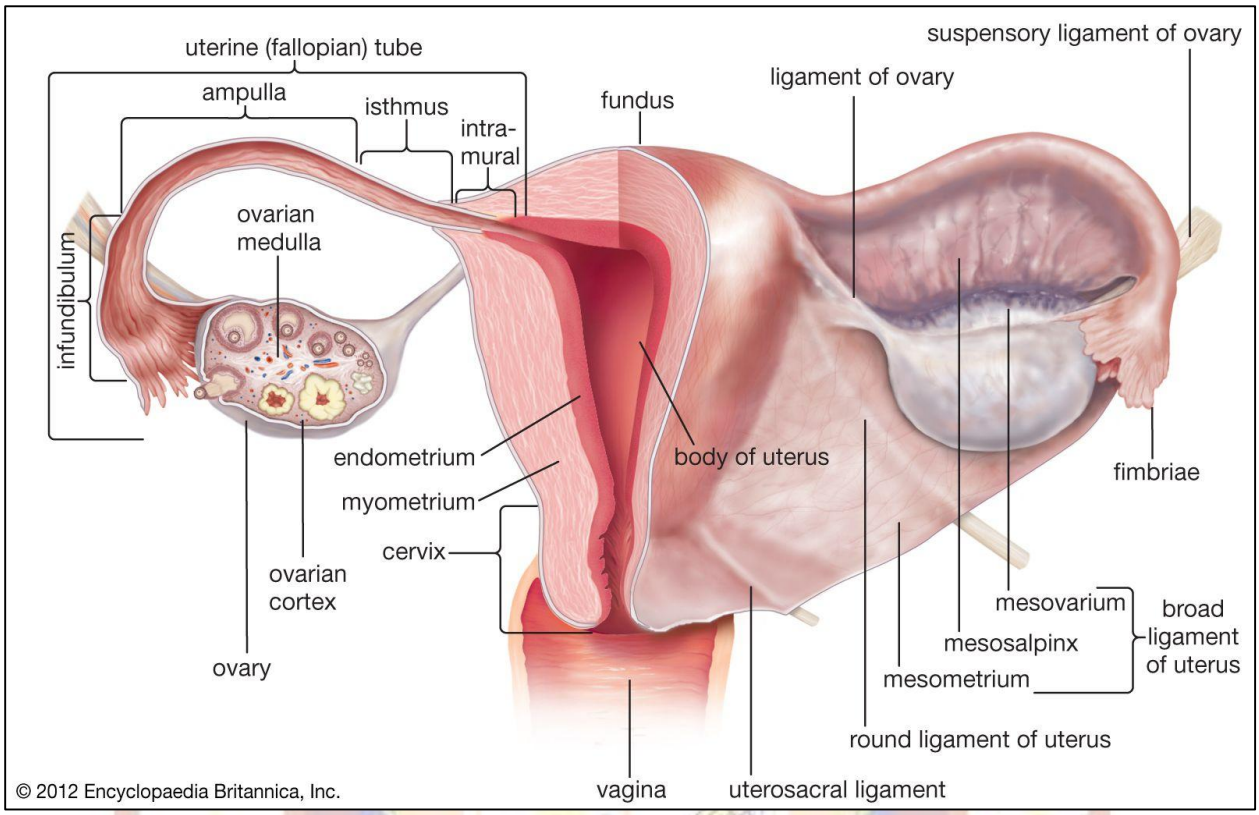
- Paired ligaments, also peritoneal extensions
- Originate from posterior walls of cervix and vagina and extend backwards, one on each side of rectum to the sacrum

Transverse cervical (cardinal) ligaments

- Located inferior to base of broad ligaments
- Extend one from each side of cervix and vagina to side walls of the pelvis

Pubocervical ligament

- Extends forward from the transverse cervical ligaments on each side of the bladder and attached to the posterior surface of pubic bones



LAYERS OF UTERUS

Perimetrium

- Or serosa – part of visceral peritoneum – composed of simple squamous epithelium and areolar connective tissue
- Laterally becomes broad ligament
- Anteriorly covers urinary bladder and forms shallow pouch – vesicouterine pouch
- Posteriorly covers the rectum and forms a deep pouch between the uterus and rectum – rectouterine pouch or Pouch of Douglas

Myometrium

- Middle & thickest layer of uterus
- Three layers of smooth muscle fibers interlaced with areolar tissue, blood vessels and nerves
- Thickest in fundus and thinnest in cervix
- Middle layer is circular; inner and outer layers are longitudinal or oblique

Endometrium

- Inner layer and is highly vascularized

- Consists of columnar epithelium covering a layer of connective tissue containing abundant mucus-secreting tubular glands
- Divided into two layers

1. *Functional layer*
2. *Basal layer*

Functional layer

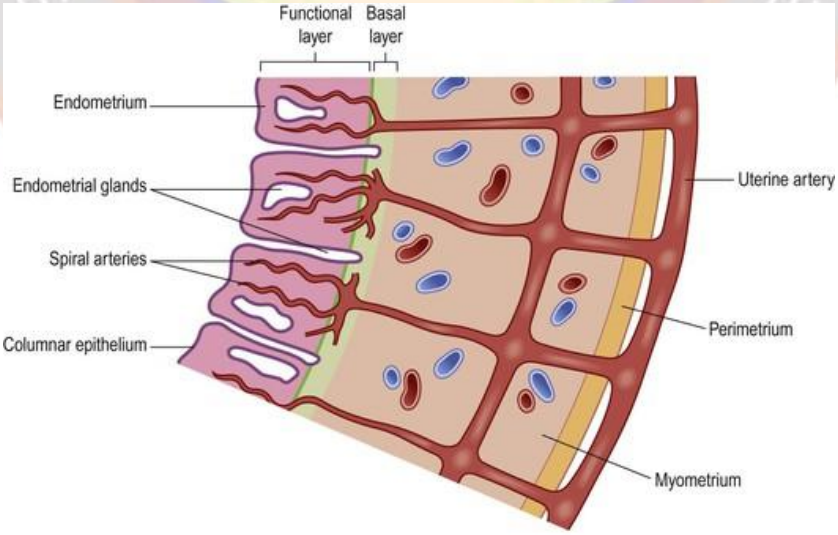
- Upper layer
- Thickens and becomes rich is blood vessels in first half of menstrual cycle
- If ovum is not fertilized and does not implant, shed during menstruation

Basal layer

- Lies close to myometrium and not lost during menstruation
- Permanent layer, fresh functional layer is regenerated during each cycle

Cervical mucus

- Secretory cells of mucosa of cervix produce a secretion called cervical mucus – mixture of water, glycoproteins, lipids, enzymes and inorganic salts
- During reproductive years, females secrete – ml/ day
- Hospitable to sperm at or near time of ovulation – less viscous & more alkaline Supplements energy needs of sperm



Functions of uterus

- After puberty, endometrium goes through regular monthly changes – menstrual cycle – influence of hypothalamic hormones, FSH and LH
- Menstrual cycle prepares the uterus to receive, nourish and protect a fertilized ovum
- Regular cycle lasts between 26-30 days
- If ovum not fertilized, functional layer is shed with vaginal bleeding called menstruation
- If ovum is fertilized, zygote embeds in uterine wall
- First 8 weeks – embryo, later fetus; accommodated by growth of uterine muscles
- First few weeks nourished by uterine secretions, ball of cells
- Later – placenta
- Placenta secretes high levels of progesterone – prevents contraction of muscular walls of uterus
- At term/ end of pregnancy – estrogen increases uetrine contractility + oxytocin stimulates uterine contractions – labor

VAGINA

The vagina is a **fibromuscular canal**, about **10 cm long**, extending from cervix to exterior.

Structure

- Vaginal wall has three layers –

1. Outer covering of areolar connective tissue
2. Middle layer of smooth muscle
3. Inner mucosa made of stratified squamous epithelium that forms rugae or ridges

- No secretory glands, but surface kept moist by cervical secretions
- Between puberty and menopause, Lactobacillus acidophilus is normally present – maintains pH between 3.5-4.9 – inhibits growth of other microbes that may contaminate vagina from perineum or during sexual inetrcourse

Hymen

- Thin layer of mucus membrane stretches across vaginal lumen
- Present just inside vaginal orifice
- Normally incomplete to allow passage of menstrual flow
- Stretched or completely torn away by sexual intercourse, insertion of tampon or childbirth

Functions:

- Passage for menstrual flow
- Receives penis during sexual intercourse

- Acts as birth canal during childbirth

EXTERNAL GENITALIA (VULVA)

The following components make up the vulva –

Mons pubis

- An elevation of adipose tissue covered by skin and coarse pubic hair that cushions the pubic symphysis
- Anterior to vaginal and urethral openings

Labia majora

- Two large folds of skin from mons pubis forming the boundary of vulva
- Compose of fibrous and adipose tissue, covered in skin and contain large number of sebaceous and eccrine sweat glands
- Posteriorly they merge with skin of perineum
- At puberty, hair grows on mons pubis and on the lateral surfaces of labia majora
- Homologous to scrotum

Labia minora

- These are two smaller folds of skin between the labia majora
- Do not have pubic hair and fat
- Contain numerous sebaceous and eccrine sweat glands
- Produce antimicrobial substance and provide lubrication during sexual intercourse
- Homologous to spongy urethra

Clitoris

- Corresponds to penis in the male and contains sensory nerve endings and erectile tissue
- A small cylindrical mass composed of two small erectile bodies, corpora cavernosa
- Located at anterior junction of labia minora
- A layer of skin formed at point where labia minora unite and covers body of clitoris – prepuce of clitoris

- It is capable of enlargement on tactile stimulation and role in sexual excitement in female

Vestibule

- Region/ cleft between labia minora
- Within vestibule are hymen, vaginal orifice, external urethral orifice and openings of ducts of several glands

- Homologous to intermediate urethra of males
- Vaginal orifice occupies greater portion
- Anterior to vaginal orifice and posterior to clitoris is external urethral orifice
- Skene's glands (paraurethral glands) – mucus secreting glands embedded in the wall of urethra and open on either side of external urethral orifice (homologous to prostate)
- Vestibular glands or Bartholin's glands – present on either side of vaginal opening and ducts open into vestibule immediately lateral to attachment of hymen – secrete mucus that keeps vulva moist – homologous to bulbourethral glands

Perineum

- a roughly triangular area extending from base of labia minora to the anal canal
- Consists of connective tissue, muscle and fat
- Gives attachment to muscles of pelvic floor

Mammary Glands/ Breast

- Breast is a hemisphere projection that anchors to chest wall
- Each breast has a modified sweat gland that produces milk called mammary gland
- Supported by fatty tissue and fibrous connective tissue
- Each breast contains 15-20 lobes or compartments separated by variable amount of fat
- Each lobe has several smaller compartments called lobules – open into tiny lactiferous ducts, which drain milk towards the nipple

- Breast itself covered in subcutaneous fat
- In lactating breast, glands proliferate to support milk production and recedes again after lactation stops

Nipple

- A small conical eminence at the center of breast surrounded by a pigmented area called areola
- Surface of areola has numerous sebaceous glands (Montgomery's tubercles) – lubricate the nipple during lactation

Functions

- Until puberty, breasts are small in females
- Grow and develop under the influence of estrogen and progesterone
- During pregnancy, further growth
- After baby is born, prolactin stimulates production of milk and oxytocin stimulates ejection of milk in response to stimulation of nipple by sucking baby

Puberty in females

- It is the age at which internal reproductive organs reach maturity – between the ages of 12 and 14
- This is called menarche and marks the beginning of childbearing period
- Rise in production of reproductive hormones and initiation of female reproductive cycle
- Ovarian activity controlled by FSH and LH – begin to secrete estrogens – stimulate physical changes associated with puberty – secondary sexual characteristics

1. Maturation of uterus, uterine tubes and ovaries
2. Development and enlargement of breasts
3. Growth of pubic and axillary hair
4. Increase in height and widening of pelvis
5. Increased fat deposition in hips and breasts

REPRODUCTIVE CYCLE, PREGNANCY AND PARTURITION

THE REPRODUCTIVE CYCLE

The reproductive cycle is a **series of events occurring regularly in females every 26–30 days** throughout the child-bearing period between **menarche and menopause**.
It is also called the **menstrual cycle**.

The reproductive cycle consists of a series of **concurrent changes** taking place in:

- **Ovaries** (oogenesis)
- **Uterine lining**

The cycle is **stimulated by changes in blood concentrations of hormones** secreted by:

- Hypothalamus
- Anterior pituitary gland
- Ovaries

The reproductive cycle includes:

- Ovarian cycle
- Uterine cycle
- Hormonal changes regulating the cycles
- Cyclical changes in the breasts and cervix

OVARIAN CYCLE

The ovarian cycle is a **series of events occurring in the ovaries** during and after the maturation of an **oocyte**.

UTERINE CYCLE

The uterine cycle is a **concurrent series of changes in the endometrium of the uterus** to prepare it for the arrival of a **fertilized ovum**, which will develop there until birth.

If fertilization does not occur:

- Ovarian hormone levels decrease
- Functional layer of endometrium is sloughed off

HORMONAL REGULATION OF THE REPRODUCTIVE CYCLE

The hypothalamus secretes **luteinising hormone releasing hormone (LHRH)**, which stimulates the anterior pituitary to secrete **FSH and LH**.

Follicle Stimulating Hormone (FSH)

- Promotes maturation of ovarian follicles
- Stimulates secretion of **estrogen**

- Predominantly active in the **first half of the cycle**
- Secretion is suppressed after ovulation to prevent maturation of other follicles during the same cycle

Luteinising Hormone (LH)

- Triggers **ovulation**
- Stimulates development of **corpus luteum**
- Stimulates secretion of **progesterone**

Hormones secreted during the cycle are regulated by **negative feedback mechanisms**.

The hypothalamus responds to changes in blood levels of estrogen and progesterone:

- Stimulated by **high estrogen alone** (first half of cycle)
- Suppressed by **estrogen and progesterone together** (second half of cycle)

HORMONES OF FEMALE REPRODUCTION

Hormone	Secreted by	Functions
FSH	Anterior pituitary	• Initiates development of ovarian follicles • Stimulates secretion of estrogen by follicle cells
LH	Anterior pituitary	• Causes ovulation • Converts the ruptured ovarian follicle into the corpus luteum • Stimulates secretion of progesterone by the corpus luteum
Estrogen*	Ovary (follicle) Placenta during pregnancy	• Promotes maturation of ovarian follicles • Promotes growth of blood vessels in the endometrium • Initiates development of the secondar sex characteristics: —growth of the uterus and other reproductive organs —growth of the mammary ducts and fat deposition in the breasts —broadening of the pelvic bone —subcutaneous fat deposition in hips and thighs
Progesterone	Ovary (corpus luteum) Placenta during pregnancy	• Promotes further growth of blood vessels in the endometrium and storage of nutrients
Inhibin	Ovary (corpus luteum)	• Inhibits secretion of FSH
Relaxin	Ovary (corpus luteum) Placenta during pregnancy	• Inhibits contractions of the myometrium to facilitate implantation • Promotes stretching of ligaments of the pubic symphysis

*Estrogen has effects on organs such as bones and blood vessels in both men and women. Estrogen is produced in fat tissue in the breasts and hips. In men, testosterone is converted to estrogen in the brain.

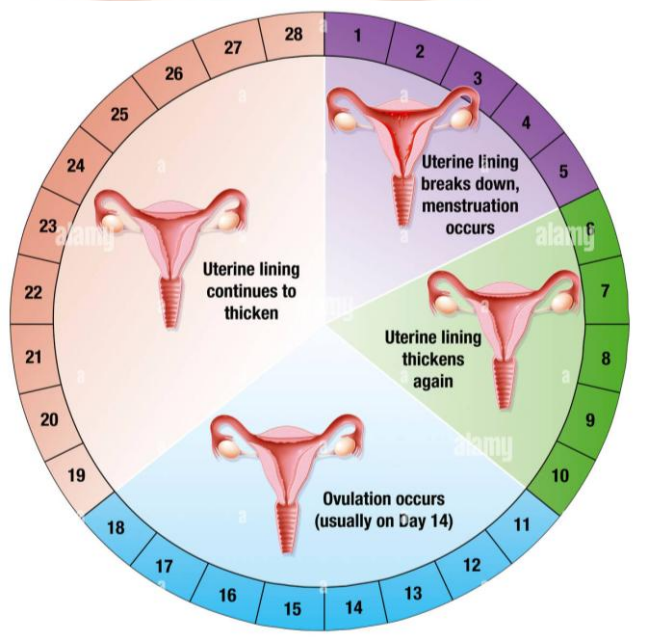
PHASES OF MENSTRUAL CYCLE

Average length of the menstrual cycle is **about 28 days**.

By convention, the days of the cycle are numbered from the **beginning of the menstrual phase**, followed by proliferative and secretory phases.

The phases of the menstrual cycle are:

1. Menstrual phase (Menstruation)
2. Proliferative / Follicular phase
3. Ovulation
4. Luteal / Secretory phase



MENSTRUAL PHASE

Also called **menstruation**, it lasts for **4–5 days**.

The loss of the functional layer of the endometrium is called **menses or menstruation**.

When the ovum is not fertilized:

- Corpus luteum degenerates
- Progesterone and estrogen levels fall
- Functional layer of endometrium is shed

Menstrual flow consists of:

- Secretions from endometrial glands
- Endometrial cells
- Blood from degenerating capillaries

- Unfertilized ovum

During this phase:

- Estrogen and progesterone levels are very low
- Due to degeneration of corpus luteum
- Hypothalamus and anterior pituitary are stimulated
- Levels of FSH begin to rise
- New cycle is initiated

PROLIFERATIVE / FOLLICULAR PHASE

This phase lasts for approximately **10 days**.

FSH:

- Stimulates growth of one or more ovarian follicles toward maturity
- Stimulates secretion of estrogen from follicular cells

LH:

- Secretion increases slowly

FSH and estrogen:

- Promote growth and maturation of the ovum

Estrogen:

- Stimulates proliferation of the functional layer of endometrium
- Promotes growth of blood vessels
- Prepares uterus for reception of fertilized ovum

During this phase:

- Endometrium thickens
- Becomes highly vascular
- Develops mucus-secreting glands

This phase ends with **ovulation**, which occurs due to **LH surge** triggered by rising estrogen levels.

OVULATION

Ovulation is the **rupture of a mature (Graafian) follicle** and release of the **secondary oocyte** into the pelvic cavity.

- Usually occurs on **day 14** of a 28-day cycle
- High estrogen levels during late proliferative phase trigger LH surge
- LH causes rupture of mature follicle
- Usually only one follicle ruptures

LUTEAL / SECRETORY PHASE

Under the influence of LH:

- The ruptured follicle becomes **corpus luteum**
- Corpus luteum secretes **progesterone and estrogen**

Progesterone:

- Stimulates further growth of blood vessels in the endometrium
- Endometrium becomes edematous
- Secretory glands produce increased watery mucus

As progesterone secretion increases:

- LH secretion decreases

If ovum is not fertilized:

- Progesterone secretion decreases
- Endometrium cannot be maintained
- Sloughing occurs → menstruation

FSH secretion begins to increase again as estrogen and progesterone fall.

Corpus luteum also secretes:

- **Inhibin** – inhibits secretion of FSH (and possibly LH)
- **Relaxin** – inhibits contractions of myometrium, aiding implantation

After ovulation:

- Progesterone, estrogen and inhibin suppress hypothalamus and anterior pituitary
- FSH and LH fall
- Low FSH prevents further follicular development

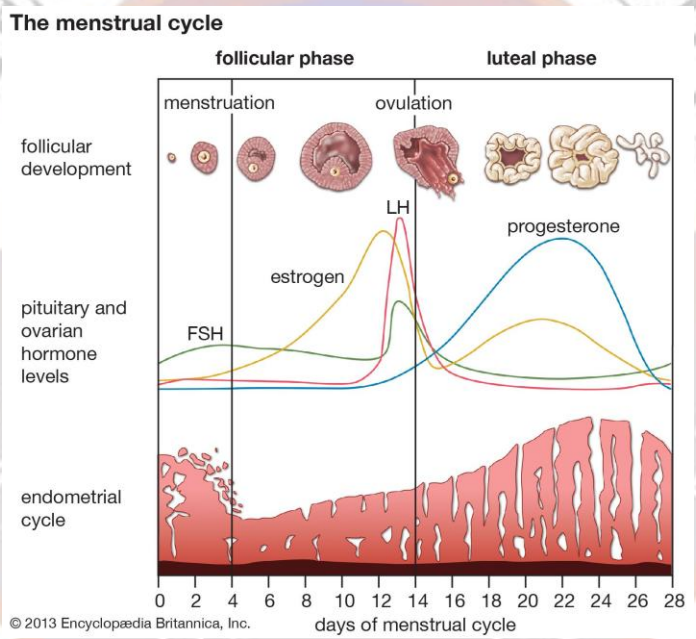
If ovum is not fertilized:

- Corpus luteum degenerates
- Estrogen, progesterone and inhibin decline
- Endometrium degenerates

- Menstruation occurs
- New cycle begins

If ovum is fertilized:

- Endometrium is maintained
- No menstruation occurs
- Zygote travels to uterus
- Implantation occurs
- Produces **hCG**, similar to LH
- hCG maintains corpus luteum
- Progesterone and estrogen secreted for first **3–4 months**
- Placenta develops and secretes estrogen, progesterone and gonadotrophins



REPRODUCTIVE FUNCTIONS OF ESTROGEN AND PROGESTERONE

Estrogen

- Stimulates development of secondary sexual characteristics
- Supports thickening of uterine lining during proliferative phase
- Triggers LH surge leading to ovulation
- Stimulates secretion of FSH and LH in first half of cycle

Progesterone

- Supports glandular development of uterine lining during secretory phase

- With estrogen, inhibits secretion of FSH and LH in second half of cycle

FERTILIZATION

Fertilization is the process in which **genetic material from a haploid sperm and a haploid secondary oocyte merge** to form a **single diploid nucleus**.

- Normally occurs in the fallopian tube
- Occurs within **12–24 hours after ovulation**
- Sperm remains viable for about **48 hours**
- Secondary oocyte viable for **24 hours**

Pregnancy is most likely if intercourse occurs during a **3-day window**:

- 2 days before ovulation
- 1 day after ovulation

MECHANISM OF FERTILIZATION

- About **200 million sperm** are deposited
- Only about **200 reach the oocyte**

Capacitation:

- Tail beats more vigorously
- Plasma membrane prepared for fusion
- Sperm attracted to oocyte

Sperm penetrates:

- Corona radiata
- Zona pellucida (via acrosome enzymes)

Fusion with oocyte:

- Completion of meiosis II
- Ovum formed

Nucleus of sperm → male pronucleus
Nucleus of ovum → female pronucleus

Fusion of pronuclei (**syngamy**) produces:

- Single diploid nucleus
- Fertilized ovum called **zygote**
- Zygote contains **46 chromosomes**

PREGNANCY

- Pregnancy is a sequence of events that begins with fertilization, proceeds to implantation, embryonic development and fetal development and ideally ends with birth after gestation
- The period between fertilization and birth is called Gestation and lasts for about 38 – 40 weeks
- First 8 weeks of development – ***Embryonic Period***; developing human is called an ***Embryo***
- The period from 9 weeks till birth – ***Fetal Period***; developing human is called a ***Fetus***

PRENATAL DEVELOPMENT

–Time from fertilization to birth and includes both the embryonic and fetal periods

- It is divided into periods of three calendar months each called trimesters

First trimester

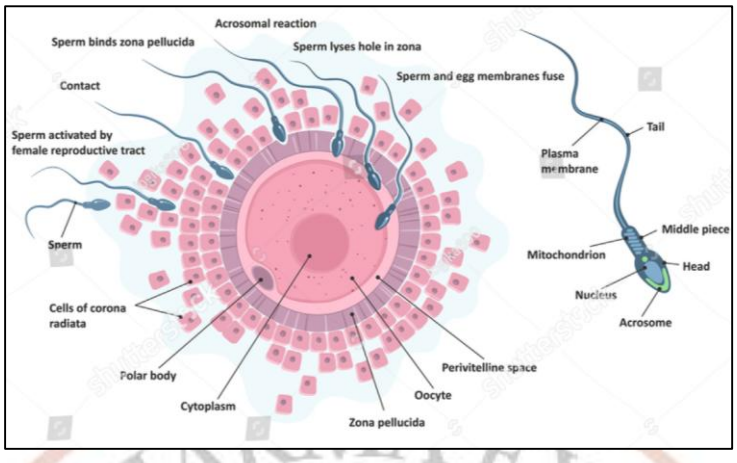
- Most critical stage of development
- All of the major organ-systems begin to form
- Extensive activity – developing organism most vulnerable to the effects of drugs, radiation & microbes

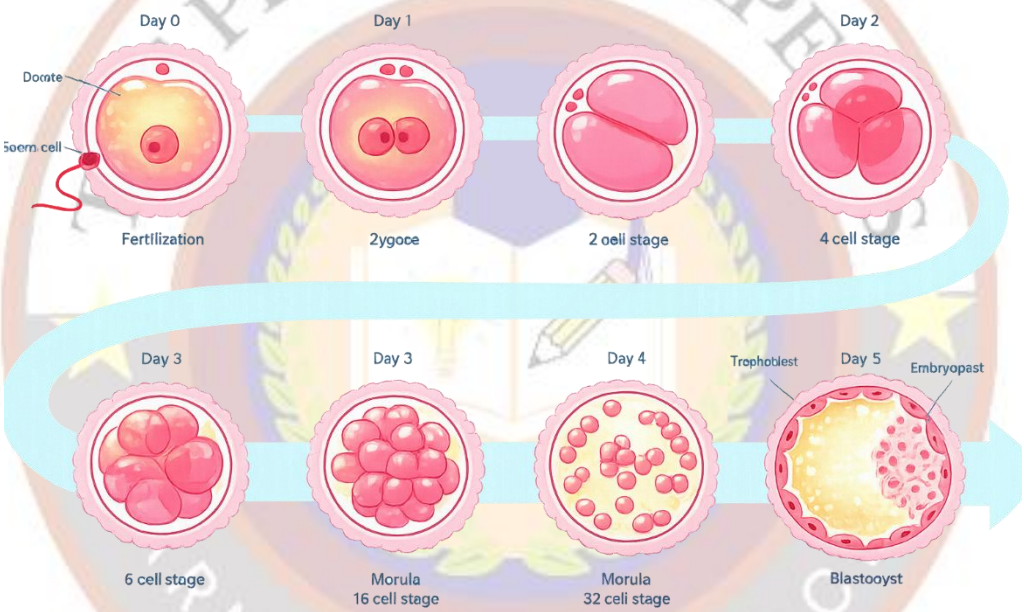
Second trimester

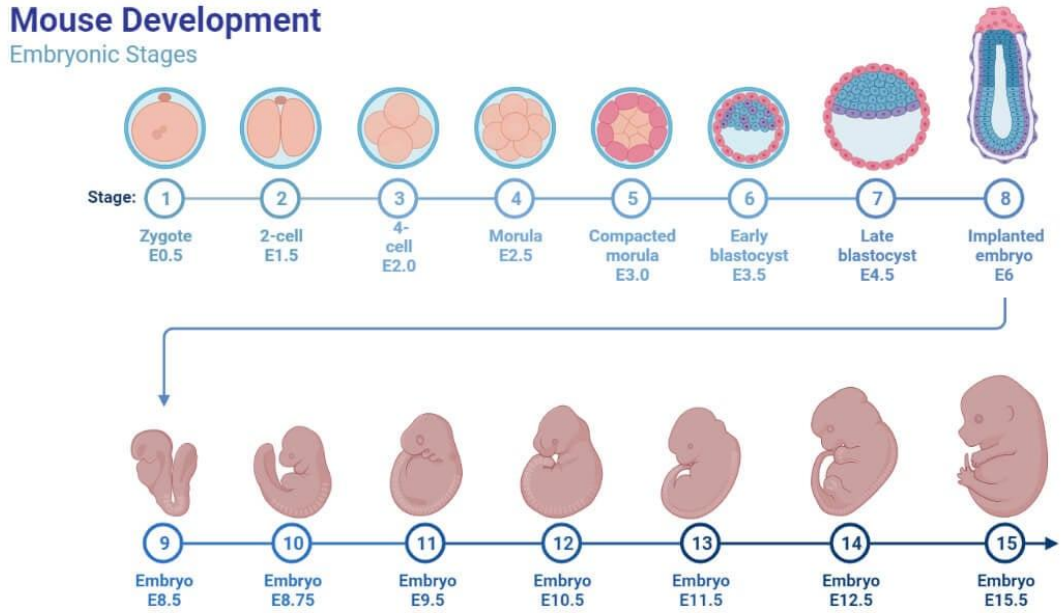
- Nearly complete development of organ systems
- By the end, the fetus assumes distinctively human features

Third trimester

- Period of rapid fetal growth; weight of the fetus doubles
- During early stage – most organ systems become fully functional By peristalsis of the uterine tube – zygote travels towards the uterus – takes about week
- By 10 days after fertilization, it is firmly embedded in the uterine lining
- During this period – rapid and repeated cell divisions, so by the time implants in endometrium it has become a blastocyst, a hollow ball of 70-100 cells
- Blastocyst – has inner mass of cells, develops into the fetus and its amniotic sac, a bag of membranes enclosing it
- Outer layer, trophoblast becomes an important layer of the placenta
- ***Nourishment***
- Early stages – small enough, so simple diffusion
- 3rd & 10th weeks of pregnancy – placenta develops, attached firmly to uterine wall
- Fetus attached to placenta by umbilical cord & absorbs oxygen, nutrients from maternal blood stream, as well as excretes wastes


Acrosomal reaction
Sperm binds zona pellucida
Sperm lyses hole in zona
Contact
Sperm and egg membranes fuse
Sperm activated by female reproductive tract
Tail
Plasma membrane
Middle piece
Mitochondrion
Head
Nucleus
Acrosome
Sperm
Cells of corona radiata
Polar body
Cytoplasm
Perivitelline space
Oocyte
Zona pellucida


Day 0
Day 1
Day 2
Donate
Sperm cell
Fertilization
2ygote
2 cell stage
4 cell stage
Day 3
Day 3
Day 4
Day 5
Trophoblast
Embryopast
6 cell stage
Morula
16 cell stage
Morula
32 cell stage
Blastocyst



IMPLANTATION AND PLACENTA

Zygote travels through uterine tube by peristalsis and reaches uterus in about **one week**.

By **10 days after fertilization**, it implants in endometrium.

During implantation:

- Rapid cell divisions occur
- Forms **blastocyst** (70–100 cells)

Blastocyst:

- Inner cell mass → fetus and amniotic sac
- Outer layer (**trophoblast**) → placenta

Early nourishment by diffusion.
Placenta develops between **3rd and 10th week**.

Fetus connected to placenta by **umbilical cord**.

Main Landmarks in Embryonic/ Fetal Development

Month	Length	Weight	Main developmental features
1	5 mm	0.02 g	- Heart is beating - Main respiratory and GI organs appear - Neural tube appears (from which the nervous system develops) - Limb buds apparent
2	28 mm	2.7 g	- Endocrine glands appear - Respiratory tree in place - Vascular system laid down - Heart development complete - Skin, nails and sweat glands present in skin - Cartilage models for bones appear - Face has human profile
3	78 mm	26 g	- Blood cells produced in bone marrow - Basic brain & spinal cord structure in place - Ossification of bones begins & muscles form - Gonads appear
4	133 mm	150 g	- Formation of hair - Eyes and ears in place - Rapid central nervous system development - Joints formed
5	250-300 mm	200-450 g	- Head proportionate to rest of body - Eyebrows and head hair visible - Brown fat forms - Fetal movements commonly felt by mother
6	270-350 mm	550-800 g	- Head even more proportionate to body - Substantial weight gain - Skin is pink & wrinkled - 24 weeks & old – survive if born prematurely
7	133 mm	150 g	- Formation of hair - Eyes and ears in place - Rapid central nervous system development - Joints formed
8	250-300 mm	200-450 g	- Head proportionate to rest of body - Eyebrows and head hair visible - Brown fat forms - Fetal movements commonly felt by mother
9	270-350 mm	550-800 g	- Head even more proportionate to body - Substantial weight gain - Skin is pink & wrinkled - 24 weeks & old – survive if born prematurely

PARTURITION

Parturition or labor is the process by which the fetus is expelled through the vagina.
Also called **childbirth**.

Onset of labor is controlled by complex interactions of placental and fetal hormones.

Progesterone inhibits uterine contractions, so labor begins only when its effects diminish.

Near end of gestation:

- Estrogen levels rise
- Myometrium contracts weakly
- Estrogen stimulates prostaglandin release
- Cervix softens
- Fetus usually assumes head-down position

POSITIVE FEEDBACK MECHANISM IN LABOR

- Uterine contractions push fetus into cervix
- Cervix stretches
- Stretch receptors stimulate hypothalamus
- Posterior pituitary releases **oxytocin**
- Oxytocin intensifies contractions
- Cycle continues until birth

TYPES OF LABOUR

True Labour

- Regular painful contractions
- Increasing intensity
- Cervical dilation
- Presence of "show" (blood-tinged mucus)

False Labour

- Irregular contractions
- No cervical dilation
- No show
- Pain does not intensify

STAGES OF TRUE LABOUR

Stage of Dilation

- From onset of labor to full dilation (10 cm)
- Lasts 6–12 hours
- Rupture of amniotic sac

Stage of Expulsion

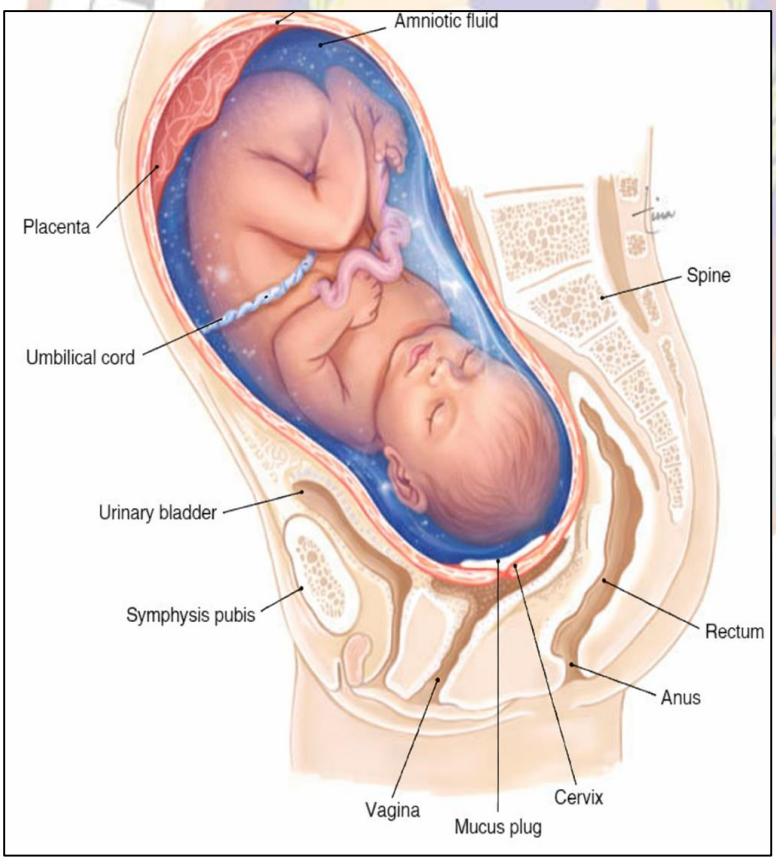
- From full dilation to delivery of baby
- Lasts 10 minutes to several hours

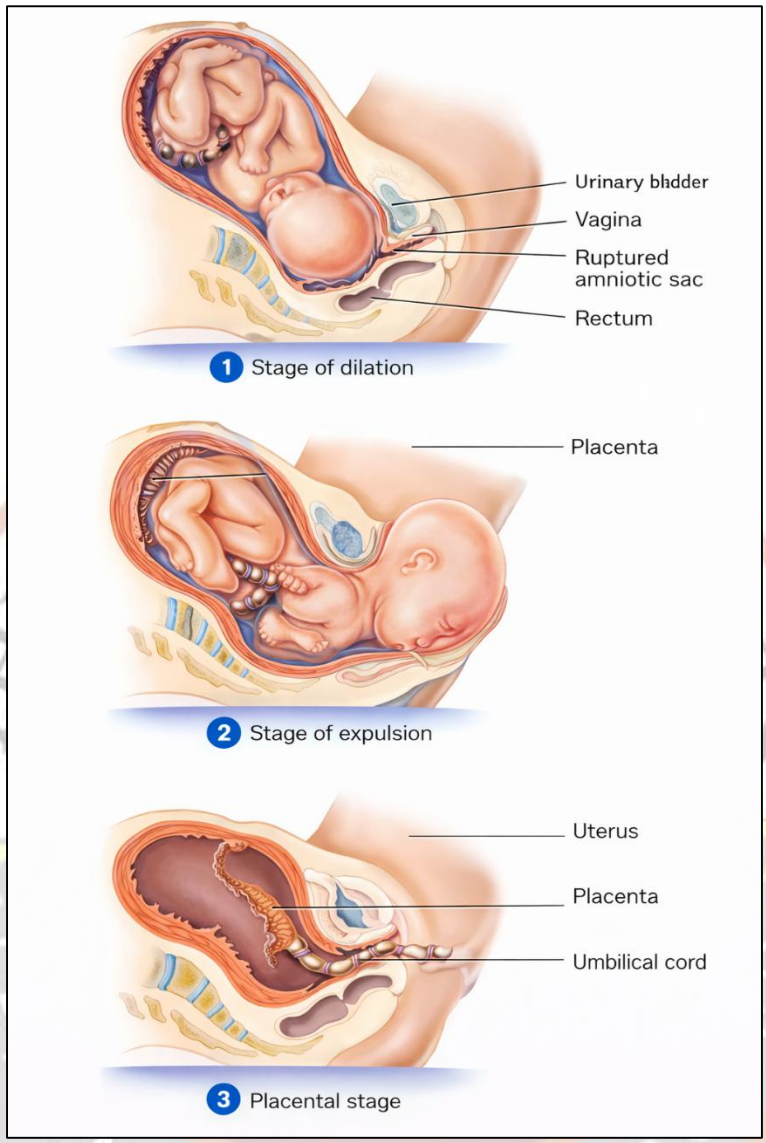
Placental Stage

- Expulsion of placenta
- Lasts 5–30 minutes
- Uterine contractions reduce hemorrhage

Labor duration:

- First child birth → ~14 hours
- Subsequent child birth → ~8 hours




Urinary bladder
Vagina
Ruptured amniotic sac
Rectum
1 Stage of dilation
Placenta
2 Stage of expulsion
Uterus
Placenta
Umbilical cord
3 Placental stage