Unit 24 · Reproductive System

STUDY NOTES

WHAT NEB'S GRADE 12 EXAM ASKS

- **CDC's grid (2078):** Human Biology (Units 17–24 together): 16 of 75 marks; 4 MCQs (knowledge, understanding, application, higher ability), 1 short question (4 marks: knowledge 1, application 2, higher ability 1) and 1 long question (8 marks: understanding 2, application 2, higher ability 4)
- **The paper:** Botany 37 + Zoology 38; each part: MCQs × 1 (5 Botany, 6 Zoology) · 4 short × 4 · 2 long × 8; one OR in each short and long group; 3 hours; 1 mark per expected point
- **CDC's model paper:** MCQ on the corpus luteum (with Unit 23)
- **Our model papers:** Paper 2 MCQ (fertilization in the ampulla) and long question (LH in ovulation and after; the day of ovulation from the cycle length, 14 days before the next period; why menstruation starts without fertilization and stops in pregnancy); Paper 3 MCQ (after a vasectomy: semen with no sperms)
- **MCQ (1 mark)**
  - primary male sex organ, and the one making the hormone: testes
  - unit of the testis: seminiferous tubule; of the ovary: ovarian follicle
  - most of semen: seminal vesicles; urinogenital organ: male urethra
  - homologous to the scrotum: labia majora
  - no menstrual cycle: lemur
  - ovulation at the end of the proliferative phase
  - ovarian hormones of the cycle: estrogen, progesterone; endometrium in the uterus
- **Short and long (in parts)**
  - label the male organs (A–F) and the uterus from the front (A–G), with functions
  - ovarian cycle; menstrual cycle; ovaries; male accessory glands
  - draw a transverse section of the testis
  - male organs (long); the reproductive cycles of a woman (long)

Key terms

Oogamous: sperm tiny, swimming; egg large, food-filled, still.

Viviparous: young grow inside the mother, born alive; fertilization **internal**.

Unisexual (dioecious): male or female, not both.

Sexual dimorphism: bodies differ beyond the sex organs (**secondary sexual characters**, from **puberty**).

Primary sex organs: the **gonads** (testes, ovaries): gametes + hormones.

Secondary (accessory) sex organs: ducts and external parts carrying gametes or baby.

Accessory sex glands: secretions help gametes or baby.

Urinogenital system: urinary + reproductive organs.

Puberty: becoming sexually mature; **adolescence**: puberty to adulthood.

Menarche (~10–14 y) / **menopause** (~45–55 y, ~50).

Sexual reproduction

- humans reproduce only **sexually**; **anisogamous** → **oogamous**
- **copulation**: **semen** into the **vagina**; sperms swim to the egg in a fallopian tube
- two linked monthly cycles: **ovarian** and **menstrual (uterine)**

Feature	Male	Female
face	hair, mustache, beard	little or none
neck	**Adam's apple**	small
shoulders / hips	broad / narrow	narrower / **broad** (childbirth)
voice	low	high
breasts	—	develop
muscle, fat	more muscle	more fat (hips, thighs, breasts)

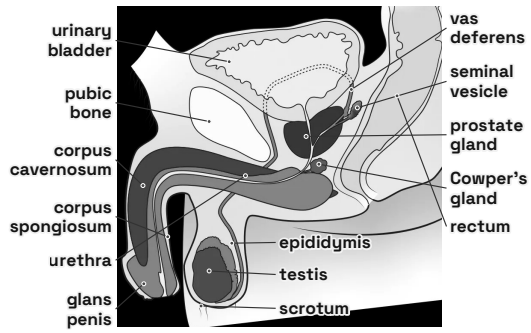
- voice breaks: **testosterone** → larynx, vocal cords grow fast; longer, heavier cords vibrate slower

	Male	Female
primary	testes	ovaries
secondary	epididymis, vas deferens, urethra, penis, scrotum	fallopian tubes, uterus, cervix, vagina, vulva (vestibule, clitoris, labia minora, labia majora, mons pubis)
accessory glands	**seminal vesicles**, **prostate**, **Cowper's**	**Bartholin's**, **Skene's**, **mammary**

- **external genitalia**: penis, scrotum; **vulva**
- all sex glands internal except the **mammary glands**

Male organs

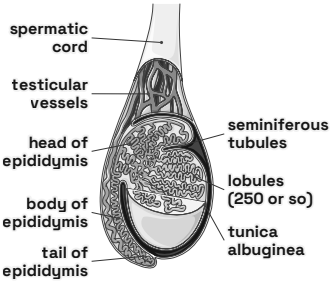
- sperm path: seminiferous tubule → **rete testis** → **vasa efferentia** → **epididymis** → **vas deferens** → **ejaculatory duct** → **urethra** → out



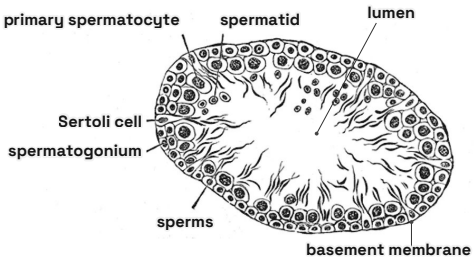
The male organs from the left side.

Testes

- make **sperms** and **testosterone**; in the **scrotum**, outside the abdomen
- oval, 4–5 × 2.5–3 × 2–3 cm, 15–20 g; often the left lower
- coverings: **tunica vaginalis** (outer, double sac) · **tunica albuginea** (tough, white; septa → **~250 lobules**) · **tunica vasculosa** (vessels)
- each lobule: **1–4** coiled **seminiferous tubules** (≤ 80 cm)
- between tubules: interstitial tissue, vessels, **Leydig cells** → **testosterone**
- germinal epithelium:
  - **spermatogonia** on the basement membrane: mitosis, meiosis → sperms (Unit 15); later stages toward the lumen
  - **Sertoli** (sustentacular) cells: tall; **nourish** sperms, blood–testis barrier, **inhibin** (slows FSH)
- tubules → rete testis → 10–20 vasa efferentia → epididymis



A testis cut lengthwise, with the epididymis.



A seminiferous tubule cut across (transverse section).

Epididymis: on the **back** of each testis; one tube ~6 m coiled into ~5 cm; from the **Wolffian duct**

- **caput** (head; vasa efferentia enter) · **corpus** · **cauda** (tail → vas deferens)
- ~2 weeks: sperms **mature** (swim, fertilize); tail **stores**
- **spermatic cord**: through the **inguinal canal**; vas deferens, testicular artery, veins, nerves, lymph, cremaster
- removal of a testis: **orchidectomy**; both: **castration**

Vas deferens: muscular, 30–45 cm; tail of epididymis → spermatic cord → inguinal canal → over the **ureter** → behind the **bladder** (ampulla) + seminal vesicle duct = **ejaculatory duct** → through the prostate → urethra

- **vasectomy**: each cut and tied → semen with **no sperms**; testes still make sperms, testosterone

Accessory glands (semen: <5% sperms)

Gland	Number, place	Fluid
seminal vesicles	pair, behind the bladder; coiled pouch ~5 cm	**65–75%** of semen; alkaline (pH ~7.2–7.8); **fructose** (fuel), prostaglandins, clotting protein
prostate	single, walnut, round the urethra below the bladder	**25–30%**; milky, **slightly acidic** (~6.5, citric acid); zinc, **PSA** liquefies the clot in 15–30 min
Cowper's (bulbourethral)	pair, pea-sized, below the prostate	drops of **alkaline** mucus: neutralize urine's acid, **lubricate**

- "uterus masculinus" = **prostatic utricle**, not the seminal vesicle
- **BPH** (men > 50): non-cancerous enlargement squeezes the urethra; **prostatitis**: inflammation

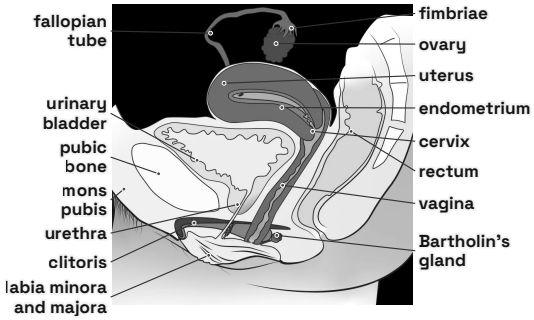
Urethra: 18–20 cm; prostatic · membranous · spongy (penile); **urethral orifice**; urine and semen: **urinogenital duct**

Penis: organ of copulation; erectile tissue: two **corpora cavernosa** (top), one **corpus spongiosum** (round the urethra) → **glans penis**; **prepuce** (foreskin)

- erection: arteries widen, spaces fill, veins squeezed shut

Scrotum: skin and muscle; **scrotal septum** → two compartments; **inguinal canals**; **gubernaculum** guided the testis down (now a ligament)

Female organs

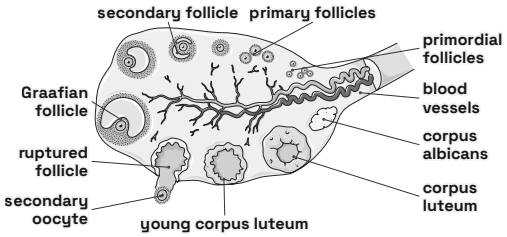


The female organs from the left side.

Ovaries

- make **eggs**; **estrogens**, **progesterone**; beside the uterus on the pelvic wall
- almond, 3–4 × 2 × 1 cm, a few grams; **hilum**

- held by **mesovarium** (broad ligament), **ovarian ligament** (to uterus), **suspensory ligament** (to pelvis)
- solid; **not joined** to its tube
- **germinal epithelium** (cuboidal; eggs don't come from it) · **stroma**: **cortex** (follicles) and **medulla** (vessels)
- follicles: **primordial** (one flat layer) → **primary** (cuboidal) → **secondary** (fluid space) → **Graafian**
- 1–2 million at birth, ~400,000 at puberty, ~400 ovulated; rest **atresia**



An ovary, with one follicle's stages laid round it in order.

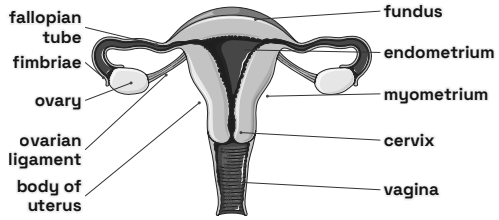
- **Graafian follicle** (~2 cm):
  - **theca externa** (fibrous), **theca interna** (glandular)
  - **membrana granulosa**
  - **antrum** with **liquor folliculi**
  - **cumulus oophorus** (discus proligerus)
  - **zona pellucida**, **corona radiata** round the oocyte
- theca and granulosa → **estrogens**
- before ovulation: primary oocyte → **secondary oocyte** + polar body
- after: **corpus haemorrhagicum** → **corpus luteum** (progesterone, some estrogen) → **corpus albicans**

Fallopian tubes (uterine tubes, oviducts): pair, 10–12 cm

- **infundibulum** (**ostium**, **fimbriae** catch the egg) · **ampulla** (**fertilization**) · **isthmus** · **intramural** part
- **ciliated columnar epithelium**; cilia + muscle waves move the egg
- zygote → morula in the uterus after 3–4 days → **blastocyst** → implants ~6–7 days after fertilization
- **ectopic pregnancy**: implants in the tube; may burst (~2nd month)

Uterus (womb): hollow, muscular, upside-down pear; above, behind the bladder

- ~7.5 × 5 × 2.5 cm; grows to hold a 3 kg baby, placenta, ~1 L fluid
- **fundus** · **body** · **cervix**
- wall: **perimetrium** (serous) · **myometrium** (smooth muscle, birth) · **endometrium** (vessels, glands; built and shed each cycle; **implantation**)



Uterus, tubes and ovaries from the front.

Cervix: 2.5–3 cm; **internal os**, **external os**; mucus thick (plug) most of the month, thin around ovulation; cervical cancer preventable

Vagina: elastic, muscular, 8–10 cm

- **non-keratinized stratified squamous epithelium**, **no glands**
- glycogen → *Lactobacillus* → **lactic acid**, pH ~3.8–4.5
- receives semen; **birth canal**; **vaginal orifice**

Vulva

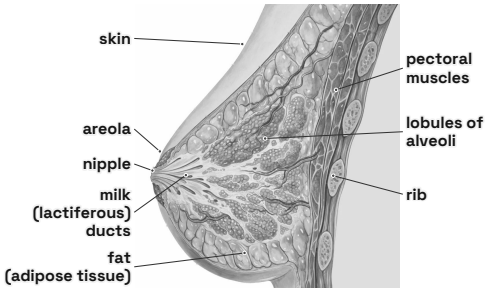
- **vestibule**: between labia minora; urethra and vagina open into it
- **clitoris**: erectile, front of the vestibule; no urethra; **glans clitoridis**, **prepuce**
- **urethral orifice** behind it, then **vaginal orifice** (**hymen**: varies, tells nothing about sex; WHO: "virginity testing" unscientific); **perineum**, **anus**
- **labia minora**: thin, no fat or hair
- **labia majora**: thick, fat, hair outside
- **mons pubis**: fat pad over the pubic bone

Homologous organs

Female	Male
ovary	testis
clitoris	penis
prepuce of clitoris	prepuce of penis
labia majora	scrotum
Skene's glands (paraurethral)	prostate
Bartholin's glands (greater vestibular; lubricate)	Cowper's glands

Mammary glands: pair, modified **sweat glands**; secondary sexual character

- 15–20 **lobes** → **lobules** → **alveoli** (make, store milk) → **lactiferous ducts** → **nipple**; **areola**
- size from **fat**, not gland
- develop under **estrogens**, **progesterone**; **prolactin** makes milk, **oxytocin** lets it down
- **colostrum**: first days; protein, **antibodies** (IgA)



A breast cut through from the side.

Ovarian cycle

- **~28 days**, menarche to menopause; ovarian and menstrual cycles together
- **FSH**: follicles grow · **LH**: ovulation, keeps the corpus luteum · **estrogens**: build the lining · **progesterone**: lining ready for an embryo
- moderate estrogen, progesterone **hold back** FSH, LH; high estrogen ~2 days → **LH surge**
- either ovary, not strictly in turns

Phase	Days	What happens
follicular (pre-ovulatory, estrogenic)	1–13	FSH rises; follicles grow; one **dominant** → Graafian; rest **atretic**; **estrogens** rise
ovulation	~14	**LH surge**; ~10–12 h after its peak, enzymes break the wall → **secondary oocyte** (zona, corona) released
luteal (post-ovulatory, progestational)	15–28	corpus haemorrhagicum (~3 days) → **corpus luteum** (**lutein**; granulosa and theca lutein cells): **progesterone**

- ovulation **~14 days before the next period**, whatever the cycle length (35-day cycle → day 21)
- none in pregnancy; often held back by breastfeeding, not reliably
- trigger is the **LH surge**, not osmotic bursting; corpus luteum kept by **LH** (hCG), not prolactin
- **not fertilized**: corpus luteum lasts **10–14 days**; LH falls → **corpus albicans** → progesterone, estrogen fall → **menstruation**; FSH rises → next cycle
- **fertilized**: embryo's **hCG** keeps the corpus luteum (pregnancy) 2–3 months until the **placenta** takes over; pregnancy tests find hCG in urine

Menstrual cycle

- first day of one period to the next; ~28 days (21–35 normal)

Phase	Days	Hormone	Endometrium
menstrual	1–5	**progesterone, estrogen fall**	**spiral arteries** spasm → ischemia → necrosis; **stratum compactum + spongiosum** (functional layer) shed; **basale** stays
regenerative	4–6	—	stratum basale rebuilds the surface from gland ends
proliferative (follicular, estrogenic)	6–14	**estrogens**	1 → 3–5 mm; glands straight, no secretion; ends with **ovulation**
secretory (luteal, progestational)	15–28	**progesterone**	5–7 mm; glands coiled, **secrete glycogen**; spiral arteries coil; embryo implants ~day 20–21

- flow: blood, tissue, mucus; **30–40 mL** a period ($\leq$ 80 normal); fibrin dissolved, so no clots
- **amenorrhea** (none) · **menorrhagia** (heavy) · **oligomenorrhea** (rare, > 35 d) · **polymenorrhea** (often, < 21 d) · **dysmenorrhea** (painful)
- **chhaupadi** is a crime in Nepal
- **menstrual** cycle: humans, apes, Old World monkeys; others (and **lemurs**): **oestrous** cycle

Why menstruation (paper question)

- not fertilized: no hCG → corpus luteum dies → progesterone falls → spiral arteries spasm → lining shed
- pregnant: **hCG** keeps the corpus luteum → progesterone stays → lining kept; then the placenta

COMMON MISTAKES

✗ The seminal vesicle is the uterus masculinus
✓ that is the **prostatic utricle**.

✗ The prostate's fluid is alkaline
✓ it is **slightly acidic** (~6.5); the seminal vesicles' and Cowper's are alkaline.

✗ Most of semen is sperms
✓ under **5%**; two-thirds is the **seminal vesicles'** fluid.

✗ A vasectomy stops testosterone
✓ testes still work; semen just lacks **sperms**.

✗ The egg comes from the germinal epithelium
✓ from **germ cells** that moved in during the embryo.

✗ Fertilization happens in the uterus
✓ in the **ampulla** of the fallopian tube.

✗ The follicle bursts from osmotic pressure
✓ the **LH surge** sets off enzymes that weaken its wall.

✗ Prolactin (LTH) keeps the corpus luteum
✓ **LH**, and in pregnancy **hCG**.

✗ Ovulation is always on day 14
✓ **14 days before the next period**.

✗ About 180 mL of blood is lost
✓ **30–40 mL** in a whole period.

✗ The stratum basale is shed
✓ it **stays** and rebuilds the lining.