Human Reproduction Class 12 Notes

The Ultimate 12th NCERT Revision Guide for Class 12 Biology (2026–27 / New NCERT)

Full-colour diagrams, formula boxes, NEET-ready summary tables

Chapter 2: Human Reproduction

Also see for this chapter: NCERT Solutions | Formula Sheet | Exemplar Solutions

How to use these notes

This chapter is best learned event by event: **male anatomy** → **female anatomy** → **gametogenesis** → **menstrual cycle** → **fertilisation** → **implantation** → **pregnancy** → **parturition** → **lactation**. Every NCERT figure cited in prose is reproduced from the source book, with extra TikZ diagrams to make hormone flows and process timelines visual. Revisit each **Quick Tip**, **Common Mistake** and **Memory Aid** box just before the exam — they cover the highest-yield NEET and CBSE traps.

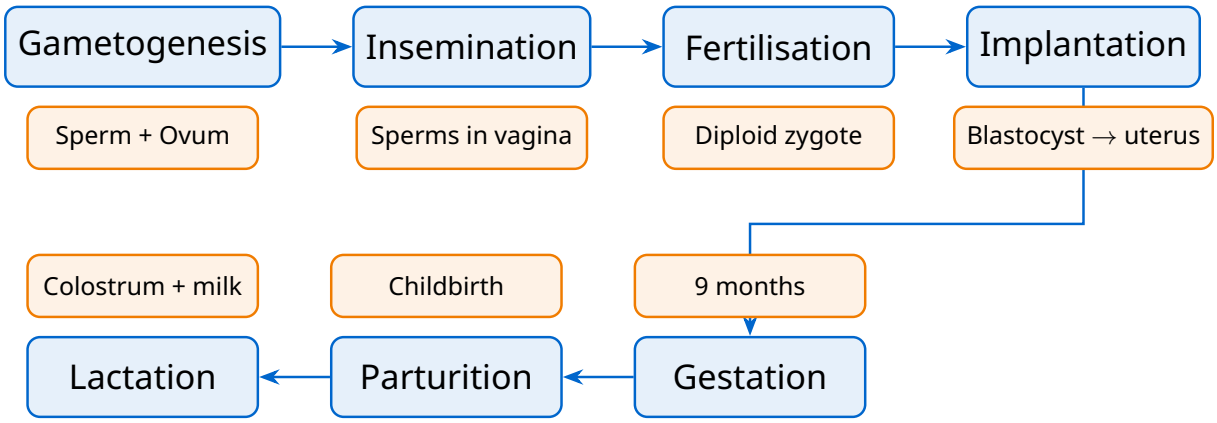
Contents

1 Reproductive Events in Humans: Overview

Humans are **sexually reproducing** and **viviparous** mammals. The reproductive cycle in adults runs through a fixed sequence of events that you must be able to name and order:

1. **Gametogenesis** — formation of sperms in males (spermatogenesis) and ova in females (oogenesis).
2. **Insemination** — transfer of sperms into the female genital tract during copulation.
3. **Fertilisation** — fusion of male and female gametes, producing a diploid zygote.
4. **Implantation** — formation of the blastocyst and its attachment to the uterine wall.
5. **Gestation** — embryonic and foetal development inside the uterus (about 9 months in humans).
6. **Parturition** — delivery of the foetus (childbirth).
7. **Lactation** — secretion of milk to feed the new-born.

All these events begin at **puberty**. One key male–female asymmetry: sperm formation continues into old age, but ovum formation ceases at **menopause** (around 50 years).



The seven-event roadmap

G-I-F-I-G-P-L — *Gametogenesis, Insemination, Fertilisation, Implantation, Gestation, Parturition, Lactation*. Every NCERT or NEET question on "order the steps of human reproduction" is a permutation of these seven words.

Seven events of reproduction

"**Good Indians Find Indian Girls Pretty Lovely**"
Gametogenesis → **I**nsemination → **F**ertilisation → **I**mplantation → **G**estation → **P**arturition → **L**actation.

2 The Male Reproductive System

The male reproductive system is located in the **pelvic region**. It has three parts:

- A pair of **testes** (primary sex organs).
- **Accessory ducts**: rete testis, vasa efferentia, epididymis, vas deferens, ejaculatory duct, urethra.
- **Accessory glands**: a pair of seminal vesicles, a single prostate, a pair of bulbourethral (Cowper's) glands.
- External genitalia: the **penis**.

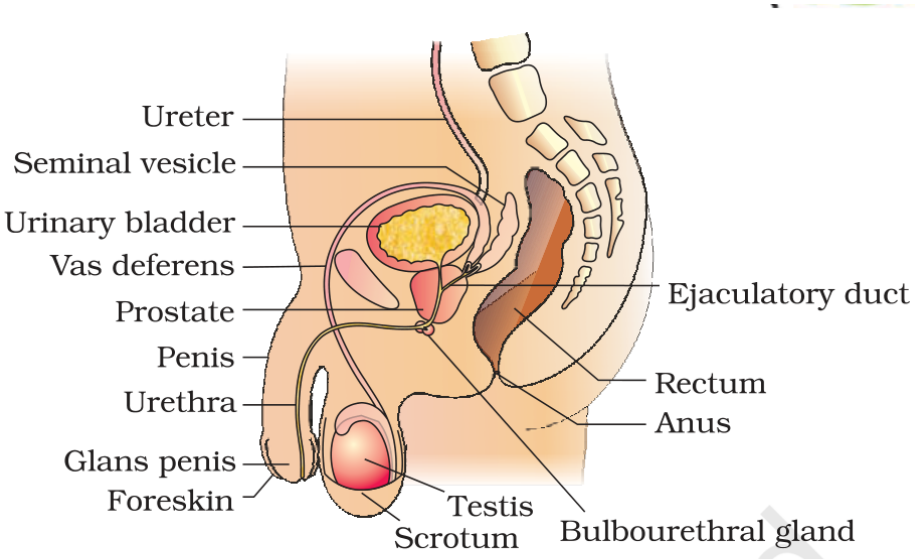


Figure 2.1(a) Diagrammatic sectional view of male pelvis showing reproductive system

Source: NCERT Class 12 Biology, Chapter 2 — Fig. 2.1(a): Diagrammatic sectional view of the male pelvis showing reproductive system.

2.1 The Testes and Scrotum

The testes sit *outside* the abdominal cavity in a pouch of skin called the **scrotum**. This is not an accident: spermatogenesis needs a temperature about **2–2.5 °C lower than core body temperature**, and the scrotum provides that cooler microenvironment.

Each testis is oval, 4–5 cm long $\times$ 2–3 cm wide, covered by a dense fibrous capsule. Inside, each testis is divided into about **250 testicular lobules**. Each lobule contains **1–3 highly coiled seminiferous tubules** in which sperms are produced.

Testis at a glance

Location: Outside abdomen, in scrotum (cooler by 2–2.5 °C).
Dimensions: 4–5 cm long $\times$ 2–3 cm wide.
Compartments per testis: $\sim$250 testicular lobules.
Per lobule: 1–3 seminiferous tubules.
Function: Spermatogenesis + androgen secretion.

Quick Tip

NEET examiners love asking "why are testes located outside the body?" — the one-line answer is "**to maintain the low temperature (2–2.5 °C below body temperature) needed for spermatogenesis**." Memorise that number.

2.2 Seminiferous Tubule: Germ Cells and Sertoli Cells

Each seminiferous tubule has two distinct cell types on its inner wall:

- **Male germ cells (spermatogonia)** — diploid cells that undergo meiosis to form sperms.
- **Sertoli cells** — tall "nurse cells" that provide nutrition to the dividing germ cells.

Outside the seminiferous tubules lie the **interstitial spaces**, which contain small blood vessels and **interstitial cells (Leydig cells)**. The Leydig cells synthesise and secrete **androgens** (testosterone is the principal one). Immunologically competent cells are also present here.

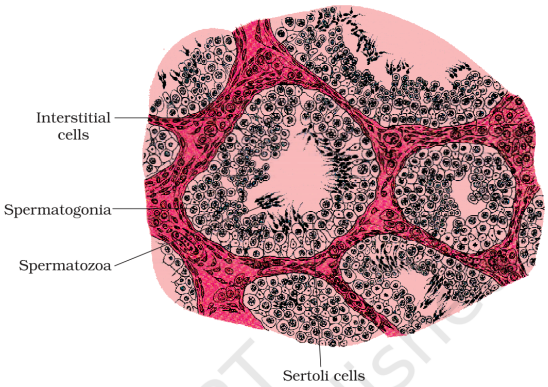


Figure 2.2 Diagrammatic sectional view of seminiferous tubule

Source: NCERT Class 12 Biology, Chapter 2 — Fig. 2.2: Diagrammatic sectional view of a seminiferous tubule showing spermatogonia and spermatozoa arranged within the wall, Sertoli cells inside, and interstitial (Leydig) cells in the spaces between adjacent tubules.

Two compartments, two jobs

Inside the seminiferous tubule: sperm production.
Outside the tubule (interstitial space): hormone production by Leydig cells.
The tubule is the *factory floor*; the interstitium is the *endocrine office* next door.

Common Mistake

Sertoli cells do NOT produce androgens. Androgens come from the **Leydig (interstitial) cells** *outside* the tubule. Sertoli cells provide nutrition and respond to FSH; Leydig cells respond to LH. Mixing this up costs a NEET mark

almost every year.

2.3 Male Accessory Ducts

Sperms produced in the seminiferous tubules travel through a fixed pipeline before being ejaculated. Track the order:

Seminiferous tubules → Rete testis → Vasa efferentia → Epididymis → Vas deferens → Ejaculatory duct → Urethra → Urethral meatus.

- The **vasa efferentia** leave the testis and open into the **epididymis**, located along the posterior surface of each testis.
- The epididymis leads to the **vas deferens**, which ascends to the abdomen and loops over the urinary bladder.
- The 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, the **urethral meatus**.

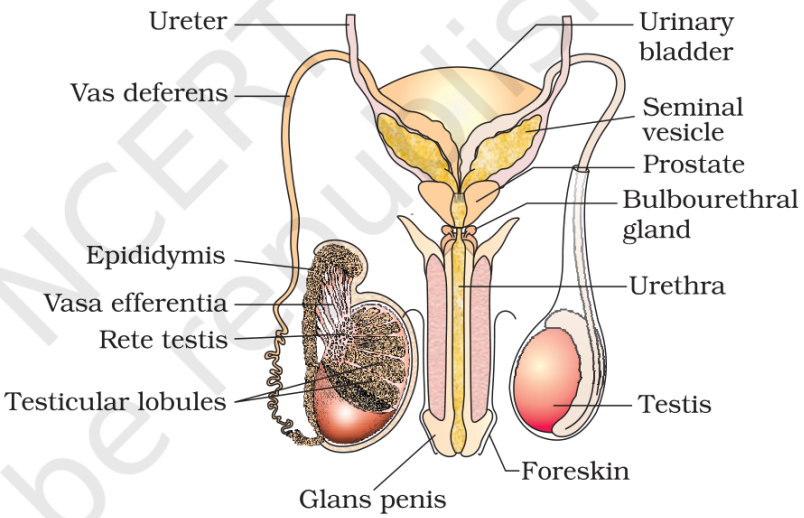
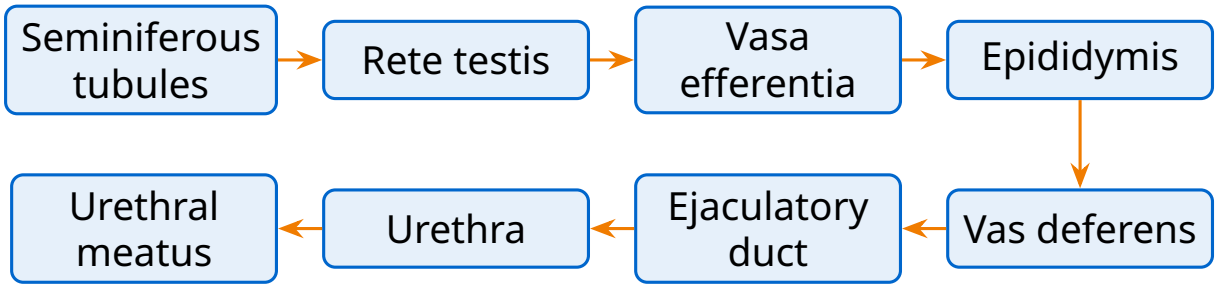


Figure 2.1(b) Diagrammatic view of male reproductive system (part of testis is open to show inner details)

Source: NCERT Class 12 Biology, Chapter 2 — Fig. 2.1(b): Diagrammatic view of male reproductive system (part of testis is open to show inner details), showing the full pipeline from seminiferous tubules to the urethra.



Sperm pipeline

"**Strange Rats Visit Every Vendor's Ejector Until Midnight**"
Seminiferous → **R**ete testis → **V**asa efferentia → **E**pididymis → **V**as deferens → **E**jaculatory duct → **U**rethra → **M**eatus.

2.4 Penis and External Genitalia

The **penis** is the male external genitalia. It is composed of erectile (spongy) tissue that fills with blood to allow erection and facilitate **insemination**. The enlarged tip is the **glans penis**, covered by a loose fold of skin called the **foreskin (prepuce)**.

2.5 Male Accessory Glands

Three sets of glands secrete the fluid component of semen:

- **Seminal vesicles** (paired) — contribute the bulk of the fluid; rich in fructose (energy for sperms).
- **Prostate gland** (single) — adds enzymes and calcium ions.
- **Bulbourethral glands / Cowper's glands** (paired) — secrete a lubricating mucus that aids penile lubrication during coitus.

Their combined secretion is the **seminal plasma**, which is rich in **fructose, calcium and certain enzymes**. The seminal plasma + sperms together constitute **semen**.

Composition of seminal plasma

Fructose — main energy source for sperm motility (from seminal vesicles).
Calcium ions — aid sperm motility and the acrosome reaction.
Enzymes — liquefy the ejaculate and assist fertilisation.
Lubricating mucus — from bulbourethral glands.

Quick Tip

"Seminal vesicle" is a *gland*, not a duct or storage sac — a frequent NEET distractor. Sperms are stored mainly in the **epididymis** and **vas deferens**, not in the seminal vesicle.

Solve the NCERT Exercises for Human Reproduction

3 The Female Reproductive System

The female reproductive system is located in the pelvic region and consists of:

- A pair of **ovaries** (primary sex organs).
- A pair of **oviducts (fallopian tubes)**, a single **uterus**, a **cervix** and the **vagina**.
- The **external genitalia**.
- A pair of **mammary glands** (secondary sexual structure).

These structures jointly support **ovulation, fertilisation, pregnancy, birth** and **child care**.

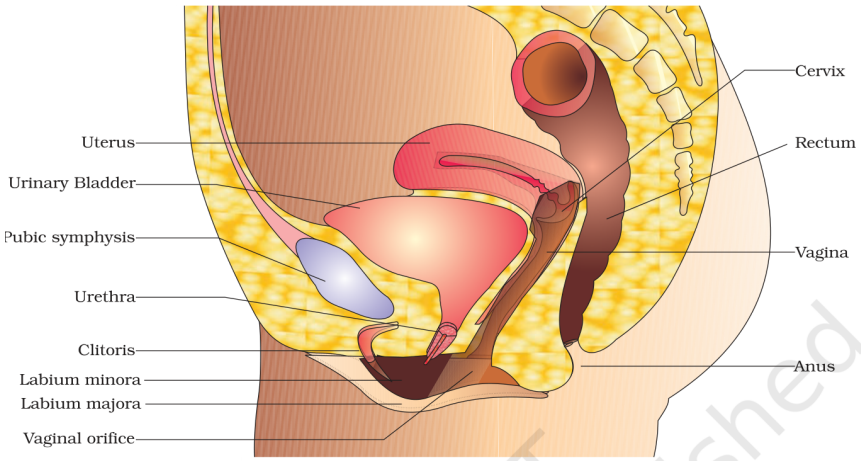


Figure 2.3 (a) Diagrammatic sectional view of female pelvis showing reproductive system

Source: NCERT Class 12 Biology, Chapter 2 — Fig. 2.3(a): Diagrammatic sectional view of female pelvis showing reproductive system.

3.1 The Ovaries

Ovaries are the **primary female sex organs**. Functions:

1. Produce the **female gamete (ovum)** by oogenesis.
2. Secrete **ovarian (steroid) hormones** — mainly estrogen and progesterone.

Each ovary is 2–4 cm long, located one on either side of the lower abdomen, and connected to the pelvic wall and uterus by ligaments. The ovary is covered by a thin epithelium enclosing the **ovarian stroma**. The stroma is divided into:

- a peripheral **cortex** (where follicles develop);
- an inner **medulla** (vascular core).

3.2 Oviducts, Uterus, Cervix and Vagina

The **oviducts (fallopian tubes), uterus** and **vagina** constitute the female accessory ducts.

Fallopian tube — 10–12 cm long, extends from the periphery of the ovary to the uterus. From ovary towards uterus, the tube has four parts:

1. **Infundibulum** — funnel-shaped open end nearest the ovary; bears finger-like **fimbriae** that pick up the ovulated ovum.
2. **Ampulla** — wider part; **site of fertilisation**.
3. **Isthmus** — narrow lumen.
4. Junction with the uterus.

Uterus (womb) — single, pear-shaped, supported by ligaments. The uterine wall has three layers:

- **Perimetrium** — outer, thin, membranous.
- **Myometrium** — middle, thick smooth muscle; contracts strongly during parturition.
- **Endometrium** — inner glandular layer; undergoes **cyclical changes during the menstrual cycle** and forms the implantation bed.

The uterus opens into the vagina through a narrow **cervix**. The cavity of the cervix is the **cervical canal**, which along with the vagina forms the **birth canal**.

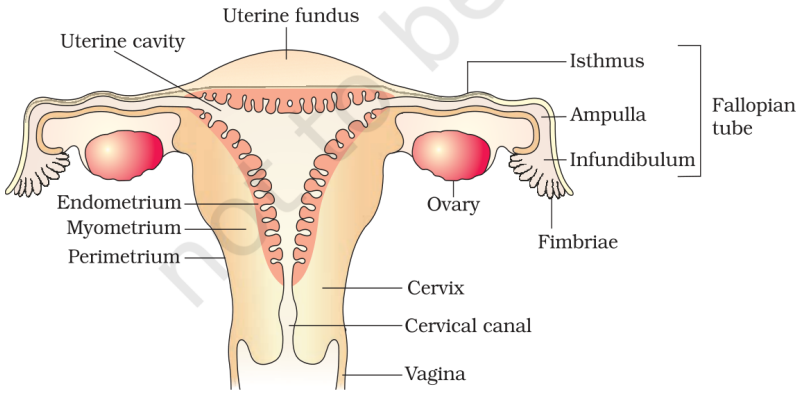


Figure 2.3 (b) Diagrammatic sectional view of the female reproductive system

Source: NCERT Class 12 Biology, Chapter 2 — Fig. 2.3(b): Diagrammatic sectional view of the female reproductive system showing ovary, fallopian tube parts (infundibulum, ampulla, isthmus), uterus with its three layers (perimetrium, myometrium, endometrium), cervix and vagina.

Three layers of the uterus

Perimetrium — outer thin serosa.
Myometrium — middle smooth muscle (parturition contractions).

Endometrium — inner glandular lining (menstrual cycle changes, implantation).

Uterine wall layers — outside in

"**PME**" — **P**erimetrium → **M**yometrium → **E**ndometrium.
Same order as outside-to-inside: think of an envelope (peri), the muscle (myo), then the lining where the embryo sticks (endo).

3.3 External Genitalia

The female external genitalia (vulva) includes:

- **Mons pubis** — cushion of fatty tissue covered by skin and pubic hair.
- **Labia majora** — fleshy folds extending down from mons pubis, surrounding the vaginal opening.
- **Labia minora** — paired folds beneath the labia majora.
- **Hymen** — a membrane partially covering the vaginal opening in many women.
- **Clitoris** — a tiny finger-like erectile structure at the upper junction of the labia minora, above the urethral opening.

Hymen is not a marker of virginity

The hymen is often torn during the first coitus, but it can also rupture by a sudden fall or jolt, insertion of a vaginal tampon, or active participation in sports like horseback riding or cycling. In some women the hymen persists even after coitus. **The presence or absence of the hymen is therefore NOT a reliable indicator of virginity or sexual experience** — this is an explicit NCERT statement and is asked in CBSE assertion-reason questions.

3.4 Mammary Glands

A functional pair of **mammary glands** is characteristic of all female mammals. Each breast contains glandular tissue and variable amounts of fat. The glandular tissue is divided into **15–20 mammary lobes**, each containing clusters of cells called **alveoli**.

Milk path: *Alveoli (secrete milk into the lumen)* → *mammary tubules* → *mammary duct* → *mammary ampulla* → *lactiferous duct* → *nipple.*

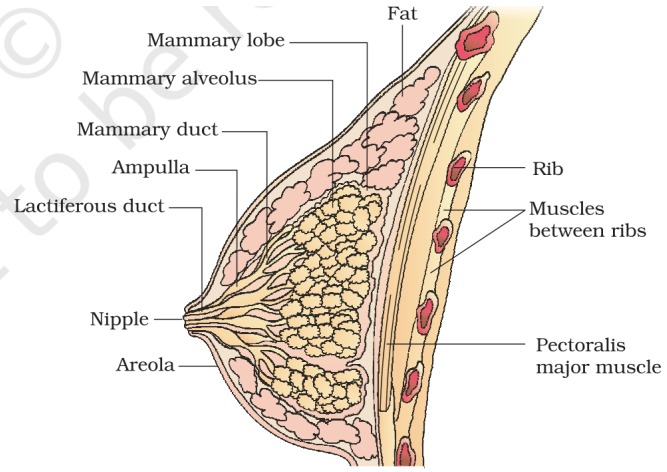


Figure 2.4 A diagrammatic sectional view of Mammary gland

Source: NCERT Class 12 Biology, Chapter 2 — Fig. 2.4: Diagrammatic sectional view of mammary gland showing mammary lobe, alveolus, mammary duct, ampulla, lactiferous duct, nipple and areola, with surrounding fat, ribs and pectoralis major muscle.

Milk pathway in the breast

Alveoli → Mammary tubules → Mammary duct → Mammary ampulla → Lactiferous duct → Nipple.

Quick Tip

NEET often tests the **number of mammary lobes per breast: 15–20**. Memorise the range, not a single number.

4 Gametogenesis

Gametogenesis is the process by which the primary sex organs produce gametes:

- **Spermatogenesis** (in testis) — produces sperms.
- **Oogenesis** (in ovary) — produces ova.

Both involve mitosis to multiply, followed by meiosis to halve the chromosome number from **diploid (46)** to **haploid (23)**.

4.1 Spermatogenesis

Site: inside wall of seminiferous tubules. **Begins:** at puberty.

Cell sequence:

1. **Spermatogonia** (diploid, 46) — multiply by mitosis.
2. Some spermatogonia become **primary spermatocytes** (diploid, 46).
3. Primary spermatocyte completes the **first meiotic (reduction) division** →

two haploid **secondary spermatocytes** (23 each).

4. Each secondary spermatocyte undergoes the **second meiotic division** → four haploid **spermatids** (23 each).
5. Spermatids transform into **spermatozoa (sperms)** by **spermiogenesis**.
6. Heads of sperms are embedded in Sertoli cells, then released into the lumen by **spermiation**.

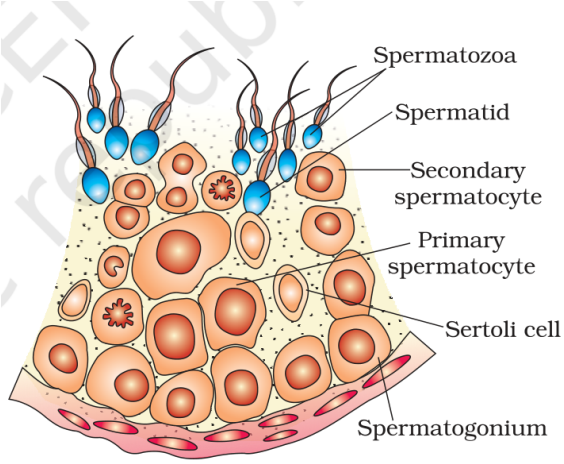


Figure 2.5 Diagrammatic sectional view of a seminiferous tubule (enlarged)

Source: NCERT Class 12 Biology, Chapter 2 — Fig. 2.5: Diagrammatic sectional view of a seminiferous tubule (enlarged) showing the cell types from spermatogonium at the base to spermatozoa at the lumen, with Sertoli cells in between.

Spermatogenesis arithmetic

1 primary spermatocyte (46) → 2 secondary spermatocytes (23 each) → 4 spermatids (23 each) → 4 sperms.
So one round of meiosis in the male gives **four functional gametes**.

Spermiogenesis vs spermiation

Spermiogenesis = morphological change of a spermatid into a streamlined motile sperm (acrosome, mitochondrial sheath, tail).
Spermiation = the release of the matured sperm from the Sertoli cell into the tubule lumen.
Both NCERT-defined terms; both have appeared as one-mark CBSE questions and as NEET distractors.

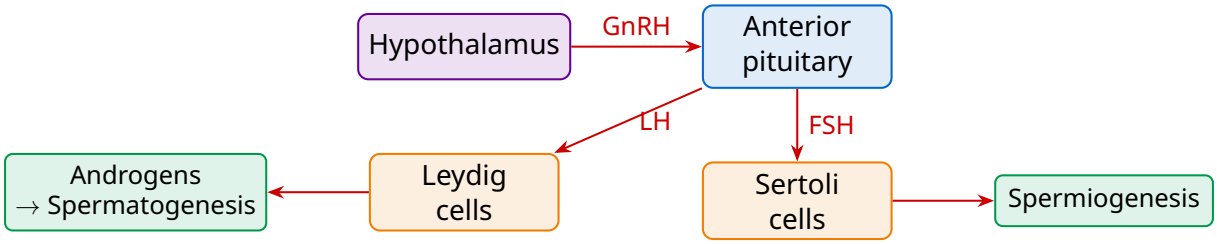
Common Mistake

Don't fuse spermiogenesis and spermiation. "Genesis" = formation of the sperm structure; "-iation" = release. "i-o" (genesis) comes *before* "i-a" (spermi-ation) alphabetically and chronologically.

Hormonal regulation of spermatogenesis

Spermatogenesis is hypothalamus–pituitary–testis controlled:

1. At puberty, the hypothalamus releases **GnRH** (gonadotropin-releasing hormone).
2. GnRH stimulates anterior pituitary → secretion of **LH (luteinising hormone)** and **FSH (follicle-stimulating hormone)**.
3. **LH** → **Leydig cells** → synthesis and secretion of androgens → androgens stimulate **spermatogenesis**.
4. **FSH** → **Sertoli cells** → secretion of factors that drive **spermiogenesis**.



Which gonadotropin acts on which cell?

"LL SF" — **L**H → **L**eydig (start with L). **F**SH → **S**ertoli (the odd one out).
Equivalent shortcut: *LH makes Lubricating-fluid-of-Life (testosterone); FSH Feeds-Sperm via Sertoli.*

Structure of a sperm

The sperm is a microscopic, motile cell with four parts: **head, neck, middle piece, tail**.

- **Head** — contains an elongated **haploid nucleus**; the anterior tip is covered by a cap-like **acrosome**, filled with enzymes that help the sperm penetrate the ovum.
- **Neck** — a short region connecting head to middle piece.
- **Middle piece** — packed with **mitochondria** that produce ATP for tail motility.
- **Tail** — a long flagellum providing motility.

The whole sperm is enveloped by a plasma membrane.

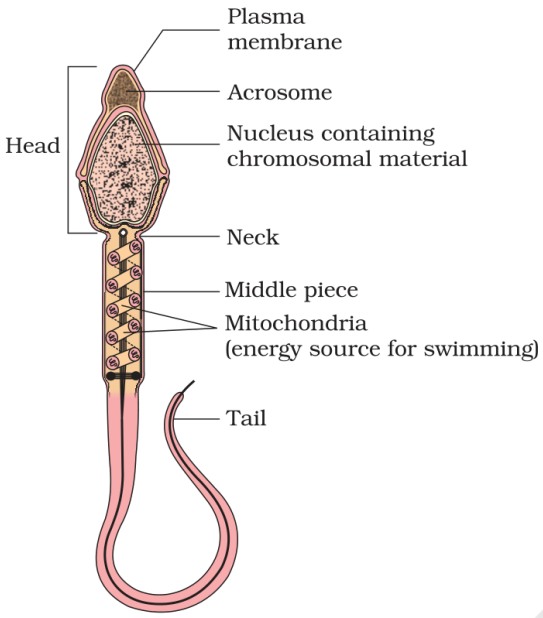


Figure 2.6 Structure of a sperm

Source: NCERT Class 12 Biology, Chapter 2 — Fig. 2.6: Structure of a sperm showing head (with plasma membrane, acrosome and nucleus containing chromosomal material), neck, middle piece (with mitochondria as energy source) and tail.

Sperm vital statistics

Ejaculate volume: contains **200–300 million sperms** per coitus.
For normal fertility: $\geq$ 60% must have normal shape and size; $\geq$ 40% must show vigorous motility.

Quick Tip

The exact NCERT-quoted numbers — **200–300 million sperms per ejaculation, 60% normal morphology, 40% motility** — are NEET favourites. Memorise the three numbers verbatim.

4.2 Oogenesis

Site: fetal ovary (initiation); adult ovary (completion). **Begins:** during embryonic development — long before birth.

Key contrasts with spermatogenesis: oogenesis (i) begins in the foetus, not at puberty, (ii) produces only **one** functional gamete per round (the rest become polar bodies), (iii) is paused for years inside the prophase-I of meiosis, and (iv) ceases at menopause.

Cell sequence:

1. During fetal life, a couple of million **oogonia** are formed in each ovary. *No more oogonia are added after birth.*
2. Oogonia enter meiosis and arrest at prophase-I as **primary oocytes**.

3. Each primary oocyte is surrounded by a single layer of granulosa cells → **primary follicle**.
4. Many primary follicles degenerate from birth to puberty; only **60,000–80,000 per ovary** survive at puberty.
5. More granulosa cell layers + a theca layer → **secondary follicle**.
6. Appearance of a fluid-filled cavity (**antrum**); theca splits into theca interna and theca externa → **tertiary follicle**.
7. Inside the tertiary follicle, the primary oocyte completes its **first meiotic division** — an unequal one — producing a large **secondary oocyte** (keeps most cytoplasm) and a tiny **first polar body**.
8. Tertiary follicle matures into a **Graafian follicle**; the secondary oocyte forms a new membrane, the **zona pellucida**.
9. Graafian follicle ruptures → release of secondary oocyte = **ovulation**.
10. Second meiotic division of the secondary oocyte is completed *only if fertilisation occurs*, producing the haploid ovum (ootid) and a second polar body.

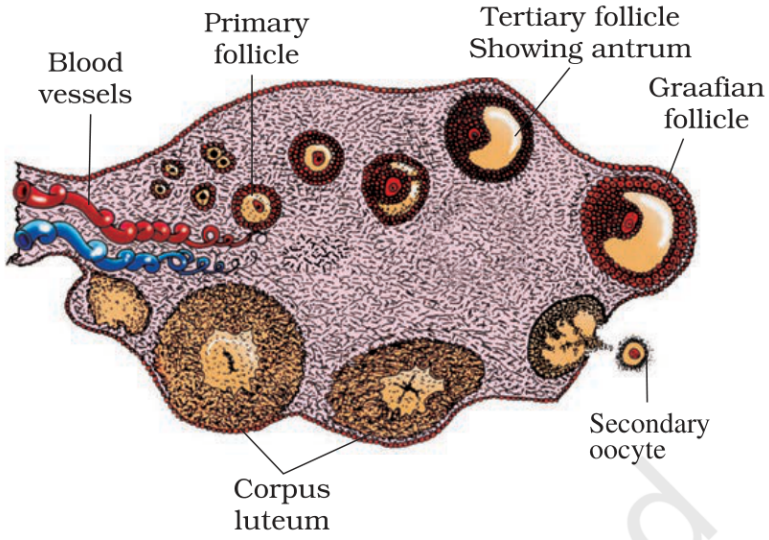


Figure 2.7 Diagrammatic Section view of ovary

Source: NCERT Class 12 Biology, Chapter 2 — Fig. 2.7: Diagrammatic section view of ovary showing primary follicle, tertiary follicle with antrum, mature Graafian follicle, the secondary oocyte released at ovulation, and the corpus luteum that forms from the remnants of the Graafian follicle.

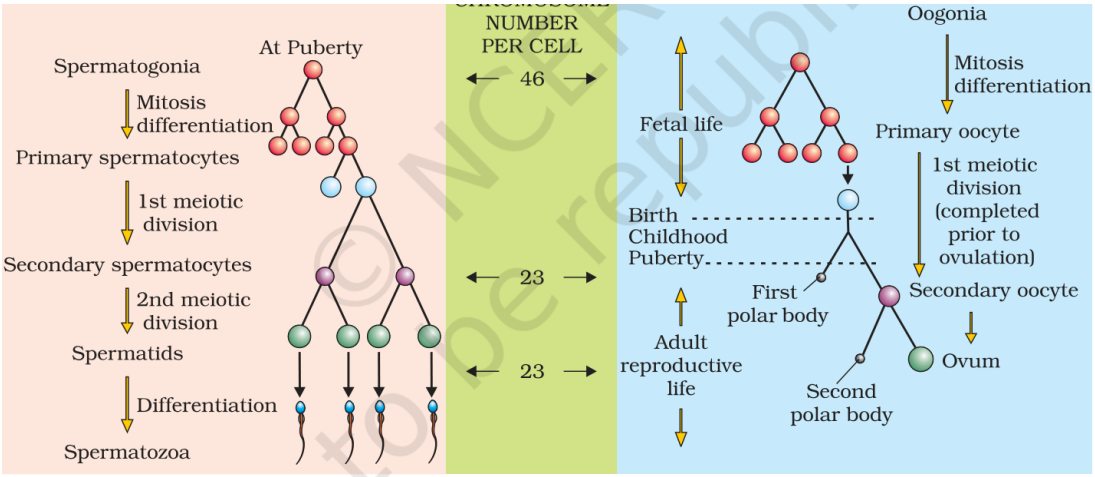


Figure 2.8 Schematic representation of (a) Spermatogenesis; (b) Oogenesis

Source: NCERT Class 12 Biology, Chapter 2 — Fig. 2.8: Schematic representation of (a) spermatogenesis and (b) oogenesis side by side. Chromosome number per cell is annotated — 46 before meiosis, 23 after.

Oogenesis arithmetic

1 primary oocyte (46) → 1 secondary oocyte (23) + 1 first polar body (23) → 1 ootid (ovum, 23) + 1 second polar body (23).
So one round of meiosis in the female gives **only one functional gamete + 2 (or 3) polar bodies**.
Polar body fate: the first polar body may divide again or degenerate (NCERT says "we are not very certain"); all polar bodies eventually degenerate.

Feature	Spermatogenesis	Oogenesis
Site	Seminiferous tubules of testis	Cortex of ovary
Begins	At puberty	In fetal life (prophase-I arrest)
Stops	Continues into old age	At menopause ($\sim$ 50 yrs)
Cells per round of meiosis	4 functional sperms	1 ovum + 2–3 polar bodies
Division equality	Equal cytokinesis	Unequal (one big oocyte)
Duration	$\sim$ 64–74 days, continuous	Decades (arrest in prophase-I)
Final cell motile?	Yes (flagellated)	No (non-motile)

Why unequal cytokinesis in oogenesis?

The female gamete must carry a large cytoplasmic store of nutrients, mitochondria and mRNAs to support early embryonic divisions before implantation. Splitting the cytoplasm equally would leave both daughter cells under-

resourced. Unequal cytokinesis dumps all the cytoplasm into one daughter cell (the secondary oocyte) and discards the genetic copy as a polar body.

Common Mistake

The secondary oocyte completes meiosis-II only AFTER a sperm fertilises it. The cell released at ovulation is the *secondary oocyte*, not a fully formed ovum. NCERT and NEET routinely trap students by asking "what is released at ovulation in humans?" — the answer is **secondary oocyte**, not ovum.

5 Menstrual Cycle

The **menstrual cycle** is the reproductive cycle in female primates (monkeys, apes and human beings).

- Begins at puberty — first menstruation = **menarche**.
- Average length: **28–29 days**.
- One ovum (secondary oocyte) is released during the middle of each cycle.
- Ends at **menopause** (around 50 years).

The cycle has **four phases**. They map onto changes in (i) pituitary hormones (LH, FSH), (ii) ovarian hormones (estrogen, progesterone), (iii) the ovary itself (follicle / corpus luteum) and (iv) the uterine endometrium.

5.1 The Four Phases

1. Menstrual phase (Days 1–5). Menstrual flow occurs due to the breakdown of the endometrial lining and its blood vessels. The blood and tissue debris exit through the vagina. *Menstruation occurs only if the released ovum is NOT fertilised.*

2. Follicular phase (Days 6–13, also called proliferative phase). Primary follicles grow into a mature **Graafian follicle**, and the endometrium of the uterus regenerates by proliferation. Pituitary secretion of **LH and FSH** rises gradually; growing follicles secrete **estrogen**.

3. Ovulatory phase (Day 14). Both LH and FSH peak; the rapid surge of LH (**LH surge**) induces **rupture of the Graafian follicle and release of the secondary oocyte**.

4. Luteal phase (Days 15–28, also called secretory phase). The remnants of the Graafian follicle transform into the **corpus luteum**, which secretes large amounts of **progesterone**. Progesterone maintains the endometrium for possible implantation. If no fertilisation occurs, the corpus luteum degenerates, progesterone falls, the endometrium disintegrates and a new menstrual phase begins.

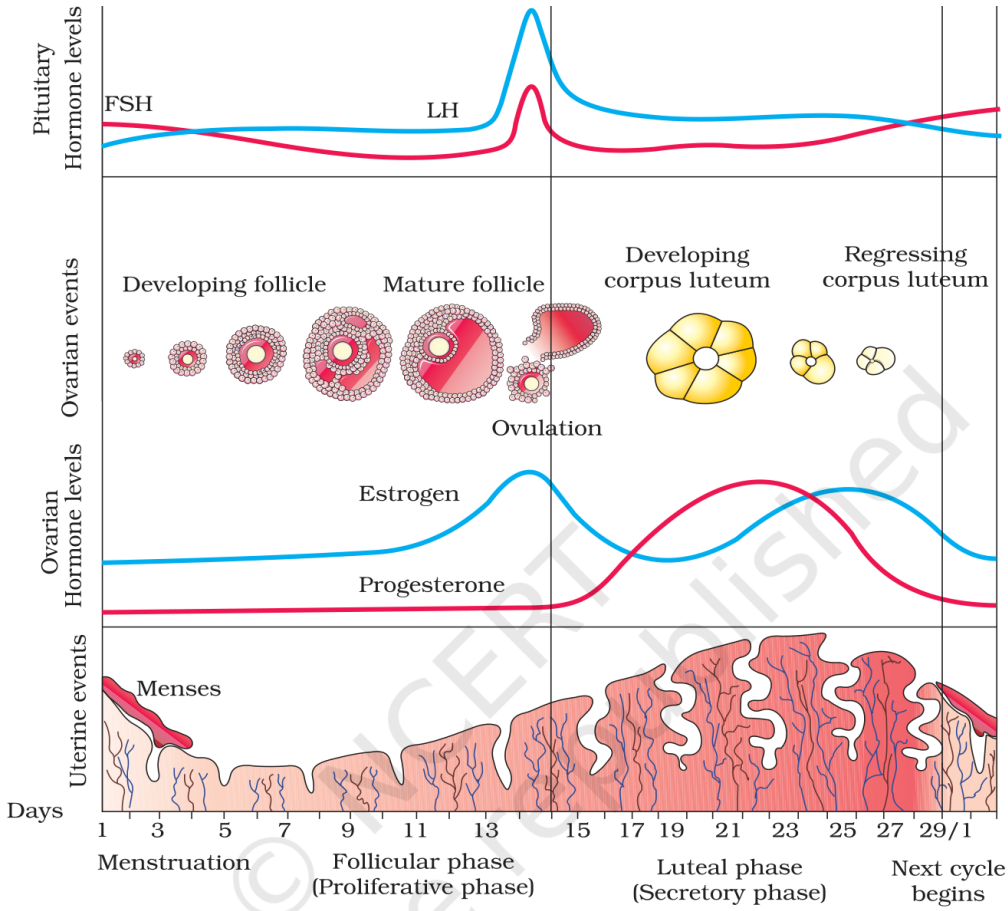
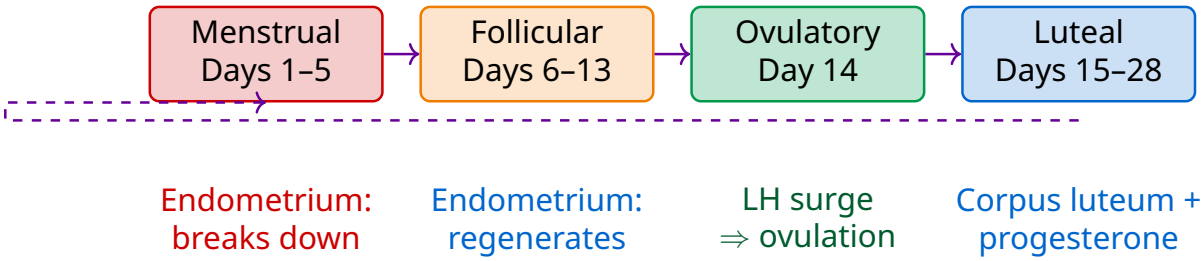


Figure 2.9 Diagrammatic presentation of various events during a menstrual cycle

Source: NCERT Class 12 Biology, Chapter 2 — Fig. 2.9: Diagrammatic presentation of various events during a menstrual cycle — pituitary hormone levels (FSH and LH peak at mid-cycle), ovarian events (follicle development, ovulation, corpus luteum, regression), ovarian hormone levels (estrogen peaks just before ovulation; progesterone dominates the luteal phase), and uterine events (menses, proliferation, secretory).



Hormones of the menstrual cycle — who peaks when?

FSH: rises during follicular phase; sharp mid-cycle peak.
LH: rises during follicular phase; **sharp "LH surge" at day 14 ⇒ ovulation**.
Estrogen: peaks just *before* ovulation; drives endometrial proliferation.
Progesterone: dominates the *luteal* phase; maintains endometrium.

Quick Tip

The **LH surge** is the single hormonal event most asked in NEET and CBSE — "what triggers ovulation?" Answer: "a sudden rapid rise in LH (LH surge) at mid-cycle that causes rupture of the Graafian follicle."

Menstruation = no pregnancy

Menstruation only occurs if the released ovum is **not fertilised**. During pregnancy, all events of the menstrual cycle stop — no menstruation. So *lack of menstruation may be indicative of pregnancy*, but it can also be caused by stress, poor health, etc.

Common Mistake

Estrogen does NOT trigger ovulation directly. The LH *surge* does. Estrogen rises first; that rise is the *signal* that prompts the pituitary to release the LH surge. NCERT prose places the surge mid-cycle, after estrogen has built up.

Real-World Application

Menstrual hygiene matters: change sanitary napkins or homemade pads every 4–5 hours; wash hands with soap after handling; never throw used napkins in toilet drainpipes or the open — wrap them in paper before disposing. The NCERT prints this exact advice as a sidebar in the chapter.

6 Fertilisation and Implantation

6.1 Fertilisation: One Sperm, One Ovum

During copulation, the penis releases semen into the vagina (**insemination**). The motile sperms swim rapidly through the cervix, enter the uterus, and reach the **ampullary region** of the fallopian tube. The ovum (technically: secondary oocyte) released by the ovary is also transported to the ampullary region.

Site of fertilisation: ampulla of the fallopian tube. Fertilisation can only happen if ovum and sperms arrive there simultaneously — which is why not every copulation leads to pregnancy.

The fertilisation steps:

1. A sperm contacts the **zona pellucida** of the ovum. This contact induces membrane changes that **block additional sperms** — so only *one* sperm fertilises one ovum.
2. **Acrosomal enzymes** digest a path through the zona pellucida and plasma membrane.

3. The sperm entry triggers the secondary oocyte to complete its **second meiotic division** (also unequal), producing a haploid ovum (ootid) and a **second polar body**.
4. The haploid sperm nucleus fuses with the haploid ovum nucleus → **diploid zygote (46 chromosomes)**.

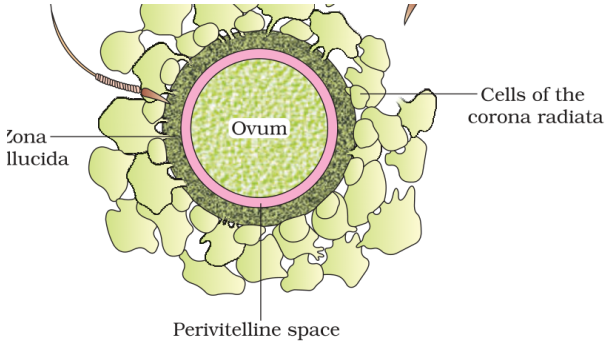


Figure 2.10 Ovum surrounded by few sperms

Source: NCERT Class 12 Biology, Chapter 2 — Fig. 2.10: Ovum surrounded by a few sperms; the cells of the corona radiata enclose the ovum, with the zona pellucida between corona radiata and ovum, and the perivitelline space inside.

Why only one sperm fertilises

Contact of the first sperm with the **zona pellucida** triggers a fast **block to polyspermy** — the zona hardens and the membrane changes electrically/chemically, preventing further sperm entry. Result: every ovum is fertilised by exactly one sperm.

Real-World Application

IVF (in-vitro fertilisation) reproduces this exact step in a lab dish: ovum + sperm in culture medium, allow the zona-pellucida-block to occur, then transfer the resulting zygote (or early embryo) back to the uterus. The biology you are learning here is what makes IVF possible.

Sex determination of the baby

The chromosome pattern: female XX, male XY. All ova carry an X chromosome. Sperms carry either X or Y — 50% each.

- Sperm with **X** + ovum (X) ⇒ **XX** zygote ⇒ female baby.
- Sperm with **Y** + ovum (X) ⇒ **XY** zygote ⇒ male baby.

The sex of the baby is determined by the father

Because the ovum always contributes an X, the sex chromosome that decides the baby's sex (X or Y) comes entirely from the sperm — which is contributed by the father. NCERT explicitly states: *"scientifically it is correct to say that the sex of the baby is determined by the father and not by the mother!"* This is a high-priority CBSE 2-mark question.

6.2 Cleavage, Morula and Blastocyst

After fertilisation, the zygote moves through the **isthmus** of the oviduct toward the uterus. Along the way, it undergoes **cleavage** — rapid mitotic divisions *without* cell growth between divisions:

$$1 \rightarrow 2 \rightarrow 4 \rightarrow 8 \rightarrow 16 \text{ daughter cells (blastomeres).}$$

Each daughter cell is called a **blastomere**.

At the 8–16 blastomere stage, the embryo is called a **morula** (looks like a mulberry). The morula keeps dividing and transforms into a **blastocyst** as it moves further into the uterus. The blastomeres in the blastocyst arrange into:

- an outer layer = **trophoblast**;
- an inner group of cells attached to the trophoblast = **inner cell mass**.

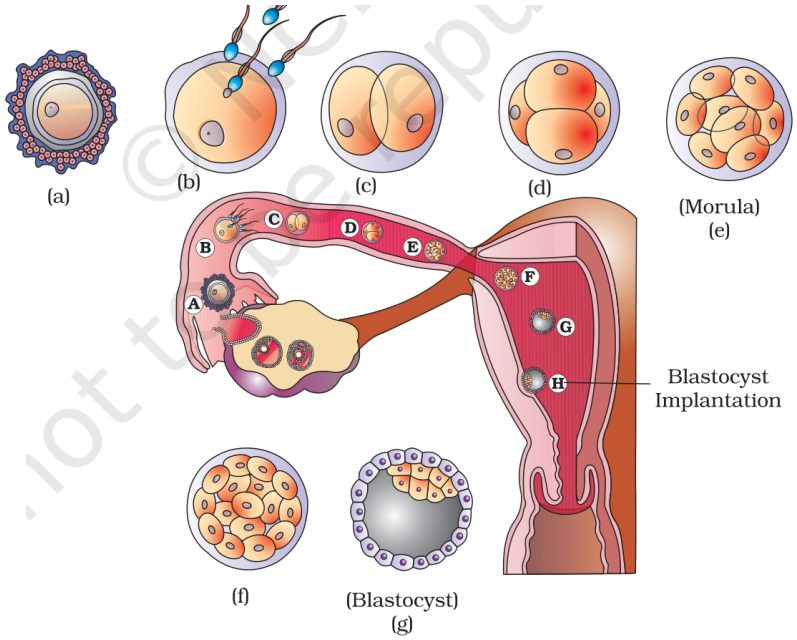


Figure 2.11 Transport of ovum, fertilisation and passage of growing embryo through fallopian tube

Source: NCERT Class 12 Biology, Chapter 2 — Fig. 2.11: Transport of ovum, fertilisation and passage of the growing embryo through the fallopian tube — from ovulation (a), sperm entry (b), 2-cell (c), 4-cell (d), morula (e), to blastocyst (g) and implantation in the uterine wall.

6.3 Implantation

The **trophoblast** layer attaches to the endometrium of the uterus. The inner cell mass differentiates into the **embryo proper**. After attachment, the uterine cells divide rapidly and *cover* the blastocyst, so the blastocyst becomes **embedded** in the endometrium.

This embedding = implantation. Implantation marks the start of **pregnancy**.

Zygote to implantation — in order

Zygote → 2-cell → 4-cell → 8-cell → 16-cell → **Morula** → **Blastocyst** (trophoblast + inner cell mass) → **Implantation** in endometrium.

Pre-implantation stages

"**Zygote Makes Many Babies**"
Zygote → **M**orula → blasto**M**ere arrangement → **B**lastocyst → Implantation.

Common Mistake

Cleavage divisions do NOT increase total embryo size. Total cytoplasm is conserved; daughter cells just get smaller. "Cleavage" is mitosis without growth between divisions — a frequent NEET assertion-reason trap.

7 Pregnancy and Embryonic Development

7.1 Placenta: The Maternal–Foetal Interface

After implantation, finger-like projections called **chorionic villi** appear on the trophoblast. They become interdigitated with the surrounding maternal uterine tissue (and maternal blood). Together they form a **structural and functional unit between the developing embryo and the mother** — the **placenta**.

The placenta is connected to the embryo through an **umbilical cord** that transports substances to and from the embryo.

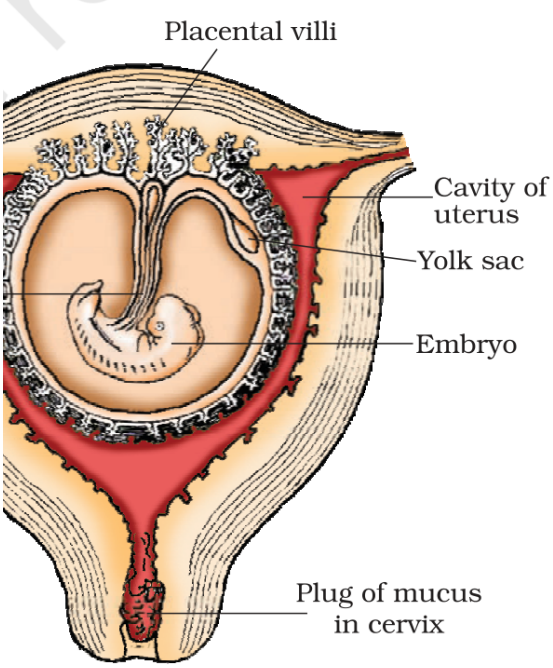
Placental functions:

- Supply of **oxygen and nutrients** from mother to embryo.
- Removal of **CO_2 and waste materials** from embryo to mother.
- Acts as an **endocrine tissue**, producing several hormones.

Placental hormones: hCG (human chorionic gonadotropin), **hPL** (human placental lactogen), **estrogens**, **progestogens**. In the later phase of pregnancy, the ovary also secretes **relaxin**.

Hormones produced in women only during pregnancy: hCG, hPL, relaxin.

In addition, during pregnancy, maternal blood levels of **estrogens, progestogens, cortisol, prolactin, thyroxine** are all increased several-fold, supporting fetal growth and maternal metabolism.



The human foetus within the uterus

Source: NCERT Class 12 Biology, Chapter 2 — Fig. 2.12: The human foetus within the uterus showing placental villi, cavity of the uterus, yolk sac, embryo, umbilical cord with its vessels, and the plug of mucus in the cervix.

Placental hormones

From the placenta: hCG, hPL, estrogens, progestogens.
From the ovary (late pregnancy): relaxin.
Pregnancy-only: hCG, hPL, relaxin — these three are NOT secreted in non-pregnant women.

Quick Tip

Home pregnancy test kits detect **hCG** in urine. hCG is produced very early by the trophoblast and rises sharply through the first trimester — which is why a urine test becomes reliable about 2 weeks after a missed period.

Pregnancy-only hormones

"**hP-h-R**" — think **h**CG, **hP**L, **R**elaxin.
Or: "**Help Pregnant Relax**" — **h**CG, h**P**L, **R**elaxin.

7.2 The Three Germ Layers

Immediately after implantation, the **inner cell mass** differentiates into the three primary germ layers:

- **Ectoderm** — outer layer (gives rise to skin, nervous system).
- **Mesoderm** — middle layer (muscle, bone, blood, kidneys).
- **Endoderm** — inner layer (gut lining, liver, pancreas, lungs).

These three layers give rise to **all the tissues and organs** of the adult. The inner cell mass also contains **stem cells** — pluripotent cells that can give rise to every tissue in the body, which is why they are central to regenerative medicine.

Real-World Application

The **inner cell mass** of a blastocyst is the source of embryonic stem (ES) cells. Their pluripotency — the ability to become any of the 200+ cell types in the human body — is what makes them therapeutically valuable for conditions like Parkinson's, spinal-cord injury and type-1 diabetes, and ethically contentious because harvesting them destroys an early embryo.

7.3 Major Embryonic Milestones (9-month timeline)

Human pregnancy lasts about **9 months (gestation period)**. NCERT highlights specific developmental markers:

Time	Major developmental milestone
End of 1 month	Embryo's **heart** is formed; first heart sound can be heard with a stethoscope.
End of 2 months	Foetus develops **limbs and digits**.
End of 12 weeks (1st trimester)	Most **major organ systems** formed; limbs and external genital organs well developed.
End of 5 months	First **foetal movements** felt; **hair appears** on the head.
End of 24 weeks (end of 2nd trimester)	Body covered with **fine hair**; **eyelids separate**; eyelashes form.
End of 9 months	Foetus is fully developed and ready for delivery.

Trimester logic

1st trimester (0–12 weeks) = organogenesis (everything starts forming; highest risk window for birth defects).
2nd trimester (13–24 weeks) = growth + refinement (movements, sensory organs).
3rd trimester (25–40 weeks) = final growth and lung maturation.

Common Mistake

The heart forms in the FIRST month, not the second. NEET routinely sets "end of month 2" as a wrong-answer distractor. NCERT states month 1.

Practise More with NCERT Exemplar Solutions

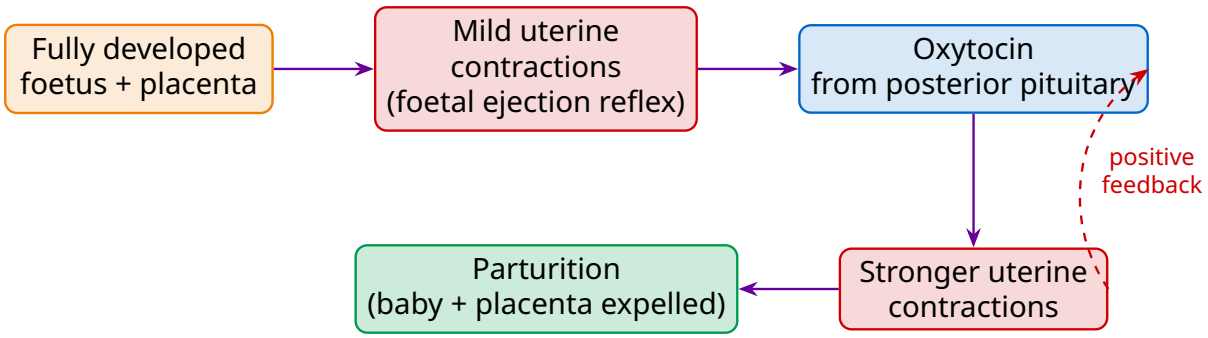
8 Parturition and Lactation

8.1 Parturition: The Foetal Ejection Reflex

Parturition = the process of delivery of the foetus at the end of pregnancy (childbirth). The average gestation period is about **9 months**.

Parturition is induced by a **neuroendocrine reflex**:

1. Signals originate from the **fully developed foetus** and the **placenta**.
2. These signals induce **mild uterine contractions** called the **foetal ejection reflex**.
3. This reflex triggers the maternal **posterior pituitary** to release **oxytocin**.
4. Oxytocin acts on the uterine muscle (myometrium) → **stronger uterine contractions**.
5. Stronger contractions trigger *more* oxytocin release. This is a classic **positive feedback loop**.
6. The cycle keeps amplifying until the foetus is expelled through the birth canal → **parturition**.
7. Soon after, the placenta is also expelled (afterbirth).



Parturition: the key hormone is oxytocin

Foetal signal → Foetal ejection reflex → **Oxytocin** release → Stronger contractions → More oxytocin (positive feedback) → **Parturition**.

Quick Tip

NCERT asks: "*what do doctors inject to induce delivery?*" — answer: **oxytocin (or synthetic equivalents like Pitocin)**. This is a stock CBSE 1-mark question.

Common Mistake

Parturition is positive feedback, not negative. Positive feedback amplifies the signal until a clear end-point (baby delivered) terminates the loop. Most physiological loops (e.g. blood-glucose, thermoregulation) are *negative* feedback — parturition is an exception you must remember.

8.2 Lactation: Colostrum and Breastfeeding

During pregnancy, the mammary glands undergo **differentiation** and start producing milk towards the end of pregnancy — this process is **lactation**.

Colostrum is the milk produced during the initial few days after delivery. Key facts:

- Yellowish, thicker than mature milk.
- Contains **several antibodies** essential for developing resistance (**passive immunity**) in the newborn.
- Doctors strongly recommend **breastfeeding during the initial period of infant growth** for healthy development.

Lactation hormones — two players

Prolactin (anterior pituitary) → *milk synthesis* in the alveolar cells.
Oxytocin (posterior pituitary) → *milk ejection (let-down reflex)* from alveoli into ducts when the baby suckles.

Real-World Application

Colostrum gives a newborn its first dose of **IgA antibodies** — passive immunity that protects against gut and respiratory infections in the first weeks of life, before the baby's own adaptive immune system matures. This is why WHO and AAP recommend the first feed must be colostrum.

Two pituitary hormones in late pregnancy

"**P**rolactin **P**roduces milk. **O**xytocin **O**ut-flows it."
P-for-Production, O-for-Out.

9 Comparison Tables and Quick Reference

9.1 Male vs Female Reproductive System — at a Glance

Feature	Male	Female
Primary sex organ	Testis (pair)	Ovary (pair)
Gamete produced	Sperm (motile, small)	Ovum (non-motile, large)
Site of gametogenesis	Seminiferous tubules	Ovarian cortex
Site of fertilisation	—	Ampulla of fallopian tube
Hormone-producing cell	Leydig (interstitial) cell	Granulosa + theca + corpus luteum
Begins functioning	At puberty	In fetal life (oogonia formed)
Stops functioning	Late life (continues)	At menopause (~50 yrs)
Outputs per meiosis	4 sperms	1 ovum + 2–3 polar bodies
External genitalia	Penis	Mons pubis, labia majora/minora, clitoris

9.2 Hormones of Human Reproduction — Master Table

Hormone	Source	Primary action
GnRH	Hypothalamus	Stimulates pituitary to release LH and FSH
FSH (male)	Anterior pituitary	Acts on Sertoli cells; drives spermiogenesis
LH (male)	Anterior pituitary	Acts on Leydig cells; stimulates androgen secretion
Androgens (Testosterone)	Leydig cells	Drive spermatogenesis; secondary sexual characters
FSH (female)	Anterior pituitary	Stimulates follicular growth and estrogen secretion
LH (female)	Anterior pituitary	**LH surge** at mid-cycle triggers ovulation
Estrogen	Growing follicle	Endometrial proliferation; secondary sex characters
Progesterone	Corpus luteum	Maintains endometrium in luteal phase / pregnancy
hCG	Placenta (trophoblast)	Maintains corpus luteum in early pregnancy

Hormone	Source	Primary action
hPL	Placenta	Supports fetal growth; alters maternal metabolism
Relaxin	Ovary (late pregnancy)	Relaxes pelvic ligaments and cervix before parturition
Oxytocin	Posterior pituitary	Uterine contractions (parturition) + milk ejection (lactation)
Prolactin	Anterior pituitary	Milk synthesis in mammary alveoli

9.3 Quick Reference — Numbers You Must Memorise

Quantity	NCERT value
Testicular temperature	2–2.5 °C below body temperature
Testicular lobules per testis	$\sim$ 250
Seminiferous tubules per lobule	1–3
Testis dimensions	4–5 cm long, 2–3 cm wide
Fallopian tube length	10–12 cm
Mammary lobes per breast	15–20
Oogonia per ovary (fetal)	A couple of million
Primary follicles per ovary at puberty	60,000–80,000
Sperms per ejaculation	200–300 million
Normal morphology threshold	$\geq$ 60%
Motility threshold	$\geq$ 40%
Menstrual cycle length	28–29 days
Menstrual flow duration	3–5 days
LH/FSH peak (cycle day)	$\sim$ 14
Menopause (typical age)	$\sim$ 50 years
Gestation period	$\sim$ 9 months
Chromosomes: zygote / sperm / ovum	46 / 23 / 23

The five "order" sequences this chapter expects you to know

1. **Seven events:** Gametogenesis $\rightarrow$ Insemination $\rightarrow$ Fertilisation $\rightarrow$ Implantation $\rightarrow$ Gestation $\rightarrow$ Parturition $\rightarrow$ Lactation.
2. **Sperm pipeline:** Seminiferous $\rightarrow$ Rete $\rightarrow$ Vasa efferentia $\rightarrow$ Epididymis $\rightarrow$ Vas deferens $\rightarrow$ Ejaculatory duct $\rightarrow$ Urethra.

3. **Spermatogenesis:** Spermatogonium → Primary spermatocyte → Secondary spermatocyte → Spermatid → Sperm.
4. **Oogenesis follicles:** Primary → Secondary → Tertiary → Graafian.
5. **Embryo development:** Zygote → 2-cell → 4-cell → 8-cell → 16-cell → Morula → Blastocyst → Implantation.

Related Collegedunia Resources

Same chapter — other resources:
- NCERT Solutions
- Formula Sheet
- NCERT Book PDF
- Exemplar Book PDF
- Exemplar Solutions
- Handwritten Notes

Continue learning:
- Ch 2: Human Reproduction
- Ch 4: Principles of Inheritance and Variation
- Class 12 Biology — All Chapters

10 NEET / CBSE Pitfalls — Final Revision Pass

Quick Tip

NCERT word-for-word lines that appear as one-mark CBSE questions:
- "Scientifically it is correct to say that the sex of the baby is determined by the father and not by the mother."
- "The presence or absence of hymen is not a reliable indicator of virginity or sexual experience."
- "Fertilisation takes place in the ampullary region of the fallopian tube."

Common Mistake

The five most common errors students make in this chapter:
- Calling the cell released at ovulation an "ovum" — it is a **secondary oocyte**.
- Attributing androgens to Sertoli cells — they come from **Leydig cells**.
- Saying "ovum + sperm → zygote" completes meiosis in the male — meiosis is completed in both gametes *before* fusion in the male, but **after** sperm entry in the female.
- Confusing **spermiogenesis** (differentiation) with **spermiation** (release).
- Forgetting that parturition is **positive** feedback (most other reflexes are negative).

Real-World Application

Why this chapter matters beyond the exam: every assisted-reproduction

technology (IVF, ICSI, IUI, surrogacy) is engineered around the biology you have just learned. Hormonal contraceptives are designed around the LH/FSH/estrogen/progesterone loop. Pregnancy tests detect hCG. Lactation support drugs target prolactin and oxytocin. Mastering these notes is the foundation for both NEET and Chapter 3 (Reproductive Health).