Collegedunia NCERT Formula Sheet

Class 12 / 12th Biology — Chapter 2 (NCERT 2026-27 / Latest Edition)

Chapter 2: Human Reproduction

Male & Female Systems | Gametogenesis | Menstrual Cycle | Fertilisation | Implantation | Pregnancy | Parturition & Lactation

Also see for this chapter: NCERT Solutions | Revision Notes | Exemplar Solutions

Cell / Structure	Ploidy	Where it appears
Spermatogonium / Oogonium	$2n$ (diploid)	Germinal epithelium of testis / foetal ovary
Primary spermatocyte / Primary oocyte	$2n$ (diploid)	Enters meiosis-I (oocyte arrests at prophase-I until puberty)
Secondary spermatocyte / Secondary oocyte	n (haploid)	Product of meiosis-I; oocyte arrests at metaphase-II until fertilisation
Spermatid / Ovum	n (haploid)	Product of meiosis-II; spermatid matures to sperm by spermiogenesis
Polar bodies (1st & 2nd)	n (haploid)	Non-functional by-products of unequal oocyte cytokinesis
Zygote	$2n$ (diploid)	Formed by fusion of haploid sperm + haploid ovum in ampulla
Morula Blastocyst	$2n$	Pre-implantation stages in fallopian tube / uterus

1 1. Male Reproductive System (NCERT 2.1)

The male reproductive system comprises a **pair of testes**, accessory ducts (rete testis, vasa efferentia, epididymis, vas deferens), accessory glands (seminal vesicles, prostate, bulbourethral) and the external genitalia. The testes are extra-abdominal (in the **scrotum**) so that the local temperature stays $\sim$2–2.5 °C *below* core body temperature, the optimal range for spermatogenesis.

Testis — structural & numerical facts

Feature	Value / count	Function / note
Number of testes	**2**, in scrotum	Held outside body cavity for cooler temperature
Size of each testis	∼4–5 cm long, ∼2–3 cm wide	Oval, slightly flattened
Testicular lobules per testis	∼**250**	Compartments separated by septa
Seminiferous tubules per lobule	1–3	Site of sperm production
Cells lining seminiferous tubule	Spermatogonia + **Sertoli cells**	Sertoli ("nurse") cells nourish germ cells
Cells between seminiferous tubules	**Leydig cells** (interstitial)	Secrete **androgens** (mainly testosterone)
Working temperature	∼**2–2.5 °C below 37 °C**	Cryptorchidism (undescended testis) impairs spermatogenesis

Sertoli cells = somatic nurse cells inside the tubule; **Leydig cells** = endocrine cells outside the tubule. Both are essential — Sertoli for sperm support, Leydig for testosterone.

Male duct system – flow path

Seminiferous tubule Rete testis Vasa efferentia Epididymis (caput, corpus, cauda) Vas deferens Ejaculatory duct Urethra (prostatic, membranous, penile) Urethral meatus.

Sperm are produced in the seminiferous tubules, mature in the **epididymis**, and are propelled along the **vas deferens** during ejaculation. **Vasectomy** is a surgical cut of the vas deferens. Mnemonic: "**SR-VEEUU**".

Accessory glands & semen composition

Gland	Pairs	Contribution to semen
Seminal vesicles	1 pair (2)	∼60 % of seminal fluid; fructose (energy), prostaglandins, clotting proteins, alkaline pH
Prostate gland	1 (unpaired)	∼25–30 % of seminal fluid; citrate, zinc, proteolytic enzymes
Bulbourethral (Cowper's)	1 pair (2)	Pre-ejaculate mucus; lubricates urethra & neutralises acidic urine residue
Semen — average values per ejaculate (WHO reference)		
Volume per ejaculate	—	**2–5 mL**
Sperm concentration	—	**60–150 million / mL** (normal ≥15 million/mL)
Sperms per ejaculate	—	**200–600 million** (NCERT-tested range)
Motility (forward)	—	≥60 % (NCERT)
Normal morphology	—	≥60 %
pH of semen	—	7.2–7.8 (slightly alkaline)

Semen = sperm + secretions from seminal vesicles, prostate and bulbourethral glands. **Sperm count below 15 million/mL** (*oligospermia*) is a leading cause of male infertility.

Sperm structure — dimensions & composition

Part	Approx. size	Contents / role
Head	4–5 µm long	Elongated haploid nucleus; **acrosome** cap covers anterior 2/3
Acrosome	Cap of head	Lysosome-derived; carries **hyaluronidase** & **acrosin** to penetrate egg
Middle piece	∼5 µm	Densely packed **mitochondria** (60–75) provide ATP for motility
Tail (flagellum)	40–50 µm	9+2 microtubule axoneme; whip-like beating
Total length	∼50–60 µm	Survives 24–72 h in female tract

Sperm is the **smallest** human cell (∼60 µm) by volume; the ovum is the **largest** (∼100 µm diameter). Head carries the genome, middle piece carries the engine.

Glands of male system

"S P B" — **S**eminal vesicle (60%, fructose), **P**rostate (25–30%, citrate), **B**ulbourethral (lubricant). Volumes add up to semen.

2 2. Female Reproductive System (NCERT 2.2)

The female system has **a pair of ovaries**, a pair of fallopian (oviduct) tubes, a uterus, a cervix, a vagina and external genitalia, together with a pair of **mammary glands**. The ovaries are intra-abdominal and produce both gametes (ova) and the female sex hormones (oestrogens, progesterone, inhibin, relaxin).

Ovary — structural & numerical facts

Feature	Value	Note
Number of ovaries	**2** (right + left)	Lie in shallow ovarian fossa
Size of each ovary	∼2–4 cm long	Almond shape
Primordial follicles at birth (per ovary)	∼**1–2 million**	Already arrested in prophase-I of meiosis-I
Total at birth (both ovaries)	∼**2 million**	Of which ∼60,000 follicles remain by puberty (rest atretic)
Follicles ovulated in lifetime	∼**400–500**	Out of ∼60,000 entering puberty pool
Mature follicle (Graafian)	∼15–20 mm diameter	Releases secondary oocyte at ovulation

Unlike males (continuous sperm production), females have a **fixed lifetime gamete pool**. Most follicles undergo *atresia*; only ∼400–500 actually ovulate.

Female duct system & accessory parts

Part	Function / division
Fallopian tube (oviduct)	∼10–12 cm long; 4 regions: **infundibulum** (fimbriae) → **ampulla** (longest; site of fertilisation) → **isthmus** → **uterine part**
Uterus (womb)	Inverted-pear, ∼7.5 cm long; 3 layers: **perimetrium** (outer serosa), **myometrium** (thick smooth muscle, contracts at parturition), **endometrium** (inner glandular mucosa; sheds in menstruation)
Cervix	Narrow neck of uterus; lumen = **cervical canal**; opens via cervical os into vagina
Vagina	∼8–10 cm fibromuscular tube; copulation & birth canal
Mammary glands	15–20 **mammary lobes** per breast; each lobe → lobules → alveoli (milk cells) → mammary tubules → **mammary duct** → mammary ampulla → **lactiferous duct** (nipple)

Fertilisation occurs in the ampulla of the fallopian tube — *never* in the uterus. The cervix + vagina together form the **birth canal**.

Where does fertilisation happen?

NCERT explicitly states fertilisation occurs in the **ampullary–isthmic junction of the fallopian tube**, *not* in the uterus. The zygote then travels down to the uterus over 3–4 days and implants as a blastocyst.

3 3. Gametogenesis — Spermatogenesis & Oogenesis (NCERT 2.3)

Gametogenesis is the formation of haploid gametes from diploid germ cells. **Spermatogenesis** (sperm formation) starts at puberty and continues through life; **oogenesis** (ovum formation) starts in foetal life and pauses twice — once at prophase-I of meiosis-I (until puberty) and once at metaphase-II of meiosis-II (until fertilisation).

Spermatogenesis — stages & chromosome number

Stage	Ploidy	Chrom. #	Event
Spermatogonium	$2n$	46	Multiplies by mitosis in germinal epithelium
Primary spermatocyte	$2n$	46	Enters meiosis-I
Secondary spermatocyte	n	23	Product of meiosis-I; enters meiosis-II
Spermatid	n	23	Product of meiosis-II; round, non-motile
Spermatozoon (sperm)	n	23	After **spermiogenesis** (spermatid sperm)

One primary spermatocyte ($2n$, 46) **4 spermatids** (n, 23) **4 functional sperms**. **Spermiogenesis** = morphological transformation; **spermiation** = release of sperm into the lumen of the seminiferous tubule.

Oogenesis — stages & timing

Stage	Ploidy	Chrom. #	When / where
Oogonium	$2n$	46	Multiplies by mitosis in **foetal** ovary; stops before birth
Primary oocyte	$2n$	46	Arrests at **prophase-I** from foetal life until puberty
Secondary oocyte + 1st polar body	n	23	Meiosis-I resumes at each cycle just before ovulation
Released at ovulation	n	23	**Secondary oocyte arrested in metaphase-II**
Ovum (mature) + 2nd polar body	n	23	Meiosis-II completes **only after** sperm entry

One primary oocyte ($2n$, 46) **1 functional ovum** (n, 23) + **2–3 polar bodies**. Compare with male: 1 PSC 4 sperms. The *ratio of useful gametes per primary cell* is the most-asked Class 12 fact for this section.

Layers around the ovulated secondary oocyte

Layer (inside → outside)	Description
Plasma membrane	Surrounds ooplasm
Zona pellucida	Thick translucent glycoprotein layer; sperm must penetrate this for fertilisation
Corona radiata	Single layer of granulosa cells radially attached to zona pellucida

Three concentric layers from inside outward: **plasma membrane → zona pellucida → corona radiata**. The **antrum** is the fluid-filled cavity *inside* the Graafian follicle (around the oocyte), not a layer of the oocyte.

"Ovum is released" — what's actually released?

At ovulation the ovary releases a **secondary oocyte arrested in metaphase-II** — *not* a fully mature ovum. Meiosis-II is completed **only after** the sperm enters, with simultaneous extrusion of the 2nd polar body. Examiners love this distinction.

4 4. Menstrual Cycle (NCERT 2.4)

The menstrual cycle is the reproductive cycle of female primates (humans, apes, monkeys). It has a mean length of **28 days** (range 21–35), starts at **menarche** (∼10–14 years), and ends at **menopause** (∼45–50 years). The four standard phases (menstrual, follicular/proliferative, ovulatory, luteal/secretory) are driven by the hypothalamus–pituitary–ovary axis.

Menstrual cycle — phase-by-phase reference

Phase	Days	Ovary event	Endometrium / hormones
Menstrual	1–5	Follicle pool starts recruiting	Endometrial lining sheds; all hormones low
Follicular	6–13	Dominant follicle matures to Graafian	**Oestrogen** rises; endometrium re-grows; FSH then **LH surge**
Ovulatory	**14**	**Ovulation**: Graafian ruptures, releases secondary oocyte	Triggered by sharp **LH surge**; oestrogen peaks just before
Luteal	15–28	Ruptured follicle → **corpus luteum**	**Progesterone** dominant; endometrium glandular, ready to implant

If fertilisation **occurs**: hCG from the trophoblast rescues the corpus luteum, progesterone stays high, menstruation is suppressed. If **not**: corpus luteum degenerates into corpus albicans, progesterone falls, endometrium sheds → next menstruation.

Hormone peaks & roles in the 28-day cycle

Hormone	Peak	Source / role
FSH	Early follicular	Anterior pituitary; stimulates follicle growth + oestrogen synthesis
LH	**Day 13–14 surge**	Anterior pituitary; triggers **ovulation**; maintains corpus luteum
Oestrogen	Late follicular ($\sim$d 13)	Granulosa cells; endometrial proliferation; +ve feedback on LH
Progesterone	Mid-luteal ($\sim$d 21)	**Corpus luteum**; endometrial secretory phase; maintains pregnancy

Two key spikes: **oestrogen peak just before ovulation** *causes* the LH surge (positive feedback); the **LH surge** *causes* ovulation $\sim$10–12 h later. GnRH (hypothalamus) and inhibin (granulosa / corpus luteum) regulate the loop in the background.

NEET extension — fertile window

Although NCERT highlights **day 14** as ovulation in a 28-day cycle, viable conception is possible across the *fertile window* **day 9 to day 18** because sperm survive 24–72 h and the secondary oocyte survives $\sim$24 h post-ovulation. This is the basis of the rhythm (calendar) method of contraception.

Hormone domain map

"F O L P" — **F**SH grows follicle, **O**estrogen proliferates endometrium, **L**H surges ⇒ ovulates, **P**rogesterone (luteal) makes endometrium secretory.

Menstruation $\neq$ menopause $\neq$ menarche

Menarche = first menstrual period (puberty onset). **Menstruation** = monthly endometrial shedding. **Menopause** = permanent cessation of menstrual cycles (cycle ends). Don't confuse the three onset/end terms.

5 5. Fertilisation & Implantation (NCERT 2.5)

After ovulation the secondary oocyte is swept into the ampulla by the ciliated fimbriae. If a sperm reaches it within $\sim$24 h, fertilisation occurs, and the resulting zygote begins cleavage as it travels toward the uterus. By day 6–7 after fertilisation, the blastocyst implants in the uterine endometrium.

Fertilisation — step-by-step

#	Event
1	Sperm penetrates the **corona radiata** (aided by hyaluronidase from acrosome)
2	Sperm binds **zona pellucida** (ZP3 receptor); acrosomal reaction releases acrosin
3	Sperm head fuses with oocyte plasma membrane; **cortical reaction** hardens zona to block polyspermy
4	Sperm entry triggers **completion of meiosis-II** in oocyte $\Rightarrow$ ovum + 2nd polar body
5	Male and female pronuclei fuse diploid **zygote** ($2n$, 46 chromosomes)
6	Sex of zygote determined: **XX = female**, **XY = male** (sperm contributes X or Y)

Only **one** sperm fuses with the oocyte; the cortical reaction guarantees a **block to polyspermy**. The Y or X chromosome of the fertilising sperm determines foetal sex.

Cleavage Blastocyst Implantation timeline

Day post-fert.	Stage	Event / location
Days 1–3	2- / 4- / 8-cell	Cleavage divisions; in fallopian tube
Day 4	**Morula** (16–32 cells)	Solid ball; enters uterus
Day 5–6	**Blastocyst**	Hollow ball; **trophoblast** (outer) + **inner cell mass**; zona pellucida shed
Day 7	**Implantation**	Trophoblast invades endometrium

Cleavage = rapid mitotic divisions *without growth* between divisions, so cells (blastomeres) get smaller. **Trophoblast** placenta; **inner cell mass** embryo proper.

What is the blastocyst?

A **blastocyst** is a hollow embryo of ~60–100 cells with two parts: the outer **trophoblast** (gives rise to the placenta and foetal membranes) and the inner **embryoblast** or **inner cell mass** (gives rise to the embryo proper). It is the stage at which **implantation** occurs in the uterus.

Cleavage vs ordinary mitosis

Cleavage divisions are mitotic but happen **without an intervening growth phase** — the morula has the same total volume as the zygote, just divided into many tiny cells. Ordinary mitosis (later in development) restores the G1 & G2 phases and cells grow between divisions.

6 6. Pregnancy & Embryonic Development (NCERT 2.6)

Human gestation lasts ~**280 days** (40 weeks, 9 months) from the last menstrual period. Major organ systems lay down during weeks 4–8 (organogenesis); the placenta becomes the dominant endocrine organ from ~week 10. NCERT specifies the appearance of major features by month, which CBSE often asks as fill-in-the-blank.

Embryonic milestones — month-wise (NCERT-listed)

Month	Milestone (NCERT, Sec. 2.6)
End of month 1	**Heart** formed; embryo ∼5 mm
End of month 2	**Limbs and digits** develop
End of month 3	Most **major organ systems** formed; external genital organs developed
End of month 5	First **movements of foetus** (“quickening”); **hair on head** appear
End of month 6	Body covered by **fine hair** (lanugo); **eyelids separate**; eyelashes form
End of month 9	**Full-term** foetus, ready for delivery

NCERT specifically uses months **1, 2, 3, 5, 6, 9**. The 5-month foetal movement / scalp hair pair, and the 6-month lanugo + eyelid pair, are the most frequently asked CBSE numericals.

Three germ layers — quick derivatives

The inner cell mass differentiates into three primary germ layers: **ectoderm** (epidermis, nervous system, eye lens), **mesoderm** (muscle, bone, kidney, gonads, blood, heart) and **endoderm** (gut epithelium, lungs, liver, pancreas, thyroid). Every adult tissue traces back to one of these three.

Placenta — structure & hormones

Feature	Detail
Composition	Foetal **chorionic villi** + maternal **endometrial tissue**
Connection to foetus	**Umbilical cord** (2 umbilical arteries + 1 umbilical vein)
Functional role	Supply O_2 & nutrients; remove CO_2 & waste; produces hormones
Hormones produced	**hCG** (human chorionic gonadotropin), **hPL** (human placental lactogen), **oestrogens**, **progestogens**, **relaxin** (late pregnancy)
Maternal ovarian hormones in pregnancy	Oestrogen, progesterone (from corpus luteum until ∼wk 10, then placenta); **relaxin** in late pregnancy
hCG role	Maintains corpus luteum during first trimester; basis of **pregnancy test**

Pregnancy-test strips detect **hCG in urine** as early as ∼10 days post-fertilisation. **hPL** promotes maternal metabolic adaptation (insulin resistance, glucose available for foetus).

NEET extension — extra-embryonic membranes

Four membranes form during development: **amnion** (fluid-filled cushion), **chorion** (forms placenta with endometrium), **yolk sac** (early haematopoiesis), **allantois** (early blood vessels of

umbilical cord). All are extra-embryonic and discarded at birth.

Placenta hormone shortlist

"hCG, hPL, E, P, R" — **h**CG (rescue luteum), **h**PL (mother's metabolism), **E**strogen, **P**rogesterone, **R**elaxin (loosens pelvis at term).

Umbilical cord vessels

Two **arteries** carry **deoxygenated** blood *from* foetus to placenta; one **vein** carries **oxygenated** blood *back* to foetus. This is the only place in the body where arteries carry deoxygenated and the vein carries oxygenated blood — *opposite* of normal systemic circulation (compare with pulmonary vessels too).

7 7. Parturition & Lactation (NCERT 2.7)

After ∼280 days of gestation the foetus is delivered through the birth canal — the process is **parturition**. It is triggered by a foeto–maternal neuro-endocrine signal cascade involving **oxytocin** (a textbook example of *positive feedback*). Lactation follows, supported by prolactin (milk synthesis) and oxytocin (milk ejection).

Parturition — hormone cascade

Foetal ejection reflex → oxytocin from maternal posterior pituitary → uterine myometrium contracts → stronger contractions release more oxytocin (positive feedback) → cervix dilates → foetus expelled → placenta ("afterbirth") delivered.

Parturition is the classic Class 12 example of **positive feedback** in the endocrine system. **Relaxin** (from placenta + corpus luteum) softens the pubic symphysis & cervix in the days before labour.

Lactation — milk hormones & colostrum

Item	Detail
Prolactin	From anterior pituitary; stimulates milk synthesis in alveolar cells of mammary glands
Oxytocin	From posterior pituitary; triggers milk **ejection** (let-down reflex) on suckling
Colostrum	First milk (first few days post-delivery); rich in **IgA antibodies**; provides passive immunity to neonate
WHO breastfeeding advice	**Exclusive breastfeeding for first 6 months** (NCERT-cited)

Two-hormone split is testable: **prolactin makes milk**, **oxytocin releases milk**. Colostrum's **IgA** explains why breastfeeding lowers infant infection rate dramatically.

Oxytocin's two jobs

"O for Out" — oxytocin pushes things *out*: baby *out* (parturition) and milk *out* (let-down).

Prolactin vs Oxytocin in lactation

Many students reverse the roles: **prolactin** = milk *synthesis* (anterior pituitary); **oxytocin** = milk *ejection* (posterior pituitary). The mnemonic "**P**rolactin **P**roduces, **O**xytocin **O**ut-flows" helps lock the pair.

Read the Full Revision Notes

8 8. Quick Reference — Numbers to Remember

One-glance lookup of the most exam-relevant numerical and categorical facts of Class 12 Biology Chapter 2. Lock these down the night before the exam.

Top numerical facts — Class 12 Bio Ch 2

#	Fact	Value
1	Testicular temperature below body	$\sim$2–2.5 °C
2	Semen volume / sperm concentration	2–5 mL ; $\geq$15 million / mL
3	Sperms per ejaculate	200–600 million
4	Primordial follicles at birth (both ovaries)	$\sim$2 million
5	Follicles ovulated in lifetime	$\sim$400–500
6	Functional gametes per primary spermatocyte / oocyte	4 sperms / 1 ovum (+ 2 polar bodies)
7	Mean menstrual-cycle length / ovulation day	28 days / day 14 (LH surge)
8	Site of fertilisation	Ampulla of fallopian tube
9	Oocyte arrest stages	Prophase-I, Metaphase-II
10	Days from fertilisation to implantation	$\sim$6–7 days
11	Blastocyst cells that form placenta	Trophoblast (ICM embryo)
12	Gestation period (LMP)	$\sim$280 days = 40 wk = 9 mo
13	Heart / limbs by end of month	1 / 2
14	Foetal movement & scalp hair / lanugo by month	5 / 6
15	Umbilical vessels	2 arteries (deoxy) + 1 vein (oxy)
16	Placenta hormones	hCG, hPL, oestrogen, progesterone, relaxin
17	Parturition trigger / lactation hormones	Oxytocin (+ve feedback); Prolactin + Oxytocin
18	Colostrum antibody / exclusive-feeding period	IgA / first 6 months (WHO)

Last-minute exam advice

Most CBSE / NEET questions on Class 12 Bio Ch 2 hinge on **four** fact families:
(a) the gametogenesis comparison (4 sperms vs 1 ovum, two oocyte-arrest stages);
(b) the menstrual-cycle hormone map (FSH grows follicle, oestrogen peak LH surge ovulation, progesterone luteal);
(c) the site & timing of fertilisation & implantation (ampulla, day 6–7);

(d) parturition / lactation hormones (oxytocin positive feedback; prolactin vs oxytocin in milk). Lock these and you cover ∼70 % of the chapter's numerical / mechanism questions.

Related Collegedunia Resources

Same chapter — other resources:

- NCERT Solutions
- Revision Notes
- NCERT Book PDF
- Exemplar Book PDF
- Exemplar Solutions
- Handwritten Notes

Continue learning:

- Ch 1: Sexual Reproduction in Flowering Plants
- Ch 3: Reproductive Health
- Class 12 Biology — All Chapters