Collegedunia NCERT Formula Sheet

Class 12 / 12th Biology — Chapter 1 (NCERT 2026-27 / Latest Edition)

Chapter 1: Sexual Reproduction in Flowering Plants

Flower & Stamen | Microsporogenesis | Megasporogenesis | Pollination | Double Fertilisation | Seed & Fruit | Apomixis

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

Cell / Structure	Ploidy	Where it appears
Microspore mother cell (MMC)	$2n$ (diploid)	In sporogenous tissue of anther; undergoes meiosis
Microspore / Pollen grain	n (haploid)	Product of meiosis in MMC; tetrads of four
Generative cell & Vegetative cell	n each	2-celled stage of mature pollen grain
Male gametes (sperm)	n each (2 per pollen)	Formed by mitosis of generative cell
Megaspore mother cell (MMC)	$2n$ (diploid)	In nucellus of ovule; undergoes meiosis
Functional megaspore	n (haploid)	1 of 4 megaspores survives; gives the embryo sac
Embryo sac (female gametophyte)	7-celled, 8-nucleate, all n	Polygonum type — 3+3+1+1 layout
Egg cell (oosphere)	n	Inside egg apparatus at micropylar end
Synergids (2)	n each	With **filiform apparatus**; guide pollen tube
Antipodal cells (3)	n each	At chalazal end; degenerate later
Central cell, two polar nuclei	$n + n$	Fuse with sperm $\to$ **PEN** $(3n)$
Zygote	$2n$ (diploid)	egg (n) + sperm (n) — **syngamy**
Primary endosperm nucleus (PEN)	$3n$ (triploid)	2 polar nuclei + 1 sperm — **triple fusion**
Endosperm tissue	$3n$	Nutritive; from PEN by free-nuclear / cellular divisions
Perisperm (when present)	$2n$	Residual nucellus, e.g. black pepper, beet

1 1. Flower — A Fascinating Organ of Angiosperms (NCERT 1.1)

The flower is the **reproductive shoot** of an angiosperm. Four whorls — calyx (sepals), corolla (petals), **androecium** (stamens, male), **gynoecium** (carpels, female) — are arranged on the thalamus. Stamens and carpels produce the male and female gametophytes that will fuse during fertilisation.

Whorls of a typical flower

Flower $=$ Calyx (sepals) $+$ Corolla (petals) $+$ Androecium (stamens) $+$ Gynoecium (carpels)

where androecium is the **male whorl** and gynoecium is the **female whorl**.

The two non-essential whorls (sepals, petals) protect or advertise the flower; the two **essential whorls** (androecium, gynoecium) carry out reproduction.

Stamen, Pistil and their parts

A **stamen** has two parts: **filament** (slender stalk) and **anther** (terminal, generally *bilobed*, *dithecous* — two thecae each with two pollen sacs ⇒ **tetragonal** four-microsporangiate structure). A **pistil/carpel** has three parts: **stigma** (receptive top), **style** (slender connecting stalk), and **ovary** (basal bulged region bearing one or more **ovules** on the **placenta**).

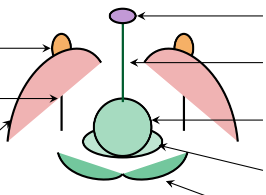

Figure: Typical bisexual flower (L.S.) — four whorls and the two essential reproductive parts.

2 2. Pre-fertilisation: Stamen & Pollen (1.2.1)

The anther wall has four layers from outside in: **epidermis**, **endothecium**, **middle layers**, and **tapetum**. The innermost **tapetum** nourishes developing pollen; the outer three help in **dehiscence** (release of pollen).

Anther wall layers (outer → inner)

Epidermis → Endothecium → Middle layers → **Tapetum** → Sporogenous tissue

where outer three layers handle **protection & dehiscence**; **tapetum** provides **nourishment** to microspores.

Tapetal cells are typically **multinucleate** with dense cytoplasm — a clue that they are highly metabolically active in feeding the developing pollen.

Microsporogenesis — meiotic ploidy

$$\text{MMC } (2n) \longrightarrow \text{microspore tetrad } (4 \times n) \quad \text{(meiosis)}$$

where MMC = microspore mother cell in sporogenous tissue; each tetrad gives **4 haploid microspores** arranged in a tetrahedral cluster.

Microsporogenesis = **meiotic** formation of microspores from MMCs. Each microspore later dissociates to become a **pollen grain**.

Structure of pollen grain

A typical pollen grain is **spheroidal**, $\sim 25\text{–}50\,\mu$m in diameter, with a **two-layered wall**: outer hard **exine** of **sporopollenin** (the most resistant biological material known — survives high temperatures, strong acids/alkalis, no enzyme degrades it) and inner thin **intine** of cellulose + pectin. Exine has **germ pores** where sporopollenin is absent — the pollen tube emerges here. The mature pollen is either **2-celled** (vegetative + generative; $\sim 60\%$ of angiosperms) or **3-celled** (vegetative + 2 male gametes; e.g. grasses) at shedding.

Pollen → male gametes (mitosis)

Microspore $(n) \longrightarrow$ Vegetative cell (n) + Generative cell (n) (mitosis-I)

Generative cell $(n) \longrightarrow$ **2 male gametes** (sperms), each n (mitosis-II)

where the vegetative cell forms the **pollen tube**; the generative cell divides (in pollen or in the tube) to give the two sperms required for double fertilisation.

Mitosis-II occurs *inside* the pollen before shedding in 3-celled types, and *inside the pollen tube* after germination in 2-celled types.

Pollen viability & storage

Viability lasts **30 min** in cereals (rice, wheat), but several months in *Rosaceae*, *Leguminosae* and *Solanaceae*. Long-term storage at $-196°$C (liquid N_2) in **pollen banks** preserves germplasm for crop breeding — a frequent NEET MCQ.

Sporopollenin vs. cellulose

The hard outer exine is **sporopollenin**, NOT cellulose — cellulose is in the inner **intine**. Students routinely swap the two. Sporopollenin's chemical inertness is why pollen fossils survive intact for millions of years.

3 3. Pistil, Megasporangium & Embryo Sac (1.2.2–1.2.3)

The pistil contains **ovules** inside the ovary. Each ovule develops a **female gametophyte** (embryo sac) through megasporogenesis and megagametogenesis. The dominant pattern in $\sim 80\%$ of angiosperms is the **Polygonum type** — monosporic, 7-celled, 8-nucleate.

Parts of an ovule

Ovule (megasporangium) = **Funicle** (stalk) + **Hilum** (junction with ovary) + **Integuments** (1 or 2 protective layers) + **Micropyle** (gap in integuments) + **Chalaza** (basal end opposite micropyle) + **Nucellus** (mass of cells housing the embryo sac)

Micropyle is the entry point for the pollen tube during fertilisation; chalaza marks the basal pole of the ovule.

Megasporogenesis — ploidy chain

MMC $(2n) \longrightarrow$ Linear tetrad of 4 megaspores (n) (meiosis)

3 megaspores **degenerate**; 1 functional megaspore $(n) \longrightarrow$ **8 nuclei**, organised as **7 cells** (3 mitoses)

where 8 nuclei → 3 (egg apparatus: egg + 2 synergids) + 3 (antipodals) + 2 (polar nuclei in central cell).

This is the **monosporic, Polygonum-type** development — the standard NCERT case. Note: only **one** of four megaspores survives.

Embryo sac — 7 cells, 8 nuclei

The mature embryo sac has **7 cells** and **8 nuclei**:

1. **Egg apparatus** (micropylar end): 1 **egg cell** + 2 **synergids**. Synergids carry a thickened

filiform apparatus that guides the pollen tube to the egg.

2. **Central cell** (centre): contains **2 polar nuclei** which later fuse to form the **secondary nucleus** ($2n$, diploid).
3. **Antipodals** (chalazal end): 3 cells, usually degenerate before/after fertilisation.

All cells are **haploid** (n); the central cell's two polar nuclei are $n + n$ and act effectively as $2n$ for triple fusion.

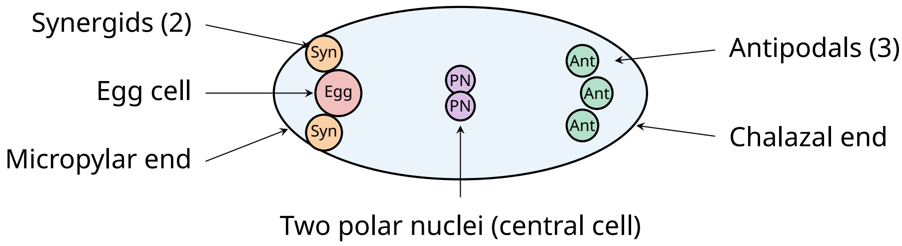

Figure: Polygonum-type embryo sac — 7 cells, 8 nuclei (3 + 2 + 3 layout).

Ovule types by orientation

Six ovule types appear in NEET: **Orthotropous** (upright; micropyle, chalaza, funicle in line) ⇒ *Piper, Polygonum*; **Anatropous** (inverted; micropyle near hilum; the most common, $\sim 82\%$); **Hemianatropous** (90°); **Campylotropous** (curved body); **Amphitropous** (more curved, embryo sac horseshoe); **Circinotropous** (funicle coils around).

4 4. Pollination — Agents and Types (NCERT 1.2.4)

Pollination is the transfer of pollen grains (shed from the anther) to the stigma of a pistil. Three types by source; pollination agents are **abiotic** (wind, water) or **biotic** (insects, birds, bats, etc.).

Three kinds of pollination

Autogamy: pollen → stigma of the *same flower*

Geitonogamy: pollen → stigma of *another flower on the same plant*

Xenogamy: pollen → stigma of *a different plant* (genetically different)

Only **xenogamy** brings genetically different pollen during pollination — it is **the only true cross-pollination** for genetic recombination purposes. Geitonogamy, though carried by external agents, is functionally self-pollination.

Pollination agents — characteristic adaptations

Anemophily (wind): pollen *light, dry, non-sticky*; stigma *feathery*; large amount produced — grasses, maize.

Hydrophily (water): rare; in *Vallisneria* (epihydrophily, surface) and *Zostera* (hypohydrophily, submerged); pollen long, ribbon-like, sometimes mucilage-coated.

Entomophily (insects): flowers *large, brightly coloured, fragrant*, with nectar; pollen *sticky, spiny* — the most common agent.

Ornithophily/Chiropterophily (birds/bats): large, sturdy flowers; copious nectar/pollen.

Both wind- and water-pollinated flowers are not colourful and do not produce nectar.

Reward for biotic pollinators: nectar or pollen.

Outbreeding devices (NCERT 1.2.4)

To prevent self-pollination in bisexual flowers, plants evolved several devices: **(i)** pollen release and stigma receptivity **not synchronised** (dichogamy — protandry / protogyny); **(ii)** anther and stigma placed at **different positions** (herkogamy); **(iii) self-incompatibility** — a genetic mechanism preventing pollen of the same plant from fertilising the egg; **(iv) unisexual flowers** produced (e.g. papaya is dioecious — no chance of self-pollination at all).

Pollen-pistil interaction

Compatibility check: pistil recognises pollen $\rightarrow$ if **compatible**: pollen germinates, pollen tube grows through style to ovule; if **incompatible**: pistil rejects pollen, no germination.

Pollen tube path: *pollen tube emerges from a germ pore* $\rightarrow$ grows through style $\rightarrow$ enters ovule via **micropyle** $\rightarrow$ enters **one synergid** via filiform apparatus $\rightarrow$ releases the two male gametes.

The chemical guidance is largely from the **filiform apparatus** of the synergids. **Artificial hybridisation** uses controlled pollination (emasculation + bagging) to bypass this natural barrier.

Self-incompatibility is genetic, not physical

Self-incompatibility is a **genetic (molecular)** barrier between pollen and pistil from the same plant — not a structural/timing issue. Don't confuse it with **dichogamy** (timing) or **herkogamy** (position), which are physical mechanisms.

Three pollinations — "Auto, Geito, Xeno"

Auto = same flower (Greek *autos* = self). **Geito** = same plant, different flower (Greek *geiton* = neighbour). **Xeno** = different plant (Greek *xenos* = stranger). The Greek roots give the meaning away.

5 5. Double Fertilisation (NCERT 1.3)

The defining event of angiosperms: **two fusion events** in the embryo sac. One gamete fuses with the egg ($\rightarrow$ zygote), the other with the polar nuclei / central cell ($\rightarrow$ PEN). The phenomenon is called **double fertilisation** — unique to flowering plants.

Syngamy — the first fusion

Male gamete (n) + Egg (n) $\longrightarrow$ **Zygote** $(2n)$

This is the classical sexual union — one haploid sperm fuses with one haploid egg cell to give the **diploid zygote** that becomes the embryo.

Triple fusion — the second fusion

Male gamete (n) + 2 polar nuclei $(n+n)$ $\longrightarrow$ **Primary Endosperm Nucleus, PEN** $(3n)$

The other sperm fuses with the secondary (diploid) nucleus formed by the two polar nuclei. The result is a **triploid** ($3n$) primary endosperm nucleus.

Double fertilisation — the combined process

$$\underbrace{\text{Sperm}_1 + \text{Egg} \rightarrow \text{Zygote } (2n)}_{\text{Syngamy}} \quad + \quad \underbrace{\text{Sperm}_2 + 2 \text{ PN} \rightarrow \text{PEN } (3n)}_{\text{Triple fusion}}$$

Because **two fusion events** occur in the same embryo sac, the process is called **double fertilisation**. It is **exclusive to angiosperms** (flowering plants) — gymnosperms show only single syngamy.

Why triploid endosperm matters

The triploid endosperm represents **1 maternal copy + 1 maternal copy + 1 paternal copy** ($2m + 1p$). This 2:1 imbalance is thought to enforce **parental conflict-resolution** and ensure resource investment in viable embryos. The endosperm later **nourishes the developing embryo** — the entire functional role of triple fusion.

Double fertilisation = unique to angiosperms

Frequently asked — **double fertilisation** (i.e. syngamy *plus* triple fusion in one embryo sac) is a **defining feature of flowering plants**; it is absent in gymnosperms and all non-flowering groups.

6 6. Post-fertilisation: Endosperm, Embryo, Seed (NCERT 1.4)

After fertilisation, three things develop in parallel: **endosperm** (from PEN), **embryo** (from zygote), and the **ovule** → **seed / ovary** → **fruit** transformation. Endosperm forms *before* embryo to ensure nutrition is ready.

Endosperm development — two modes

PEN $(3n)$ → **Free-nuclear divisions** (no cytokinesis) → many free nuclei → **cell-wall formation** → cellular endosperm.

where the most common pattern is **nuclear endosperm** (e.g. coconut — *coconut water* = free-nuclear stage; *coconut meat / kernel* = cellular endosperm).

Endosperm is the **food reserve** of the seed — entirely consumed during embryo growth in **non-endospermic seeds** (pea, bean, gram), but persists in **endospermic seeds** (cereals — wheat, maize, rice; castor).

Embryogeny (dicot vs. monocot)

Zygote $(2n)$ → **Proembryo** → **Globular** → **Heart-shaped** → **Mature dicot embryo**

Dicot embryo: embryonal axis + **two cotyledons**; axis has **epicotyl** (above cotyledons, ends in plumule) and **hypocotyl** (below cotyledons, ends in radicle).

Monocot embryo: one cotyledon (**scutellum**); axis carries **plumule** enclosed in **coleoptile** and **radicle** enclosed in **coleorhiza** (both protective sheaths).

Cotyledon count is the **primary classification key** for angiosperms — monocots (1) vs. dicots

(2). Coleoptile / coleorhiza are unique to monocots (e.g. wheat, maize).

Ovule → Seed transformations

Integuments → **Seed coat** (testa + tegmen) ; **Nucellus** (usually) → *consumed*; rarely persists as **Perisperm** (e.g. pepper, beet).

Micropyle → persists as a **small pore** for water entry during germination. **Ovule** → **Seed**. **Ovary wall** → **Pericarp of fruit**. **Ovary** → **Fruit**.

Seed = **fertilised ovule**; Fruit = **fertilised ovary**. A **true fruit** develops only from the ovary; if other floral parts (e.g. thalamus) also contribute, it is a **false fruit** (e.g. apple).

Seed dormancy & viability

Seeds remain alive even after dispersal because of **dormancy** (delayed germination) and very low metabolic activity. Recorded seed-viability: lupine seeds germinated after **10,000 yr**; date-palm seeds after **2000 yr**. NCERT-stated cause of dormancy: impermeable seed coat, inhibitors, or immature embryo — breakable by stratification, scarification, or growth regulators.

Fruit classification — short summary

True fruit: develops only from ovary (e.g. mango, grape).

False fruit: thalamus or other floral parts also contribute (e.g. **apple, strawberry, cashew**).

Parthenocarpic fruit: develops *without fertilisation*, hence **seedless** (e.g. **banana, papaya, grape**); can be artificially induced with growth regulators.

Banana being a parthenocarpic fruit is a very common NEET MCQ — it has no fertilised seed, only vestigial ovules.

Seed coat layers — testa vs. tegmen

The outer layer of the seed coat is the **testa** (from outer integument) and the inner layer is the **tegmen** (from inner integument). Students reverse the two. Mnemonic: *outer T, inner T* — **T**esta is on **T**op.

7 7. Apomixis and Polyembryony (NCERT 1.5)

Some seeds do not arise from the normal zygotic route. **Apomixis** produces seeds *without meiosis or fertilisation*; **polyembryony** produces *more than one embryo* in a single seed.

Apomixis — definition

Apomixis = asexual seed formation with **no meiosis** and **no fertilisation**

where the embryo develops directly from a $2n$ cell of the nucellus or from an unreduced megaspore.

Apomixis ⇒ embryo is **genetically identical to the parent** (a natural clone). It is common in **Asteraceae** and many grasses (e.g. *Asteraceae* weeds). Of huge interest in **hybrid-seed agriculture** — if a hybrid plant becomes apomictic, farmers can re-sow hybrid seeds year after year without losing vigour.

Polyembryony — definition

Polyembryony $=$ occurrence of **more than one embryo** in a single seed

where extra embryos may arise from nucellus, integuments, synergids, or by zygotic division.

Classic example: **Citrus** and **mango**, where nucellar tissue gives rise to additional embryos alongside the zygotic one. Useful for clonal propagation of horticultural varieties.

Why apomixis is a holy grail for plant breeders

Hybrid seeds (e.g. hybrid maize) give high yield but **lose vigour from F_2 onwards** due to segregation. If apomixis can be engineered into hybrids, F_1 **hybrid-vigour traits would breed true** year after year — no need to buy fresh hybrid seed each season.

Difference: apomixis vs. parthenocarpy

Both bypass normal fertilisation, but: **Apomixis** = *seed* produced without fertilisation (asexual seed). **Parthenocarpy** = *fruit* produced without fertilisation (seedless fruit, e.g. banana). Don't confuse the two — apomixis still gives seeds, parthenocarpy does not.

8 8. Coverage Map — Other NCERT Concepts

Concept-only items that do not carry a formula but feature in the NCERT subsections. Listed here so the formula sheet has *zero gaps* against the chapter table of contents.

Bisexual vs. unisexual; staminate vs. pistillate (1.1)

Bisexual flower: both stamens and pistil in the same flower (e.g. hibiscus, mustard). **Unisexual** flower: only stamens (**staminate**, "male") or only pistil (**pistillate**, "female"). **Monoecious**: both sexes on the same plant (cucurbits, maize). **Dioecious**: separate male and female plants (papaya, date palm) — **automatically prevents self-pollination**.

Continuous vs. episodic flowering

Most angiosperms have a **seasonal** flowering pattern, but **Bamboo** flowers only once in 50–100 years, produces large amounts of seed, and dies (mass-flowering, monocarpic). **Strobilanthus kunthiana** (*neelakuranji*) flowers once every 12 years, painting the Western Ghats blue. Both are recurring NEET trivia.

Artificial hybridisation: emasculation & bagging (1.2.4)

For cross-breeding a known male and female parent, the breeder uses **emasculation** (removal of anthers from the bisexual flower bud before they dehisce, preventing self-pollination) and **bagging** (covering the emasculated flower with butter-paper bag to keep out unwanted pollen). When the stigma is receptive, pollen of the chosen male is dusted on it, and the flower is re-bagged. For **unisexual female flowers**, emasculation is unnecessary — just bagging suffices.

Sporopollenin's significance

The exine's **sporopollenin** is the **most resistant organic material known**: it withstands enzymatic action, high temperatures, strong acids and alkalis. Consequence: pollen grains are well preserved as **fossils** (palynology) — ancient pollen identifies past vegetation and climate. Also, pollen **allergens** (Parthenium, hay-fever pollen) survive long enough to cause severe respiratory allergies.

Read the Full Revision Notes

9 9. Quick Reference — Ploidy & Process Index

Process / Structure	Key event / equation	Result / ploidy
Microsporogenesis	MMC $(2n) \rightarrow$ 4 microspores (meiosis)	Tetrad of $4n$ haploids
Pollen maturation	Microspore $(n) \rightarrow$ Veg. + Gen. cells (mitosis)	2-celled or 3-celled pollen
Male-gamete formation	Gen. cell $(n) \rightarrow$ 2 sperms (mitosis)	2 male gametes, both n
Megasporogenesis	MMC $(2n) \rightarrow$ 4 megaspores (meiosis; 3 die)	1 functional megaspore, n
Megagametogenesis	1 megaspore $\rightarrow$ 8 nuclei / 7 cells (3 mitoses)	Polygonum-type embryo sac
Syngamy	Sperm $(n)+$ Egg (n)	**Zygote,** $2n$
Triple fusion	Sperm $(n)+$ 2 PN $(n+n)$	**PEN,** $3n$
Double fertilisation	Syngamy $+$ triple fusion (same sac)	Zygote $2n$ & PEN $3n$
Endosperm development	PEN $(3n) \rightarrow$ free-nuclear $\rightarrow$ cellular	Triploid endosperm tissue
Embryogeny (dicot)	Zygote $\rightarrow$ proembryo $\rightarrow$ globular $\rightarrow$ heart $\rightarrow$ mature	2 cotyledons, plumule, radicle
Embryogeny (monocot)	Same path, ending with scutellum + coleoptile + coleorhiza	1 cotyledon, sheaths present
Ovule $\rightarrow$ Seed	Integuments $\rightarrow$ seed coat; ovule $\rightarrow$ seed	Mature seed
Ovary $\rightarrow$ Fruit	Ovary wall $\rightarrow$ pericarp	True/false/parthenocarpic fruit
Pollination types	Autogamy / Geitonogamy / Xenogamy	Self vs. cross gene flow
Apomixis	Embryo from $2n$ nucellar cell, no syngamy	Clonal seed, parent-identical
Polyembryony	> 1 embryo per seed (nucellus origin)	Multiple seedlings per seed

Related Collegedunia Resources

Same chapter — other resources:

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

Continue learning:

- Ch 2: Human Reproduction
- Class 12 Biology — All Chapters

End of Formula Sheet — Class 12 Biology Chapter 1: Sexual Reproduction in Flowering Plants.

Continue with Chapter 2 (Human Reproduction) for the animal-side comparison, or revisit NCERT Sec. 1.3 for the original double-fertilisation diagram.