FREE EDITION · NOTES + 3 SAMPLE MCQS

CUET · BIOLOGY · CLASS XI · CODE 304

Plant Growth and Development

CUET unit: Plant Physiology → Plant Growth and Development

By **UniDrill** · NCERT-grounded study material

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📌 Snapshot

- Establishes that development = growth + differentiation, and that plant growth is indeterminate (open) due to permanently active meristems.
- Defines growth quantitatively (arithmetic vs geometric, sigmoid curve, absolute vs relative growth rate) and lists the three phases (meristematic, elongation, maturation).
- Distinguishes differentiation, dedifferentiation and redifferentiation, and introduces plasticity (heterophylly in cotton, coriander, larkspur, buttercup).
- Walks through the accidental discovery of the five PGRs (auxin, gibberellin, cytokinin, ABA, ethylene) and their physiological/agricultural roles.
- High-yield for CUET because almost every section produces direct factual recall items — discoverers, formulae, applications, antagonisms.

📖 Detailed Notes

2.1 Core concepts

- **Development = growth + differentiation**, a precise and highly ordered succession of events that produces roots, leaves, branches, flowers, fruits and seeds, and ends in death; seed germination is the first step and needs favourable conditions, failing which the seed remains in suspended growth or rest (NCERT §13 intro, p. 166).
- **Growth** is defined as an irreversible permanent increase in size of an organ, its parts, or even a single cell, generally accompanied by anabolic and catabolic metabolism at the expense of energy (NCERT §13.1, p. 167).
- **Plant growth is indeterminate** — plants retain unlimited growth capacity throughout life due to meristems whose cells divide and self-perpetuate; this is called the open form of growth (NCERT §13.1.1, p. 167).
- Root apical meristem and shoot apical meristem drive **primary growth (elongation along the axis)**; in dicots and gymnosperms, **lateral meristems — vascular cambium and cork cambium — appear later** and cause **secondary growth (increase in girth)** (NCERT §13.1.1, p. 168).
- Growth at the cellular level is principally an **increase in protoplasm**, measured indirectly by fresh weight, dry weight, length, area, volume or cell number; one maize root apical meristem can give rise to **more than 17,500 new cells per hour**,

whereas a watermelon cell can increase in size **up to 3,50,000 times** (NCERT §13.1.2, p. 168).

- **Three phases of growth** in a root tip: **meristematic** (cells with dense protoplasm, large nuclei, thin primary cellulosic walls, abundant plasmodesmata), **elongation** (increased vacuolation, cell enlargement, new wall deposition), and **maturation** (maximal wall thickening and protoplasmic modifications) (NCERT §13.1.3, pp. 168–169).
- **Arithmetic growth**: after mitosis only one daughter cell continues to divide while the other differentiates; expressed as $L_t = L_0 + rt$, giving a linear curve (e.g., root elongating at a constant rate) (NCERT §13.1.4, p. 170).
- **Geometric growth**: both daughter cells retain divisional ability — initial slow lag phase, then exponential/log phase, then a stationary phase due to limited nutrients; plotted against time it gives a **sigmoid (S-shaped) curve**, characteristic of all cells, tissues and organs in nature; expressed as $W_1 = W_0 e^{rt}$, where r is the relative growth rate and the **efficiency index** (NCERT §13.1.4, pp. 170–171).
- **Absolute growth rate** = total growth per unit time; **relative growth rate** = growth per unit time expressed on a common basis (e.g., per unit initial parameter); two leaves with the same absolute increase (5 cm^2) can have very different relative growth rates (NCERT §13.1.4, p. 171, Fig. 13.7).
- **Conditions for growth**: water (turgidity drives cell enlargement, medium for enzymes), oxygen (releases metabolic energy), nutrients (macro + micro elements for protoplasm and energy), optimum temperature range, plus environmental signals such as light and gravity (NCERT §13.1.5, p. 171).
- **Differentiation** = act leading to maturation of cells from meristems/cambium, involving structural changes in walls and protoplasm — e.g., a tracheary element loses its protoplasm and develops strong, elastic, lignocellulosic secondary walls to transport water under tension (NCERT §13.2, p. 172).
- **Dedifferentiation** = living differentiated cells that had lost divisional capacity regain it — e.g., interfascicular cambium and cork cambium form from fully differentiated parenchyma; these meristems then **redifferentiate** to give cells that again lose divisional capacity but mature for specific functions (NCERT §13.2, p. 172).
- **Differentiation in plants is open**: cells from the same meristem develop different structures depending on location — e.g., cells away from the root apical meristem become root-cap cells, while peripheral cells mature into epidermis (NCERT §13.2, p. 172).
- **Plasticity** — plants follow different developmental pathways in response to environment or life phase, e.g., **heterophylly in cotton, coriander and larkspur** (juvenile vs adult leaves) and in **buttercup** (leaves in air vs in water) (NCERT §13.3, p. 173, Fig. 13.9).
- **PGRs** are small simple molecules of diverse chemistry: indole compounds (IAA), adenine derivatives (kinetin = N^6-furfurylamino purine), carotenoid derivatives (ABA),

terpenes (GA_3), or gases (ethylene, C_2H_4); also called plant growth substances, plant hormones or phytohormones (NCERT §13.4.1, p. 174).

- Two functional groups of PGRs: **promoters** (auxins, gibberellins, cytokinins) and **inhibitors/stress responders** (ABA); **ethylene** fits either group but is largely a growth inhibitor (NCERT §13.4.1, p. 174).
- **Discovery — Auxin**: Charles Darwin and Francis Darwin observed that canary grass coleoptiles bent towards unilateral light (phototropism); the tip was the site of the transmittable influence. **F. W. Went** later isolated auxin from oat coleoptile tips (NCERT §13.4.2, p. 174, Fig. 13.10).
- **Discovery — Gibberellin**: 'bakanae' (foolish seedling) disease of rice caused by Gibberella fujikuroi; **E. Kurosawa (1926)** reproduced symptoms using sterile fungal filtrates; the active substance was later identified as **gibberellic acid** (NCERT §13.4.2, p. 175).
- **Discovery — Cytokinin**: **F. Skoog and co-workers** found that tobacco internode callus proliferated only when auxin was supplemented with vascular tissue extract, yeast extract, coconut milk or DNA; **Miller et al. (1955)** isolated and crystallised the cytokinesis-promoting substance and named it **kinetin** (from autoclaved herring sperm DNA) (NCERT §13.4.2, p. 175).
- **Discovery — ABA**: in the mid-1960s, three independent groups characterised inhibitor-B, abscission II and dormin, which were later shown to be chemically identical and named **abscisic acid (ABA)** (NCERT §13.4.2, p. 175).
- **Discovery — Ethylene**: **H. H. Cousins (1910)** confirmed that ripened oranges release a volatile substance that hastens ripening of stored unripened bananas; this was later identified as ethylene (NCERT §13.4.2, p. 175).
- **Auxins** (Greek auxein, "to grow") — first isolated from human urine; natural: IAA, IBA; synthetic: NAA, 2,4-D; produced at growing apices of stems and roots and migrate to sites of action; promote **rooting in stem cuttings**, flowering in pineapples, prevent early fruit/leaf drop, promote abscission of older mature leaves/ fruits, induce **apical dominance** (apical bud suppresses axillary buds — decapitation releases laterals; used in tea plantations and hedge-making), induce **parthenocarpy** (e.g., tomatoes), and **2,4-D acts as a herbicide** killing dicot weeds while sparing mature monocots; auxin also controls xylem differentiation and helps in cell division (NCERT §13.4.3.1, pp. 175–176).
- **Gibberellins** — more than 100 known (GA_1, GA_2, GA_3...); **GA_3 was the first discovered and most studied**; all GAs are acidic; **increase length** (lengthens grape stalks; elongates and improves apple shape; delays senescence so fruit can stay on the tree longer), speed up **malting** in the brewing industry, increase **sugarcane** stem length and yield (up to **20 tonnes per acre**), **hasten maturity** of juvenile conifers for early seed production, and promote **bolting** (internode elongation just before flowering in rosette plants like beet and cabbage) (NCERT §13.4.3.2, p. 176).

- **Cytokinins** — discovered as kinetin (modified adenine, a purine) from **autoclaved herring sperm DNA**; kinetin does not occur naturally; **zeatin** isolated from corn-kernels and coconut milk; synthesised where rapid cell division occurs (root apices, developing shoot buds, young fruits); help produce new leaves, chloroplasts, lateral shoots, adventitious shoots; **overcome apical dominance**; promote nutrient mobilisation thereby **delaying leaf senescence** (NCERT §13.4.3.3, pp. 176–177).
- **Ethylene** — simple gaseous PGR synthesised in large amounts by senescing tissues and ripening fruits; causes horizontal seedling growth, axis swelling and apical hook in dicot seedlings; promotes senescence and abscission of leaves/flowers; highly effective in **fruit ripening** and raises the respiration rate ("**respiratory climacteric**"); breaks seed and bud dormancy, initiates germination in peanut, sprouting of potato tubers; promotes rapid internode/petiole elongation in **deep-water rice** (keeps leaves above water); promotes root growth and root hair formation; initiates and synchronises flowering/fruit-set in pineapple and induces flowering in mango; **ethephon** is the most widely used ethylene source — hastens ripening in tomato/apple, accelerates abscission (thinning cotton, cherry, walnut), promotes female flowers in cucumber (NCERT §13.4.3.4, p. 177).
- **Abscisic acid (ABA)** — discovered via regulation of abscission and dormancy; acts as a **general plant growth inhibitor** and inhibitor of metabolism; **inhibits seed germination**; **stimulates stomatal closure** and increases tolerance to stresses — hence the **"stress hormone"**; important in seed development, maturation and dormancy (helps seeds withstand desiccation); **antagonistic to GAs in most situations** (NCERT §13.4.3.5, pp. 177–178).
- PGR roles can be **complementary or antagonistic, individualistic or synergistic**; events like seed/bud dormancy, abscission, senescence and apical dominance involve more than one PGR; PGRs are only one kind of intrinsic control, working alongside genomic control and extrinsic factors (temperature, light) which often act via PGRs to control events such as **vernalisation, flowering, dormancy, seed germination and plant movements** (NCERT §13.4.3.5, p. 178).

2.2 Definitions to memorise

Term	Definition	Page
Growth	Irreversible permanent increase in size of an organ, its parts or even a single cell, generally accompanied by metabolism	167
Open form of growth	Mode in which new cells are continually added by meristematic activity, giving indeterminate growth	167
Primary growth	Elongation of plant axes driven by root and shoot apical meristems	168
Secondary growth	Increase in girth driven by lateral meristems (vascular cambium, cork cambium) in dicots and gymnosperms	168
Meristematic phase		

Term	Definition	Page
	Region of constantly dividing cells with dense protoplasm, large nuclei, thin primary cellulosic walls, plasmodesmata	168–169
Elongation phase	Cells just proximal to the meristem showing increased vacuolation, enlargement and new cell-wall deposition	169
Maturation phase	Most proximal region where cells attain maximal size with wall thickening and protoplasmic modifications	169
Arithmetic growth	After mitosis only one daughter divides further; $L_t = L_0 + rt$; gives a linear curve	170
Geometric growth	Both daughters keep dividing; lag → log/exponential → stationary; $W_1 = W_0 e^{rt}$; gives a sigmoid curve	170
Efficiency index	Relative growth rate r in $W_1 = W_0 e^{rt}$; measures the ability of the plant to produce new plant material	170
Absolute growth rate	Total growth per unit time	171
Relative growth rate	Growth per unit time expressed on a common basis (e.g., per unit initial parameter)	171
Differentiation	Maturation of meristem/cambium-derived cells into structurally and functionally specialised cells	172
Dedifferentiation	Regaining of divisional capacity by living differentiated cells (e.g., interfascicular cambium from parenchyma)	172
Redifferentiation	Cells produced by dedifferentiated meristems again losing divisional capacity and maturing for specific functions	172
Development	All changes from seed germination to senescence; sum of growth and differentiation	172
Plasticity	Ability of plants to follow different developmental pathways under different environments/life phases (e.g., heterophylly)	173
Plant growth regulator (PGR)	Small, simple, chemically diverse molecules controlling plant growth/development; also called phytohormones	174
Apical dominance	Inhibition of axillary bud growth by the growing apical bud; mediated by auxin	175
Parthenocarpy	Development of fruit without fertilisation; induced by auxin (e.g., tomato)	176
Bolting	Internode elongation just prior to flowering in rosette plants; induced by gibberellins	176
Respiratory climacteric	Ethylene-induced rise in respiration rate during fruit ripening	177
Stress hormone	ABA, because it stimulates stomatal closure and increases tolerance to stresses	177

2.3 Diagrams / processes to remember

- **Figure 13.1, p. 167** — germination and seedling development in bean (seed coat, epicotyl hook, cotyledons, hypocotyl, soil line).
- **Figure 13.2, p. 168** — locations of root apical meristem, shoot apical meristem and vascular cambium with arrows showing direction of growth.
- **Figure 13.3, p. 168** — detection of zones of elongation in a root by the parallel-line technique (zones A, B, C, D immediately behind the apex elongate most).
- **Figure 13.4, p. 169** — arithmetic vs geometric growth; embryo stages showing geometric phase (all cells divide) and arithmetic phase (some daughters lose divisional capacity).
- **Figure 13.5, p. 170** — constant linear growth curve (height vs time).
- **Figure 13.6, p. 170** — idealised sigmoid growth curve with lag, exponential and stationary phases.
- **Figure 13.7, p. 171** — comparison of absolute vs relative growth rates using two leaves A (5 → 10 cm²) and B (50 → 55 cm²) that show the same absolute increase but very different relative increases.
- **Figure 13.8, p. 173** — developmental sequence in a plant cell: Meristematic cell → (cell division, plasmatic growth, expansion/elongation, differentiation, maturation) → Mature cell → senescence → death.
- **Figure 13.9, p. 173** — heterophylly in larkspur (juvenile vs adult) and buttercup (terrestrial vs aquatic leaves).
- **Figure 13.10, p. 174** — Darwin/Went-style coleoptile tip experiment showing the tip is the source of auxin and phototropic response.
- **Figure 13.11, p. 176** — apical dominance: plant with intact apical bud vs decapitated plant showing growth of lateral buds.

2.4 Common confusions / NTA trap points

- **Arithmetic vs geometric growth** — students often swap the formulae. $L_{?} = L_0 + rt$ is arithmetic (linear); $W_1 = W_0 e^{rt}$ is geometric (exponential). Sigmoid curve belongs to geometric growth in a natural environment.
- **Absolute vs relative growth rate** — two leaves can have the same absolute increase yet very different relative rates; in Fig. 13.7 the smaller leaf A has the higher relative growth rate.
- **Kinetin source** — kinetin was crystallised from autoclaved **herring sperm DNA**, not from a plant; **zeatin** is the natural cytokinin from corn-kernels and coconut milk.
- **PGR chemistry trap** — IAA is an indole compound, kinetin is an adenine (purine) derivative, ABA is a carotenoid derivative, GA_3 is a terpene, ethylene is a gas; NTA loves to scramble these matches.

- **Auxin discovery** — Darwin only inferred a transmittable influence in the coleoptile tip; **F. W. Went** actually isolated auxin from oat coleoptile tips.
- **2,4-D selectivity** — kills dicot weeds, does **not** affect mature monocots; used for weed-free lawns.
- **Bolting vs apical dominance** — bolting is gibberellin-induced internode elongation before flowering in rosette plants; apical dominance is auxin-induced suppression of laterals. Cytokinin overcomes apical dominance.
- **ABA vs ethylene** — both inhibit, but ABA is the stress hormone (closes stomata, inhibits germination) while ethylene is the ripening hormone (climacteric, abscission, dormancy-breaking in peanut/potato).

🎯 Practice MCQs

Q1. Growth is best defined as

A. A reversible increase in cell size accompanied by water uptake only

B. An irreversible permanent increase in size of an organ, its parts or even an individual cell, generally accompanied by metabolic processes

C. The qualitative change in cells leading to formation of specialised tissues

D. The sum of cell division and senescence in a meristem

Q2. Match the plant growth regulator with its chemical class: | PGR | Chemical class | |---|---| | P. IAA | 1. Terpene | | Q. Kinetin | 2. Carotenoid derivative | | R. GA_3 | 3. Indole compound | | S. ABA | 4. Adenine derivative |

A. P-3, Q-4, R-1, S-2

B. P-3, Q-2, R-1, S-4

C. P-1, Q-4, R-3, S-2

D. P-3, Q-1, R-4, S-2

Q3. Which of the following statements about arithmetic and geometric growth are correct? I. In arithmetic growth, after mitosis only one daughter cell continues to divide while the other matures. II. Arithmetic growth follows the equation $W_1 = W_0 e^{rt}$. III. The sigmoid curve has lag, log and stationary phases and is typical of cells in culture and many higher plant organs. IV. In geometric growth, both progeny cells retain the ability to divide initially.

A. I, II and III only

B. I, III and IV only

C. II, III and IV only

D. I, II and IV only

📊 PYQ Alignment

In CUET (UG) 2023–25, "Plant Growth and Development" reliably yields 6–8 MCQs each session under the Plant Physiology unit. The dominant question types are (i) PGR–effect matching (auxin → apical dominance/parthenocarpy/2,4-D; GA → bolting/malting/grape stalk; ethylene → climacteric/ripening; ABA → stress/stomatal closure), (ii) discoverer matches (Darwin, Went, Kurosawa, Skoog, Miller, Cousins), (iii) phases of growth and the arithmetic vs geometric formulae, and (iv) statement-based items distinguishing differentiation, dedifferentiation and redifferentiation.

Plant Growth and Development appeared in CUET (UG) Biology across 1 cycle(s) — 1 question(s) total. The questions below were extracted from official CUET (UG) papers and matched to this chapter by topic. See `/pyq/biology` for the full PYQ archive.

CUET 2023 — Actual PYQs from this chapter

Q.26 (CUET 2023) Which of the following is not a cyanobacteria?

- A) Nostoc
- B) Glomus
- C) Anabaena
- D) Oscillatoria

Tests: aligns with chapter content Answer: Not in extracted key — verify against official NTA key