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CHAPTER NOTES

Plant Growth and Development

Class 11 Notes | CBSE Biology

Chapter 13

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Plant Growth and Development Class 11 Notes | CBSE Biology Chapter 13

Plant Growth and Development is Chapter 13 of CBSE Class 11 Biology — and one of the most fact-heavy, NEET-favourite chapters in the entire syllabus. It explains *how* a tiny seed becomes a towering tree: how plant cells grow, divide, specialise, and how five chemical messengers called plant growth regulators silently control flowering, ripening, dormancy, and the fall of leaves.

By the end of these notes you will be able to describe the phases and conditions of growth, distinguish differentiation, dedifferentiation and redifferentiation, recall every plant growth regulator with its discovery and functions, and confidently answer questions on photoperiodism, vernalisation, and seed dormancy. This is a high-yield chapter — almost every NEET paper carries 1–2 direct questions from it, and boards test it for 4–6 marks.

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Key Concepts

1. What is Growth?

Growth is an irreversible permanent increase in size of an organ, its parts, or even an individual cell. It is accompanied by metabolic processes (both anabolic and catabolic) that consume energy.

In plants, growth is largely confined to specialised regions of active cell division called **meristems**. Plants retain the capacity for unlimited growth throughout their life because meristems keep dividing — this is called **indeterminate growth**.

- **Apical meristems:** at root and shoot tips → cause increase in length (primary growth).
 - **Lateral meristems (cambium):** vascular cambium and cork cambium → cause increase in girth (secondary growth) in dicots.
 - **Intercalary meristems:** at the base of internodes/leaves (e.g., grasses) → help regrowth after grazing.
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2. Phases of Growth

Growth at the cellular level proceeds through three distinct phases that follow one another in the region behind the root/shoot tip.

- **Meristematic phase (phase of formation):** cells at the apex divide actively; they have rich protoplasm, large nuclei, thin cellulose walls and abundant plasmodesmata.
 - **Elongation phase:** cells just behind the meristem enlarge by water absorption (vacuolation), deposit new cell wall material and elongate.
 - **Maturation phase:** cells attain their maximal size, develop thickened walls and acquire specific protoplasmic modifications — they mature into permanent tissue.
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3. Growth Rate and Its Mathematical Expression

The increased growth per unit time is called the **growth rate**. Growth can be measured arithmetically or geometrically.

- **Arithmetic growth:** only one daughter cell continues to divide while the other matures. Length increases linearly. $L_t = L_0 + rt$ (L_0 = length at start, r = growth rate, t = time). Example: a root elongating at constant rate.
- **Geometric growth:** early stage is slow (lag phase), followed by rapid exponential growth (log phase), then slowing as nutrients become limiting (stationary phase) — giving a sigmoid (S-shaped) curve. $W_1 = W_0 e^{rt}$ (W_0 = initial size, r = relative growth rate, e = base of natural log).

[DIAGRAM: A sigmoid (S-shaped) growth curve showing lag phase, log/exponential phase, and stationary phase plotted as size vs time.]

Absolute vs Relative Growth Rate

- **Absolute growth rate:** measurement and comparison of total growth per unit time.
 - **Relative growth rate:** growth of a system per unit time expressed on a common basis (e.g., per unit initial size).
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4. Conditions for Growth

Plants need certain external and internal conditions for healthy growth.

- **Water:** essential for cell enlargement (turgidity) and as a medium for enzymatic reactions.
 - **Oxygen:** needed for respiration to release energy for growth.
 - **Nutrients (macro and micro):** raw material for protoplasm synthesis and energy.
 - **Optimum temperature:** for the enzyme-driven metabolic reactions of growth.
 - **Light and gravity:** affect the direction and form of growth (tropic responses).
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5. Differentiation, Dedifferentiation and Redifferentiation

This trio of terms is a guaranteed NEET question. They describe how cells gain, lose, and regain the ability to divide and specialise.

Term	Meaning	Example
Differentiation	Cells derived from meristems mature to perform specific functions; involves structural changes in cell walls and protoplasm	Formation of tracheary elements losing protoplasm and developing thick lignified walls
Dedifferentiation	Living differentiated cells regain the capacity to divide under certain conditions	Formation of interfascicular cambium and cork cambium from parenchyma
Redifferentiation	Cells produced by dedifferentiated meristem lose the capacity to divide again and mature	Secondary xylem, secondary phloem and cork formed from cambium

Key idea: The growth in plants is **open** and the differentiation in plants is **open** too — the same apical meristem can form a leaf at one time and a flower at another, depending on the position and conditions.

6. Development

Development is the sum total of growth and differentiation. It includes all the changes an organism goes through during its life cycle, from seed germination to senescence.

A plant can follow different developmental pathways from the same genetic make-up, forming different kinds of structures. This flexibility is called **plasticity**.

- **Heterophylly** in cotton, coriander and larkspur — leaves of the juvenile plant differ in shape from those of the mature plant.
- **Heterophylly in buttercup** — leaves formed in air differ from those formed in water (an environmental effect).

Development is controlled by both **intrinsic factors** (intracellular = genetic; intercellular = plant growth regulators) and **extrinsic factors** (light, temperature, water, oxygen, nutrition).

7. Plant Growth Regulators (PGRs)

Plant growth regulators are small, simple molecules of diverse chemical composition that regulate growth and development. They are also called plant hormones or phytohormones.

They fall into two broad groups:

- **Growth promoters:** auxins, gibberellins and cytokinins — involved in cell division, cell enlargement, flowering, fruiting and seed formation.
- **Growth inhibitors:** abscisic acid (ABA) and ethylene (a gaseous PGR) — involved in dormancy, abscission and responses to stress.

(a) Auxins

- **Discovery:** first isolated from human urine; the term comes from Greek *auxein* (to grow). Charles Darwin and Francis Darwin observed coleoptile bending toward light; later F.W. Went isolated auxin from oat (*Avena*) coleoptile tips.
- **Examples:** natural — indole-3-acetic acid (IAA), indole butyric acid (IBA); synthetic — NAA (naphthalene acetic acid), 2,4-D (2,4-dichlorophenoxyacetic acid).
- **Functions:** promote cell elongation; induce rooting in stem cuttings; promote flowering in pineapple; prevent fruit and leaf drop at early stages but promote abscission of older leaves/fruits; induce **parthenocarp**y (seedless fruits, e.g., tomato); control **apical dominance** (suppress growth of lateral buds); 2,4-D is used as a weedicide to kill dicot weeds.

(b) Gibberellins

- **Discovery:** identified from the fungus *Gibberella fujikuroi*, which caused the "bakanae" (foolish seedling) disease of rice. GA₃ was the first gibberellin to be discovered; over 100 gibberellins are now known.
- **Functions:** cause increase in length of the axis (used to increase stem length in sugarcane and yield); promote **bolting** (internode elongation just before flowering) in rosette plants like beet and cabbage; delay senescence so fruits can be left longer on the tree; speed up the **malting** process in the brewing industry; help break seed and bud dormancy; promote the formation of seedless grapes (increase fruit size and bunch length).

(c) Cytokinins

- **Discovery:** the first cytokinin, **kinetin** (a modified adenine), was isolated from herring sperm DNA. The first natural cytokinin **zeatin** was isolated from corn kernels and coconut milk.
- **Functions:** promote cell division (cytokinesis); help produce new leaves, chloroplasts in leaves, lateral shoot growth and adventitious shoot formation; overcome apical dominance; promote nutrient mobilisation; delay leaf senescence (the **Richmond–Lang effect**).

(d) Ethylene

- **Nature:** a simple gaseous PGR, synthesised in large amounts by tissues undergoing senescence and ripening fruits.
- **Functions:** promotes horizontal growth of seedlings, swelling of the axis and apical hook formation in dicot seedlings; promotes senescence and abscission of leaves and flowers; **ripens fruits** and enhances respiration during ripening (respiratory climactic); breaks seed and bud dormancy; promotes rapid internode/petiole elongation in deep-water rice; promotes root growth and root hair formation; induces flowering in mango. **Ethephon** (the most widely used source of ethylene) hastens fruit ripening in tomato and apple and accelerates female flowers in cucumber.

(e) Abscissic Acid (ABA)

- **Discovery:** first called "dormin" / "abscisin II"; it acts as an antagonist to gibberellins.
- **Functions:** a general plant growth inhibitor and an inhibitor of plant metabolism; inhibits seed germination; stimulates the **closure of stomata** under water stress and increases tolerance to stresses — hence it is called the **stress hormone**; induces and maintains seed and bud dormancy, helping seeds withstand desiccation. In most situations ABA acts as an antagonist to GAs.

8. Photoperiodism

Photoperiodism is the response of plants to periods of day length (light) that affects flowering. Some plants require a precise duration of light to flower.

Type	Requirement	Examples
Long-day plants	Flower when light period is more than a critical duration	Spinach, radish, wheat
Short-day plants	Flower when light period is less than a critical duration	Chrysanthemum, soybean, rice, tobacco
Day-neutral plants	No correlation between flowering and day length	Tomato, cucumber, maize

Key idea: It is actually the duration of the **dark period** (night) that is critical, not just the light. The **leaves** perceive the photoperiodic stimulus, and a hormonal substance (florigen) is believed to migrate from leaves to the shoot apex to induce flowering. A pigment called **phytochrome** is responsible for perceiving light.

9. Vernalisation

Vernalisation is the promotion of flowering by exposure of a plant to a period of low temperature (cold treatment). It prevents premature flowering and lets the plant attain maturity.

- Some plants need cold to flower — e.g., winter varieties of wheat, barley and rye. If winter varieties are planted in spring they normally fail to flower unless given a cold treatment.
- Biennial plants such as sugar beet, cabbage and carrots are monocarpic plants that normally flower in the second season; vernalisation can shorten this to one season.

10. Seed Dormancy

Seed dormancy is the state in which a viable, mature seed fails to germinate even under favourable conditions (adequate water, oxygen and suitable temperature). It is a survival strategy that prevents germination at the wrong time.

Causes of Dormancy

- Impermeable and hard seed coats** that block water and oxygen entry.
- Presence of chemical **inhibitors** such as abscisic acid, phenolic acids and para-ascorbic acid.
- Immature or rudimentary embryo.

Breaking Dormancy

- Scarification:** mechanical abrasion / softening of hard seed coats (also by vigorous shaking or working through animal digestive tracts).

- **Chilling and light/dark treatments** to overcome internal blocks.
- Applying gibberellins and other growth promoters; removing or leaching out inhibitors.

Weightage in Board & Entrance Exams

Exam	Typical Weightage	Most-Tested Areas
CBSE Board (Class 11)	4–6 marks	PGRs and functions, differentiation trio, photoperiodism, vernalisation
NEET	1–2 questions	Discovery of PGRs, functions, growth phases, dormancy facts
State CETs	1–2 questions	Auxin/gibberellin/cytokinin functions, growth curve

[TABLE: Question-type split — VSA (1 mark): PGR examples & definitions; SA (2–3 marks): differentiation trio, photoperiodism types, growth phases; LA (5 marks): PGRs with discovery & functions, conditions for growth.]

Important Definitions

Term	Definition
Growth	An irreversible permanent increase in size of an organ or its parts or an individual cell
Meristem	A region of actively dividing cells responsible for growth in plants
Differentiation	Maturation of meristem-derived cells to perform specific functions
Dedifferentiation	Regaining of the capacity to divide by living differentiated cells
Redifferentiation	Loss of dividing capacity and maturation of dedifferentiated cells
Development	Sum total of growth and differentiation over the life of a plant
Plasticity	Ability of plants to follow different developmental pathways under different conditions
Photoperiodism	Response of flowering to the relative lengths of day and night
Vernalisation	Promotion of flowering by exposure to a period of low temperature
Seed dormancy	Failure of a viable seed to germinate even under favourable conditions
Parthenocarpy	Development of seedless fruits without fertilisation (induced by auxins)

Solved Examples & NEET Facts

Example 1

A root grows from 10 mm to 22 mm in 6 hours at a constant rate. Identify the type of growth and find the growth rate.

Answer: Constant rate of increase = arithmetic growth. Using $L_t = L_0 + rt$: $22 = 10 + r(6)$, so $r = 12/6 = 2 \text{ mm/hour}$.

Example 2

Which PGR would you spray to (a) induce rooting in a stem cutting and (b) ripen fruits quickly?

Answer: (a) **Auxin (IBA/NAA)** induces rooting. (b) **Ethylene (ethephon)** hastens fruit ripening.

Example 3

Name the PGR called the "stress hormone" and give one reason for the name.

Answer: Abscissic acid (ABA) — it closes stomata under water stress and increases the plant's tolerance to various stresses.

Example 4

A rosette plant suddenly elongates its stem before flowering. Which PGR is responsible and what is the phenomenon called?

Answer: Gibberellins; the phenomenon is **bolting**.

Example 5

Why do gardeners pinch off the apical bud of a hedge plant to make it bushy?

Answer: Removing the shoot tip removes the source of auxin causing **apical dominance**; lateral (axillary) buds then grow out, making the plant bushy.

Example 6

Spinach flowers only when day length exceeds a critical value. Classify it and name the pigment that perceives light.

Answer: Spinach is a **long-day plant**. The light-perceiving pigment is **phytochrome**, and the leaves perceive the photoperiodic stimulus.

Important Questions for Board Exams

1-Mark Questions (VSA)

1. Define growth as understood in plants.
2. Name the natural auxin and one synthetic auxin.
3. Which PGR is gaseous in nature?
4. What is parthenocarpy? Name the PGR that induces it.
5. Name the pigment responsible for the perception of light in photoperiodism.

2–3-Mark Questions (SA)

1. Differentiate between differentiation, dedifferentiation and redifferentiation with one example each.
2. Distinguish between long-day plants and short-day plants with examples.
3. Explain arithmetic and geometric growth with their mathematical expressions.
4. What is vernalisation? How is it significant for winter varieties of wheat?
5. List any three functions of gibberellins.

5-Mark Questions (LA)

1. Describe the discovery and functions of auxins and cytokinins.
 2. What is seed dormancy? Discuss its causes and the methods used to break it.
 3. Describe the phases of growth and draw/explain the sigmoid growth curve.
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Quick Revision Points

- Growth = irreversible permanent increase in size; meristems drive indeterminate growth
- Three phases: meristematic (division) → elongation → maturation
- Arithmetic: $L_t = L_0 + rt$; Geometric (sigmoid): $W_1 = W_0 e^{rt}$
- Differentiation → dedifferentiation → redifferentiation; development = growth + differentiation
- Growth promoters: auxin, gibberellin, cytokinin; inhibitors: ABA, ethylene (gas)
- Auxin: apical dominance, rooting, parthenocarpy; 2,4-D weedicide; from *Avena* coleoptile (Went)
- Gibberellin: bolting, malting, stem elongation; from *Gibberella fujikuroi* (GA₃)
- Cytokinin: cell division, delays senescence (Richmond–Lang); kinetin from herring sperm DNA, zeatin from corn
- Ethylene: ripening, senescence, apical hook; ethephon source
- ABA = stress hormone: closes stomata, maintains dormancy, antagonist of GA
- Photoperiodism: leaves perceive day length, phytochrome pigment; vernalisation = cold-induced flowering

- Seed dormancy: hard coat/inhibitors/immature embryo; broken by scarification, chilling, GA
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Next Chapter: Plant Physiology — Transport & Mineral Nutrition



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