

NCERT Exemplar Solutions of Class 11 Biology – Chapter 15: Plant Growth and Development

VERY SHORT ANSWER TYPE QUESTIONS

1. Fill in the places with appropriate word/words.

- A phase of growth which is maximum and fastest is _____.
- Apical dominance as expressed in dicotyledonous plants is due to the presence of more _____ in the apical bud than in the lateral ones.
- In addition to auxin, a _____ must be supplied to the culture medium to obtain a good callus in plant tissue culture.
- _____ of vegetative plants are the sites of photoperiodic perception.

Solution: a) **Log phase or exponential phase**

b) **Auxins**

c) **Cytokinin** (kinetin, zeatin, and 6-benzyl amino purine)

d) **Leaves**

Enhanced Explanation:

- **Log phase:** Period of maximum growth rate following sigmoid growth curve
- **Auxin dominance:** Higher auxin concentration in apical buds suppresses lateral growth
- **Tissue culture:** Requires balanced auxin:cytokinin ratio for optimal callus formation
- **Photoperiodism:** Phytochrome in leaves detects day/night length changes

2. Plant growth substances (PGS) have innumerable practical applications. Name the PGS you should use to

- Increase the yield of sugar cane
- Promote lateral shoot growth
- Cause sprouting of potato tuber
- Inhibit seed germination

Solution: a. **Gibberellins** - Increase stem elongation and sugar storage

b. **Cytokinins** - Break apical dominance and promote branching

c. **Ethylene** - Break tuber dormancy and stimulate sprouting

d. **Abscisic acid** - Maintains seed dormancy and prevents premature germination

3. A primary root grows from 5 cm to 19 cm in a week. Calculate the growth rate and relative growth rate over the period.

Solution:

Given:

- Initial length (L_0) = 5 cm
- Final length (L_1) = 19 cm
- Time period (t) = 1 week

Calculations:

Growth Rate: Using the formula: $L_1 = L_0 + rt$ $19 = 5 + r \times 1$ $r = 19 - 5 = \mathbf{14 \text{ cm per week}}$

Relative Growth Rate: Formula: $RGR = (\text{Change in length}/\text{Initial length}) \times 100$ $RGR = (L_1 - L_0)/L_0 \times 100$ $RGR = (19 - 5)/5 \times 100$ $RGR = 14/5 \times 100 = \mathbf{280\%}$

Enhanced Explanation: The relative growth rate of 280% indicates that the root grew to nearly 3 times its original length, showing very rapid growth typical of primary root development during early plant establishment.

4. Gibberellins were first discovered in Japan when rice plants were suffering from bakane (the foolish seedling disease) caused by a fungus *Gibberella fujikuroi*.

- Give two functions of this phytohormone
- Which property of Gibberellin caused foolish seedling disease in rice?

Solution: a) **Two functions of Gibberellins:**

- Fruit development:** Cause fruits to elongate and improve shape, delay senescence
- Stem elongation:** Increase internode length, enhance sugar production in sugarcane (increases yield by ~20 tonnes per acre)

b) **Property causing foolish seedling disease: Elongation of internodes**

Enhanced Explanation: The excessive elongation caused by fungal gibberellins made rice seedlings appear abnormally tall and weak, hence "foolish." This discovery led to understanding gibberellins' role in normal stem development.

5. Gibberellins promote the formation of _____ flowers on genetically _____ plants in Cannabis whereas ethylene promotes formation of _____ flowers on genetically _____ plants.

Solution: Gibberellins promote the formation of **male** flowers on genetically **female** plants in Cannabis, whereas ethylene promotes formation of **female** flowers on genetically **male** plants.

Enhanced Explanation: This demonstrates the role of plant hormones in sex determination in monoecious plants. The hormonal control allows for agricultural manipulation of sex ratios in economically important crops.

6. Classify the following plants into Long-Day Plants (LDP), Short Day Plants (SDP) and Day Neutral Plants (DNP): Xanthium, Henbane (*Hyoscyamus niger*), Spinach, Rice, Strawberry, Bryophyllum, Sunflower, Tomato, Maize.

Solution:

Long Day Plants (LDP):

- **Henbane** (*Hyoscyamus niger*)
- **Spinach**

Short Day Plants (SDP):

- **Xanthium**
- **Rice**
- **Strawberry**

Day Neutral Plants (DNP):

- **Sunflower**
- **Tomato**
- **Maize**

Special Category:

- **Bryophyllum:** Long-Short Day Plant (LSDP)

Enhanced Explanation:

- **LDP:** Require >12 hours daylight to flower
- **SDP:** Require <12 hours daylight to flower
- **DNP:** Flower regardless of day length
- **LSDP:** Require long days followed by short days

7. A farmer grows cucumber plants in his field. He wants to increase the number of female flowers in them. Which plant growth regulator can be applied to achieve this?

Solution: Ethylene (C_2H_4) can be applied to increase female flower production.

Enhanced Explanation: Ethylene promotes feminization in cucurbit plants by influencing sex gene expression. This is commercially important as female flowers produce fruits, directly affecting crop yield.

8. Where are the following hormones synthesized in plants?

- IAA
- Gibberellins
- Cytokinins

Solution: a. **IAA:** Tips of shoots and apical buds

b. **Gibberellins:** Young leaves and tips of roots

c. **Cytokinins:** Meristematic zones of roots

Enhanced Explanation: Hormone synthesis sites often correlate with their primary functions - auxins from growing tips for growth direction, gibberellins from young tissues for growth promotion, and cytokinins from roots for cell division.

9. In botanical gardens and tea gardens, gardeners trim the plants regularly so that they remain bushy. Does this practice have any scientific explanation?

Solution: Yes, this practice has a scientific basis. Trimming removes the **shoot tips**, which eliminates the source of auxin production. This breaks **apical dominance**, allowing **lateral buds to grow**, resulting in a bushy appearance.

Enhanced Explanation: This is called **decapitation** or **pinching**. The removal of auxin-producing apical buds shifts the auxin:cytokinin balance, favoring lateral bud activation and creating dense, compact growth.

10. Light plays an important role in the life of all organisms. Name any three physiological processes in plants which are affected by light.

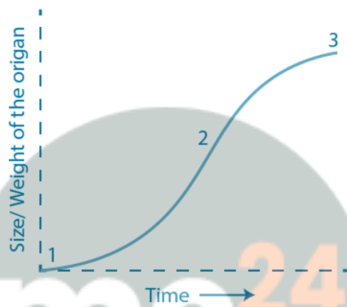
Solution: a) **Photosynthesis:** Light energy converts CO_2 and water into carbohydrates using chlorophyll

b) **Photoperiodism:** Flowering regulation based on day length exposure (photoperiod)

c) **Phototropism:** Directional growth response toward light sources

Additional processes: Chlorophyll synthesis, stomatal opening, circadian rhythms, phytochrome activation

11. In the figure of sigmoid growth curve given below, label segments 1, 2 and 3.



Solution: 1: **Lag phase** - Initial slow growth period

2: **Log phase** - Maximum/exponential growth period

3: **Stationary phase** - Growth plateaus due to limiting factors

Enhanced Explanation: The sigmoid curve represents typical growth patterns where initial establishment (lag) is followed by rapid growth (log) until resources become limiting (stationary).

12. Growth is one of the characteristics of all living organisms. Do unicellular organisms also grow? If so, what are the parameters?

Solution: Yes, unicellular organisms grow through:

- **Increase in cell mass** (biomass accumulation)
- **Increase in cell number** (through cell division)
- **Increase in cell size** (hypertrophy before division)

Enhanced Explanation: Unicellular growth differs from multicellular growth as it involves both individual cell expansion and population increase through binary fission or budding.

13. The rice seedlings infected with fungus *Gibberella fujikuroi* are called foolish seedlings. What was the reason behind it?

Solution: The **elongation of internodes** caused by excessive gibberellin production from the fungus made the seedlings abnormally tall and weak, appearing "foolish" compared to healthy plants.

Enhanced Explanation: This abnormal elongation without proportional strengthening made plants vulnerable to lodging and reduced grain production, hence the term "foolish."

SHORT ANSWER TYPE QUESTIONS

1. *Nicotiana tabacum*, a Short Day Plant, when exposed to more than a critical period of light fails to flower. Explain.

Solution: Short day plants require a **prolonged dark period** (critical night length) for flowering because essential biochemical transformations occur during darkness. These plants actually measure night length rather than day length. When exposed to light periods longer than critical, the dark period becomes insufficient for the synthesis of flowering hormones, preventing flower induction.

Enhanced Explanation: The critical factor is **uninterrupted darkness**. Even brief light exposure during the dark period (called night break) can prevent flowering in short day plants by disrupting phytochrome-mediated dark reactions.

2. What are the structural characteristics of:

- a. Meristematic cells near root tip
- b. The cells in the elongation zone of the root

Solution:

a) Meristematic cells near root tip:

- **Large nucleus** with prominent nucleoli
- **Dense protoplasm** rich in ribosomes and mitochondria
- **Few small vacuoles** or absent
- **Thin cellulose cell walls**
- **High nucleo-cytoplasmic ratio**

b) Cells in elongation zone:

- **Large central vacuole** for turgor-driven expansion
 - **New cellulosic walls** being deposited
 - **Increased cell size** (primarily length)
 - **Reduced nuclear size** relative to cell volume
 - **Active water uptake** machinery
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3. Does the growth pattern in plants differ from that in animals? Do all parts of plants grow indefinitely? If not, name the regions of the plant which can grow indefinitely.

Solution: Yes, plant growth patterns differ significantly from animals:

Plant Growth:

- **Indeterminate growth** - continues throughout life
- **Localized to meristems** - specific growth regions
- **Open growth system** - new organs continuously formed

Animal Growth:

- **Determinate growth** - stops at maturity
- **Diffuse growth** - occurs throughout body
- **Closed growth system** - fixed body plan

Regions with indefinite growth:

- **Apical meristems** (shoot and root tips)
- **Cambium** (secondary growth in woody plants)
- **Intercalary meristems** (in grasses and bamboo)

4. Explain in 2-3 lines each of the following terms with examples from plant tissues:

a. Differentiation

b. De-differentiation

c. Redifferentiation

Solution:

a) Differentiation: Process where meristematic cells mature and acquire specialized functions. **Example:** Cells from root apical meristem differentiate into xylem vessels, phloem tubes, or cortical cells with specific structural and functional characteristics.

b) De-differentiation: Mature, differentiated cells regain capacity for cell division under specific conditions. **Example:** Mature cortical cells in wounded stems can de-differentiate to form callus tissue in tissue culture or wound healing.

c) Redifferentiation:

De-differentiated cells lose their divisional capacity and mature into specialized cells again. **Example:** Callus cells in tissue culture redifferentiate into specific tissues like xylem, phloem, or epidermis when provided with appropriate hormone combinations.

5. Auxins are growth hormones capable of promoting cell elongation. They have been used in horticulture to promote growth, flowering and rooting. Explain the meaning of the following terms related to auxins:

a. Auxin precursors

b. Anti-auxins

c. Synthetic auxins

Solution:

a) Auxin precursors: Compounds that serve as **raw materials for auxin biosynthesis**.

Example: Tryptophan is the primary precursor for IAA synthesis through various biochemical pathways in plants.

b) Anti-auxins: Compounds that **inhibit auxin action** by competing for the same receptor sites or blocking auxin transport. **Example:** TIBA (2,3,5-triiodobenzoic acid) blocks auxin transport and nullifies auxin effects.

c) Synthetic auxins: Artificially synthesized compounds with auxin-like activity used in agriculture and research. **Examples:** NAA (1-Naphthaleneacetic acid), IBA (Indole-3-butyric acid), 2,4-D (2,4-Dichlorophenoxyacetic acid).

6. The role of ethylene and abscisic acid is both positive and negative. Justify the statement.

Solution:

Positive Roles of Ethylene:

- **Fruit ripening** - enhances palatability and seed dispersal
- **Root hair formation** - increases absorption capacity
- **Flower induction** in some plants
- **Breaking seed dormancy** in certain species

Negative Role of Ethylene:

- **Premature senescence** - reduces plant longevity
- **Abscission** - premature leaf and fruit drop
- **Growth inhibition** - retards stem elongation

Positive Role of Abscisic acid:

- **Stress tolerance** - closes stomata during water stress
- **Seed dormancy** - prevents germination in unfavorable conditions
- **Cold hardiness** - helps survive winter conditions

Negative Role of Abscisic acid:

- **Growth inhibition** - reduces overall plant growth
- **Bud dormancy** - delays sprouting and development

Enhanced Explanation: The dual nature of these hormones reflects their role in balancing growth with survival, demonstrating that plant hormones optimize fitness rather than simply promoting growth.

7. While experimentation, why do you think it is difficult to assign any effect seen to any single hormone?

Solution: It's difficult to attribute effects to single hormones because of:

1. Synergistic interactions: Multiple hormones work together to enhance effects (e.g., auxin + cytokinin for tissue culture)

2. Antagonistic interactions: Hormones counter each other's effects (e.g., ABA vs. gibberellins in seed germination)

3. Concentration-dependent effects: Same hormone produces different effects at different concentrations

4. Tissue sensitivity: Different tissues respond differently to the same hormone

5. Environmental interactions: External factors modify hormonal responses

Enhanced Explanation: Plant responses result from **hormonal networks** rather than individual hormone action, making it essential to consider the **hormone balance** and **physiological context**.

8. What is the mechanism underlying the phenomenon by which the terminal/apical bud suppresses the growth of lateral buds? Suggest measures to overcome this phenomenon.

Solution:

Mechanism - Apical Dominance: The **apical bud produces auxin (IAA)** which is transported basipetally (downward) through the stem. This auxin:

- **Inhibits lateral bud activation**
- **Suppresses cytokinin activity** in lateral buds
- **Maintains dormancy** of axillary meristems

Measures to overcome:

1. **Decapitation** - Remove apical bud/shoot tip
2. **Cytokinin application** - Apply to lateral buds to counter auxin inhibition
3. **Anti-auxin treatment** - Use compounds like TIBA to block auxin action
4. **Mechanical methods** - Pruning, pinching, or bending shoots

Enhanced Explanation: The auxin:cytokinin ratio determines bud fate - high auxin favors apical dominance, while increased cytokinin promotes lateral branching.

9. In animals, there are special glands secreting hormones, whereas there are no specialized glands in plants. Where are plant hormones formed? How are the hormones translocated to the site of activity?

Solution:

Hormone synthesis sites:

- **Dispersed throughout plant tissues** - tips of shoots, roots, young leaves, seeds, fruits
- **Meristematic regions** - active sites of cell division
- **Specialized cells** - not organized into discrete glands

Translocation methods:

1. **Vascular transport** - through xylem and phloem
2. **Cell-to-cell movement** - via plasmodesmata
3. **Polar transport** - directional movement (especially auxins)
4. **Diffusion** - especially gaseous ethylene

Enhanced Explanation: Unlike animal endocrine systems, plants use a **distributed hormone system** where multiple tissues participate in synthesis and transport, providing more localized and flexible responses.

10. Many discoveries in science have been accidental. This is true for plant hormones also. Can you justify this statement by giving an example? Also what term is used for such accidental findings?

Solution:

Example - Discovery of Gibberellins: Accidental observation: Japanese rice farmers noticed abnormally tall, weak rice plants ("foolish seedlings") **Investigation:** Kurosawa (1926) found these symptoms were caused by fungus *Gibberella fujikuroi* **Discovery:** The fungus produced a growth-promoting substance later named gibberellin **Impact:** Led to understanding of plant growth hormones and their agricultural applications

Term for accidental findings: Serendipity

Enhanced Explanation: Many major scientific breakthroughs, including penicillin discovery and X-rays, resulted from unexpected observations during routine investigations, highlighting the importance of careful observation in research.

11. To get carpet-like grass lawns, they are mowed regularly. Is there any scientific explanation for this?

Solution:

Scientific explanation - Decapitation effect: Regular mowing removes **apical buds** containing auxin, which:

1. **Eliminates apical dominance**
2. **Activates lateral/basal buds**
3. **Promotes tillering** (formation of side shoots)
4. **Creates dense, compact growth**

Result: Multiple shoots from the base create a **carpet-like appearance** with uniform height and dense coverage.

Enhanced Explanation: This practice mimics natural grazing patterns and exploits the plant's ability to regenerate from basal meristems, essential for grass survival in natural grasslands.

12. In a slide showing different types of cells, can you identify which type of cell may be meristematic and which is incapable of dividing? How?

Solution:

Meristematic cells identification:

- **Large, prominent nucleus** with dense chromatin
- **Dense cytoplasm** rich in organelles
- **Small or absent vacuoles**

- **Thin cellulose cell walls**
- **Small cell size** with high nucleo-cytoplasmic ratio

Non-dividing (differentiated) cells:

- **Small nucleus** relative to cell size
- **Large central vacuole**
- **Thick, specialized cell walls**
- **Specialized structures** (e.g., lignified walls in sclerenchyma)
- **Lower cytoplasmic density**

Enhanced Explanation: The structural differences reflect functional requirements - meristematic cells need dense metabolic machinery for division, while differentiated cells are optimized for specific functions like support or transport.

13. A rubber band stretches and reverts to its original position. Bubble gum stretches, but would not return to its original position. Is there any difference between the two processes? Discuss it with respect to plant growth.

Solution:

Rubber band - Elasticity (Reversible):

- **Temporary deformation** under stress
- **Returns to original form** when stress is removed
- **No permanent structural change**

Bubble gum - Plasticity (Irreversible):

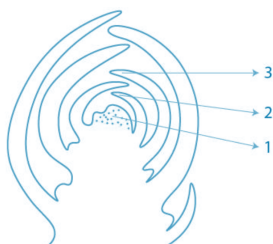
- **Permanent deformation** under stress
- **Cannot return** to original form
- **Structural changes** are permanent

Relation to plant growth: Plant growth involves **plasticity** - cells undergo **irreversible expansion** through:

- **Cell wall loosening** and new material deposition
- **Vacuolar expansion** creating permanent size increase
- **Developmental changes** like heterophylly in cotton

Enhanced Explanation: Plant development demonstrates plasticity through environmental responses - the same genotype can produce different phenotypes (e.g., sun vs. shade leaves) based on conditions.

14. Label the diagram



[Diagram shows shoot apex with numbered parts 1, 2, 3]

a. This is which part of a dicotyledonous plant?

b. If we remove part 1 from the plant, what will happen?

Solution: a) This is the **shoot apex (apical meristem)** of a dicotyledonous plant.

Labels:

- **1:** Apical bud/terminal bud
- **2:** Leaf primordia
- **3:** Lateral buds/axillary buds

b) If part 1 (apical bud) is removed:

- **Apical dominance is broken**
- **Lateral buds (part 3) will grow** into branches
- **Plant becomes bushy** instead of growing tall
- **Auxin production stops** from the apex

15. Both animals and plants grow. Why do we say that growth and differentiation in plants are open and not so in animals? Does this statement hold for sponges also?

Solution:

Plant growth - "Open":

- **Indeterminate growth** - continues throughout life
- **Meristematic tissues** retain embryonic characteristics
- **New organs** continuously formed (leaves, branches, roots)
- **Morphological plasticity** - can modify structure based on environment

Animal growth - "Closed":

- **Determinate growth** - stops at maturity
- **Fixed body plan** established early in development
- **Limited regeneration** capacity in most tissues
- **Defined organ number** and structure

Exception - Sponges: Sponges show **"open" growth** similar to plants:

- **Indeterminate growth** throughout life
- **High regenerative capacity**
- **Can reform** entire organism from fragments
- **Modular construction** allows continuous expansion

Enhanced Explanation: The "open" vs. "closed" distinction reflects different evolutionary strategies - plants optimize for environmental exploitation while most animals optimize for mobility and complex behavior.

16. Define parthenocarpy. Name the plant hormone used to induce parthenocarpy.

Solution:

Parthenocarpy: Development of **fruit without fertilization**, resulting in **seedless fruits**. The ovary develops into fruit without sexual reproduction or seed formation.

Types:

- **Natural parthenocarpy** - occurs naturally (bananas, pineapples)
- **Induced parthenocarpy** - artificially stimulated

Hormones used to induce parthenocarpy:

- **Gibberellins** (primary hormone)
- **Auxins** (NAA, 2,4-D)
- **Cytokinins** (supporting role)

Enhanced Explanation: Commercial applications include seedless grapes, tomatoes, and cucumbers. This technique is valuable for producing consumer-preferred seedless fruits and ensuring fruit set under adverse pollination conditions.

17. While eating watermelons, all of us wish it was seedless. As a plant physiologist, can you suggest any method by which this can be achieved?

Solution:

Methods to achieve seedless watermelons:

1. Parthenocarpy induction:

- Apply **gibberellins** to unpollinated flowers
- Use **auxins** (NAA, 2,4-D) during early fruit development
- Treat with **growth hormone combinations**

2. Genetic approaches:

- Develop **triploid varieties** ($3n$) - produce sterile pollen
- Create **hybrid varieties** with reduced fertility
- Use **chromosome manipulation** techniques

3. Practical application:

- **Spray hormone solutions** on female flowers before pollination
- **Apply at appropriate concentrations** (gibberellins: 100-500 ppm)
- **Time application** during early fruit development

Enhanced Explanation: Modern seedless watermelons are typically triploids produced by crossing diploid and tetraploid parents, but hormone-induced parthenocarpy remains important for research and specialty applications.

18. A gardener finds some broad-leaved dicot weeds growing in his lawns. What can be done to get rid of the weeds efficiently?

Solution:

Selective herbicide treatment using auxins:

Method: Apply **synthetic auxin herbicides** like **2,4-D** (2,4-Dichlorophenoxyacetic acid)

Mechanism:

- **Selective toxicity** - affects dicots more than monocots (grass)
- **Disrupts normal growth** patterns in broadleaf weeds
- **Causes uncontrolled cell division** and growth

- **Eventually kills** the weed plants

Why it works:

- **Grass (monocots)** are relatively resistant to auxin herbicides
- **Dicot weeds** are highly sensitive to auxin overdose
- **Differential metabolism** between plant types

Application: Spray during **active growth period** for maximum effectiveness

Enhanced Explanation: This selective action is due to differences in auxin metabolism, transport, and sensitivity between monocots and dicots, making it an effective tool for lawn maintenance without damaging grass.

19. On germination, a seed first produces shoot with leaves, flowers appear later.

- a. Why do you think this happens?
- b. How is this advantageous to the plant?

Solution:

a) Why shoots and leaves appear first:

- Plants follow **sequential developmental phases**:
 - **Juvenile/vegetative phase** - shoot, leaves, root development
 - **Reproductive phase** - flower and fruit formation
- **Flowering hormone (florigen)** synthesis requires mature photosynthetic apparatus
- **Adequate biomass** must accumulate before reproduction

b) Advantages:

1. Energy accumulation:

- **Photosynthesis** provides energy for reproduction
- **Biomass buildup** supports fruit and seed development

2. Resource acquisition:

- **Root system** develops for nutrient and water uptake
- **Leaf area** maximizes photosynthetic capacity

3. Competitive advantage:

- **Larger size** improves light competition
- **Better establishment** before energy diversion to reproduction

Enhanced Explanation: This strategy follows the principle of **optimal resource allocation** - invest in growth infrastructure before reproduction to maximize reproductive success.

20. Fill in the blanks:

- a. Maximum growth is observed in _____ phase.
- b. Apical dominance is due to _____
- c. _____ hormone initiates rooting
- d. Pigment involved in photoperception in flowering plants is _____

Solution: a. **Exponential (Log)** phase

b. **Presence of auxins**

c. **Auxins** hormone initiates rooting

d. **Phytochrome**

