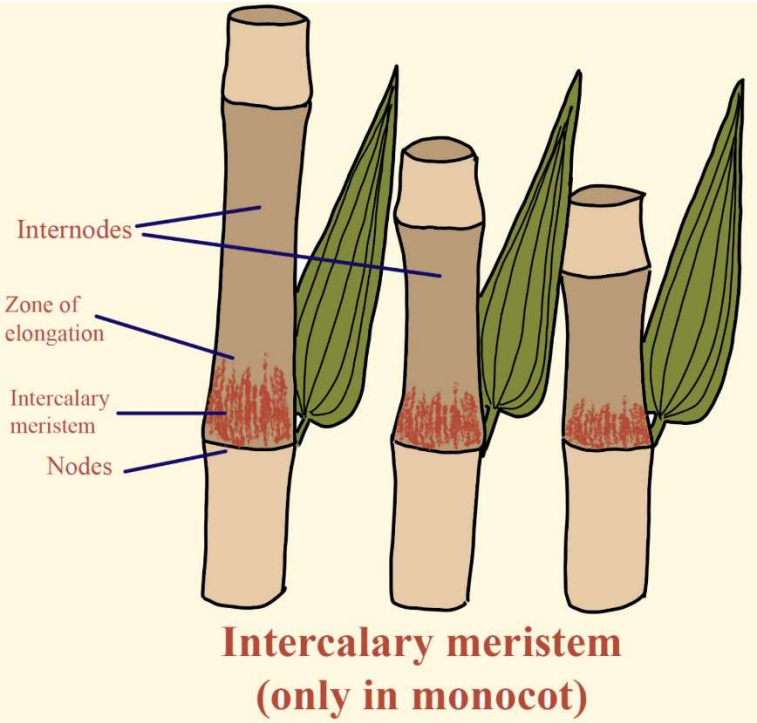
# BIOLOGY

# PLANT GROWTH AND DEVELOPMENT

## Plant Growth and Development

Root, stem, leaves, flowers, fruits and seeds arise in orderly manner in plants. The sequence of growth is as follows:

- **Life cycle of plant:** Plants complete their vegetative phase to move into reproductive phase in which flower and fruits are formed for continuation of life cycle of plant.
- **Growth and differentiation:** Development is the sum of two processes growth and differentiation. Intrinsic and extrinsic factors control the process of growth and development in plants.
- **Growth:** Growth is a permanent or irreversible increase in dry weight, size, mass or volume of cell, organ or organism. It is internal or intrinsic in living beings.
- **Growth is a quantitative phenomenon:** In plants growth is accomplished by cell division, increase in cell number and cell enlargement. So, growth is a quantitative phenomenon which can be measured in relation to time.
- **Plant growth is generally indeterminate:** Plant growth is generally indeterminate due to capacity of unlimited growth throughout the life. Meristem tissues are present at the certain locality of plant body.
- **Open form of growth:** The plant growth in which new cells are always being added to plant body due to meristem is called open form of growth.
- **Root apical meristem and shoot apical meristem:** Root apical meristem and shoot apical meristem are responsible for primary growth and elongation of plant body along the axis.
- **Intercalary meristem:** Intercalary meristem located at nodes produce buds and new branches in plants.




## Secondary growth in plants

Secondary growth in plants is the function of lateral meristem that is vascular cambium and cork cambium.

- **Seed Germination:** The seed germinates only when favourable conditions for growth exists in the environment. In absence of favourable conditions it goes into a period of suspended growth or rest, called dormancy.
- **Abscission:** Shedding of plant organs like leaves, flowers and fruits etc. from the mature plant.
- **Apical dominance:** Suppression of the growth of lateral buds in presence of apical bud.
- **Dormancy:** A period of suspended activity and growth usually associated with low metabolic rate. Some, seeds undergo a period of dormancy and can germinate only after dormancy period gets over.
- **Phytochrome:** A pigment, found in plants which control the light dependent developmental process.
- **Phytohormone:** Chemical's secreted by plants in minute quantities which influence the physiological activities.
- **Senescence:** The last phase of growth when metabolic activities decrease.
- **Vernalization:** A method of promoting flowering by exposing the young plant to low

temperature.

- **Quiescence:** Non germination of a viable seed due to non-availability of proper environmental conditions.
- **Vivipary:** It is the germination of seed while it is still attached to the parent plant and is nourished by it. e.g., Rhizophora and Sonneratia. As the germinating seed forms a seedling. It all down into the mud due to increase in weights. In the mud, lateral roots develops for anchorage.
- **Heterophylly:** Occurrence of more than one type of leaves in plants e.g., larkspur, Coriander leaves of Juvenile plant are different in shape from mature plant.
- **Bolting:** Elongation of internodes prior to flowering in plants like Cabbage.

## Photoperiodism

Response of Plants to relative periods of day/ night to induce flowering.

**Long Day Plants (LDP):** Plants which need exposure to light for period exceeding critical duration e.g., wheat, rice, cucumber.

**Short Day Plants (SDP):** Plants that need exposure to light for period less than the critical length e.g., Cabbage.

**Day Neutral Plants (DNP):** There is no correlation between exposure to light duration & induction of flowering e.g., Tomato.

## Growth is measurable

- At cellular level, growth is the increase in amount of protoplasm. It is difficult to measure the increase in amount of protoplasm but increase in cell, cell number and cell size can be measured.
- The parameter used to measure growth is increase in fresh weight, dry weight, length, area, and volume and cell number. All parameters are not used for every kind of growth.

## Phase of growth

- Formative phase
- Phase of Enlargement
- Phase of maturation

**Formative phase:** Formative phase is also called as the phase of cell formation or cell division.

It occurs at root apex, shoot apex and other region having meristematic tissue. The rate of respiration is very high in the cells undergoing mitosis division in formative phase.

**Phase of Enlargement:** Phase of Enlargement newly formed cells produced in formative phase undergo enlargement. Enlarging cells also develops vacuoles that further increase the volume of cell. Cell enlargement occurs in all direction with maximum elongation in conducting tissues and fibers.

**Phase of maturation:** the enlarged cells develops into special or particular type of cells by undergoing structural and physiological differentiation.

## Growth Rate

Growth Rate increase in growth per unit time is called growth rate. Growth rate may be arithmetic or geometrical.

## Arithmetic Growth

Arithmetic Growth the rate of growth is constant and increase in growth occurs in arithmetic progression- 2, 4, 6, 8 ……. It is found in root and shoot elongation.

$L_t = L_0 + rt$

Length after time = length at beginning + growth rate x time.

## Geometric Growth

- Here initial growth is slow and increase rapidly thereafter. Every cell divides. The daughter cells grow and divide and the granddaughter cells that result into exponential growth.
- Geometrical growth is common in unicellular organisms when growing in nutrient rich medium.
- Sigmoid growth curve consists of fast dividing exponential phase and stationary phase. It is typical of most living organisms in their natural environment.

**Exponential growth can be represented as follows:**

$W_1 = W_0e^{rt}$. $W_1$ = final size, $W_0$ = initial size, r = growth rate, t = time of growth and e is the base of natural logarithms (2.71828).

- Quantitative comparison between the growth of living system can be made by
- Measurement and comparison of total growth per unit time is called the absolute rate.
- The growth of given system per unit time expressed on a common basis is called relative growth rate.

## Condition for growth

- Necessary condition for growth includes water, oxygen and essential elements. Water is required for cell enlargement and maintaining turgidity. Water also provides medium for enzymatic conditions.
- Protoplasm formation requires water and micro and macronutrients and act as source of energy.
- Optimal temperature and other environmental conditions are also essential for growth of the plant.
- Cells produced by apical meristem become specialized to perform specific function. This act of maturation is called differentiation.
- The living differentiated cells that have lost ability of division can regain the capacity of division. This phenomenon is called dedifferentiation. For example, interfascicular cambium and cork cambium.
- Dedifferentiated cells mature and lose the capacity of cell division again to perform specific functions. This process is called redifferentiation.

## Development

It is the sequence of events that occur in the life history of cell, organ or organism which includes seed germination, growth, differentiation, maturation, flowering, seed formation and senescence.

**Sequence of development process in plant cell:** Different structures develop in different phases of growth as well as in response to environment. The ability to change under the influence of internal or external stimuli is called plasticity. Heterophylly in cotton plant is the example of plasticity.

## Plant Growth Regulators

- Plant Growth Regulators are simple molecules of diverse chemical composition which may be indole compounds, adenine derivatives or derivatives of carotenoids.
- Auxin was isolated by F.W. Went from tips of coleoptiles of oat seedlings.
- The ‘bakane disease’ of rice seedlings is caused by fungal pathogen Gibberella fujikuroi. E. Kurosawa found that this disease is caused due to presence of Gibberellin.
- Skoog and Miller identified and crystallized the cytokinesis, promoting active substance called kinetin.

## Auxin

Auxin was first isolated from human urine. It is commonly indole-3-acetic acid (IAA). It is generally produced at stem and root apex and migrate to site of action.

**Functions:**

- Cell enlargement.
- Apical dominance
- Cell division
- Inhibition of abscission
- Induce Parthenocarpy

## Gibberellins

Gibberellins are promotery PGR found in more than 100 forms named as $GA_1$, $GA_2$, $GA_3$….. $GA_{100}$ The most common one is $GA_3$ (Gibberellic Acid).

**Functions:**

- Cell elongation.
- Breaking of dormancy.
- Early maturity
- Seed germination.

## Cytokinins

Cytokinins the plant growth hormone is basic in nature. Most common forms include kinetin, zeatin, etc. They are mainly synthesized in roots.

**Functions:**

- Cell division and cell differentiation.
- Essential for tissue culture.
- Overcome apical dominance.
- Promote nutrient mobilization.

## Ethylene

Ethylene it is a gaseous hormone which stimulates transverse or isodiametric growth but retards the longitudinal one.

**Functions:**

- Inhibition of longitudinal growth.
- Fruit ripening
- Senescence

- Promote apical dominance

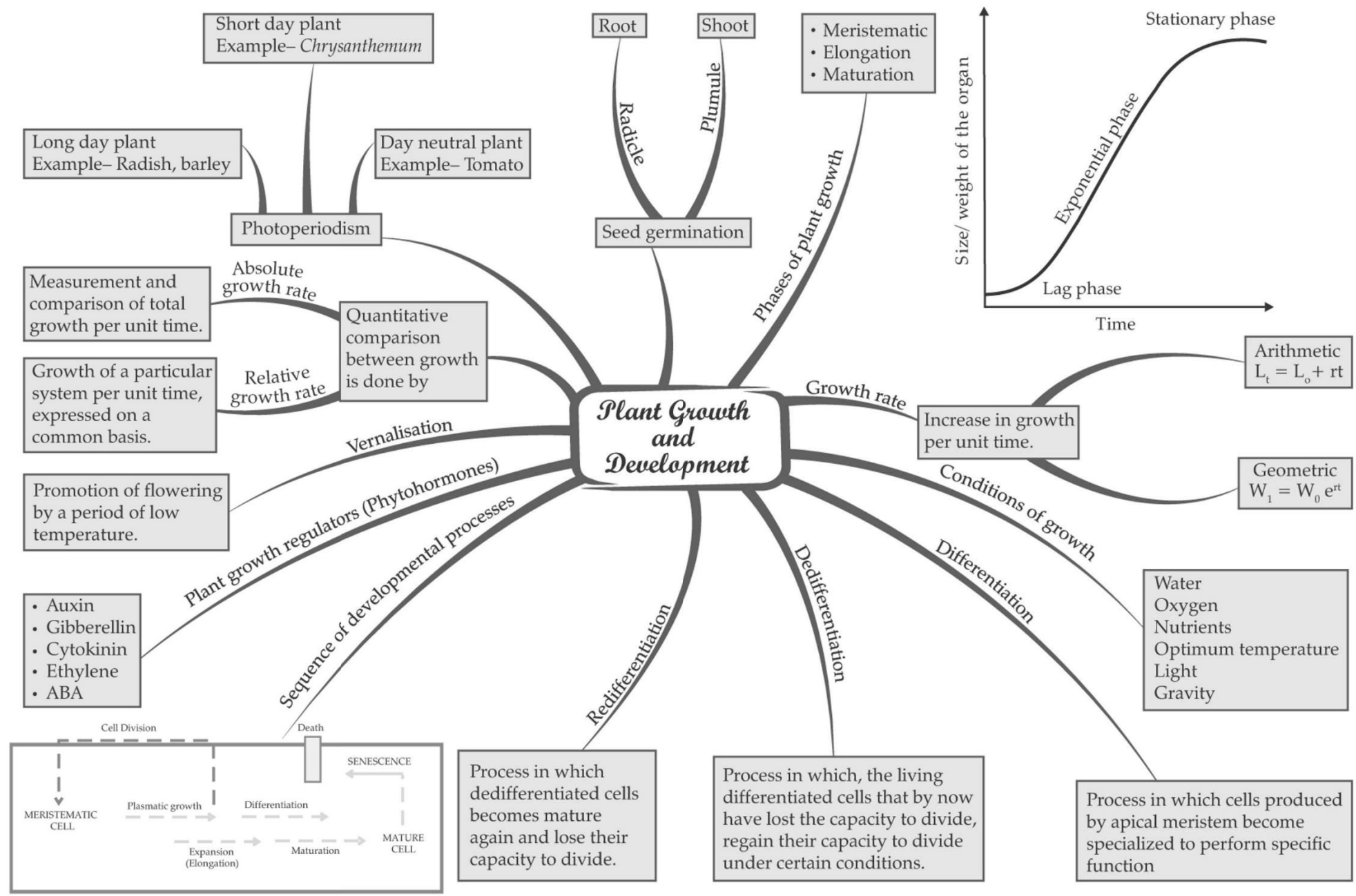
## Abscisic Acid

Abscisic Acid it is also called stress hormone or doormen. It acts as a general plant growth inhibitor. Abscisic acid is produced in the roots of the plant and terminal buds at the top of plant.

**Function:**

- Bud dormancy
- Leaf senescence
- Induce Parthenocarpy
- Seed development and maturation.

# CHAPTER : 15 PLANT GROWTH AND DEVELOPMENT



# Important Questions

## ➢ Multiple Choice Questions:

Question 1. Three important growth promotor hormones in plants are

(a) Auxins, gibberellins and ethylene

(b) Auxins, gibberellins and cytokinins

(c) Ethylene, abscisic acid and cytokinins

(d) Gibberellins, cytokinins and abscisic acid

Question 2. First hormone isolated from human urine suffering from pellagra disease was

(a) Gibberelins

(b) Auxins

(c) Cytokinins

(d) Abscisic acid

Question 3. Indole 3 acetic acid (IAA) is a naturally occuring plant hormone called

(a) Gibberellins

(b) Auxins

(c) Cytokinins

(d) Abscisic acid

Question 4. Auxins hormone was first discoverd by

(a) Kogletal

(b) Went

(c) Darwin

(d) Boysen Jenson

Question 5. Auxin is synthesised in the apical meristems from amino acid

(a) Isoleucine

(b) Methionine

(c) Niacin

(d) Tryptophan

Question 6. Growth regulator which is known to promote cell division in vascular cambium is

(a) IAA

(b) ABA

(c) Cytokinins

(d) Ethylene

Question 7. Growth regultor which is known to induce parthenocarphy is plants is called

(a) Gibberellins

(b) ABA

(c) Ethylene

(d) Cytokinins

Question 8. The formation of seedless fruits without the act of fertilization is known as

(a) Parthenocarpy

(b) Pseudocarpy

(c) Apomixis

(d) Parthenogenesis

Question 9. The major sites of gibberellin production in plants are

(a) Embryos

(b) Roots

(c) Young leaves

(d) All of these

Question 10. Gibberellin was isolated in pure form by

(a) Brian et al

(b) Went

(c) Yabuta

(d) Kurosava

Question 11. Internodal elongation of genetically dwarf plants in known as

(a) Bolting

(b) Elongation

(c) Etiolation

(d) None of these

Question 12. Cytokinins are in nature

(a) Acidic

(b) Neutral

(c) Basic

(d) All of these

Question 13. Cytokinins help in promoting

(a) Cell division

(b) Stem elongation

(c) Cell enlargement

(d) Parthenocarpy

Question 14. The first natural cytokinins obtained from unripe maize grains is known as

(a) Indole 3-acetic acid

(b) ABA

(c) Zeatin

(d) Kinetin

Question 15. Two important growth inhibitors in plants are

(a) Ethylene and abscisic acid

(b) Auxins and abscisic acid

(c) Gibberellins and abscisic acid

(d) Cytokinins and ethylene

## ➢ Fill In the Blanks:

1. ……. is regarded as one of the most fundamental and conspicuous characteristics of a living being.
2. Plant growth is ……. because plants retain die capacity for unlimited growth throughout their life.
3. This form of growth wherein new cells are always being added to the plant body by the activity of the meristem is called the …….
4. Growth is, therefore, measured by a variety of parameters some o,r which are ……. dry weight; length; area volume and cell number.
5. The period of growth is generally divided into three phases, namely, ……., ……. and …….
6. The increased growth per unit time is termed as …….

## ➢ True or False:

1. Ethylene also promotes root growth and root hair formation, thus helping the plants to increase their absorption surface.
2. Abscisic acid (ABA) was discovered for its, role in regulating abscission and dormancy.

3. The former group of plants are long day plants while the later ones are termed short day plants.
4. Flowering in certain plants depends not only on a combination of light and dark exposures but also their relative durations. This is termed photoperiodism.
5. Biennials are monocarpic plants that normally flower and die in the second season.
6. Vernalisation refers specially to the promotion of flowering by a period of low temperatures.

## ➢ Very Short Question:

1. In which phase of the growth curve the growth is maximum?
2. Write the full form of IAA?
3. Which plant hormone controls the process of apical dominance?
4. Which hormone acts as a “stress hormone”?
5. Name the only gaseous natural plant growth regulator.
6. What are photo plastic seeds?
7. What is the exponential period of growth?
8. What is vernalization?
9. What is senescence?
10. What will happen if short-day plants are exposed in day lengths in excess of their certain critical photoperiod?

## ➢ Short Questions:

1. Draw a diagram to show the sigmoid growth curve and write the names of the three phases in it.
2. What is vernalization? Give its importance in flowering plants.
3. Explain the biological meaning of growth. In what essential ways does plant growth differ from animal growth?
4. Explain how the method of science operated in the discovery of auxins?
5. Discuss the role of growth regulators in agriculture.
6. Explain Bolting.
7. Write the functions of Auxin (IAA).
8. What part of the plant perceives the light response?

## ➢ Long Questions:

1. What do you understand by senescence? What are the various types of senescence observed in plants? Can growth regulators restart senescence?

2. Mention any two causes of seed dormancy. Give its significance.
3. What do you understand by the spontaneous and induced movements in plants? Illustrate your answer with suitable diagrams.
4. Describe the various steps involved in seed germination

## Assertion Reason Question-

1. In these questions, a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

   (a) If both Assertion and Reason are true and Reason is the correct explanation of Assertion.

   (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

   (c) If Assertion is true but Reason is false.

   (d) If both Assertion and Reason are false.

   **Assertion:** As a whole plant growth is indefinite.

   **Reason:** Plants retain the capacity of continuous growth throughout their life.

2. In these questions, a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

   (a) If both Assertion and Reason are true and Reason is the correct explanation of Assertion.

   (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

   (c) If Assertion is true but Reason is false.

   (d) If both Assertion and Reason are false.

   **Assertion:** For the synthesis of protoplasm nutrients are required by plants which act as source of energy.

   **Reason:** Water provides the medium for enzymatic activities needed for growth.

## ✓ Answer Key-

## ➢ Multiple Choice Answers:

1. (b) Auxins, gibberellins and cytokinins
2. (b) Auxins
3. (b) Auxins
4. (b) Went
5. (d) Tryptophan
6. (a) IAA
7. (a) Gibberellins

8. (a) Parthenocarpy.
9. (d) All of these
10. (a) Brian et al
11. (a) Bolting
12. (c) Basic
13. (a) Cell division
14. (c) Zeatin
15. (a) Ethylene and abscisic acid

## ➢ Fill In the Blanks:

1. Growth
2. Unique
3. open form of growth
4. increase in fresh weight
5. meristematic, elongation, maturation
6. growth rate

## ➢ True or False:

1. True
2. True
3. False
4. True
5. True
6. True

## ➢ Very Short Answers:

1. Answer: Exponential phase
2. Answer: Indole acetic acid
3. Answer: Auxin
4. Answer: Abscisic acid (ABA)
5. Answer: Ethylene.
6. Answer: Photo plastic seeds require light for germination.
7. Answer: It is the second phase of maximum growth.

8. Answer: Vernalization is a promoter of flowering by previous cold treatment.
9. Answer: It is the period between reproductive maturity and the death of a plant.
10. Answer: These will remain only vegetative.

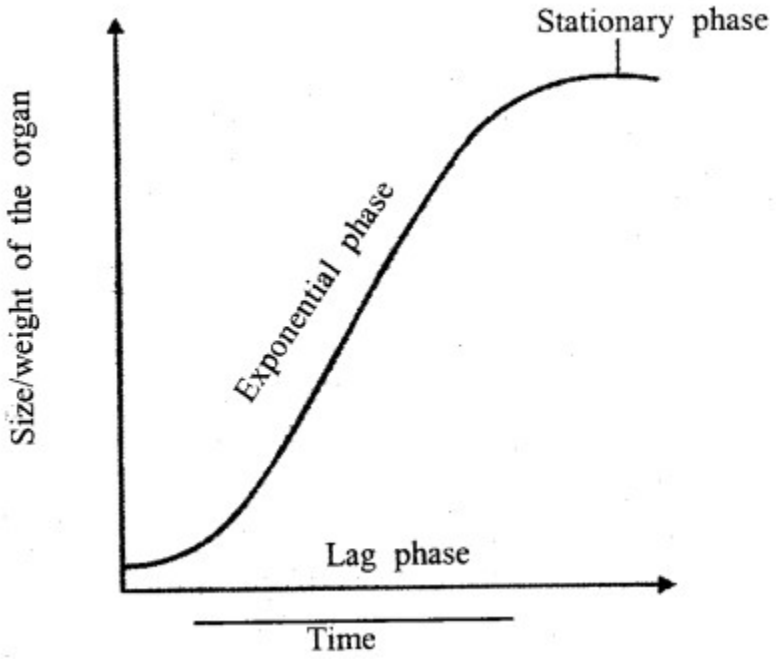
## ➢ Short Answer:

1. Answer: The rate of growth whether measured as length, area, volume or weight is not uniform. Under ideal conditions when the rate of growth is plotted against time, an S-shaped curve called the sigmoid curve.

   i. Lag-phase: Growth is slow in the initial stage.

   ii. Exponential period: It is the second period of maximum growth.

   iii. Stationary phase: When the nutrients become limiting growth slows down.




   S-shaped or sigmoid population growth curve characteristic of many species when introduced into a variable new environment.

2. Answer: The term vernalizations are the promotor of flowering by previous cold treatment. In flowering plants, plants that require cold treatment usually behave as biennials. They germinate and grow vegetatively in the first season and produce flowers in the second season. It is now definitely known that by various grafting experiments the growing point is the site that receives the cold stimulus. It is responsible for the productions of a hormone-like substance called remain.

   The effect of vernalization can be removed if plants are again treated with high temperatures.

3. Answer: Growth is the sum total of various processes that combine to cause an irreversible increase in mass, weight, or volume. The growth is invariably accompanied by

differentiation, which is explained by quantitative changes in terms of the structure and functions of the cell. Plant growth differs from animal growth in its unlimited and undefined pattern of growth.

4. Answer: The discovery of auxin was the result of an investigation by Darwin (1880) while studying the bending of the coleoptile of phalaris sp (grass) towards the light. He established that the tip of coleoptiles was able to perceive the light stimulus.

   The light stimulus was transmitted to the sub-apical region where differential growth caused bending. A hypothesis was formulated that there is a transmitter. Boysen-Jensen (1913) demonstrated experimentally. In (1928) it was finally proved the existence of a chemical transmitter and called the substance Auxin.

5. Answer: Growth regulators play important role in agriculture:

   i. Dorminy of seed is broken within a few time

   ii. The miniature of the plait body is improved.

   iii. Time of germination becomes less.

   iv. Some plant growth regulators are IBA, IAA

   v. Initiation and promotion of cell division are very useful in tissue culture by growth regulators.

6. Answer: Just prior to the reproductive phase in 'rosette' plants like cabbage, the internodes elongate enormously causing a marked increase in stem height. This is called Bolting. In natural conditions, bolting requires either long days or cold nights.

7. Answer:

   i. Auxin promotes elongation and growth of stems and roots and the enlargement of fruits by stimulating cell walls to stretch in more than one direction.

   ii. Auxin promotes cell division in vascular cambium.

   iii. Auxin promotes root initiation.

   iv. It causes the development of callus in tissue cultures.

   v. Auxin is also involved in apical dominance and abscission.

8. Answer: It has been demonstrated that a plant from which all leaves have been removed fails to flower even under the inductive light regime. This has been confirmed from experiments with Xanthium, a short-day plant. Even if one eight of a leaf was exposed to short days, flowering occurred. Even a single leaf exposed to a short day was able to induce flowering when it was grafted onto a plant kept under non-inductive conditions.

## ➢ Long Answer:

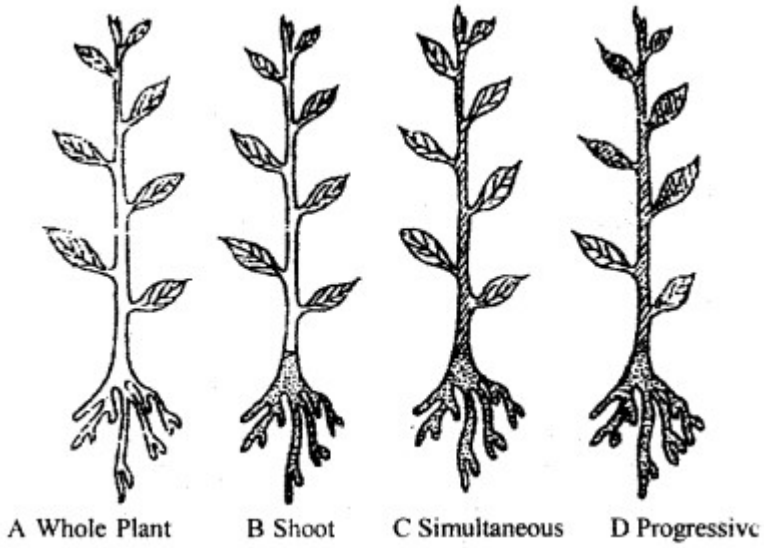
1. Answer:

1. Senescence: Senescence may be defined as the period between reproductive maturity and death of a plant or a plant part. Senescence is accompanied by a reduction in functional capacity and an increase in cellular breakdown and metabolic failures. This process ultimately leads to the complete loss of organisms or plant parts.

2. Types of senescence: In plants, it is of four types:

i. Whole plant senescence: It occurs in plants in which the whole plant dies after seed production e.g., wheat, gram, etc. These plants are annuals and die after seed production. This phenomenon also occurs in some monocarpic plants, which live for several years but flower once. For example, certain bamboos and sago palms.

ii. Sequential senescence: In some perennial plants, the tips of the main shoot and branches remain in the meristematic stage. They continue to produce new buds and leaves. The older leaves and lateral organs senescence and die. This type of senescence is called sequential senescence. Example: Mango and Eucalyptus.




Types of plant senescence

3. Shoot senescence: In certain perennial plants, the aerial shoot dies each year after flowering and fruiting. But the underground modified stem and roots survive under unfavorable conditions. These parts give rise to new shoots again next year under favorable conditions. Example: Banana and gladiolus.

4. Simultaneous or synchronous senescence: This occurs in temperate deciduous trees which shed their leaves annually in autumn. Example: Maple and elm.

5. Reduction of senescence: Cytokinins, the growth regulators retard senescence. They prevent the breakdown of proteins and other biomolecules. Instead, they stimulate the rate of synthesis of proteins and their mobilization. Auxins also retard senescence.

2. Answer: Many seeds fail to germinate even when they are provided with favorable conditions. This phase when the seed remains in action is called seed dormancy. This natural barrier for development is gradually overcome with time. Sometimes this dormancy is due to the conditions

in the seed itself then it is known as innate dormancy.

It may be due to the following reasons:

- Impermeability of seed coat: In some plants, the embryo is undifferentiated and unorganized when the seed is shed. It takes time to attain full development before it germinates.
- Due to immature embryo: In some plants, the embryo is un-differentiated and unorganized when the seed is shed. It takes time to attain full development before it germinates.

Significance of seed dormancy:

- It enables the seed to be disseminated in time and space.
- It helps them to germinate when environmental conditions are more favorable.

Advantages of reproduction by seed:

i. The plant is independent of water for sexual reproduction and therefore, better adapted for a land environment.

ii. The seed protects the embryo.

iii. The seed contains food for the embryo (either or cotyledons or in the endosperm).

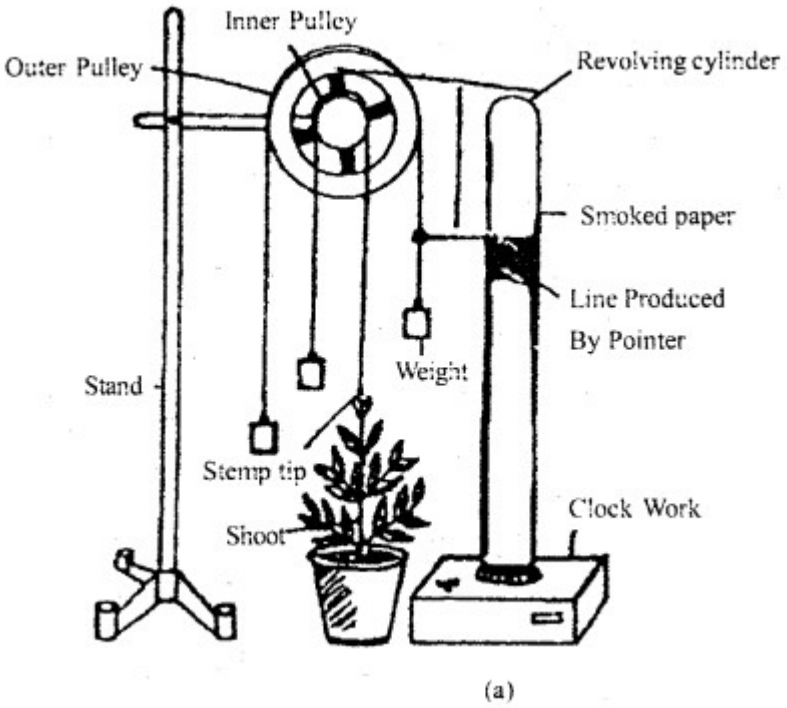
iv. The seed is usually adapted for dispersal.

v. The seed can remain dormant and survive adverse conditions.

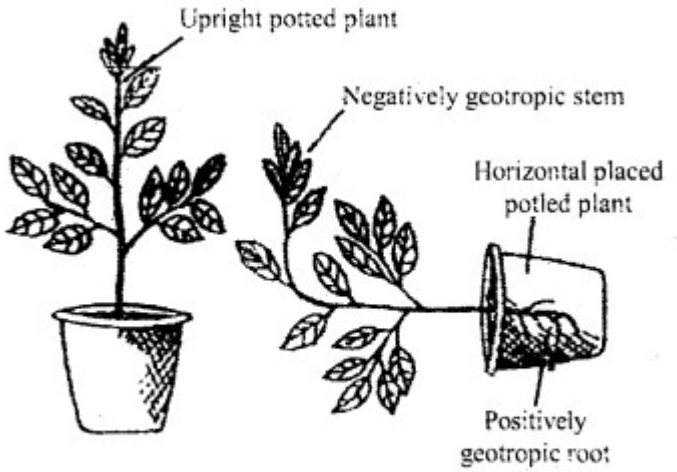
iv. The seed is physiologically sensitive to favorable conditions and sometimes must undergo a period of after-ripening so that it will not germinate immediately.

vii. The seed is a product of sexual reproduction and, therefore, has the attendant advantages of genetic variation.

3. Answer: Spontaneous movements: Plastids in cells may show movements in response to light, the stem of a plant grows upwards against the force of gravity or bends towards light. Spontaneous movement may be at protoplasm or organ or even at the whole plant level. The protoplasmic movements, accomplished by naked protoplasm in unicellular plants, are generally divided into ciliary, amoeboid, cyclosis, and gliding. Spontaneous movement is self-controlled.

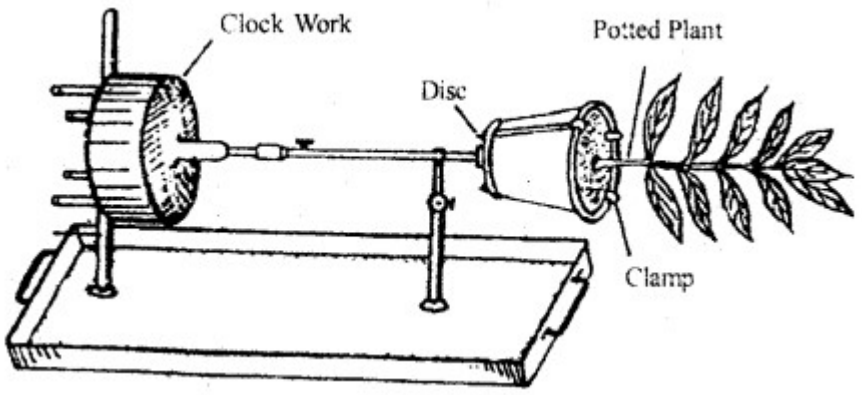



(a)




(b)

Induced movement: The induced (paratonic) movement is the movement of a complete cell or organelle and is influenced by external stimuli. This is also called tactic (taxes or taxis) movement and is common among lower plants. The movement may be due to chemical substances, such as sucrose and malic acid, present in archegonium of ferns and moss, which attract spermatozoids; and mobile bacteria are attached by peptone.




Different types of movement.

4. Answer: Awakening of inactive embryos present inside the seed into a seedling, capable of independent existence, is termed germination.

   Two conditions affect the germination of seed:
   (a) External conditions: External conditions necessary for germi¬nation are water, oxygen, temperature, and light.
   (b) Internal conditions: Sometimes the seeds fail to germinate even if various external conditions are favorable.

   Germination is also controlled by certain internal factors which are discussed as:

   1. Maturity of the embryo: In certain, plants, the embryo is immature in fully developed seeds.
   2. After ripening: In certain, plants, even if the embryo is mature but they do not possess the necessary growth hormones. These germinate only when necessary growth hormones are synthesized.
   3. Dormancy period: Certain seeds remain dormant after their shedding.
   4. Viability period: The period for which the embryo in seed remains living is termed as viability period. The seeds germinate only within the viability period.
   5. Reserve food material: The availability of sufficient reserve food material is essential for germination.
   6. Enzymes and growth hormones: Digestive and respiratory enzymes play an essential role in germination. In the absence of activation of certain enzymes, seeds will not germinate. Hormones like auxins, gibberellins, and cytokinins also play important role in germination.

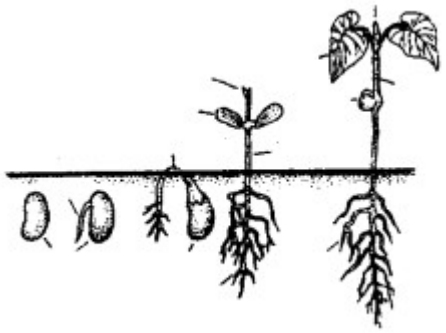
   Seed germination includes all the physical and physiological changes that occur in the seed.

   (a) Absorption of water: The water enters the seed mainly through the micropyle and imbibed by the reserve food and cell wall material, resulting in swelling of the seed. It causes the rupture of seed coats, allowing the radical to grow into the primary root. Aerobic respiration is essential for seed germination as it makes available the energy needed for the growth of the embryo.

(b) Mobilization of reserve food materials: The food is stored in the endosperm, or in cotyledons. The various enzymes convent this food into soluble substances, which serve as a respiratory substrate, and the energy released during aerobic respiration is used in various metabolic and physiological changes dining embryo growth. The digested food passed towards the embryo through cotyledon.

(c) Development of embryo into seedling: The embryonic cells become metabolically very active. The radicle starts growing and is first to emerge out through ruptured seed coats. It develops into a root that grows downwards into the soil. The root developing from the radicle is termed as the primary root.

After the development of the primary root from the radicle, either the epicotyl or the hypocotyl starts elongation, forming dicotyledonous seeds.



Different stages of germination of seed.

## Assertion Reason Answer-

1. (a) If both Assertion and Reason are true and Reason is the correct explanation of Assertion.

   **Explanation:** The shoot tip tissues in plants are meristematic.

2. (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

   **Explanation:** Nutrients are raw materials required for synthesis of protoplasm as well as source of energy. It should be rich in nitrogenous components to increase the synthesis of protoplasm and carbohydrates for energy and cell wall synthesis. All types of micronutrients and macronutrients should be available for proper growth. Water is required for cell elongation, maintenance of turgidity of growing cells and for providing medium for enzyme action. Even slight deficiency of water reduces growth. It may, however, promote differentiation. Water stress completely stops growth.