EAMCET/NEET

AP&TS

2023

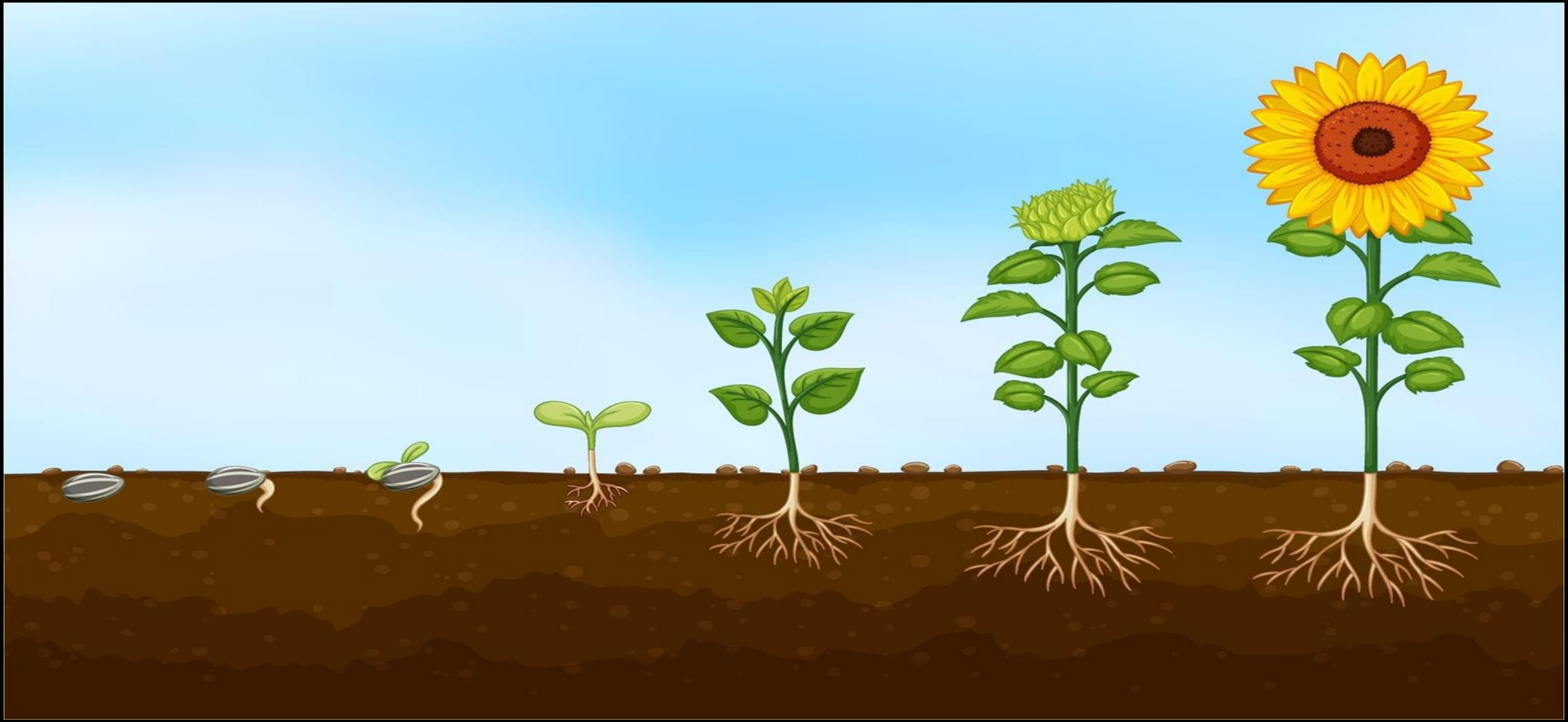
BIOLOGY

PLANT GROWTH AND REGULATION

ONE SHOT

UNSTOPPABLE

PLANT GROWTH & DEVELOPMENT



❖ GROWTH ❖ DIFFERENTIATION ❖ DEDIFFERENTIATION ❖ REDIFFERENTIATION ❖ DEVELOPMENT	❖ PLANT GROWTH REGULATORS ❖ PHOTOPERIODISM ❖ VERNALIZATION

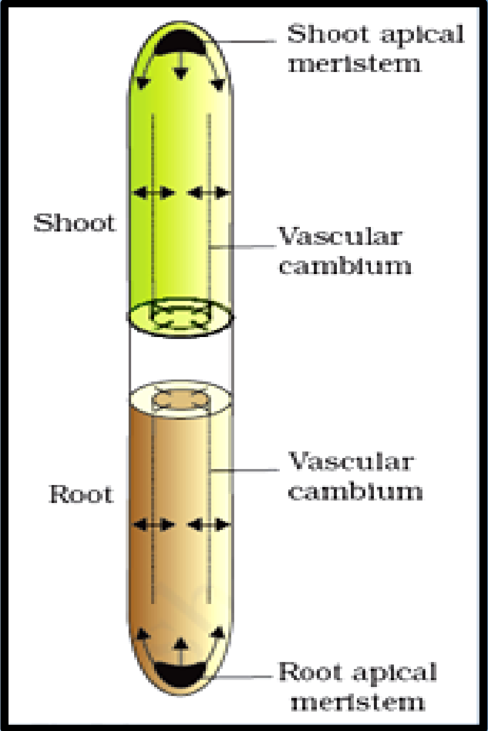
15.1 Growth

Growth is regarded as one of the most fundamental and conspicuous characteristics of a living being. What is growth? Growth can be defined as an irreversible permanent increase in size of an organ or its parts or even of an individual cell. Generally, growth is accompanied by metabolic processes (both anabolic and catabolic), that occur at the expense of energy. Therefore, for example, expansion of a leaf is growth. How would you describe the swelling of piece of wood when placed in water?

Growth = Addition of cells + Increase in cell size

GROWTH

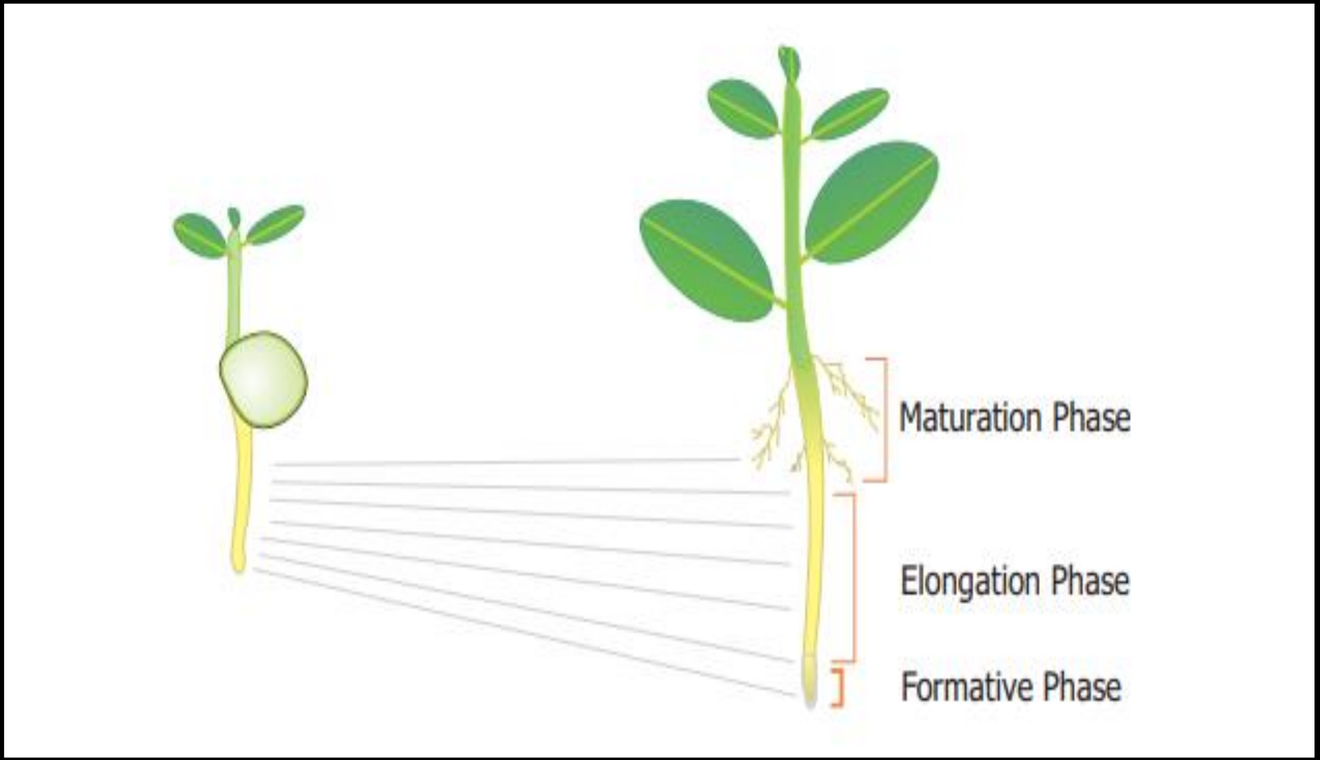
- Growth is defined as *"an irreversible permanent increase in size of an organ or its part or even of an individual cell."*
- **Plant Growth is generally Indeterminate:**
  - Plants are capable of growing throughout their life due to meristematic tissues present in certain parts.
- **Growth is Measurable:**
  - Growth can be measured by an increase in cell number, length, area, volume and dry or wet weight.



PHASES OF GROWTH

- **Meristematic (formative phase) growth:**
  - It is shown by apices of roots and shoots.
  - The meristematic growth is facilitated by a thin cellulosic cell wall, along with many plasmodesmata connections.
- **Elongation (phase of enlargement):**
  - It is characterised by deposition in the cell wall and increased vacuolation.
- **Maturation:**
  - It is characterised by cell wall thickening and lignification.
  - Cells attain maturity and their maximal size and undergo protoplasmic modifications.

PHASES OF GROWTH



TYPES OF GROWTH

- **Primary Growth:**
  - Apical meristems of roots and shoots is responsible for primary growth.
- **Secondary Growth:**
  - Secondary growth is due to lateral meristems, e.g. vascular and cork cambium.
  - The plant increases in the girth due to secondary growth.

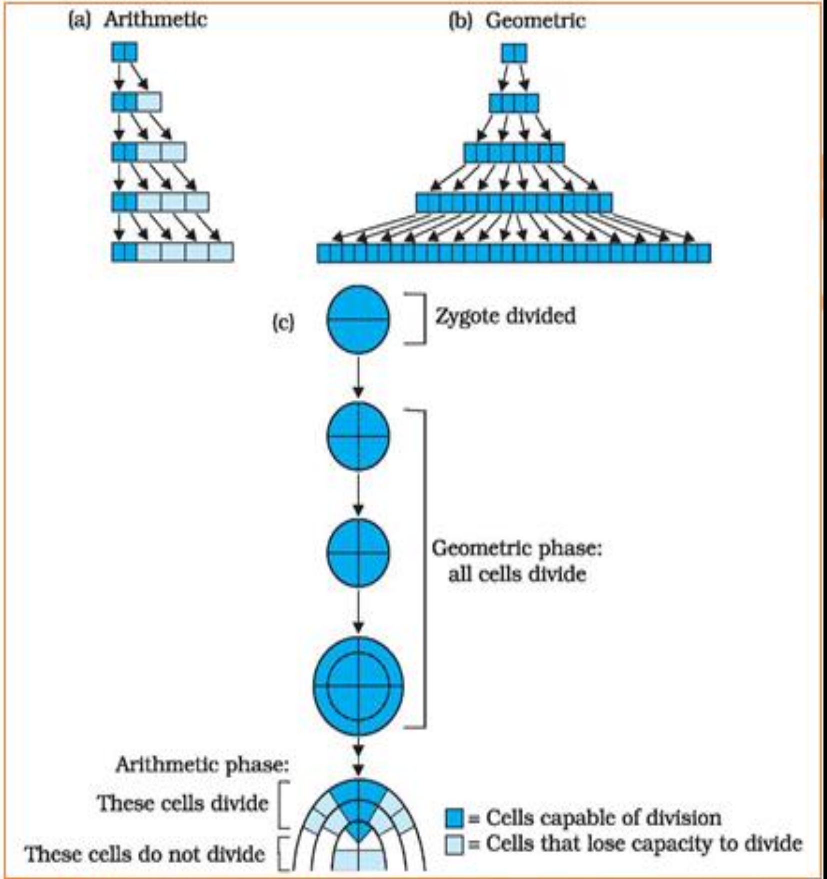


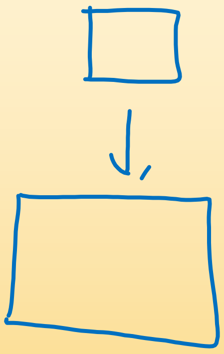
Fig: Diagrammatic representation of: (a) Arithmetic (b) Geometric growth and (c) Stages during embryo development showing geometric and arithmetic phases

GROWTH RATE

- Growth Rate is the increased growth in unit time.
- Growth can show either
  - Arithmetic progression.
  - Geometric progression.

Arithematic growth

Cell growth/elongation

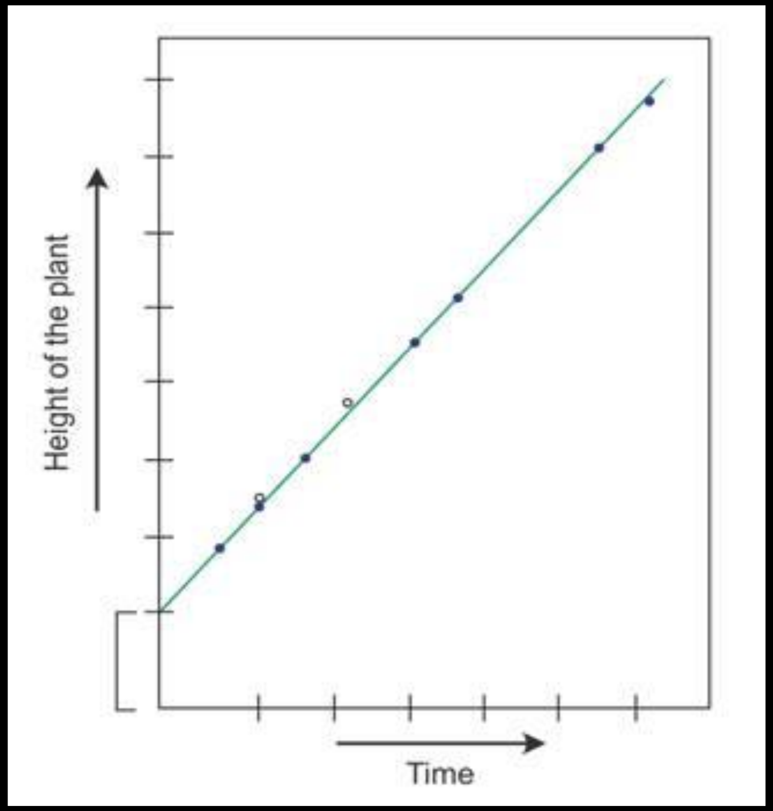


Geometric growth

Cell division

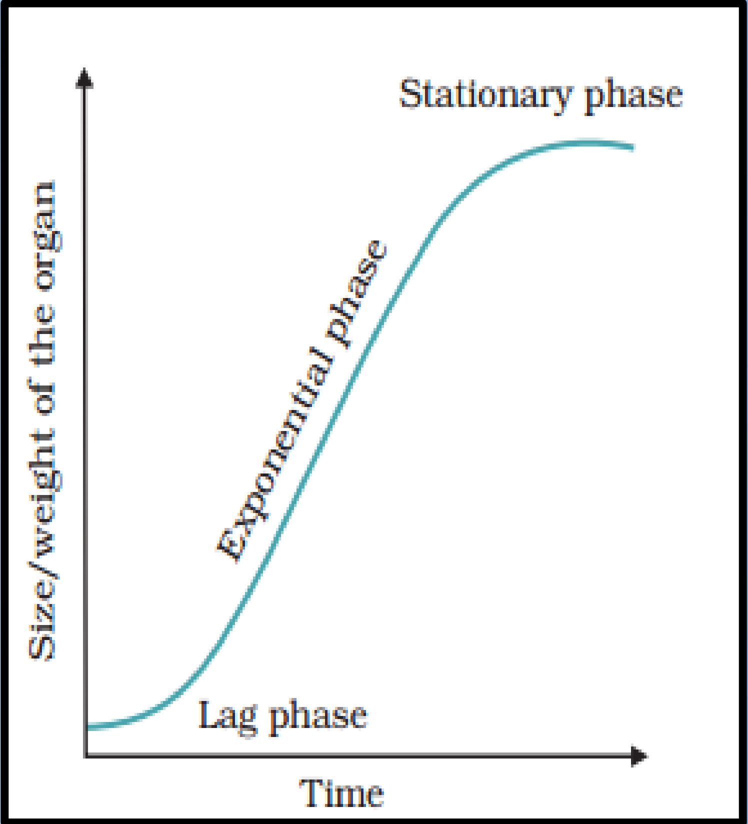
ARITHMETIC GROWTH

- It refers to the constant growth rate with time, e.g. elongation of a root and height of a plant.
- It can be represented by
  - $L_t = L_0 + rt$
  - Lo is the initial length
  - Lt is the length after time 't'
  - r is the growth per unit time



GEOMETRIC GROWTH

- It is represented by
  - an initial lag phase of slow growth,
  - followed by an exponential or log phase of rapid growth
  - leads to a stationary phase, where growth slows down.
- We get a sigmoid curve.



GEOMETRIC GROWTH

- $W_t = W_0 e^{rt}$
  - Wo is the initial size, it can be increased in the number of cells, weight or height
  - Wt is the size after time ‘t’
  - r is the growth per unit time or also referred to as **efficiency index**
  - e is the base of the natural log
- Most of the living organisms follow the sigmoid curve of growth, e.g. cells, tissue and organs of plants.

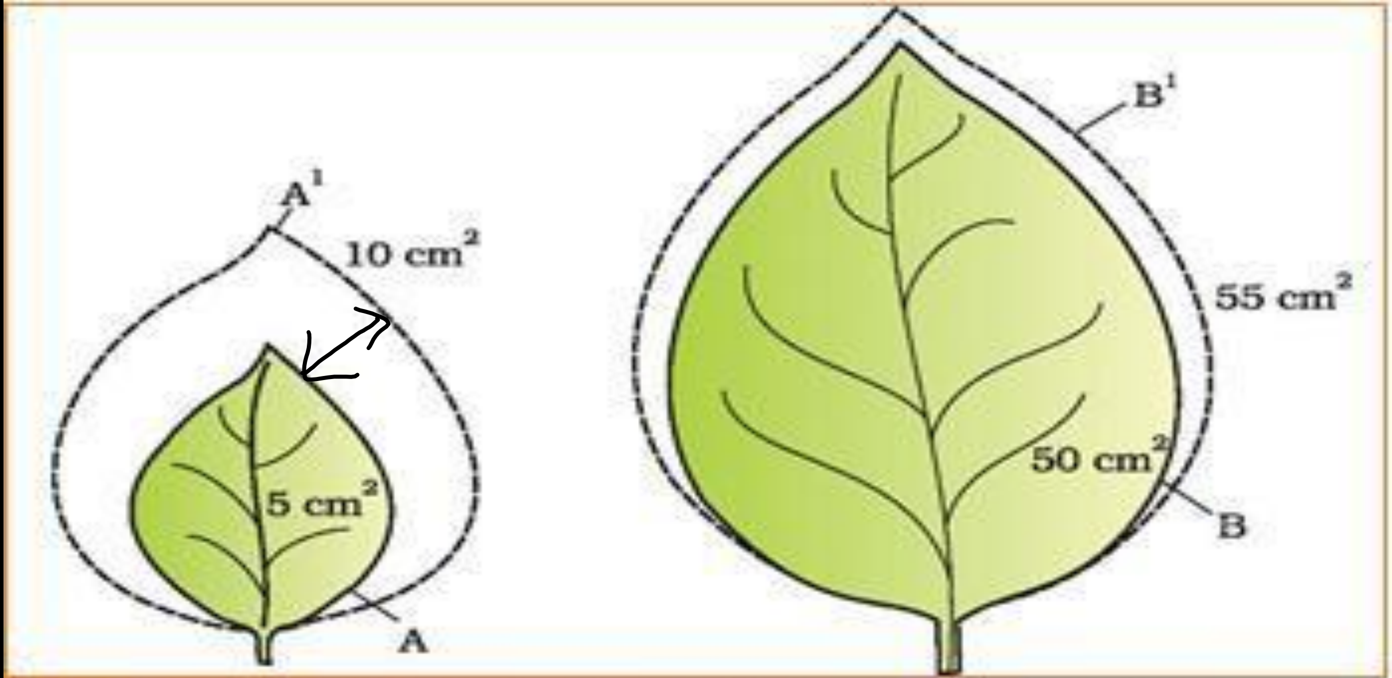


Fig: Diagrammatic comparison of absolute and relative growth rates. Both leaves A and B have increased their area by 5 cm^2 in a given time to produce A^1, B^1 leaves.

NEET QUESTION

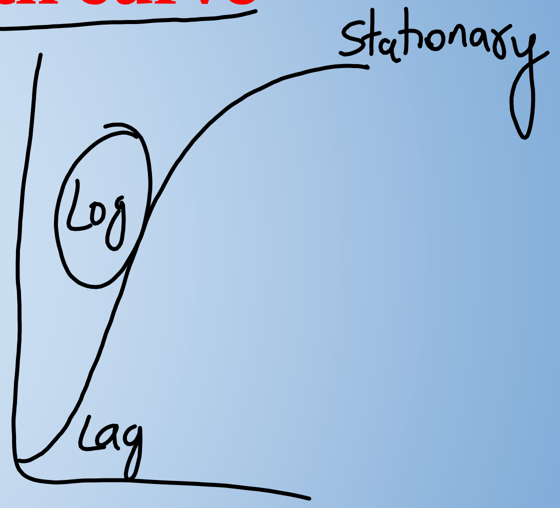
Q) Fastest phase of S-shaped growth curve is

A. Lag Phase

B. Log Phase

C. Stationary Phase

D. Both A and B



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NEET PYQ

Q) Typical growth curve in plants is

A. stair-steps shaped

B. parabolic

C. sigmoid

D. linear.

NEET PYQ

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CONDITIONS OF GROWTH

- Essential elements required for growth are:
  - **Water** is essential and also required for enzymatic activity. Turgidity helps in growth
  - **Oxygen** is required for respiration and metabolism of organic compounds to release energy required for growth
  - **Macro and micronutrients** are required as an energy source and for the synthesis of protoplasm
  - In addition to these, optimum temperature, salinity, light, etc. environmental factors also affect growth

15.2 Differentiation, Dedifferentiation and Redifferentiation

The cells derived from root apical and shoot-apical meristems and cambium differentiate and mature to perform specific functions. This act leading to maturation is termed as **differentiation**. During differentiation, cells undergo few to major structural changes both in their cell walls and protoplasm. For example, to form a tracheary element, the cells would lose their protoplasm. They also develop a very strong, elastic, lignocellulosic secondary cell walls, to carry water to long distances even under extreme tension. Try to correlate the various anatomical features you encounter in plants to the functions they perform.

Plants show another interesting phenomenon. The living differentiated cells, that by now have lost the capacity to divide can regain the capacity of division under certain conditions. This phenomenon is termed as **dedifferentiation**. For example, formation of meristems – interfascicular cambium and cork cambium from fully differentiated parenchyma cells. While doing so, such meristems/tissues are able to divide and produce cells that once again lose the capacity to divide but mature to perform specific functions, i.e., get **redifferentiated**. List some of the tissues in a woody dicotyledenous plant that are the products of redifferentiation.

DIFFERENTIATION

- Meristematic cells differentiate and undergo structural changes to perform specific functions.
- Examples:
  - Tracheary elements develop lignocellulosic cell walls, which is strong, elastic and required for the transport of water to long-distance.
  - Peripheral meristematic cells develop into the epidermis
  - Cells present apically differentiate into the root cap.

DEDIFFERENTIATION

- When living differentiated cells regain their ability to divide and differentiate, the process is called dedifferentiation.
- Example:
  - Parenchyma cells again differentiate into the cork and interfascicular cambium.

REDIFFERENTIATION

- The dedifferentiated cells again lose their capacity to divide, it is called **redifferentiation.**

DEVELOPMENT

- Development refers to growth as well as differentiation. The development includes all the phases of the lifecycle from seed germination to senescence.
- Development is controlled by various intrinsic and extrinsic factors:
- **Intrinsic Factors:**
  - These include genetic as well as hormonal control
- **Extrinsic Factors:**
  - Environmental factors like oxygen, temperature, water, nutrients, etc.

Development
=> Growth
+
Differentiation

DEVELOPMENT

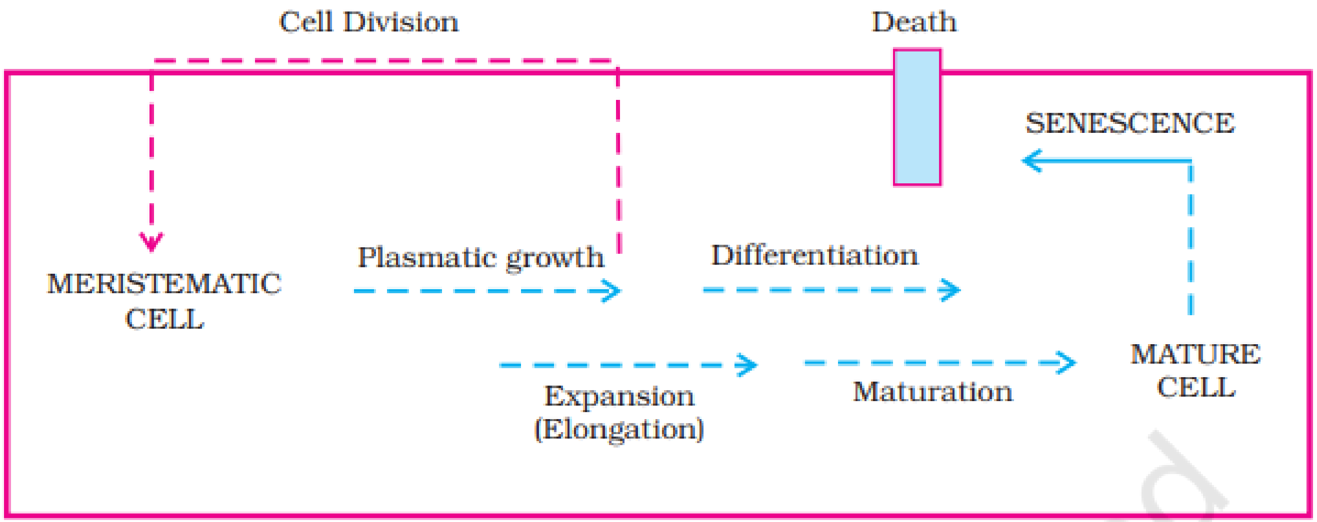
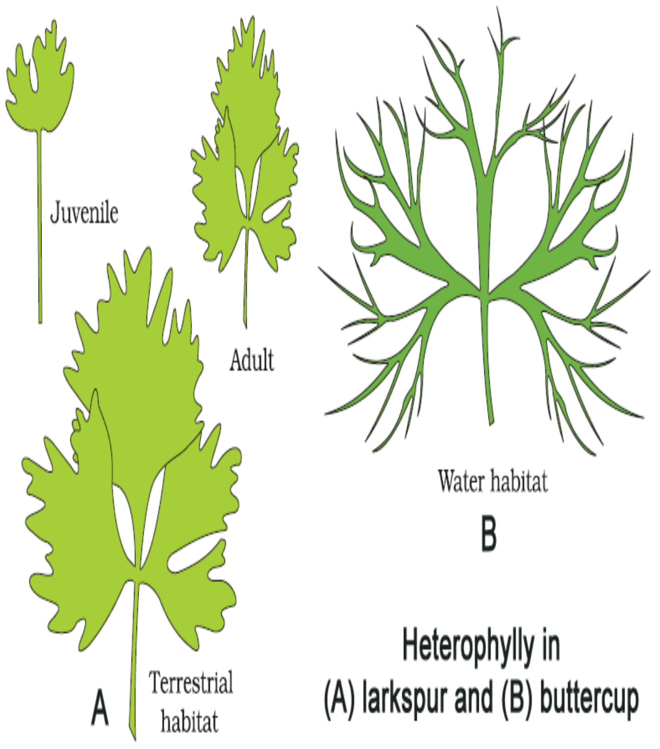


Figure 15.8 Sequence of the developmental process in a plant cell

PLASTICITY

- Plants form different types of structures in response to various environmental conditions. This is termed as **plasticity.**
- **Heterophylly**:
  - It refers to the different shapes of leaves present at different stages of life or in different environmental conditions.
  - E.g. In coriander, cotton and larkspur, leaves are of different shapes at juvenile and mature stages.
  - In buttercup, the leaves of terrestrial and aquatic habitats are different.



Heterophylly in (A) larkspur and (B) buttercup

Plants follow different pathways in response to environment or phases of life to form different kinds of structures. This ability is called **plasticity,** e.g. heterophylly in cotton, coriander and larkspur. In such plants, the leaves of the juvenile plant are different in shape from those in mature plants. On the other hand, difference in shapes of leaves produced in air and those produced in water in buttercup also represent the heterophyllous development due to environment (Figure 15.9). This phenomenon of heterophylly is an example of plasticity.

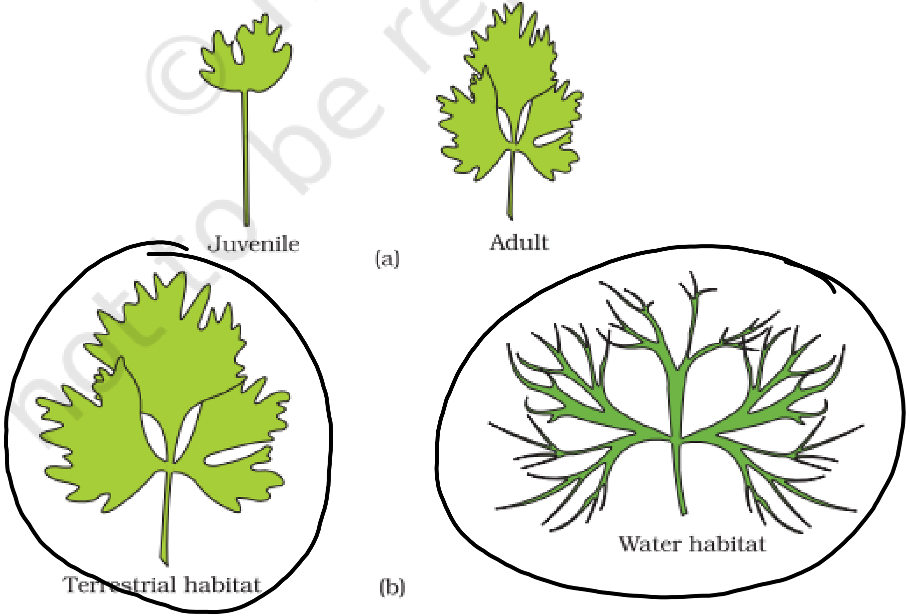


Figure 15.9 Heterophylly in (a) larkspur and (b) buttercup

NEET PYQ

Q) Juvenile Heterophylly is seen in

A. Cotton

B. Coriander

C. Larkspur

D. All the above

NEET PYQ

Q) Juvenile Heterophylly is seen in

A. Cotton

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C. Larkspur

D. All the above

PLANT GROWTH REGULATORS

- "Plant growth regulators function as chemical messengers for intercellular communication."
- They are chemical compounds and found naturally in plants.
- They are also synthesised commercially and used in agricultural practices.
- They are known as plant hormones or phytohormones.

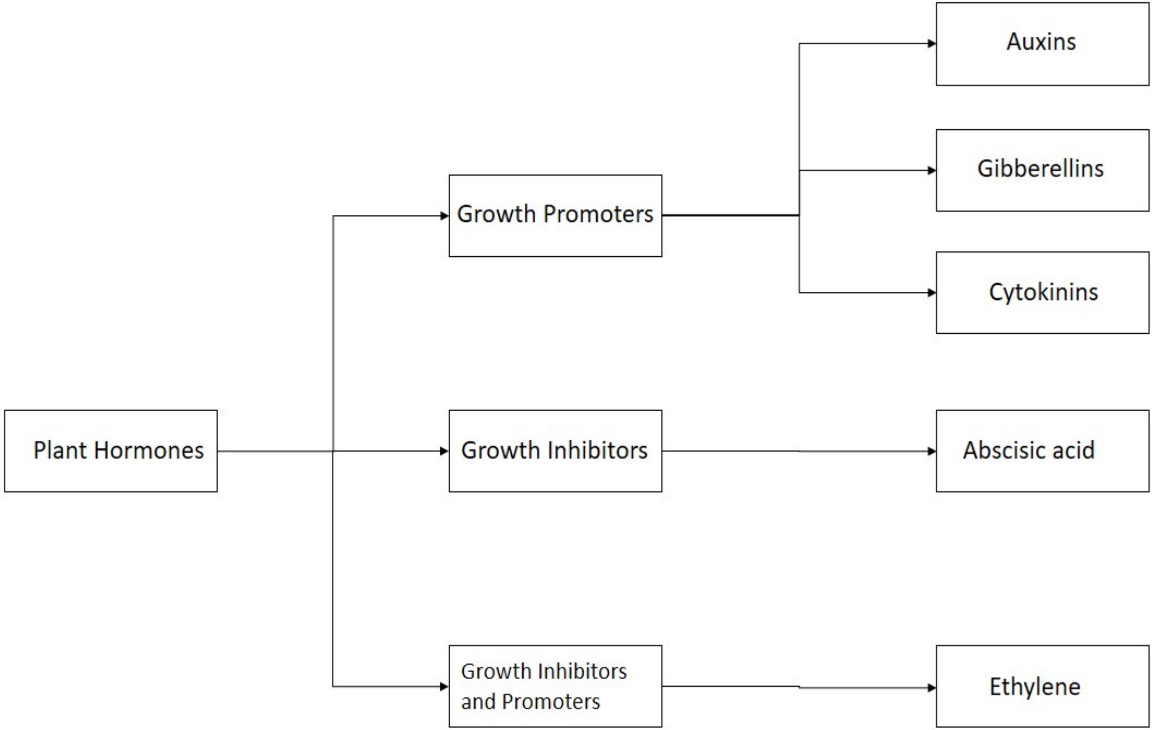
CHARACTERISTICS

- They are derivatives of:
  - adenine (kinetin),
  - carotenoids (ABA),
  - terpenes (GA3) and
  - indole compounds (auxins).
- Ethylene is a gaseous hormone
- They are present in a very low concentration and act as chemical signals between cells

CHARACTERISTICS

- Environmental factors influence gene expression and hormone production
- Plant hormones may show different effects at different stages and at different concentrations
- Plant hormones act by signal transduction, i.e. an external signal is converted to internal signal and which in turn causes one or more cellular responses.

CLASSIFICATION



CLASSIFICATION

- Plant growth promoters:
  - It induces cell division, elongation, differentiation and the formation of flowers, fruits and seeds.
  - e.g. auxins, gibberellins, cytokinins
- Plant growth inhibitors:
  - They are linked to dormancy, abscission and various stress responses,
  - e.g. Abscisic acid (ABA)
- Ethylene, the gaseous hormone has inhibitory as well as growth-promoting effects

15.4.2 The Discovery of Plant Growth Regulators

Interestingly, the discovery of each of the five major groups of PGRs have been accidental. All this started with the observation of Charles Darwin and his son Francis Darwin when they observed that the coleoptiles of canary grass responded to unilateral illumination by growing towards the light source (phototropism). After a series of experiments, it was concluded that the tip of coleoptile was the site of transmittable influence that caused the bending of the entire coleoptile (Figure 15.10). Auxin was isolated by F.W. Went from tips of coleoptiles of oat seedlings.

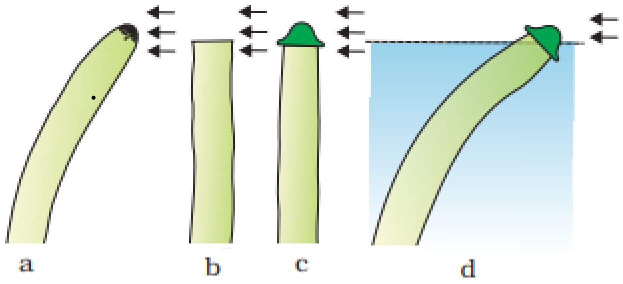


Figure 15.10 Experiment used to demonstrate that tip of the coleoptile is the source of auxin. Arrows indicate direction of light

F W Went → isolated Auxins

The 'bakane' (foolish seedling) disease of rice seedlings, was caused by a fungal pathogen *Gibberella fujikuroi*. E. Kurosawa reported the appearance of symptoms of the disease in uninfected rice seedlings when they were treated with sterile filtrates of the fungus. The active substances were later identified as gibberellic acid.

F. Skoog and his co-workers observed that from the internodal segments of tobacco stems the callus (a mass of undifferentiated cells) proliferated only if, in addition to auxins the nutrients medium was supplemented with one of the following: extracts of vascular tissues, yeast extract, coconut milk or DNA. Skoog and Miller, later identified and crystallised the cytokinesis promoting active substance that they termed kinetin. (cytokinin)

During mid-1960s, three independent researches reported the purification and chemical characterisation of three different kinds of inhibitors: inhibitor-B, abscission II and dormin. Later all the three were proved to be chemically identical. It was named abscisic acid (ABA).

Cousins confirmed the release of a volatile substance from ripened oranges that hastened the ripening of stored unripened bananas. Later this volatile substance was identified as ethylene, a gaseous PGR.

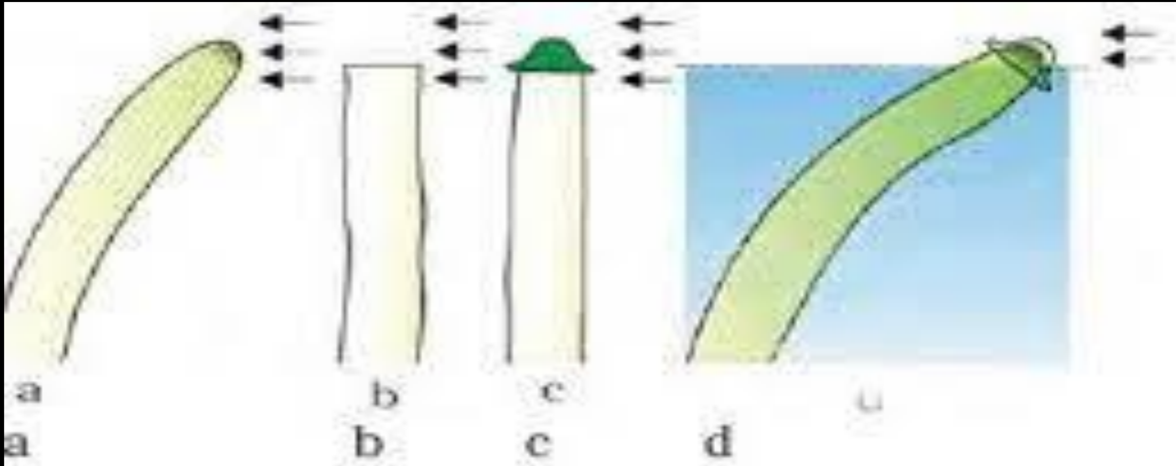
DISCOVERY

- Charles Darwin and his son Francis showed that there was some substance at the tip of coleoptile of canary grass, which is transmittable and responsible for the phototropism, i.e. bending towards the light
- Auxin was first isolated from human urine
- F.W. Went isolated Auxin from the coleoptiles of oat
- E. Kurosawa discovered that foolish seedling or 'bakanae' disease of rice seedlings was due to the presence of gibberellic acid in the fungus *Gibberella fujikuroi*

DISCOVERY

- Skoog discovered that callus proliferation in the internodal region takes place, only if auxin was supplemented with coconut milk or DNA, yeast or vascular tissue extract
- Miller et al later identified and crystallised cytokinin and termed as kinetin from herring sperm DNA.
- H.H. Cousins discovered the presence of a gaseous substance in ripened oranges, which hastened the ripening of bananas

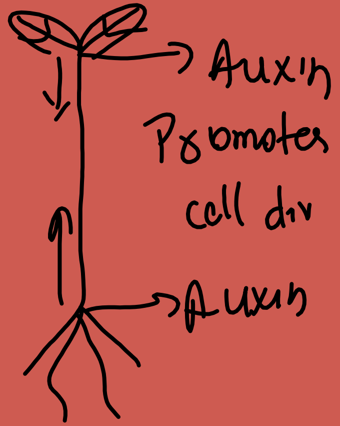
DISCOVERY OF AUXIN



gure 15.10 Experiment used to demonstrate that tip of the coleoptile is the source of auxin. Arrows indicate direction of light

AUXIN

- Produced in root and shoot apices.
- It gets transported to various parts.
- The transport of auxin is polar or unidirectional.
- **Natural auxins:**
  - IAA (Indole acetic acid)
  - IBA (Indole butyric acid)
- **Synthetic auxins:**
  - 2,4-D (2, 4-Dichlorophenoxyacetic acid)
  - NAA (naphthalene acetic acid).



PHYSIOLOGICAL EFFECTS OF AUXIN

- Apical Dominance
- Induces cell differentiation in xylem
- Induce parthenocarpy, i.e. formation of seedless fruits, e.g. Tomatoes
- Promote flowering, e.g. Pineapples
- Delay abscission of young leaves and fruits,whereas, promote falling of older leaves and fruits
- Root initiation in stem cuttings for vegetative propagation
- 2, 4-D is widely used as herbicides to kill dicot weeds

APICAL DOMINANCE

Apical dominance in plants :
(a) A plant with apical bud intact
(b) A plant with apical bud removed
Note the growth of lateral buds into branches after decapitation.

GIBBERELLIN

- More than 100s gibberellins are found.

GA_1, GA_2, $\boxed{GA_3}$

- GA3 (Gibberellic acid) is one of the first and the most common gibberellins.
- All the gibberellins are acidic.

PHYSIOLOGICAL EFFECTS OF GIBBERELLIN:

- Cell elongation
- Delay in senescence
- Stimulate malting process
- Internode elongation (sugarcane stem, grape stalks)
- Promote maturation and seed germination

Beer, wine

Bolting

Elongation of internodes before harvesting

CYTOKININ

Kinetin

- There are many naturally occurring cytokinins, e.g. zeatin.
- They influence cytokinesis and are produced in the rapidly dividing cells, e.g. growing buds, young fruits and root apices

PHYSIOLOGICAL EFFECTS OF CYTOKININ

- Cell division
- Inhibition of apical dominance, i.e. promote lateral shoot growth
- Delay of leaf senescence
- Embryo development
- Seed germination
- Promote nutrient metabolism
- Formation of chloroplasts in leaves
- Adventitious shoot formation

ABSCISIC ACID

- It is known as the stress hormone. ↑ Stress → Temp
  water
- It acts as an inhibitor of plant growth.
- It is produced in all the cells containing plastids.
- It is an antagonist of GAs → ABA x GA

PHYSIOLOGICAL EFFECTS OF ABA:

- Seed dormancy
- Closure of stomata and tolerance to various stresses
- Seed development and maturation

ETHYLENE

- It is a gaseous hormone.
- Produced by ripened fruits and tissues undergoing senescence.
- **Ethephon** is the most widely used compound (aqueous solution)

Ethephon

PHYSIOLOGICAL EFFECTS OF ETHYLENE

- Fruit ripening, e.g. tomatoes, apples,
- Senescence and abscission of leaves, flowers and fruits, e.g. cotton, walnut, cherry
- Maintenance of apical hook on seedlings
- Breaks seed and bud dormancy and initiates seed germination, e.g. peanut seeds, potato tubers
- Root initiation
- Internode and petiole elongation in water plants
- Promotes flowering and femaleness, e.g. cucumbers, mangoes
- Initiate germination in peanut seeds sprouting of potato tubers

NEET PYQ

Q. Fruit and leaf drop at early stages can be prevented by the application of:

A. Ethylene
B. Auxins
C. Gibberellic acid
D. Cytokinins

NEET PYQ

Q. Fruit and leaf drop at early stages can be prevented by the application of:

Shelf-life

A. Ethylene
B. Auxins
C. Gibberellic acid
D. Cytokinins

PHOTOPERIODISM

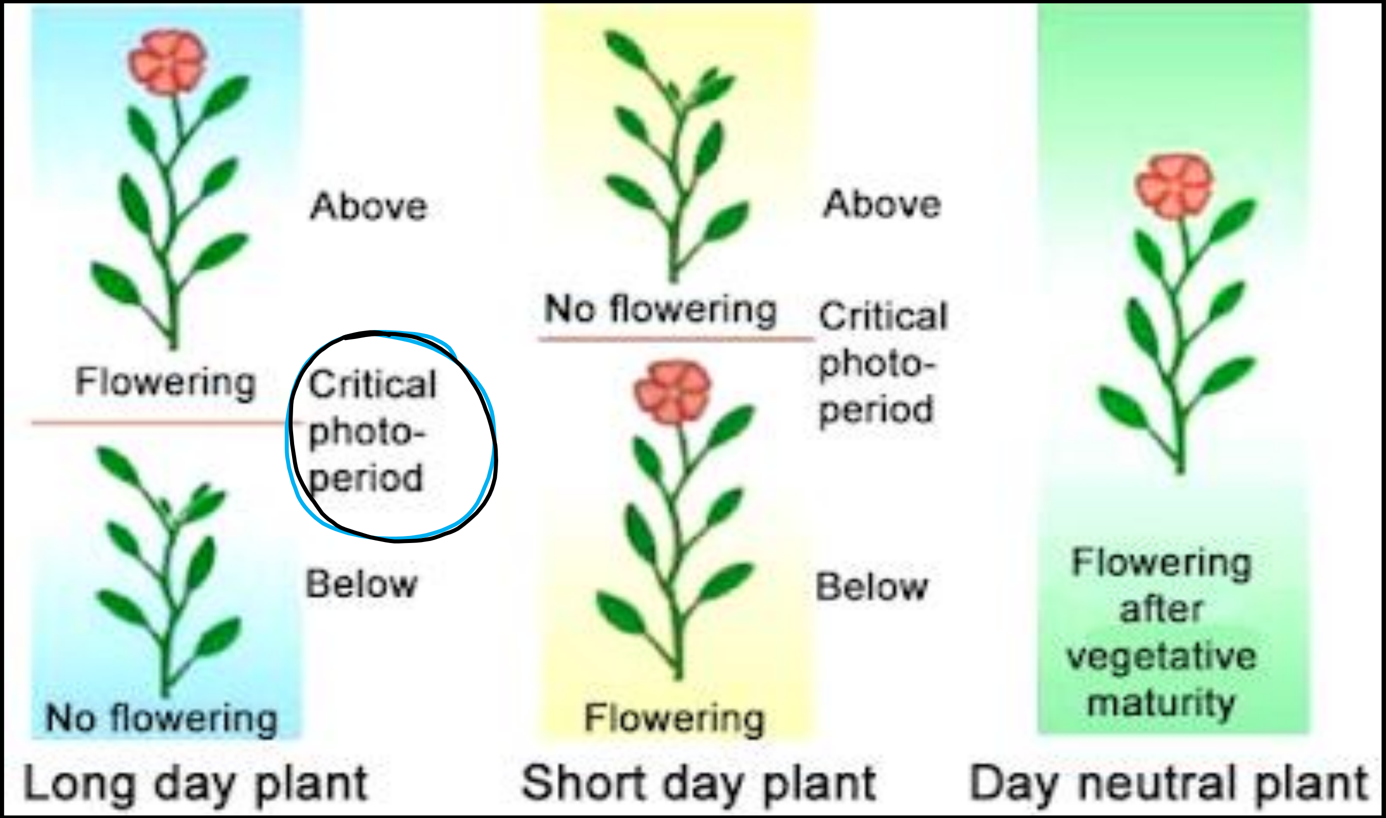
It refers to the effect of the duration of light on plant growth and development, especially flowering.

1st characterised in tobacco plant

Flowering plants are classified into the following categories, based on their flowering pattern in response to light:

- **Short day plants:** Flowering is initiated on the exposure of light for a shorter duration
- **Long day plants:** Flowering is initiated on the exposure of light for a longer duration
- **Day-neutral plants:** Flowering does not depend on the duration of light exposure

PHOTOPERIODISM



VERNALISATION

- It is a temperature-dependent phenomenon.
- Flowering is promoted by a period of cold temperature.
- Seeds are cooled during germination to accelerate flowering.
- Wheat, rye, barley, etc. food crops are grown twice in a year.
- Spring varieties are planted in spring and harvested at the end of the growing season.

Cold temperature

Promotes flowering

VERNALISATION

- Winter varieties are planted in autumn and harvested in mid-summer.
- Winter varieties will not flower within the growing season if planted in spring.
- Biennial plants need a period of low temperature to flower in subsequent months, e.g. cabbage, sugarbeet, carrots

SEED DORMANCY

- Seed dormancy is controlled endogenously.
- Seeds do not germinate even in favourable external conditions.

CAUSES OF SEED DORMANCY

- Hard and impermeable seed coat
- Chemical inhibitors, e.g. ABA, para-ascorbic acids, phenolic acids, etc.
- Immature embryo
- The seed coat is broken by natural abrasions such as microbial action and digestive tract enzymes in animals, which eat seeds. This can also be induced artificially by knives, vigorous shaking and sandpaper.
- The effect of hormones can be overcome by cold temperatures, nitrates and gibberellic acids.

NEET PYQ

Q.Photoperiodism was first characterised in

A. Tobacco
B. Cotton
C. Tomato
D. Potato

NEET PYQ

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A. Tobacco
B. Cotton
C. Tomato
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NEET PYQ

Q. Treatment of seed at low temperature under moist conditions to break its dormancy called

A. Scarification
B. Stratification
C. Vernalisation
D. Chelation

NEET PYQ

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