SNS COLLEGE OF TECHNOLOGY

(AN AUTONOMOUS INSTITUTION)

Approved by AICTE & Affiliated to Anna University
Accredited by NBA & Accrediated by NAAC with 'A+' Grade,
Recognized by UGC saravanampatti (post), Coimbatore-641035.

Department of Biomedical Engineering

Course Name: 19GET277 & BIOLOGY FOR ENGINEERS

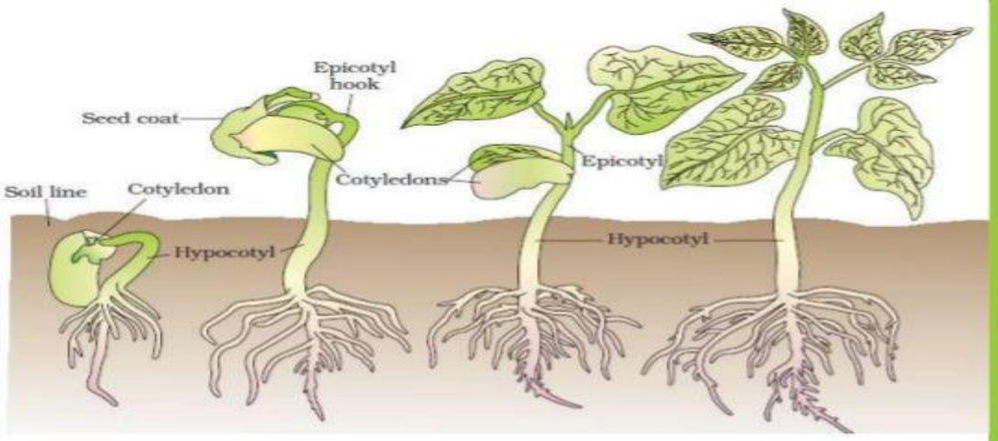
IV Year : VII Semester

Unit 2–BIODIVERSITY

Topic : Plant System: basic concepts of plant growth-nutrition

INTRODUCTION

- All cells of a plant develops from the zygote.
- Zygote produces a number of cells which organize into tissues and organs.
- Development is the sum of two processes: growth and differentiation.
- During the process of development, a complex body organisation is formed that produces roots, leaves, branches, flowers, fruits, and seeds, and eventually they die.



GROWTH

- Growth may be defined as an irreversible permanent increase in size in size, volume or mass of a cell or organ or whole organism.
- Growth is one of the fundamental characteristics of a living being.
- It is accompanied by metabolic processes i.e. anabolic and catabolic process, that occur at the expense of energy.
- Example:- expansion of a leaf, elongation of stem etc.

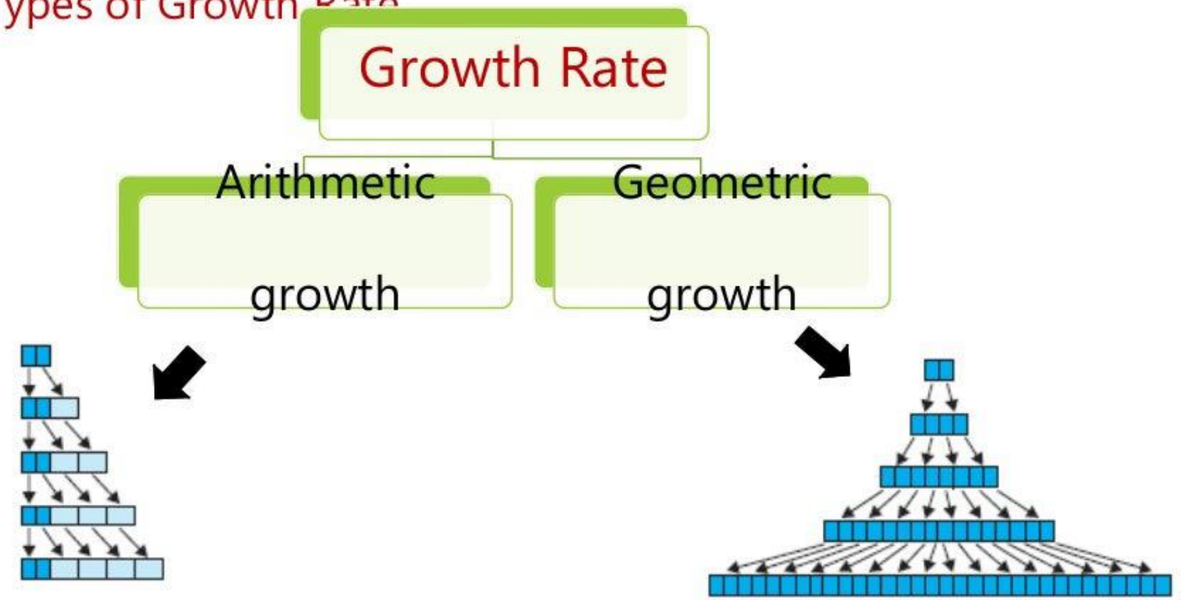
Characteristics of Growth

The main characteristics of growth are :-

1. Cellular growth
2. Cell division
3. Cell expansion
4. Cellular differentiation

Growth Rates

- Growth rate can be defined as increased growth per unit time.
- The rate of growth can be expressed mathematically.
- Types of Growth Rate



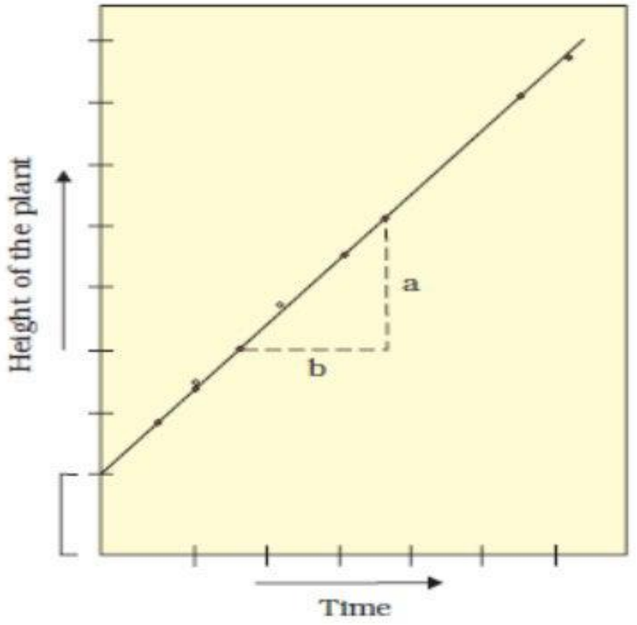
- ***Arithmetic growth*** -
- After mitotic cell division, only one daughter cell continues to divide while others differentiate or mature.
- Example – root elongating at a constant rate.
- Mathematically, it is expressed as

$L_t = L_0 + rt$

L_t = length at time 't'

L_0 = length at time 'zero'

r = growth rate / elongation per unit time



Constant linear growth, a plot of length L against time t

- ***Geometric Growth*** - Initial growth is slow (lag phase), followed by a rapid increase in growth (log/exponential phase), and followed by a phase where growth slows down (stationary phase).
- Example – all cells, tissues and organs show this type of growth
- If one plots the parameter of growth against time, it would be a typical sigmoid or S-curve.

- The exponential growth can be expressed as :

$W_1 = W_0 e^{rt}$

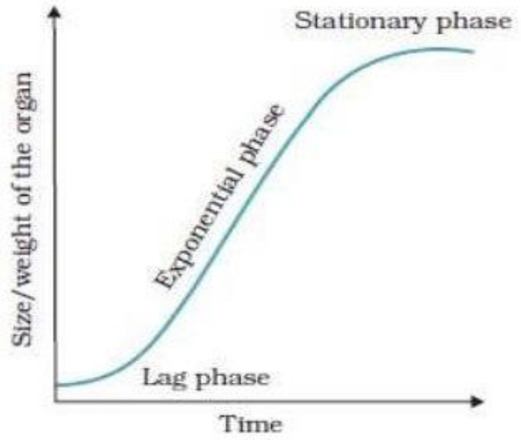
W_1 = final size (weight, height, number etc.)

W_0 = initial size at the beginning of the period

r = growth rate

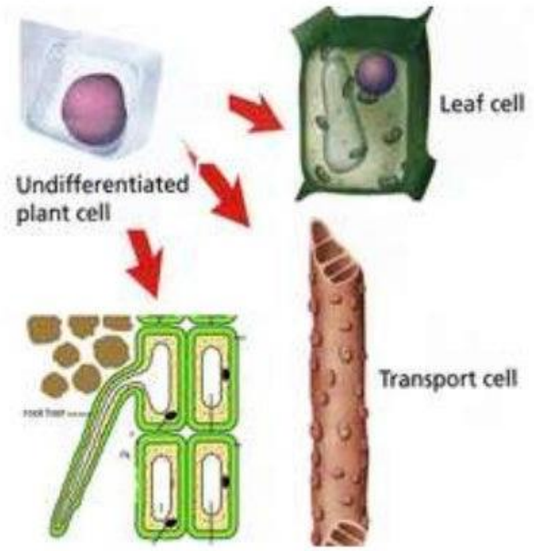
t = time of growth

e = base of natural logarithms



Differentiation, Dedifferentiation & Redifferentiation

- **Cellular differentiation** is the process by which a less specialized cell becomes a more specialized cell type.
- Cells derived from meristems and cambium differentiate and mature to perform specific functions which is termed as **differentiation**.

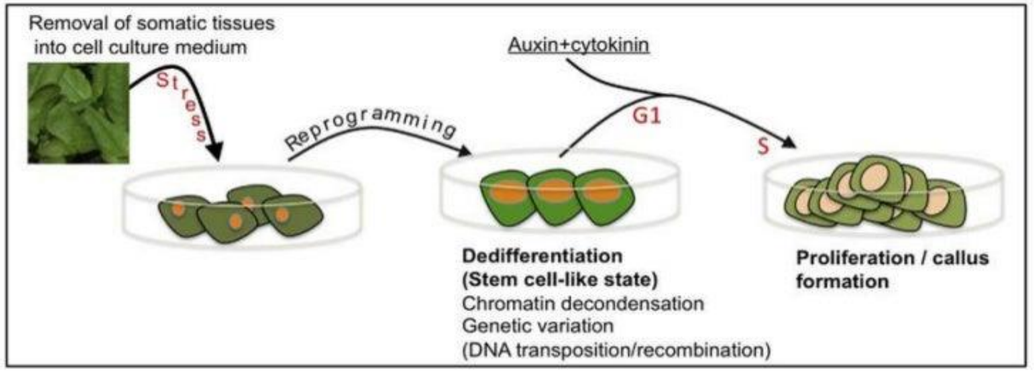


DIFFERENTIATION

- Cells undergo structural changes during differentiation.
- Changes take place both in their cell walls and protoplasm.
- Example :- Cells lose their protoplasm during the formation of tracheary elements.
- Plants develop a strong, elastic, lignocellulosic secondary cell walls, to carry water to long distances even under extreme tension.

e = base of natural logarithms

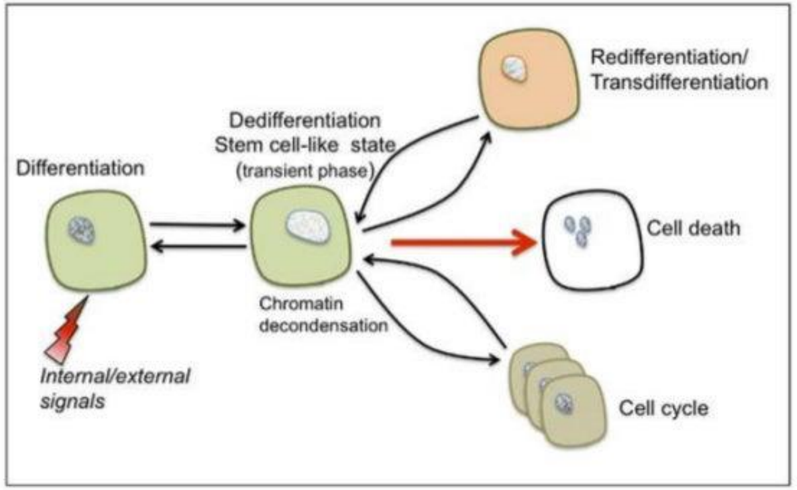
DEDIFFERENTIATION



- Dedifferentiation is an important biological phenomenon whereby cells regress from a specialized function to a simpler state reminiscent of stem cells.
- An undividable differentiated cell sometimes regains the power of division. This process is called dedifferentiation.
- Dedifferentiation is a common process in plants during secondary growth and in wound healing mechanisms.

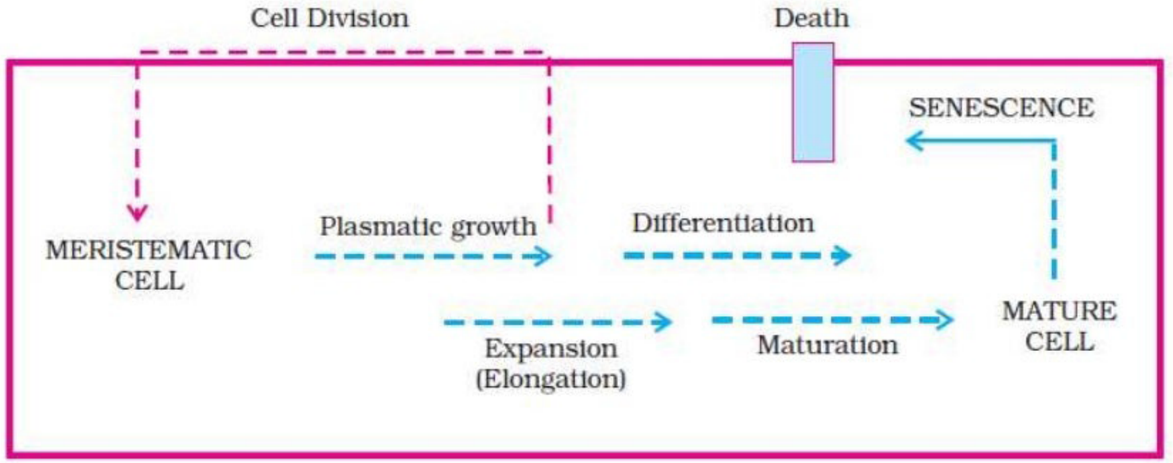
REDIFFERENTIATION

- A dedifferentiated cell can divide and produce new cells.
- New cells produced again loose the power of division and become a part of permanent tissue which is called "redifferentiation'.
- Example:- Formation of tumour cells.



DEVELOPMENT

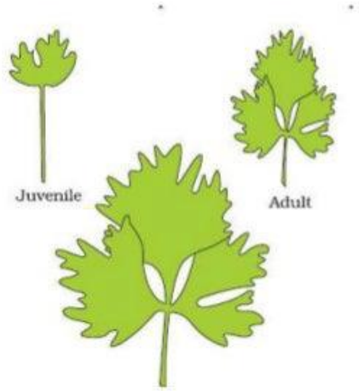
- Development is a term that includes all changes that an organism goes through during its life cycle from germination of the seed to senescence.



Sequence of the developmental process in a plant cell

Plasticity & Heterophylly

- **Plasticity –** The ability of plant to follow different pathways and produce different structures in response to environment and phases of life.
- In cotton & coriander plants, the leaves of the juvenile plant are different in shape from those in mature plants.
- Heterophylly - The phenomenon of appearance of different forms of leaves on the same plant is called heterophylly.
- e.g., heterophylly in cotton, coriander

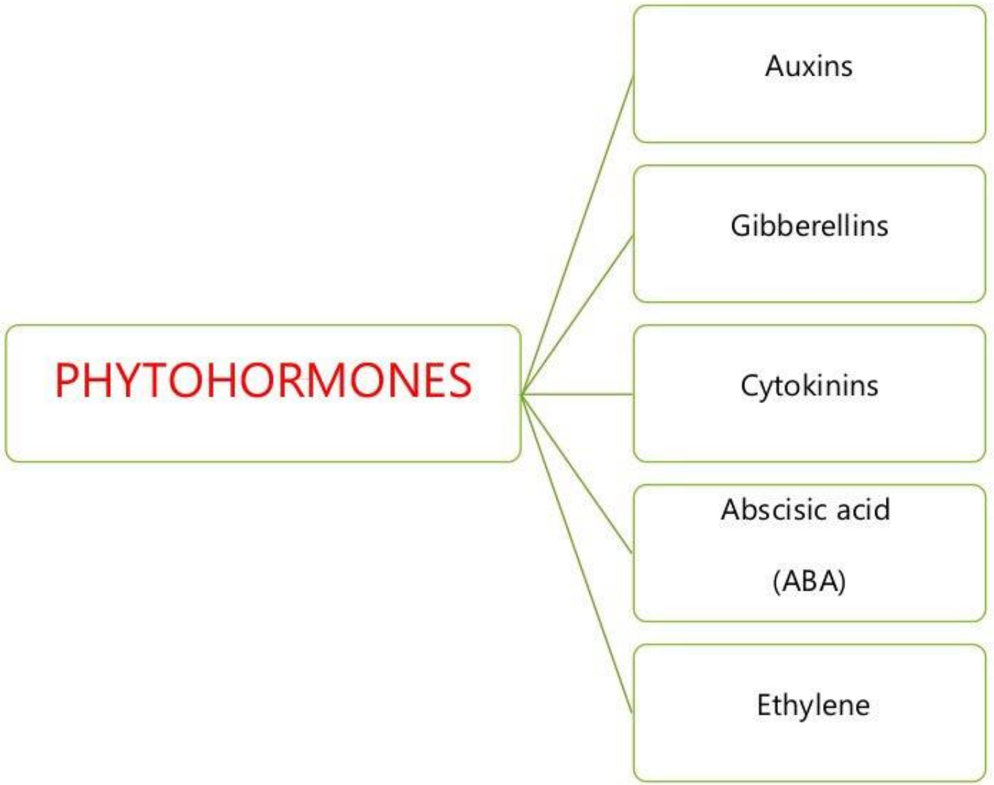


Heterophylly in larkspur (Terrestrial Habitat)

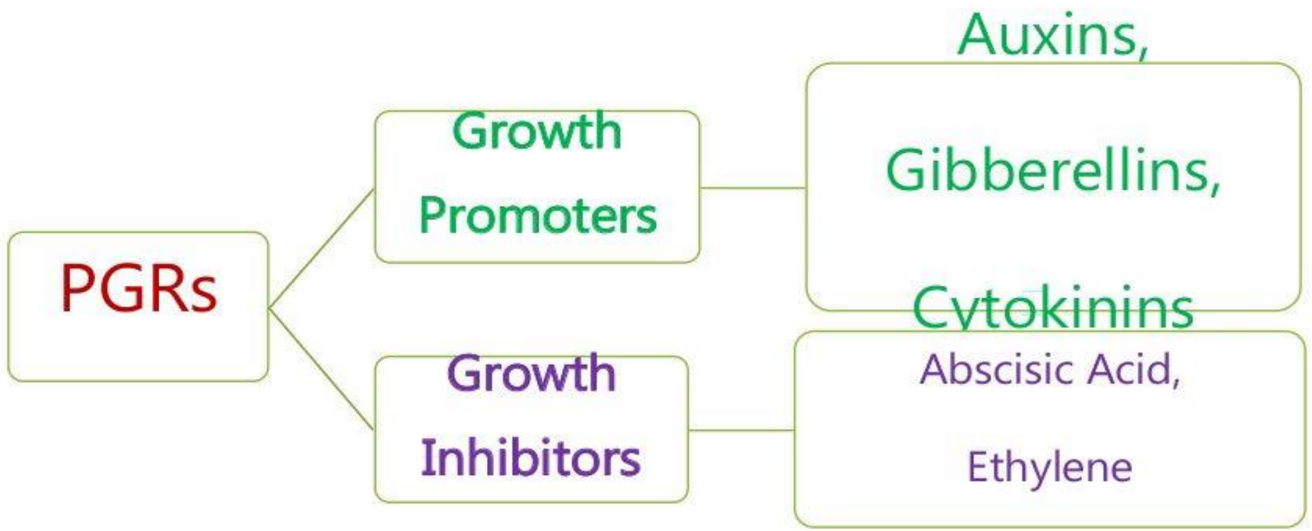
Heterophylly in buttercup (Water Habitat)

PLANT GROWTH REGULATORS

- Plant growth regulators (Phytohormones) are chemical substances that influence the growth and differentiation of plant cells, tissues and organs.
- Plant growth regulators function as chemical messengers for intercellular communication .
- They work together coordinating the growth and development of cells.
- They could be indole compounds (indole-3-acetic acid, IAA); adenine derivatives (N6-furfurylamino purine, kinetin), derivatives of carotenoids (abscisic acid, ABA); terpenes (gibberellic acid, GA3) or gases (ethylene, C2H4).


PHYTOHORMONES
Auxins
Gibberellins
Cytokinins
Abscisic acid
(ABA)
Ethylene

Classification of PGRs



AUXINS

- Auxins were discovered by Charles Darwin and Francis Darwin.
- F.W. Went isolated auxins from the tips of coleoptiles of oat seedlings.
- Went developed *Avena* curvature test for bioassay of auxins.

Synthetic Auxins

- IAA - Indole Acetic Acid
- IBA – Indole Butyric Acid
- NAA - Naphthalene Acetic Acid
- 2, 4-D - 2, 4-dichlorophenoxyacetic

Auxins

Auxins are a group of naturally occurring and artificially synthesised plant hormones.

They play an important role in the regulation of plant growth. Auxins were initially isolated from human urine.

Auxin means to “enlarge” or “increase”.

Physiological Effects of Auxins

- promote apical dominance
- initiate rooting in stem cuttings
- promote flowering e.g. in pineapples
- prevent fruit and leaf drop at early stages
- promote the abscission of older mature leaves and fruits
- induce parthenocarpy, e.g., in tomatoes
- used as herbicides
- controls xylem differentiation and helps in cell division

Gibberelins

Gibberellin (GA) is a plant hormone regulating key processes in plants; many of them are of significant agricultural importance, such as seed germination, root and shoot elongation, flowering, and fruit patterning.

Gibberellins are plant growth regulators that facilitate cell elongation, help the plants to grow taller. They also play major roles in germination, elongation of the stem, fruit ripening and flowering.

GIBBERELLINS

- E. Kurosawa, a Japanese scientist, identified gibbereilins present in a fungal pathogen Gibberella fujikuroi.
- Gibbereilins were isolated from infected rice seedlings when treated with sterile filtrates of fungus.
- **Physiological Effects of Gibberelins**
- Elongation of intact stems
- Dwarf shoots
- Bolting in rosette plants (e.g., Henbane, Cabbage)
- Overcome the natural dormancy of buds, tubers, seeds etc.
- Seed Germination
- Induce parthenocarpy or development of seedless fruits
- Promote flowering in long day plants
- Vernalization

CYTOKININS

- Skoog and Miller discovered cytokinins.
- Skoog and Miller crystallised the cytokinesis promoting active substance named it kinetin from corn-kernels and coconut milk.

Physiological Effects of Cytokinins

- induce cell-division
- delay the senescence of leaves and other organs
- promotes lateral bud
- increases cell expansion in dicot cotyledons and in leaves
- promotes chloroplast development and chlorophyll synthesis

ETHYLENE

- Cousins confirmed the release of a volatile substance from ripened oranges that hastened the ripening of stored unripened bananas.
- The volatile substance was identified as ethylene.

Physiological Effects of Cytokinins

- promotes senescence and abscission
- inhibits elongation of stems and roots
- Induce fruit ripening
- breaks seed and bud dormancy
- initiates germination in peanut seeds
- sprouting of potato tubers
- promotes root growth and root hair formation
- initiate flowering and for synchronising fruit-set in pineapples

ABSCISIC ACID

- 1963, Frederick T. Addicott and his co-workers identified Abscisic acid.
- ABA was isolated from several abscission-accelerating substances from cotton plants.
- ABA is called stress hormone.

Physiological Effects of Cytokinins

- acts as a general plant growth inhibitor
- induces seed and bud dormancy
- inhibits seed germination
- stimulates the closure of stomata
- plays an important role in seed development, maturation and dormancy

PHOTOPERIODISM

- Photoperiodism is a response of plants to the relative lengths of light and dark periods.
- Some plants require periodic exposure to light to induce flowering.
- Duration of dark period is equally important for flowering.

➢ *Long Day Plants* – Plants that require exposure to light for a period exceeding critical duration to induce flowering.

Example: Pea (*Pisum sativum*), Barley (*Hordeum vulgare*), Wheat (*Triticum aestivum*)

➢ *Short Day Plants* – Plants that require exposure to light for a period less than this critical period to induce flowering.

Example: Rice, Jowar, Cotton

➢ *Day Neutral Plants* – Plants where there is no correlation between exposure to light duration and induction of flowering.

Example: cucumber, rose, and tomato

VERNALISATION

- Vernalisation is the phenomenon of induction of flowering in plants by exposure to low temperature.
- It prevents precocious reproductive development late in the growing season, and enables the plant to have sufficient time to reach maturity.
- Example – Biennial plants
- These are monocarpic plants that flower and then die in second season.
- Examples :- sugar beet, cabbage, carrot, etc.