SEM-IV
UNIT4
Plant Growth Regulator

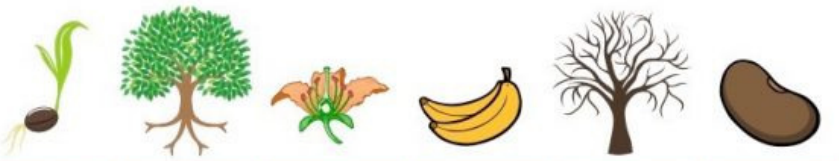
Plant hormones are naturally occurring organic substances which control morphological, physiological and biochemical responses at very low concentrations.

Plant hormones are also called phytofaormones or plant growth substances (PGS). The term plant growth regulators (PGR) arc used to represent the synthetic growth regulators.

The eight major types of plant hormones are: auxins, gibberellins, cytokinins, ethylene, abscisic acid, Brassinosteroids, Oligosaccharides and poly amines.

Classification of growth regulators (GR's)

Sr. No.	Growth regulator	Example
1	Auxins	IAA, IBA, NAA, 2,4-D
2	Gibberellins	Gibberellic acid (GA, GA_3, GA_7)
3	Cytokinins	Kinetin, Zeatin
4	Ethylene	Ethylene, Ethephon, Ethrel
5	Dormins	Abscisic Acid
6	Flowering hormones	Florigen, Anthesin, Vernalin
9	Synthetic growth retardants	CCC, Phosphon D, Morphactins, Maleic hydrazide (MH) etc.
10	Miscellaneous synthetic substances	Synthetic auxins, synthetic cytokinins etc.



	Germination	Growth to Maturity	Flowering	Fruit Development	Abscission	Seed Dormancy
Gibberellin	✓	✓	✓	✓	✗	✗
Auxin	✗	✓	✓	✓	✗	✗
Cytokinins	✗	✓	✓	✓	✗	✗
Ethylene	✗	✗	✓	✓	✓	✗
Abscisic Acid	✗	✗	✗	✗	✓	✓

(A) Auxins:

It is the 1st plant hormone which is discovered by Went (1928) from Avena curvature test. The most common naturally occurring auxin is IAA (Indole-3 -acetic acid) that resembles the amino acid tryptophan from which it is synthesized. IAA synthesized in shoots apical meristeins and transport basipetally (from apex to base) through polar transport (by parenchyma cells) and non-polar transport (by phloem). The synthetic auxins are NAA (Naphthalene acetic acid), IBA (Indolebutyric acid), 2, 4-D (2, 4- dichlorophenoxyaceticacid), 2, 4, 5-T, (2, 4, 5, -tricholrophenoxyacetic acid).

Importance/Role/Effect of IAA:

1. Promote growth in stems and coleoptiles but inhibit growth in roots.
2. Causes bending of coleoptiles towards light (phototropism) and control geotropism (growth in response to gravity)
3. Causes the growth of apical bud and inhibits the growth of lateral buds. This phenomenon is called apical dominance.
4. Delays shedding of leafs (abscission).
5. Promote the production of parthenocarpic (seedless) fruits.
6. Stimulates the differentiation of xylem and phloem.
7. Promote the formation of lateral roots and adventitious roots.
8. The 2, 4, -D and 2, 4, 5 -T are used as herbicides.
9. Synthetic auxins cause flowering, fruiting and stimulate rooting of cutting

(B) Cytokinins:

Cytokinins are naturally occurring growth promoters that in combination with auxin, promote cell division and differentiation in plants. Chemically cytokines are purine derivatives similar to adenine. In all plants, Zeatin (trans-6-purine) is the most about naturally occurring cytokinin but dihydrozeatin and isopentenyl adenine are also commonly found in higher plants and bacteria. The three zeatins found in bound form in plants such as riboside, ribotide or glycoside and convert into free zeatin by enzymes. They occur in both free and bound forms. Zeatin was first isolated from kernels of Zen mays and in liquid endospeim of coconut.

Cytokinin synthesized in root apical meristem and traported upward through xylem elements as zeatine ribosides. They also synthesized in developing embryos and in crown gall tissues. Cytokinin also occur as modified bases in certain t-RNA molecules of all organisms (bacteria to plants and human). The synthetic cytokinins are klnetin (6-furfuryl aminopurine), BAP (benzybaminopurine) etc.

Importance:

1. Cytokinin stimulates cytokinesis (cell divisions).
2. It causes the enlargement of stem cells, rather than their longitudinal extension.
3. Modify apical dominance and promote lateral bud growth.
4. Promotes chloroplast maturation.
5. Cytokinin increases the number of buds in Funaria. This helps in conversion of moss protonema into leafy gametophore.
6. Promote nutrient mobilization from other parts of plant to leaves.
7. Delay leaf senescence (Richmond-Lang effect)
8. Regulate morphogenesis of shoot and root in tissue culture.
9. Stimulate the release of dormancy of seeds and buds.
10. Induce flowering in SDP.
11. Increase resistance of plants to adverse factors such as high and low temperature and certain diseases.
12. High concentration of cytokinin induces epinasty (downward curvature of leaves).

(C) Gibbereliins:

Gibberellins (GAs) first isolated from the ascomycetes fungus, Gibberella fujikuroi that causes 'bakanae' or foolish seedling disease of rice. At present many naturally occurring GAs are known through many don't have biological activity. They are referred as GA_1 GA_2, GA_3. The most common gibberellin is GAg (gibberelic acid).

Chemically GAs is tetracylic diterpenoids consists of 4 isoprene units (C_5H_8). GAs can be subdivided into C_{20}-gibberellins (consists of 20C) and C_{19}-gibberllins (consists of 19C). GA synthesis occurs, in young leaves and buds, developing seeds and fruits and in roots. GA transported passively through xylem and phloem. They transport by non-polar method.

Effects of GA_3:

a. Causes extension of stem due to cell elongation and not by cell division.
b. In germinating seeds, embryos secrete GA that promotes the production of amylase and other hydrolases necessary for mobilization of reserve food.
c. Exogenous application breaks dormancy of seed and bud.
d. Exogenous application promote flowering in LDP, induce parthenocarpy (seedless fruits), increase the size of flower and fruit, and break dormancy of seed and buds.
e. Application GA promotes the formation of pistillate flowers in maize but promote staminate flowers in maize, spinach, cucumber, hemp etc.

f. Cause the increase in length of internodes (bolting) in rosette plants and genetically dwarf varieties of plants like corn and pea.
g. It is a substitute of vernalization (low temperature treatment) that causes early flowering in plants.
h. Commercially GA_3 is used to increase the stalk length of seedless grapes that allow the grapes to grow larger. It is also used in malting of barley in brewing process, delay senscence of citrus, increase the height of sugar cane and sugar yield.
i. Fern prothallus (gametophyte) release GA_3 derivatives that promote development of antheridia on adjacent gametophyte. Here, it acts aspheromones.

(D) Ethylene:

Ethylene or ethene ($CH_2 = CH_2$) is volatile gas present in the smoke and other industrial gases. R Gane (1934) established that ethylene is a natural plant hormone responsible for fruit ripening.

Ethylene is produced in bacteria, fungi and plant organs. Senescing tissues and ripening fruits produce more ethylene than young tissues. The precursor of ethylene biosynthesis is the amino acid methionine. Ethylene biosynthesis is increased by IAA, Cytokinins and water stress, Ethylene gas diffuses from one tissue and affects other tissues organs. It is biologically active at a concentration or 1 µl<1 per liter.

Effects of Ethylene:

a) Promotes fruit ripening, senescence of flowers and leaves.
b) Accelerates the abscission of plant organs. In the abscission zone ethylene promotes weakening of cell wall.
c) Breaks seed dormancy of cereals and bud dormancy of potato tubers.
d) Induces flowering in mango, pineapple etc. but inhibit flowering in most cases.
e) Promote formation of female flowers in cucumbers.
f) Ethylene at high concentration (10µl L^{-1}) induces adventitious rooting and root hair formation.
g) Ethylene treated shoots exhibit triple response i.e., decrease stem elongation, increased lateral growth (cell expansion) and horizontal growth in response to physical barriers by Neljubow (1901), a graduate students of Russia, in pea-seedling.
h) Ethylene induces leaf epinasty.

i) Ethephon when sprayed absorbed by plant and release ethylene slowly. This is commercially used to enhance fruit ripening, abscission of flowers and fruits and degreening of citrus.

(E) Abscisic acid (ABA):

ABA is a natural growth inhibitor synthesized in all cells of vascular plants and mosses that contain plastids. ABA is transported through xylem and phloem, Chemically, ABA is a 15-C terpenoid compound (sesquiterpene) derived from the terminal part of the carotenoid precursor.

Effects:

ABA promotes bud dormancy, leaf senescence, abscission of organs, closing of stomata etc.