AUXINS: NATURE, TRANSPORT, MODE OF ACTION & PHYSIOLOGICAL EFFECTS

MBOTCC-7
Unit-III

M.Sc. Sem-II
(2018-20)

Auxins: Chronology of Discovery & Identification of Nature

(i) Auxins were the first plant hormones to be investigated.

(ii) Darwin & Francis (1880), doing experiments on Canary grass (*Phalaris canariensis*) to investigate phototropism, showed that light was detected only by the tip of the coleoptile and that bending of the latter occurred in a lower region.

Some influence was thought to be transmitted from the upper to the lower part, causing the coleoptile to bend.

(iii) Boysen-Jensen (1913) demonstrated that the 'influence' postulated by the Darwins was more likely to be chemical rather than physical.

(iv) Paal (1919) demonstrated that the diffusible chemical had a growth-promoting effect.

(v) Went (1926-1928) proved that the growth stimulus is a diffusible chemical.

(vi) The next step was to isolate auxin and to identify it.

(vii) Identification of auxin was facilitated by the discovery of three compounds with auxin activity in human urine.

— One of these, termed heteroauxin at the time, was shown to be Indole 3-acetic acid (1934).

(viii) By mass spectrometry, auxin diffusing from coleoptile tips was conclusively identified as Indole 3-acetic acid (IAA) [1972].

(ix) IAA being the main auxin, plants have many other indole derivatives closely related to IAA. About 30 natural and synthetic auxins are known today to exhibit IAA-like influence in plants.

Transport of Auxins in Plants:

Transport or movement of auxins in the shoot and root systems of plants occurs laterally

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as well as longitudinally which are known to involve specific mechanisms and cellular components and tissues.

(a) Lateral Transport of Auxins:

(i) Lateral movement of auxin in coleoptile tips (a shoot tissue) occurs in response to light.

(ii) Light causes lateral transport of auxin from the illuminated side of the coleoptile tip to the shaded side.

(iii) This must involve detection of the light stimulus by a pigment in the tip and the coupling of this to auxin movement.

– Carotenes and flavins have been suggested to be involved in the reception of the photo-stimulus.

(iv) Lateral movement of auxin in shoots also occurs in response to gravity.

(v) In a horizontally placed plant concentration of auxin increases in the lower side and decreases in the upper side of the shoot.

– Mechanism of this process is not understood.

(vi) Meristematic cells in the shoot tip detect the gravitational pull, possibly by its effect on the distribution of intracellular inclusions, and then cause a differential auxin movement.

(vii) Lateral movement of auxin in response to gravity also occurs in roots. Positive geotropic response of roots even in horizontally placed plants is supposed to occur due to differential concentration of auxin in the upper and lower sides (higher on the lower side than on the upper).

(viii) Abscisic acid (ABA) may be more important than auxins in root geotropism.

(ix) Detection of gravity by roots appears to involve the starch grains of the amyloplasts in the root cap which redistribute themselves under the influence of gravitational pull.

(b) Longitudinal Transport of Auxins in the Shoot & Root:

(i) Movement of auxin in the shoot and root is polarized (auxins are usually transported along the longitudinal axis of the plant more rapidly in one direction than the other).

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(3)

(ii) Auxin moves basipetally (apical → basal) in shoot tissues.

(iii) The situation is more complex in roots; over the greater part of the length of the root auxin transport is acropetal (basal → apical), but near the root apex it is basipetal.

(iv) These polar auxin flows are, however, the resultant of two opposite but unequal flows.

(v) Rate of polar movement of auxin is roughly the same in shoots and roots.

(vi) In both shoots and roots, auxins are transported mainly in vascular tissues, chiefly cambium and newly formed phloem.

(c) Mechanism of Polar Transport of Auxin:

(i) Both active and passive components appear to be involved in the polar transport of auxin.
– Inhibition of polar transport by anaerobiosis indicates participation of an active transport component. Cyanide, azide and 2,4-dinitrophenol are common respiratory inhibitors used in such experiments to confirm active transport.

(ii) Mechanism of polar transport of auxin is not completely understood.

(iii) The theory prevalent until early 1970s postulated that auxin diffuses passively into the cytoplasm of a cell and is actively transported out by means of an energy-driven carrier located in the plasma membrane at one end of the cell.

(iv) Chemiosmotic theory of polar auxin transport has been put forward recently.

(v) Several structurally different compounds are specific inhibitors of auxin transport. They appear to block the cellular efflux of auxin but cannot stop its influx. Experiments using such inhibitors provide evidence in favour of chemiosmotic mechanism of auxin transport.

Mode of Action of Auxin:

(i) Target cells of auxin action are the differentiating cells of various meristems.

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(ii) Auxin enters its target cells and binds to a specific receptor molecule, probably a protein.

(iii) The resulting complex switches on specific genes which are transcribed into mRNAs which, in turn, are translated into specific proteins.

(iv) These proteins are the key enzymes which facilitate the physiological response of cell elongation.

(v) Present evidence is only partly consistent with the postulated sequence of events as above.

(vi) Cell elongation requires longitudinal wall stretching. Under the driving force of turgor pressure, longitudinal walls become more plastic.

– Such an increase in plasticity involves breaking of some of the bonds between the polysaccharide cell wall components and the remaking of others.

– Breaking of hydrogen bonds is potentiated by an increase in the H^+ ion concentration and their re-establishment by a decrease.

– Breaking and re-making of glycosidic bonds, on the other hand, involves enzymes.

(vii) Rayle and Cleland (1970) postulated that the primary effect of auxin is to cause the cell to lower the pH of the aqueous phase of the cell wall by stimulating membrane-bound H^+ ion pump. This increase in H^+ ion concentration weakens the hydrogen bonding between the cellulose microfibrils and the glucoxylans and allow them to slide past each other under the pull of turgor pressure. It may further aid wall plasticity by activating cell wall bound glycosidases, some of which are known to have low pH optima.

(viii) Auxin stimulates synthesis and deposition of new cell wall polysaccharide as well as increasing wall plasticity.

Physiological Effects of Auxins:

1. Cell Elongation – Auxin stimulates growth by promoting cell elongation.

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- However, high concentrations retard cell elongation, especially in the roots.

2. Apical Dominance -

- Auxins produce apical dominance, under which they inhibit the development of lateral buds and promote apical buds to grow.

3. Promotion of Dwarf Shoots -

- Auxins initiate the development of dwarf shoots.
- This influence is used in the cultivation of apple and pear, as fruits develop on the dwarf branches in these plants.

3. Root Formation -

- Application of IAA stimulates rapid formation of root initials.
- This property is used to promote root formation in the cuttings of economically useful plants.

4. Abscission of Leaves -

- Application of IAA to the proximal end of debladed leaf petioles accelerates abscission while the distal application retards it.

5. Induction of Parthenocarpy -

- Auxins may induce formation of fruits without fertilization (Parthenocarpy).

6. Weed Control -

- Some synthetic auxins, e.g., 2,4-D and 2,4,5-T have direct role in weed control.

7. Breaking of Dormancy -

- Use of auxins have been made with success for the breaking of dormancy in sugarcane, potato, etc.
- Dormancy may also be prolonged in potato tubers by using methyl napthalene acetate.

8. Ripening and Sweetening of fruits -

- Dichlorophenoxy acetic acid applied to bananas, apples and pears hasten the ripening process and increases sweetening of fruits.

9. Auxins are also known to prevent the pre-harvest fruit fall due to moist and windy climate.

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