PHYSIOLOGICAL ROLE OF AUXIN

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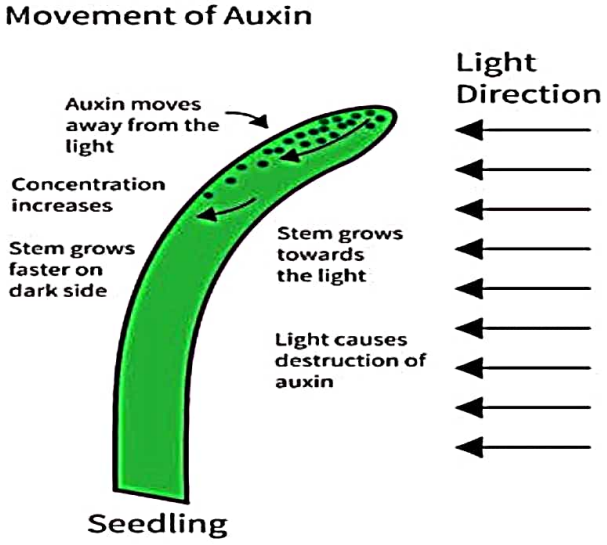
The physiological effects of auxin are both of basic and applied interests. These include -

1. Cellular elongation
2. Apical dominance
3. Root initiation
4. Parthenocarpy
5. Prevention of Abscission
6. Increased respiration
7. Callus formation
8. Increase in cambical activity

Besides the above effects, auxins have been used variously in the seed germination, flowering, fruit setting, prevention of premature drop of fruit, tissue and organ culture, weed control etc.

Many of these effects of auxin occur soon after exposure to the hormone. Such responses are referred to as rapid responses. Several auxin evoked responses are long-term. Both rapid and long-term responses provide the plants with mechanisms to adapt to changes in the environment during the course of its morphogenesis.

1. Cellular elongation: The primary physiological effect of auxin in plants is to stimulate the elongation of cells in shoots. In phototropic curvature, it has been seen that the unilateral light unequally distributes the auxin in the stem tip. The higher concentration of auxin on the shaded side causes the cells on that side to elongate more rapidly resulting in bending of the stem tip towards the unilateral light.



Many theories have been proposed to explain the mechanism of cell elongation due to auxin. According to these theories, the auxin causes cell elongation probably —

(i) by increasing the osmotic solutes of the cells,
(ii) by increasing the permeability of cells to water,
(iii) by reducing wall pressure,
(iv) formation of energy rich phosphate - ATP,
(v) by inducing the synthesis of DNA dependent new m-RNA and specific enzymic proteins.

(i) By increasing the osmotic solutes : Stafford (1967,73) explained that the amylase activity is increased due to auxin which results in more sugar available for the break down under aerobic condition.

STARCH —AMYLASE→ SUGAR (Such as maltose) → MORE RAPID TRANSLOCATION

→ INCREASED SUBSTRATE AND RESPIRATION UNDER AEROBIC CONDITION → ENZYME + O_2 via Cytochromes

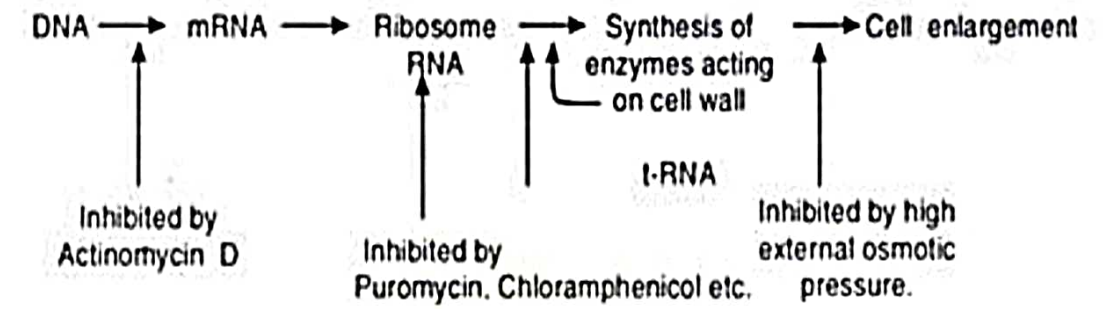
(ii) Increased permeability : Increase in the permeability of cell to water results in more rapid translocation of substrate which cause increased rate of respiration resulting in more energy available for the growth.

(iii) Reducing wall pressure :

Increased cell wall plasticity results in → Decreased Wall pressure → Increased Water Uptake → CELL ELONGATION

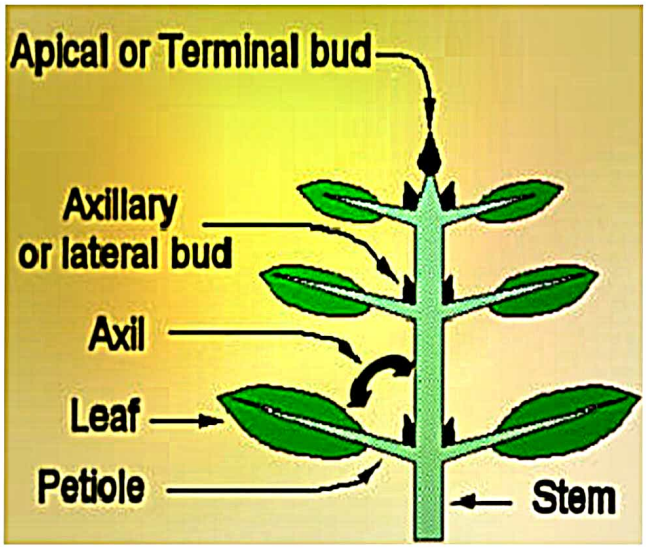
(iv) Formation of energy rich phosphate : It means more energy is available for elongation.

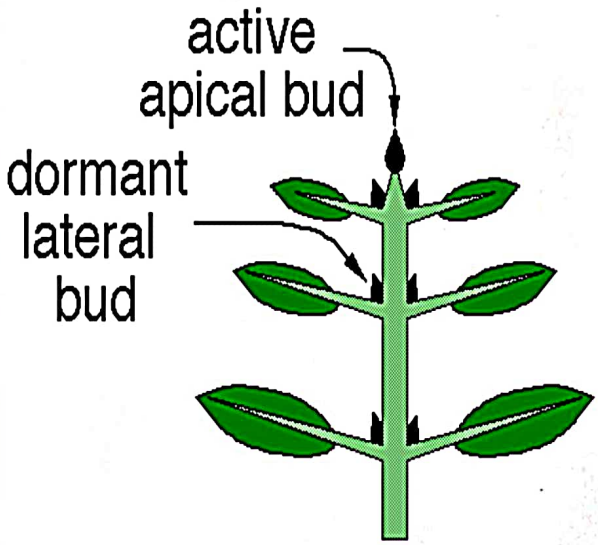
(v) Synthesis of specific enzymic proteins : By inducing the synthesis of specific DNA dependent new m-RNA and specific enzymes, which increases the cell plasticity and extension resulting ultimately in cell enlargement.

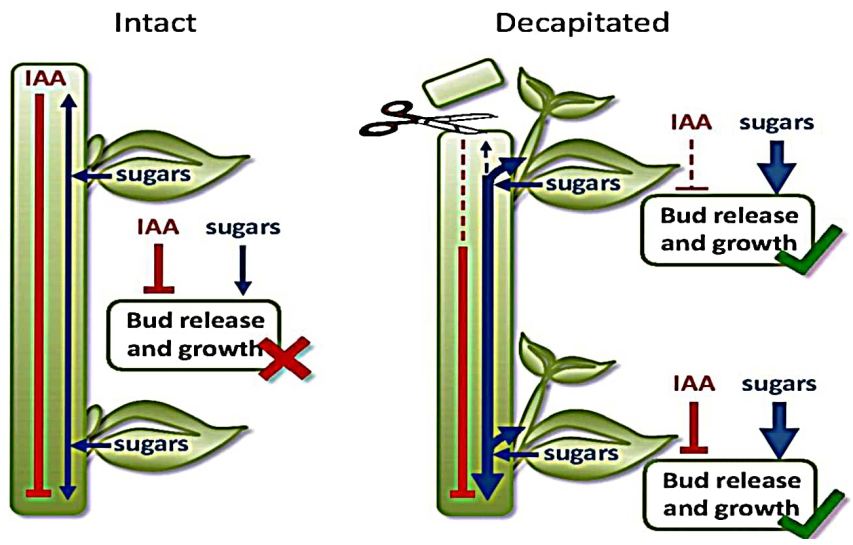


2. Apical dominance:

- The influence of apical bud in suppressing the growth of lateral buds is called apical dominance.
- It is found in many vascular plants especially the tall and sparcely branched ones. In such plants, if the terminal bud is intact and growing, the lateral buds remain suppressed.
- Removal of the apical bud results in the fast growth of the lateral buds and branches could develop fast and the hedge could be compact.
- The reason for this was explained by Thimann and Skoog (1934) and Thimann (1937). According to them, the auxin is synthesized in the apical meristem from where it is translocated downwards causing inhibition of growth of lateral buds.
- During downward movement of auxin some correlative inhibitors are synthesized which inhibits the growth of lateral buds.
- It has been shown that removal of the tip portion of shoot (decapitation) releases apical dominance and consequently lateral bud formation is stimulated. If an agar block containing auxin is again placed on the decapitated stump, the growth of lateral buds is again checked.





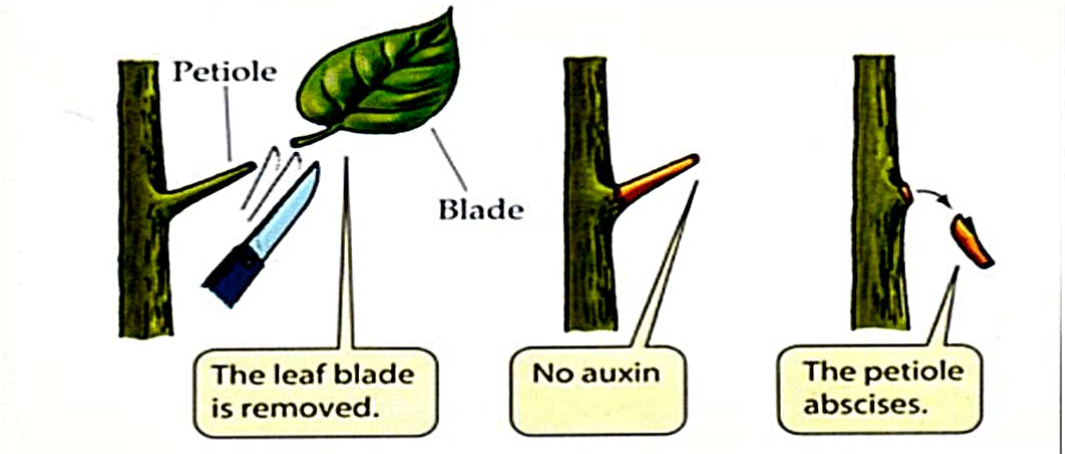


3. Root initiation : The application of relatively higher concentration of auxin (which stimulates shoot growth) inhibits the elongation of root but causes a noticeable increase in the number of lateral branches in the root. For this reason, auxin, particularly indole butyric acid, is used by plant growers to induce root formation in cuttings. Thus, this is of great practical importance and has been widely utilised to promote root formation in economically useful plants which are propagated by cuttings.

4. Parthenocarpy : Auxin is well known to induce parthenocarpy i.e, the formation of seedless fruits without the act of fertilization, in a number of plants. External application of auxin, 2,4-D (2,4, dichlorophenoxy acetic acid), NAA (Naphthalene-1-acetic acid), PAA (Phenyl acetic acid) etc. on flowers causes development of seedless fruits in tomatoes, cucumber, orange etc.

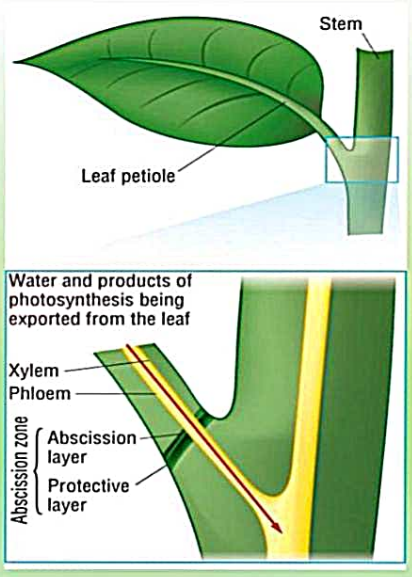
In nature, the species showing parthenocarpy has much higher concentration of auxin content than that is found in the ovaries of plants needing fertilization to produce fruit (Gustafson, 1939). In the latter case, the concentration of auxin in ovaries increases after pollination and fertilisation.

5. Prevention of abscission : The leaves and fruits fall down from the plants only when an abscission layer is formed between petiole or pedicel or fruit stalk and stem at the point of attachment. Natural auxins control the falling of fruits, flowers and leaves from the plant.



Stages in leaf abscission

- As leaves age, rate of auxin production at tip of leaf declines
- Cells in abscission zone are more sensitive to ethene production
- Drop in auxin causes an increase in ethene production
- More ethene produced, inhibits auxin production
- This increases production of enzyme cellulose, which digests the cell walls in abscission zone
- Separates the petiole from the stem



If the fruits fall prematurely, it results in reduced quality. The auxins like 2,4,5-TP (2,4,5-trichloro-phenoxy propionic acid) and others like 2,4-DP (2,4-dichloro-phenoxy analogs) etc. when applied during the mid-stages of fruit growth, have been found to prevent abscission of mature fruit.

Auxin and ethylene are the main hormones that control leaf abscission. Ethylene while promotes abscission, auxin controls it. Exposing plants to air containing ethylene gas in concentration as low as one ppm causes rapid abscission of older leaves. Young leaves because of their ability to produce higher levels of auxins can resist abscission even in the absence presence of ethylene. During the early and developing stages of the leaf, auxin is continuously translocated from the lamina to the abscission zone and maintains the attached leaf. As the leaf ages, auxin production tends to decline.

6. Increased Respiration: It has been established that the auxin stimulates respiration and there is a correlation between auxin induced growth and an increased respiration rate. According to French and Beevers (1953), the auxin increases the rate of respiration indirectly through increased supply of ADP by rapidly utilising the ATP in the expanding cells.

7. Callus formation: Initiation and promotion of cell division by auxin is very useful in tissue culture experiment and formation of callus (undifferentiated mass of cells). Healthy growth of callus depends on the auxin added in culture.

8. Increase in Cambial activity: Auxin is responsible for initiation and promotion of cell division in cambium. This effect of auxin is particularly important in secondary growth of stem and differentiation of xylem and phloem tissues.

Other effects:

9. Eradication of weeds: Some of the synthetic auxins, especially 2,4-D (2,4-dichlorophenoxy acetic acid), are used in eradication of weeds. Spraying of these substances causes overstimulated root growth of certain unwanted dicotyledonous plants, which ultimately are destroyed.

The high concentration of auxin has been found to stimulates production of ethylene. Excess ethylene can inhibit elongation growth, causes leaves to fall and lethally damage the plants.

10. Flower initiation: The synthetic auxin like NAA (Naphthalene acetic acid) promotes flowering in pineapple. Auxin is necessary for the initiation of floral primordia, and the disruption of auxin biosynthesis, polar auxin transport or auxin signalling leads to the failure of flower formation.