AUXIN

Dr. Uttam Kumar Kanp

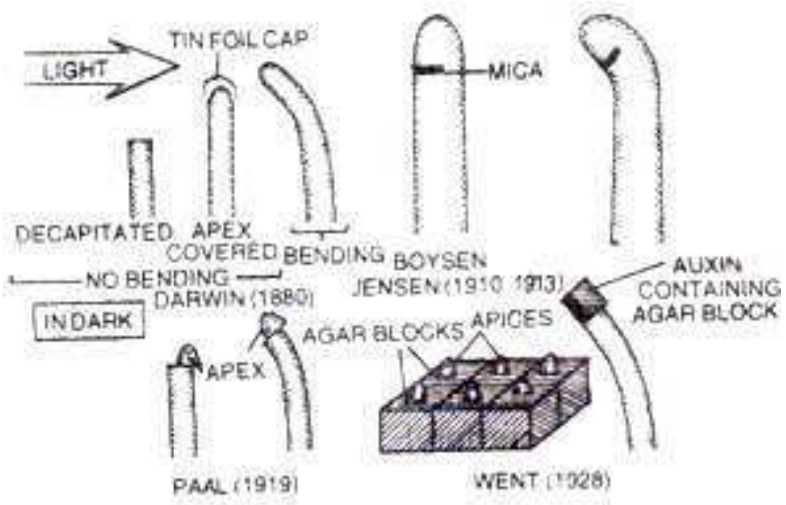
Contents: 1. Discovery, 2. Chemical nature, 3. Bioassay, 4. Physical role, 5. Uses of Auxins.

1. Discovery of Auxins:

Charles Darwin and his son Francis Darwin (1880) found that the sensation of unilateral illumination was picked up by the coleoptile tip of Canary Grass (Phalaris canarensis).

A decapitated coleoptile did not receive the sensation. Coleoptile tip covered by an opaque tin foil cap also could not perceive the stimulus of light. The sensation picked up by the coleoptiles tip is transmitted to the sub-apical part which it bends in relation to the direction of light.

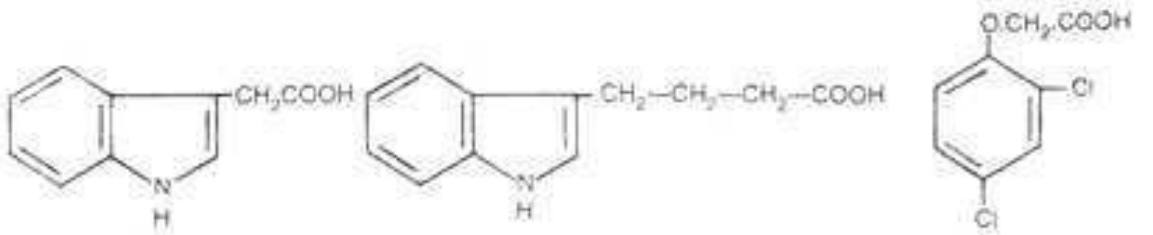
Boysen-Jensen (1910-1913) showed that the sensation of phototropism picked up by coleoptile tip could be transmitted to sub-apical region through a block of gelatine but not through a mica plate. Paal (1919) replaced the previously exposed excised tip eccentrically over the stump of coleoptile. He observed greater growth on that side even in dark. Went (1928) collected the growth stimulating substance in agar jelly.



Summary of early work on auxin.

discovered that the hormone travelled basipetally, i.e., from tip or apex towards the base. Agar block containing the chemical caused bending of a decapitated coleoptile according to its concentration. The growth promoting substance was named by him as auxin (Gk. auxein- to grow). Kogl and Haagen-Smith (1931) isolated three chemicals from human urine.

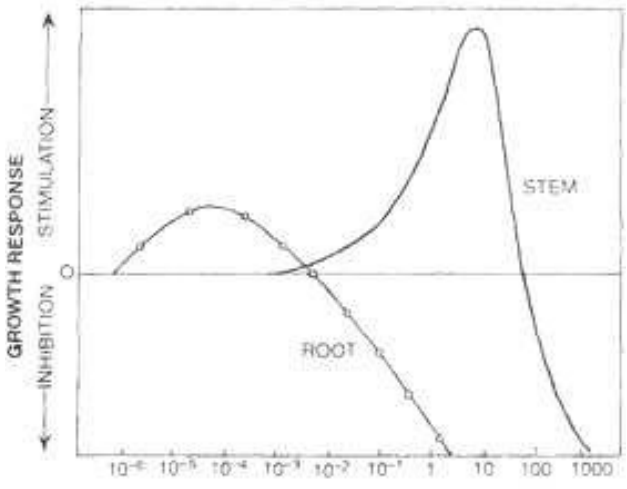
They were named as auxin a, auxin b, and hetero-auxin. Kogl (1934) found that hetero auxin is the real plant auxin and is chemically indole 3-acetic acid or IAA. It is also present in urine of human beings suffering from pellagra, a disease caused by deficiency of niacin (= nicotinic acid).



Some common auxins.

2. **Chemical Nature:** Indole 3-Acetic Acid is the universal natural auxin. It was discovered by Kogl (1934). Related chemicals are indole 3-acetaldehyde, indole 3-acetonitrile, indole 3-butyric acid (IBA), phenyl acetic acid and 4-chloro indole acetic acid. All of them have auxin like activity.

Auxin is synthesised in shoot apices, leaf primordia and developing seeds from amino acid tryptophan. A tryptophan independent pathway has also been discovered recently. Auxin passes from shoot tip to the region of elongation. Auxin movement is polar. It is basipetal in stem but acropetal in the root. Auxin helps in the elongation of both roots and shoots. However, the optimum for the two is quite different. It is 10 ppm for stem and 0.0001 ppm for the root. In higher concentration auxin inhibits growth.



Effect of auxin concentration on growth of root and stem.

The raw material which is used in synthesis of auxin is called auxin precursor. It is tryptophan for IAA. Certain compounds inhibit action of auxin. They are called anti-auxins, e.g., p-chlorophenoxy isobutyric acid (PCIB). TIBA (2, 3, 5 triiodobenzoic acid also acts as anti-auxin by blocking the transport of auxin. Active form of auxin is free auxin or auxin which can be extracted easily. Auxin which cannot be extracted easily except with the help of organic solvents is called bound auxin, e.g., IAA-aspartic acid, IBA-alanine, IAA-myoinositol, IAA-glucan, IAA-glycoprotein. Bound auxin is believed to be hormonally inactive (Hangarter and Good, 1981), being meant for storage and protection against degradation.

Synthetic Auxins:

Many synthetic auxins are also being manufactured. The important ones are 2: 4 D (2: 4-di chlorophenoxy acetic acid), 2 : 4 : 5-T (2 : 4 : 5-tri-chlorophenoxy acetic acid), IBA (indole 3- butyric acid), NAA (naphthalene acetic acid). MCPA (2-methyl 4- chloro-phenoxyacetic acid), Dicamba (2-methoxy 3-, 6-di-chlorobenzoic acid). IBA is both natural and synthetic. Synthetic auxins move in all directions inside plants.

3. Bioassay of Auxins:

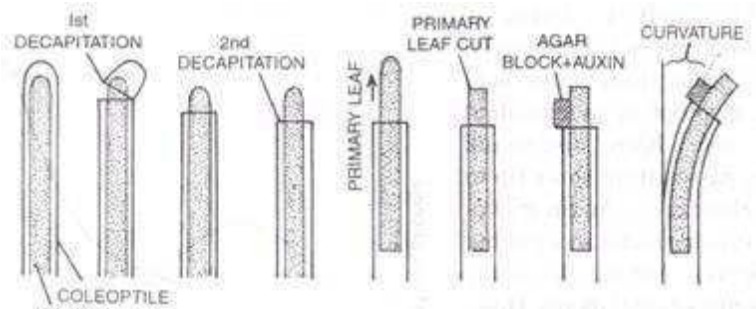
It is testing of a biological activity like growth response of a substance by employing a living material like plant or plant part. Auxin bioassay is quantitative test as it measures concentration of auxin to produce the effect and the amount of effect.

1. Avena Curvature Test :

The test is based upon experiments of Went (1928). 10° curvature is produced by auxin concentration of 150 µg/litre at 25° C and 90% relative humidity. The test can measure auxin upto 300 pg/litre.

Auxin from a shoot tip or any other plant organ is allowed to diffuse in a standard size agar block (generally 2 x 2 x 1 mm). Auxin can also be dissolved directly in agar. 15-30 mm long oat coleoptile grown in dark is held vertically over water. 1 mm tip of coleoptile is removed without injuring the primary leaf.

After 3 hours a second decapitation is carried out for a distance of 4 mm. Primary leaf is now pulled loose and agar block supported against it at the tip of decapitated coleoptile. After 90-110 minutes, the coleoptile is found to have bent. The curvature is measured. It can also be photographed and the curvature known from shadow graph.



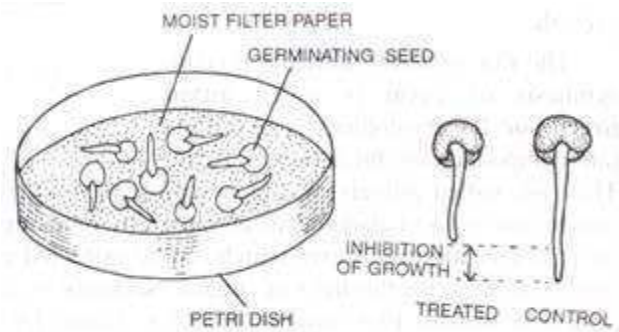
Method of Avena Curvature Test.

2. Root Growth Inhibition:

Sterilized seeds of Cress are allowed to germinate on moist filter paper. As the roots reach a length of 1 cm or so, root lengths are measured. 50% of the seedlings are placed in a test solution while the remaining are allowed to grow over moist paper.

Lengths of the roots are measured after 48 hours. It is seen that the seedlings placed in test solution

show very little root growth while root growth is normal in control seedlings.



Root growth inhibition bioassay of auxin.

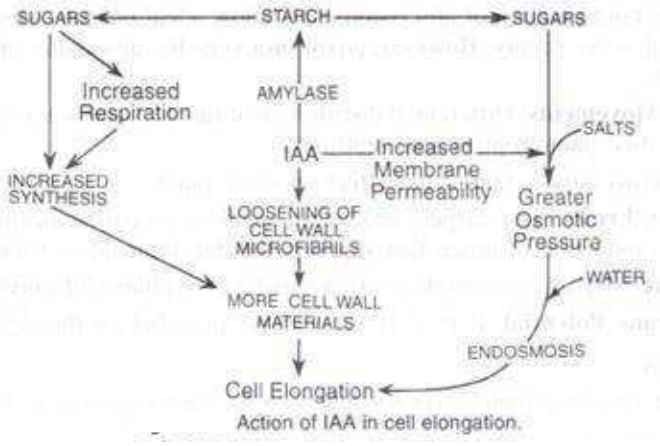
4. Physiological role of Auxins:

1. Respiration: Auxins stimulate respiration most probably by increasing availability of respiratory substrate.

2. Metabolism: Application of auxin has been found to enhance metabolism due to mobilization of plant resources.

3. Solutes: Auxins increase storage of solutes inside the cells.

4. Cell Enlargement : It is the most fundamental activity of auxins. Cell enlargement is caused by solubilisation of carbohydrates, loosening of wall micro-fibrils, synthesis of more wall materials, increased membrane permeability and respiration.



Action of IAA in cell elongation.

5. Cambial Activity: Degree of cambial activity is directly proportional to auxin concentration.

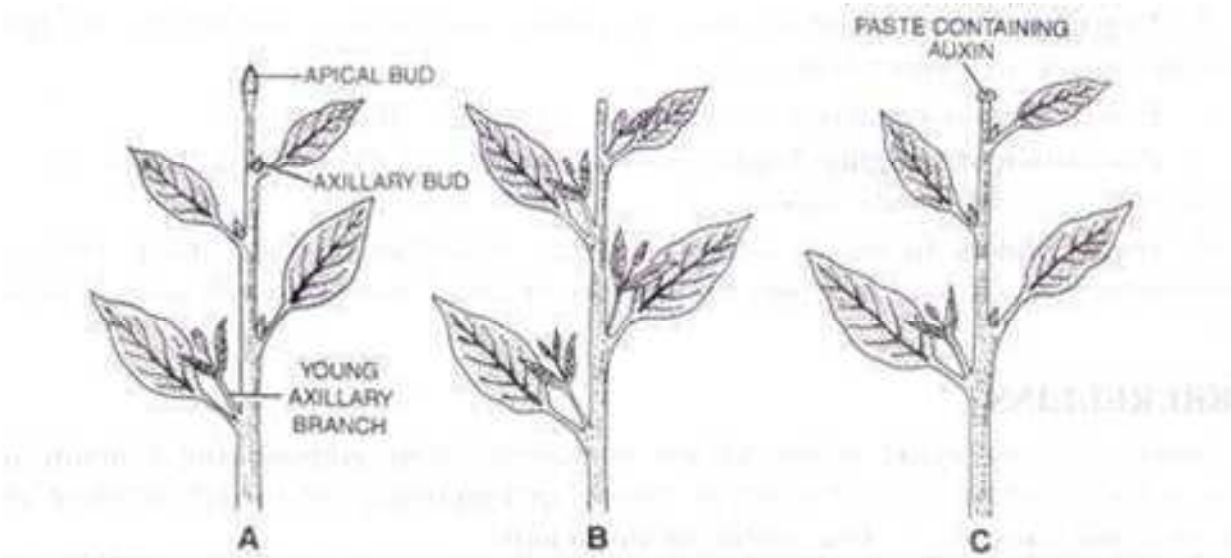
Auxin also controls xylem differentiation.

6. Cell Division: Auxin is known to promote division in the cells of vascular cambium.

7. Tissue Culture: In tissue culture, the development of callus or mass of undifferentiated cells is promoted by auxin. Differentiation of callus occurs in the presence of both auxin and cytokinin.

8. Root Formation: Auxin promotes root initiation at concentration which is inhibitory for growth of intact root.

9. Apical Dominance (Fig.): Apical dominance is the phenomenon by which presence of apical bud does not allow the nearby lateral buds to grow. When the apical bud is removed, the lateral buds sprout. This produces dense bushy growth. The phenomenon is widely used in tea plucking and hedge making. Apical bud inhibits the growth of lateral buds by releasing auxins. It is confirmed by painting the cut end of decapitated shoot by a paste of auxin. The lateral buds remain inhibited, as if the apical bud is present.



Apical dominance and auxin. A, apical bud intact. B, removal of apical bud and loss of dominance. C, auxin applied over cut end inhibits lateral bud growths as in apical dominance.

10. Inhibition of Abscission: Auxin delays abscission of young leaves and fruits. Its effect is through non-formation of abscission zone below a leaf or fruit. Abscission zone cuts off nutrients and water supply. However, auxin promotes the abscission of mature or older leaves and fruits.

11. Tropic Movements: Differential distribution of in-dole 3-acetic acid produces tropical plant responses like phototropism and geotropism.

12. **Sex:** Auxins have a feminizing effect on some plants.
13. **Seedless Fruits:** The carpels producing seedless or parthenocarpic fruits have a higher internal production of auxin that supports the development of fruits, e.g., Banana.
14. **Ethylene:** Higher concentration of IAA induces synthesis of ethylene.
15. **Membrane Potential:** It produces a negative potential on the cell membrane.

5. Uses of Auxins:

1. **Rooting:** Auxins stimulate root formation on the stem cutting, e.g., IBA, IBA-alanine, NAA.
2. **Parthenocarpy:** Application of auxins (e.g., IAA, IBA) and conjugate auxins (e.g., IBA-alanine) to un-pollinated pistils make them develop into seedless fruits or parthenocarps which carry a better market price than the normal fruits having seeds.
3. **Weedicides (= Herbicides):** They are chemicals which kill weeds growing in the fields. Application of 2: 4-D and 2:4: 5-T removes broad leaved weeds in cereal crops and lawns because they do not affect mature monocotyledons while Dalapon (2-2 di-chloropropionic acid) kills grasses in broad leaved crops. Weedicides should be used very carefully and only occasionally as they have wide spectrum and long lasting action. Thus weedicides or defoliants used in Vietnam have exterminated the wild relatives of Citrus.
4. **Flowering:** NAA and 2, 4-D are often employed for inducing flowering in Litchi and Pineapple.
5. **Storage:** Methyl ester of NAA prevents the sprouting of Potato tubers kept in storage.
6. **Pre-Harvest Fruit Drop:**
   In low concentration 2, 4-D is useful in preventing pre-harvest fruit drop of Orange and Apple. NAA is similarly useful for checking fruit drop of Tomato.
7. **Vegetable Crops:** Chlorophenoxy propionic acid enhances the quality of vegetable crops by preventing flower formation.
8. **Fruits:** Auxins enhance sweetening of fruits, e.g., IBA.
9. **Prevention of Lodging:** Naphthalene acetamide (NAAM) prevents lodging or falling of crop plants during windy season.
10. **Dwarf Shoots:** In Apple, flowers and fruits are formed on dwarf shoots. Application of naphthalene acetic acid increases the number of dwarf shoots as well as the number of fruits.

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