Auxin

Auxins are a class of plant growth substance (often called phytohormone or plant hormone). Auxins play an essential role in coordination of many growth and behavioral processes in the plant life cycle, they and the behavior they played in plant growth was first revealed by a Dutch scientist named Fritz Went (1903-1990).

Auxins derive their name from the Greek word ("auxano" -- "I grow"). They were the first of the major plant hormones to be discovered and are a major coordinating signal in plant development. Their pattern of active transport through the plant is complex. They typically act in concert with (or opposition to) other plant hormones.

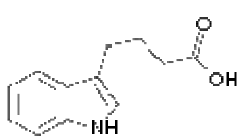
For example, the ratio of auxin to cytokinin in certain plant tissues determines initiation of root versus shoot buds. Thus a plant can (as a whole) react on external conditions and adjust to them, without requiring a nervous system. On a molecular level, auxins have an aromatic ring and a carboxylic acid group (Taiz and Zeiger, 1998).

The most important member of the auxin family is **indole-3-acetic acid** (IAA). It generates the majority of auxin effects in intact plants, and is the most potent native auxin. However, molecules of IAA are chemically labile in aqueous solution, so IAA is not used commercially as a plant growth regulator.

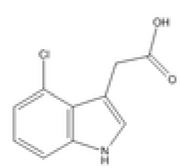
- *Naturally-occurring auxins* include 4-chloro-indoleacetic acid, phenylacetic acid (PAA) and indole-3-butyric acid (IBA).

- *Synthetic auxin analogs* include 1-naphthaleneacetic acid (NAA), 2,4-dichlorophenoxyacetic acid (2,4-D), and others.

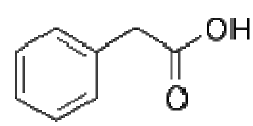
Gallery of native auxins



Indole-3-butyric acid (IBA)

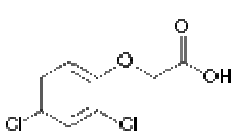


indole-3-acetic acid (IAA)

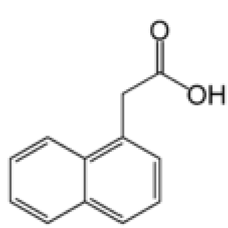


2-phenylacetic acid (PAA)

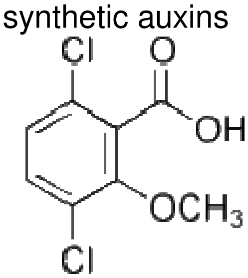
Gallery of synthetic auxins



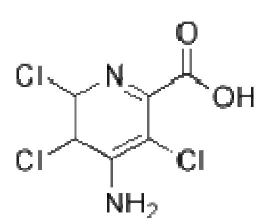
2,4-Dichlorophenoxyacetic acid (2,4-D)



α-Naphthalene acetic acid (α-NAA)



2-Methoxy-3,6-dichlorobenzoic acid (dicamba)

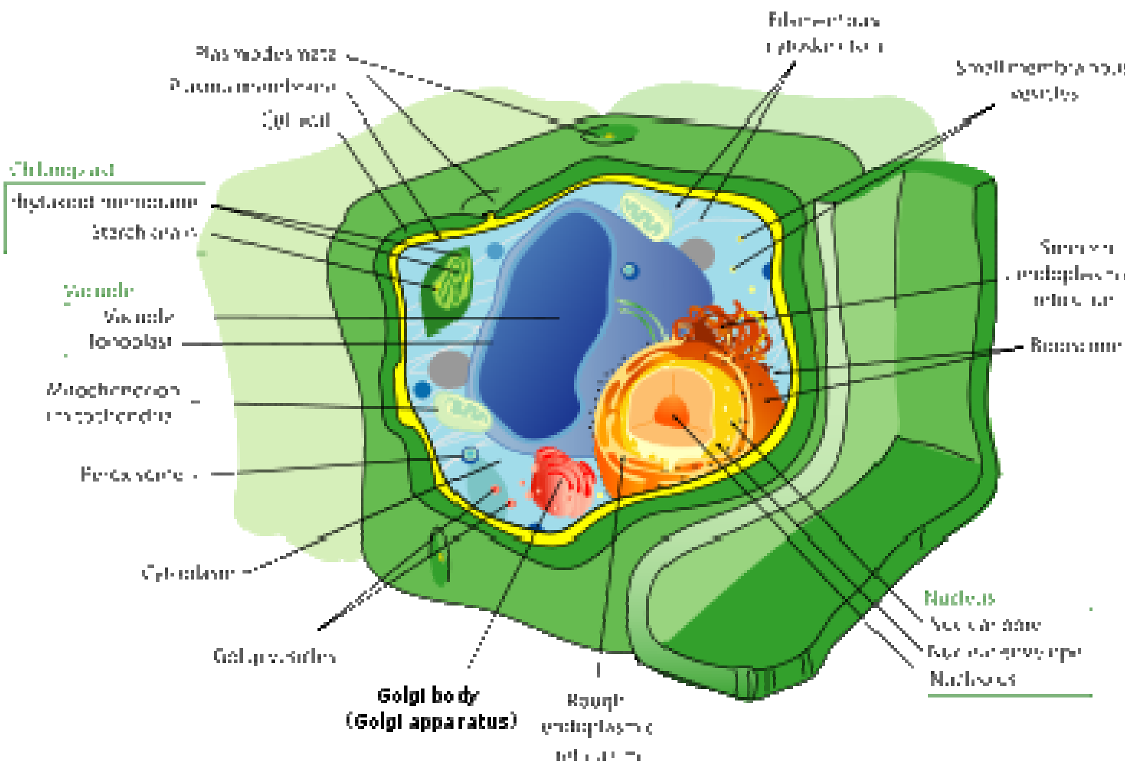


4-Amino-3,5,6-trichloropicolinic acid (tordon or picloram)

Auxins are often used to promote initiation of adventitious roots and are the active ingredient of the commercial preparations used in horticulture to root stem cuttings. They can also be used to promote uniform flowering, to promote fruit set, and to prevent premature fruit drop.

Used in high doses, auxin stimulates the production of ethylene. Excess ethylene can inhibit elongation growth, cause leaves to fall (leaf abscission), and even kill the plant. Some synthetic auxins such as 2,4-D and 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) have been used as herbicides. Broad-leaf plants (dicots) such as dandelions are much more susceptible to auxins than narrow-leaf plants (monocots) like grass and cereal crops.

Hormonal activity: Auxins coordinate development at all levels in plants, from the cellular level to organs and ultimately the whole plant.



The plant cell wall is made up of cellulose, protein, and, in many cases, lignin. It is very firm and prevents any sudden expansion of cell volume and without contribution of auxins any expansion at all.
On the cellular level, auxin is essential for cell growth, affecting both cell division and cellular expansion. Depending on the specific tissue, auxin may promote axial elongation (as in shoots), lateral expansion (as in root swelling), or isodiametric expansion (as in fruit growth). In some cases (coleoptile growth) auxin-promoted cellular expansion occurs in the absence of cell division. In other cases, auxin-promoted cell division and cell expansion may be closely sequenced within the same tissue (root initiation, fruit growth). In a living plant it appears that auxins and other plant hormones nearly always interact to determine patterns of plant development.

Organ patterns: Growth and division of plant cells together result in growth of tissue, and specific tissue growth contributes to the development of plant organs. Growth of cells contributes to the plant's size, but uneven localized growth produces bending, turning and directionalization of organs- for example, stems turning toward light sources (phototropism), roots growing in response to gravity (gravitropism), and other tropisms.

Organization of the plant: As auxins contribute to organ shaping, they are also fundamentally required for proper development of the plant itself. Without hormonal regulation and organization, plants would be merely proliferating heaps of similar cells. Auxin employment begins in the embryo of the plant, where directional distribution of auxin ushers in subsequent growth and development of primary growth poles, then forms buds of future organs. Throughout the plant's life, auxin helps the plant maintain the polarity of growth and recognize where it has its branches (or any organ) connected.

An important principle of plant organization based upon auxin distribution is **apical dominance**, which means that the auxin produced by the apical bud (or growing tip) diffuses downwards and inhibits the development of ulterior lateral bud growth, which would otherwise compete with the apical tip for light and nutrients. Removing the apical tip and its suppressive hormone allows the lower dormant lateral buds to develop, and the buds between the leaf stalk and stem produce new shoots which compete to become the lead growth. This behavior is used in pruning by horticulturists.

Uneven distribution of auxin: To cause growth in the required domains, it is necessary that auxins be active preferentially in them. Auxins are not synthesized everywhere, but each cell retains the potential ability to do so, and only under specific conditions will auxin synthesis be activated. For that purpose, not only do auxins have to be translocated toward those sites where they are needed but there has to be an established mechanism to detect those sites. Translocation is driven throughout the plant body primarily from peaks of shoots to peaks of roots. For long distances, relocation occurs via the stream of fluid in phloem vessels, but, for short-distance transport, a unique system of coordinated polar transport directly from cell to cell is exploited. This process of polar auxin transport is directional and very strictly regulated. It is based in uneven distribution of auxin efflux carriers on the plasma membrane, which send auxins in the proper direction.

The plant hormone stimulates cell elongation. It stimulates the Wall Loosening Factors, for example, elastins, to loosen the cell walls. If gibberellins are also present, the effect is stronger. It also stimulates cell division if cytokinins are present. When auxin and cytokinin are applied to callus, rooting can be generated if the auxin concentration is higher than cytokinin concentration while xylem tissues can be generated when the auxin concentration is equal to the cytokinins.

It participates in phototropism, geotropism, hydrotropism and other developmental changes. The uneven distribution of auxin, due to environmental cues (for example, unidirectional light and gravity force), results in uneven plant tissue growth.

It also induces sugar and mineral accumulation at the site of application.

Wounding response: It induces formation and organization of phloem and xylem. When the plant is wounded, the auxin may induce the Cell differentiation and regeneration of the vascular tissues.

Root growth and development: Auxin induces new root formation by breaking root apical dominance induced by cytokinins. In horticulture, auxins, especially NAA and IBA, are commonly applied to stimulate root growth when taking cuttings of plants. However, high concentrations of auxin inhibit root elongation and instead enhance adventitious root formation. Removal of the root tip can lead to inhibition of secondary root formation.

Apical dominance: It induces shoot apical dominance; the axillary buds are inhibited by auxin. When the apex of the plant is removed, the inhibitory effect is removed and the growth of lateral buds is enhanced as a high concentration of auxin directly stimulates ethylene synthesis in lateral buds causes inhibition of its growth and potentiation of apical dominance.

Ethylene biosynthesis: In low concentrations, auxin can inhibit ethylene formation and transport of precursor in plants; however, high concentrations of auxin can induce the synthesis of ethylene. Therefore, the high concentration can induce femaleness of flowers in some species.

It inhibits abscission prior to formation of abscission layer and thus inhibits senescence of leaves.

Fruit growth: Auxin delays fruit senescence.

It is required for fruit growth. When seeds are removed from strawberries, fruit growth is stopped; exogenous auxin stimulates the growth in seed removed fruits. For fruit with unfertilized seeds, exogenous auxin results in parthenocarpy ("virgin-fruit" growth).

Flowering: Auxin plays a minor role in the initiation of flowering. It can delay the senescence of flowers in low concentrations.

Herbicide manufacture: The defoliant Agent Orange was a mix of 2,4-D and 2,4,5-T. The compound 2,4-D is still in use and is thought to be safe, but 2,4,5-T was more or less banned by the EPA in 1979.

The dioxin TCDD is an unavoidable contaminant produced in the manufacture of 2,4,5-T. As a result of the integral dioxin contamination, 2,4,5-T has been implicated in leukaemia, miscarriages, birth defects, liver damage, and other diseases.