



### Syllabus page 37, sub-unit 3.5.2

Regulatory system: definition of a “growth regulator”, transport through the vascular system, combined effect, growth promoter and growth inhibitor.  
Use of plant regulators: any two examples.

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Regulatory system

Definition of growth regulator, transport through the vascular system. Different combinations of regulators bring about different effects.

Some regulators promote growth e.g. auxins.

Others inhibit growth e.g. ethene and abscisic acid.

## Introduction

The growth of plants seems somehow so natural that we seldom think much about it. Roots grow down, shoots grow up, a leaf over there, a branch here, and there's our tomato plant. If plant growth really was haphazard we might get a clump of cells instead of the leafy plant with which we are familiar. In fact, if tissue is isolated from a tobacco plant and placed in a sterile medium that supplies basic minerals, vitamins, carbohydrates, proteins, and lipids, the tissue will grow to produce a clump of cells or callus.

Obviously there must be something within the plant's system that initiates growth, directs tissue differentiation, and stops growth. In attempting to understand plant growth, botanists have discovered a group of substances collectively called plant growth regulators.

### A word about terminology:

Chemical coordination in animals is controlled by **hormones**. Hormones work at very low concentrations at *sites some distance from where they are made*.

Plants are coordinated by chemicals *that do not necessarily move from their sites of synthesis* and hence, by definition, should not always be termed hormones. In view of this, and because their effects are usually on some aspect of growth, they are called **plant growth regulators**. The precise mechanisms of action of plant growth regulators are not yet clear and they probably do not work in the same way as animal hormones.

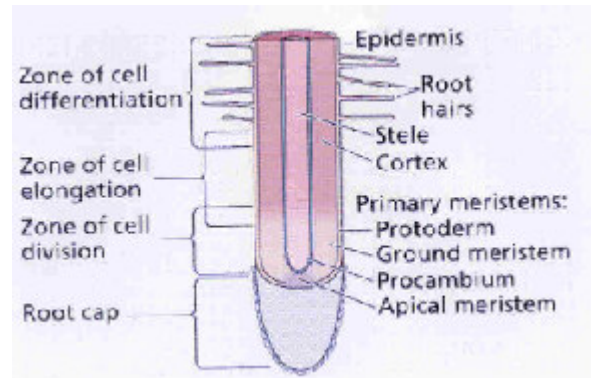
There are at least 5 known groups of plant growth regulators:

- auxins
- cytokinins
- gibberellins
- abscisic acid
- ethylene.

The first 3 generally act as growth promoters, and abscisic acid inhibits growth. Unlike the rest of the plant hormone compounds, ethylene is gaseous. It is usually associated with fruit ripening.

## Production sites

Growth regulators are produced in the plant in the meristematic regions of the root and shoot (apical meristems).



## Transport

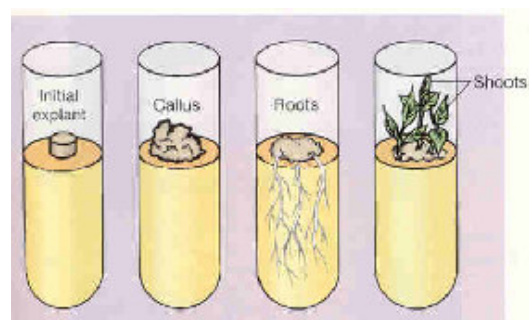
Growth regulators may travel by diffusion from cell to cell but are transported distances by the vascular system through the phloem or in the case of cytokinins, through the xylem.

## Combined effect of growth regulators

Studies of individual growth substances have shown that they generally work by interacting with one another (combined effect), rather than each controlling its own specific aspect of growth.

Two kinds of interaction occur. In one, two or more substances supplement each other's activities. It is often found that their combined effect is much greater than the sum of their separate effects e.g. gibberellins promote cell enlargement in the presence of auxins. This is called **synergism** and the substances are said to be **synergistic**. In the other, two substances have opposite effects on the same process, one promoting and the other inhibiting e.g. cytokinins inhibit auxins. This is called **antagonism** and the substances are said to be **antagonistic**. Here the balance between the substances determines the response.

Below shows the response of tobacco tissue to an auxin and a cytokinin. A low rate of cytokinin to auxin triggers root growth. Whereas a low rate of auxin to cytokinin triggers shoot growth.



## Synthetic plant growth regulators

There are synthetic **plant growth regulators**, which are often based on the structure of the naturally occurring compounds but are more effective and less easily degraded by the plant and therefore tend to be used commercially.

## Uses of plant regulators

**Cytokinins**, unlike other plant growth regulators, are found in both plants and animals. They stimulate cell division and often are included in the sterile media used for growing plants from tissue culture. If a medium's mix of growth-regulating compounds is high in cytokinins and low in auxin, the tissue culture explant (small plant part) will produce numerous shoots. On the other hand, if the mix has a high ratio of auxin to cytokinin, the explant will produce more roots. Cytokinins also are used to delay aging and death (**senescence**). They are used to prolong the life of lettuce and cabbage.

**Ethylene** is unique as a growth substance in that it is found only in the gaseous form. It induces ripening, causes leaves to droop (**epinasty**) and drop (**abscission**), and promotes senescence. Plants often increase ethylene production in response to stress, and ethylene often is found in high concentrations within cells at the end of a plant's life. The increased ethylene in leaf tissue in the fall is part of the reason leaves fall off trees. Ethylene also is used to ripen fruit (e.g., green bananas).

**Abscisic acid (ABA)** is a general plant-growth inhibitor. It induces dormancy and prevents seeds from germinating; causes abscission of leaves, fruits, and flowers; and causes stomata to close. High concentrations of ABA in guard cells during periods of drought stress probably play a role in stomatal closure.

**Auxin** causes several responses in plants:

- Bending toward a light source (phototropism)
- Downward root growth in response to gravity (geotropism)
- Promotion of **apical dominance**
- Flower formation
- Fruit set and growth
- Formation of adventitious roots

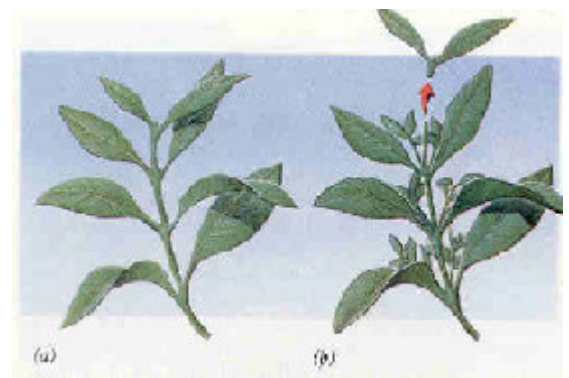
Auxin is the active ingredient in most rooting compounds in which cuttings are dipped during vegetative propagation.

Applied concentrations of these substances usually are measured in parts per million (ppm) and in some cases parts per billion (ppb). These growth-regulating substances most often are applied as a spray to foliage or as a liquid drench to soil around a plant's base. Generally, their effects are short lived, and they may need to be reapplied in order to achieve the desired effect.

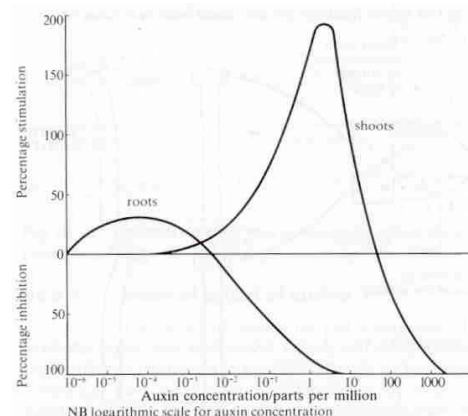


Honeysuckle cuttings treated with synthetic auxin. Many adventitious roots formed on cuttings placed in a higher concentration (*left*), whereas a few roots formed in a lower concentration (*middle*). Cuttings placed in water only (*right*) did not form any roots in the same time period.

Using the graph below, suggest an approximate concentration of auxin that could have been used for the seedlings that produced roots



Auxins inhibit the development of lateral buds. (a) When the tip of the plant (source of auxin) is intact, the lateral buds do not develop. (b) The tip of the plant has been removed. Because there are no auxins moving down from the stem, lateral buds develop into branches.



Effect of auxin concentration on growth responses of roots and shoots. Note that concentrations of auxin which stimulate shoot growth inhibit root growth.

### References

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[www.biozone.co.uk](http://www.biozone.co.uk)  
[http://www.carolina.com/life\\_science/plant\\_growth.asp](http://www.carolina.com/life_science/plant_growth.asp)