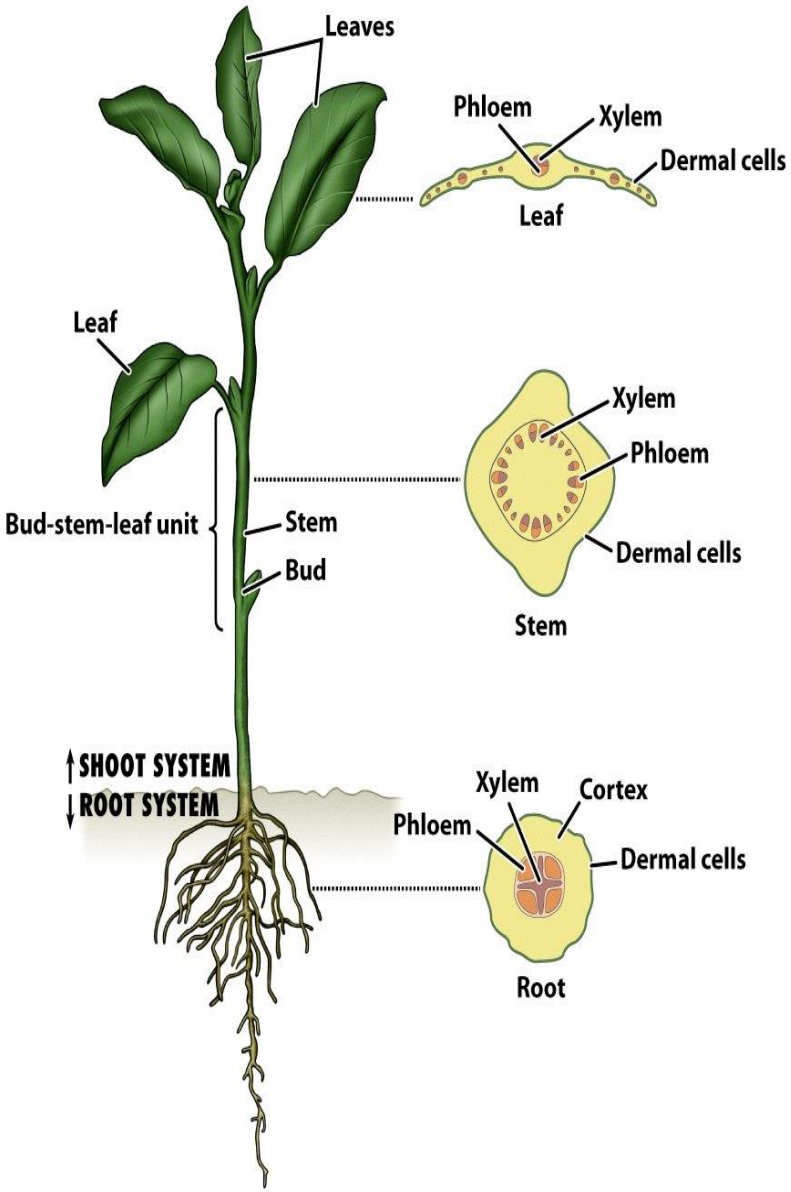
PLANT ORGANS - ROOTS

PLANT ORGANS

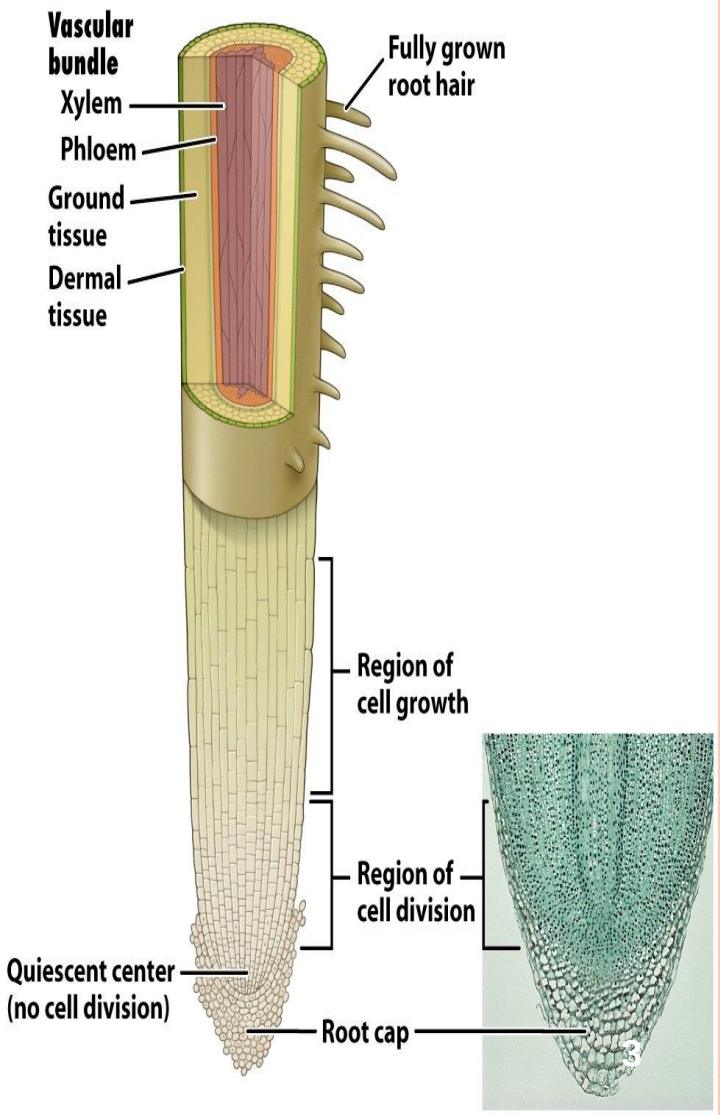
- Vegetative plant organs are **roots**, **stems**, and **leaves**. The reproductive organs are variable and in flowering plants, they are represented by the **flower**, **seed** and **fruit**.



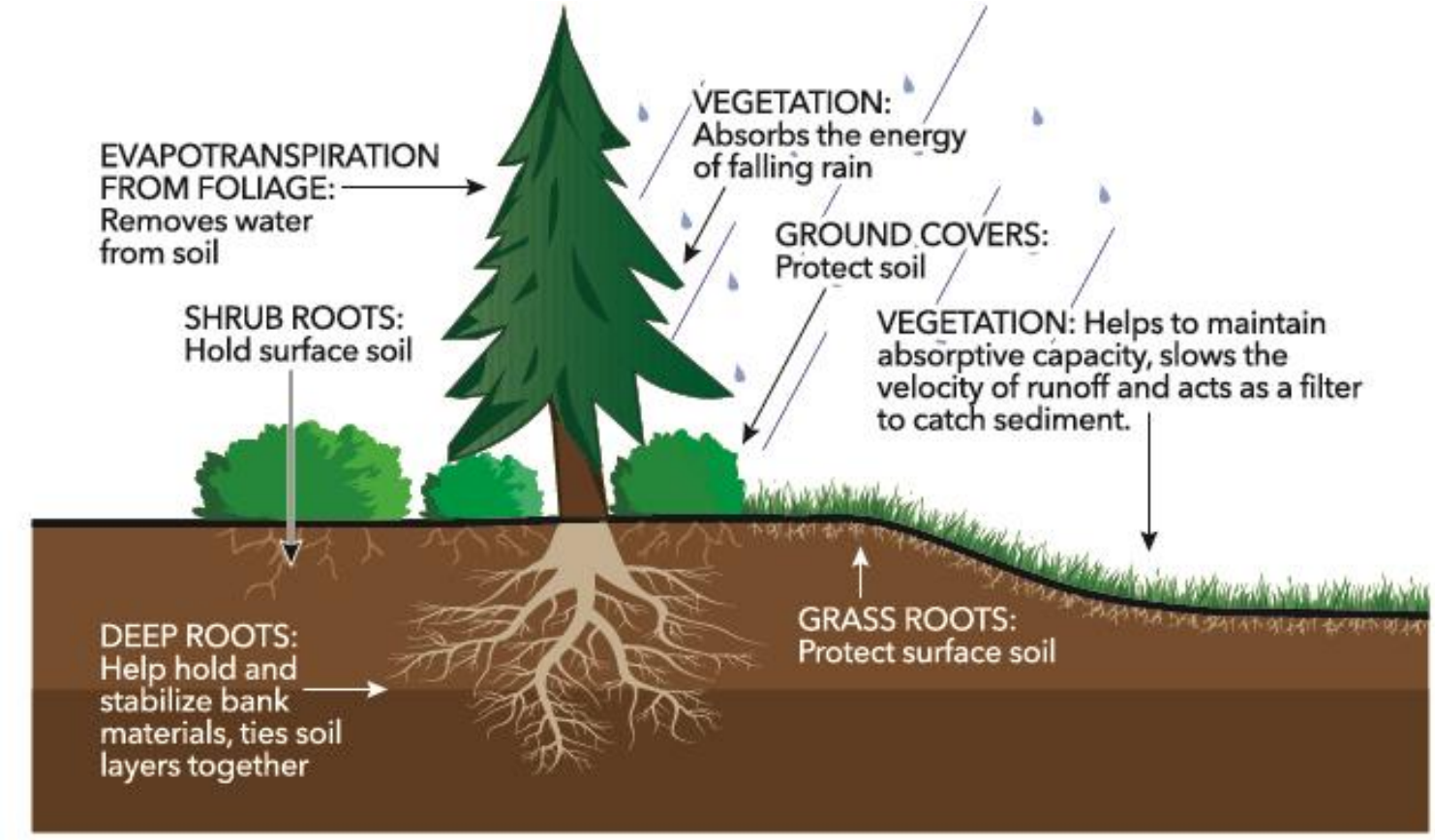
1. THE ROOT SYSTEM

- **Roots anchor the plant in the soil,** **absorb water and nutrients and store excess food for future needs.** Roots anchor the plant in one of two ways or sometimes by a combination of the two.

- The first is to occupy a large volume of shallow soil around the plants **base with a fibrous (diffuse) root system, one** **consisting of many thin, profusely branched roots.**



- Since they grow relatively close to the soil surface, they **effectively control soil erosion.** Fibrous roots capture water as it begins to percolate into the ground and must draw their mineral supplies from the surface soil before the nutrients are leached to lower levels.



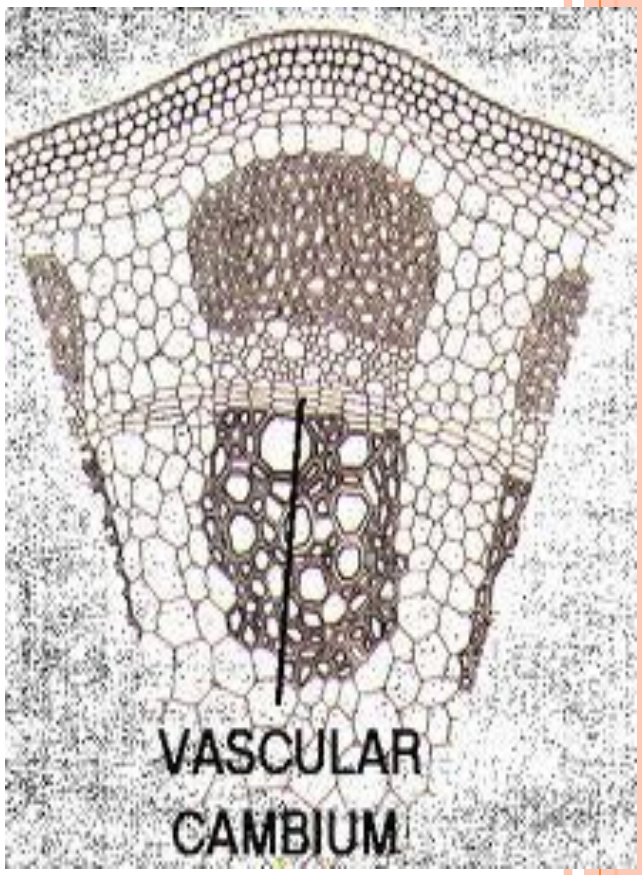
EFFECTS OF VEGETATION IN MINIMIZING EROSION

- When dissected, the arrangement of the cells in a root is **root hair, epidermis, periblem, cortex, endodermis, pericycle** and, **lastly, the vascular tissue in the centre of a root to transport the water absorbed by the root to other places of the plant.**

- Growth from apical meristems is known as **primary growth**, which encompasses **all elongation.**

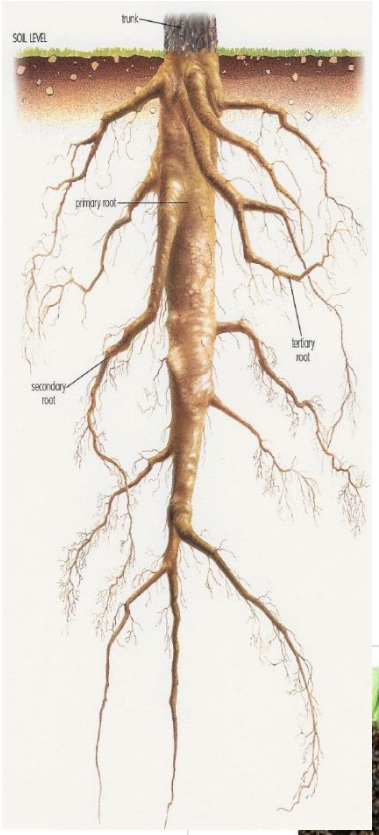
- **Secondary growth** encompasses **all growth in diameter**, a major component of woody plant tissues and many non-woody plants. For example, storage roots of sweet potato have secondary growth but are not woody. **Secondary growth occurs at the lateral meristems, namely the vascular cambium and cork cambium. The former forms secondary xylem and secondary phloem, while the latter forms the periderm.**

- In plants with **secondary growth, the vascular cambium, originating between the xylem and the phloem,** forms a **cylinder of tissue along the stem and root. The vascular cambium forms new cells on both the inside and outside of the cambium cylinder,** with those on the inside forming secondary xylem cells, and those on the outside forming secondary phloem cells. As secondary xylem accumulates, the "girth" **(lateral dimensions)** of the stem and root increases. As a result, tissues beyond the secondary phloem (including the epidermis and cortex, in many cases) tend to be pushed outward and are eventually "sloughed off" (shed).

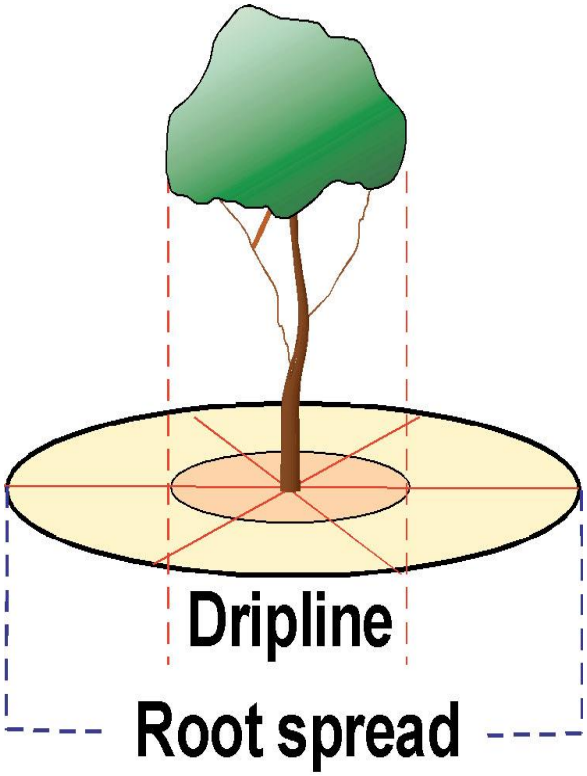


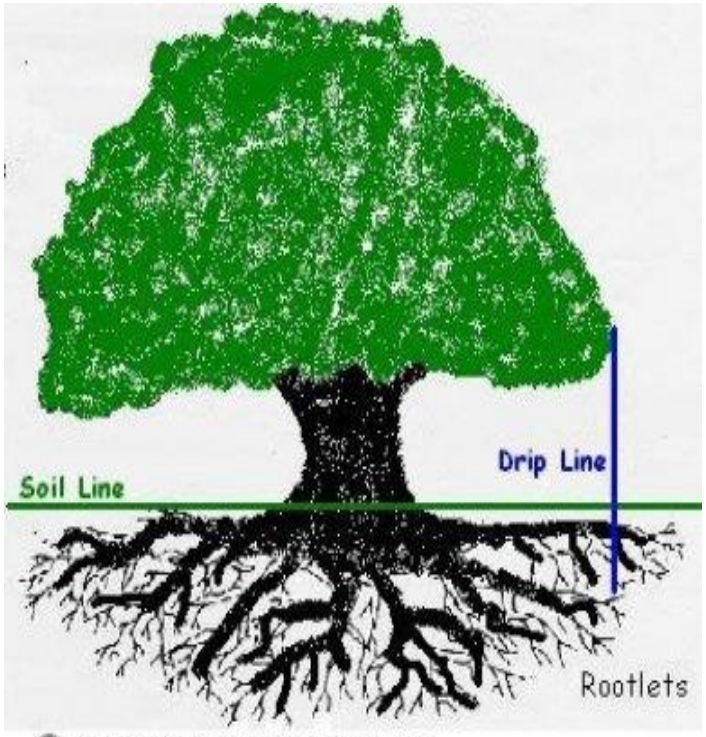
- The **cork cambium** begins to form the **periderm**, consisting of protective cork cells containing **suberin**. In roots, the **cork cambium originates in the pericycle**, **a component of the vascular cylinder.**
- The pericycle is a cylinder of **parenchyma or sclerenchyma cells that lies just inside the endodermis** and is the outer most part of the stele of plants.

- The vascular cambium produces new layers of secondary xylem annually. The xylem vessels are dead at maturity but are responsible for most water transport through the vascular tissue in stems and roots.
- **A tap root system sends one or two rapidly growing, sparsely branched roots straight down into the soil to draw from deep water tables and mineral supplies.**

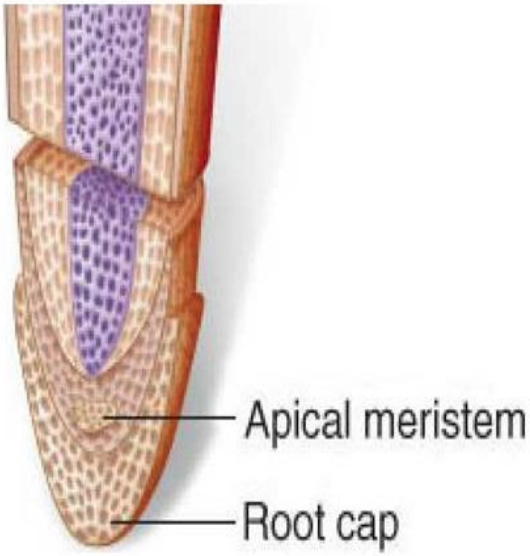


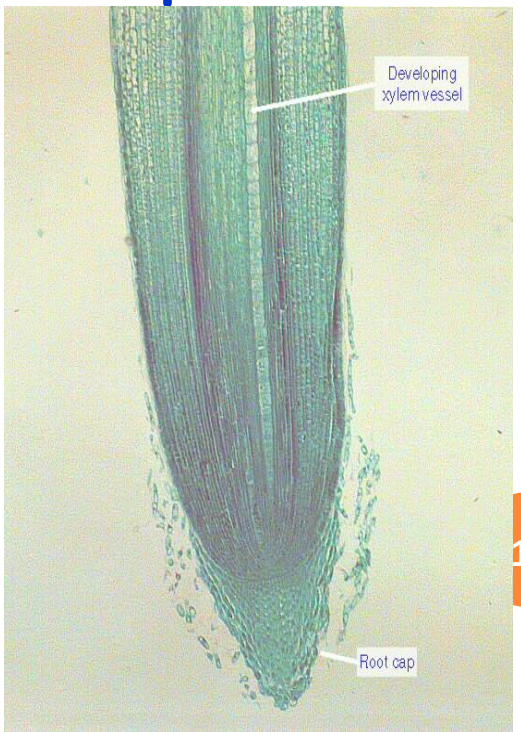
- Trees distribute their roots in a wide circle where water absorbing root tips occupy a "drip zone", an area beyond the leaf canopy where rain is channelled from the foliage above. **Because the main purpose of roots is to probe the soil for water and minerals at a distance from the plant, primary growth is their most important growth process.**





- Most new cells produced are laid down behind the growing tip. There, they augment the length of the root and when the cells elongate, the root tip pushes its way through the soil with considerable force. To protect the tip, **the root produces cells ahead of itself forming a root cap (these are sacrificed to protect the meristem).**

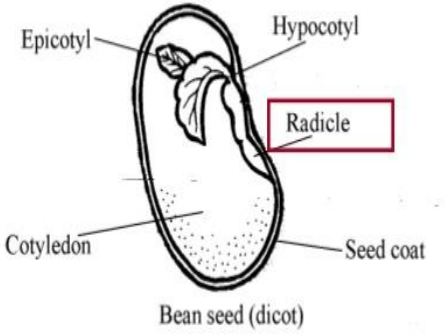




- Root cap cells are readily rubbed off, but are quickly replaced from within, much like our skin when it dries and peels off from the surface. When root cap cells are ruptured by sharp soil particles, their protoplasm forms a slimy coat lubricating the root tip as it works its way through the soil and around large objects. The first root that comes from a plant is called the **radicle.**

The Radicle

- The part of the seed where the root develops.

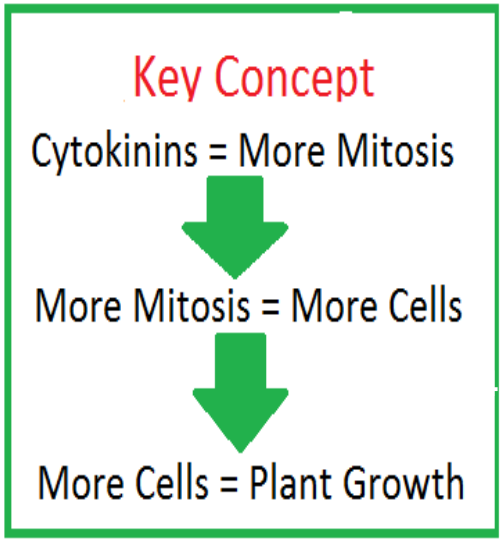


Bean seed (dicot)

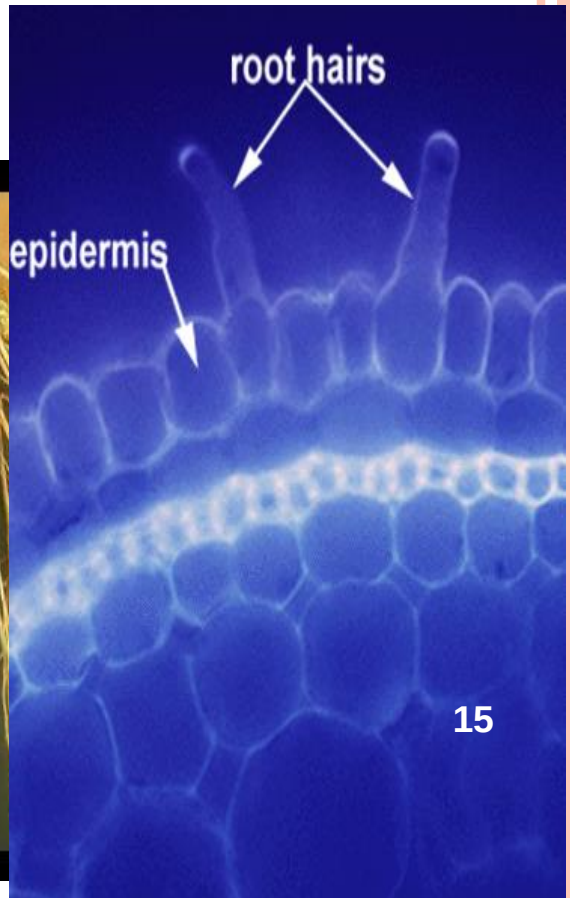
Six major functions of roots are:

- absorption of water and inorganic nutrients,
- anchoring of the plant body to the ground, and supporting it,
- storage of food and nutrients,
- vegetative reproduction,
- hormone synthesis,
- gas exchange.

- In response to the concentration of nutrients, roots also synthesise **cytokinin,** which acts as a signal as to how fast the shoots can grow. **Roots often function in storage of food and nutrients.** The roots of most vascular plant species enter into **symbiosis with certain fungi to form mycorrhizae**, and **a large range of other organisms including bacteria** also closely associate with roots.



Water absorption takes place a short distance back in an area where a fuzzy band appears around the root. This band is formed by thousands of projecting root hairs. Root hairs are extensions of the outer root cells and increase, several hundred fold, the organs absorptive surface area. The width of the root hair zone remains constant.

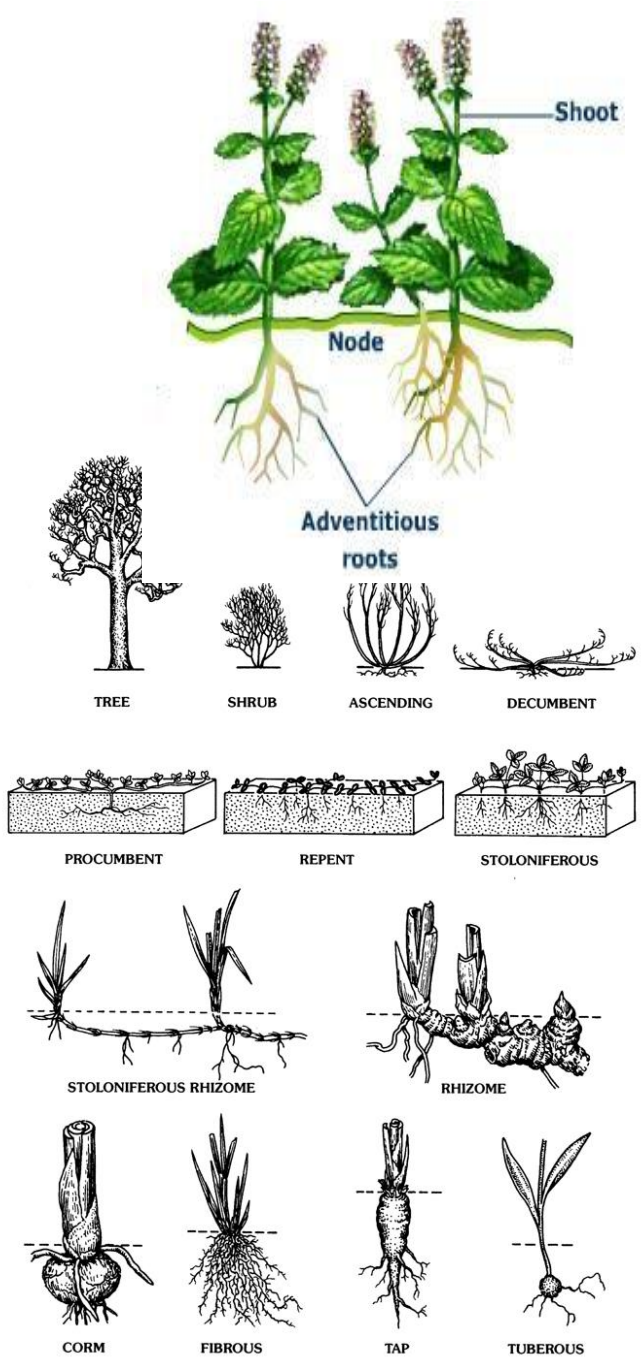


- During continued root growth, new hairs form just above the growing tip, while old ones, at the top of the group, shrivel and die. Branching begins in the slightly older root sections, some distance from the tip. Branch roots originate deep inside the parent root and tend to grow at right angles to it, better to explore other regions of soil around the plant. Each branch is an exact duplicate of the root that produced it, with the same methods of growth, a set of root hairs and the capacity to form branches of its own.

SPECIALIZED ROOTS:

The roots, or parts of roots, of many **plant species have become specialized to serve adaptive purposes**.

Adventitious roots arise out-of-sequence from the more usual root formation of branches of a primary root, and instead originate from the stem, branches, leaves, or old woody roots. **They commonly occur in monocots and pteridophytes**, but also in many dicots, such as clover (*Trifolium*), ivy (*Hedera*), strawberry (*Fragaria*) and willow (*Salix*). Most aerial roots and stilt roots are adventitious. In some conifers adventitious roots can form the largest part of the root system.

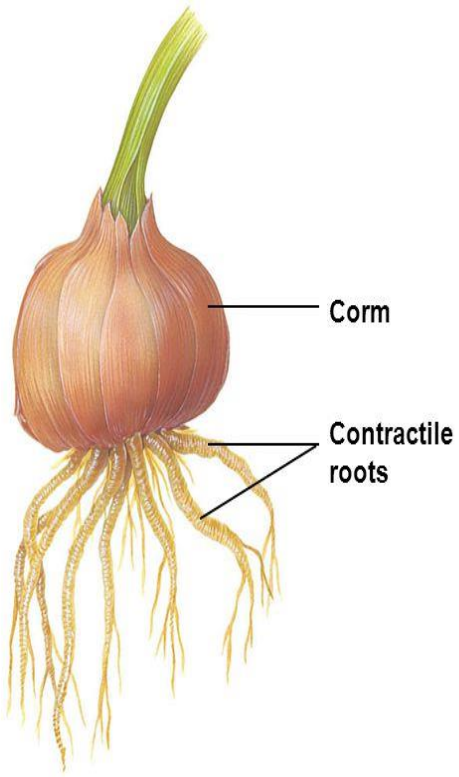


as published in Swink, F. and G. Wilhelm. 1994. *Plants of the Chicago region.* 4th ed. Indianapolis: Indiana Academy of Science.

- **Aerating roots:** roots rising above the ground, especially above water such as in some mangrove genera (*Avicennia*, *Sonneratia*). In some plants like *Avicennia* the erect roots have a large number of breathing pores for exchange of gases.

- **Aerial roots: roots entirely above the ground, such as in ivy (*Hedera*) or in epiphytic orchids.** Many aerial roots, are used to receive water and nutrient intake directly from the air. In some Epiphytes - plants living above the surface on other plants- aerial roots serve for reaching to water sources or reaching the surface, and then functioning as regular surface roots.

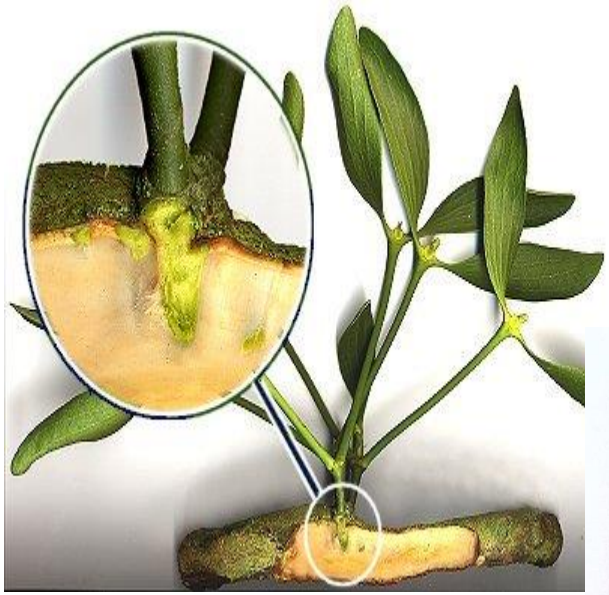
- **Contractile roots:** they pull bulbs or corms of monocots, such as hyacinth and lily, and some taproots, deeper in the soil through expanding radially and contracting longitudinally. They have a wrinkled surface.

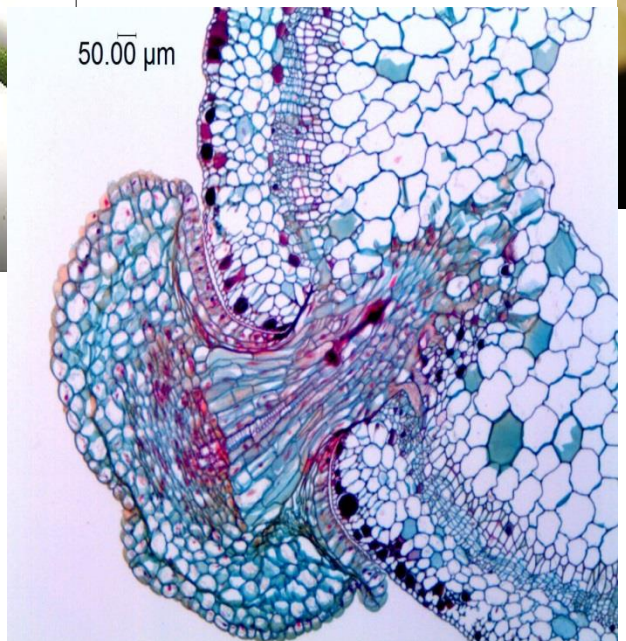


- **Coarse roots:** Roots that have undergone secondary thickening and have a woody structure. These roots have some ability to absorb water and nutrients, but their main function is transport and to provide a structure to connect the smaller diameter, fine roots to the rest of the plant.

- **Fine roots:** Primary roots usually less than 2 mm diameter that have the function of water and nutrient uptake. They are often heavily branched and support mycorrhizas. These roots may be short lived, but are replaced by the plant in an ongoing process of root 'turnover'.

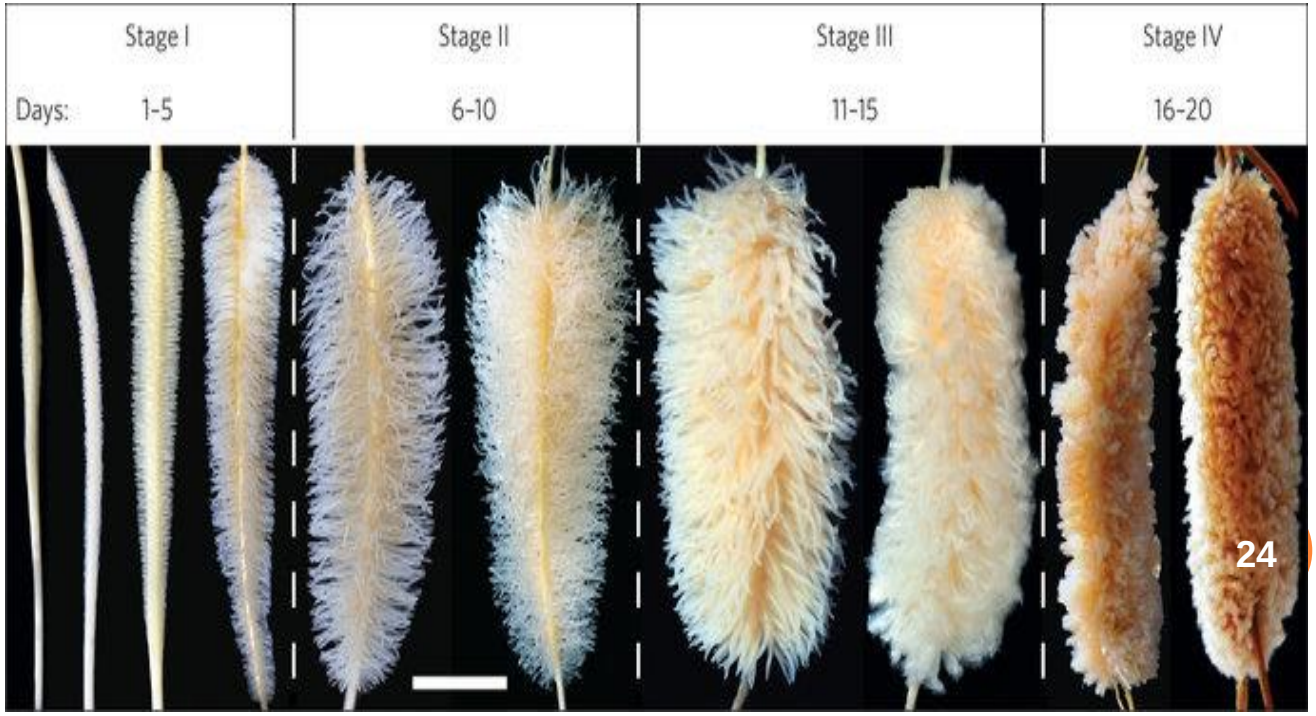
- **Haustorial roots:** roots of parasitic plants that can absorb water and nutrients from another plant, such as in mistletoe (*Viscum album*) and dodder.





- **Propagative roots:** roots that form adventitious buds that develop into aboveground shoots, termed suckers, which form new plants, as in Canada thistle, cherry and many others.

- **Proteoid roots or cluster roots:** dense clusters of rootlets of limited growth that develop under low phosphate or low iron conditions in Proteaceae and some plants from the following families Betulaceae, Casuarinaceae, Elaeagnaceae, Moraceae, Fabaceae and Myricaceae.



- **Stilt roots:** these are adventitious support roots, common among mangroves. They grow down from lateral branches, branching in the soil.

- **Storage roots:** these roots are modified for storage of food or water, such as carrots and beets. They include some taproots and tuberous roots.

- **Structural roots:** large roots that have undergone considerable secondary thickening and provide mechanical support to woody plants and trees.

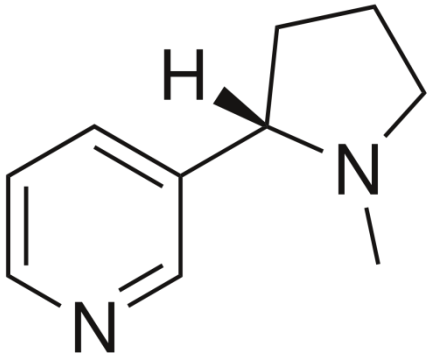
- **Surface roots:** These proliferate close below the soil surface, exploiting water and easily available nutrients. Where conditions are close to optimum in the surface layers of soil, the growth of surface roots is encouraged and they commonly become the dominant roots.

- **Tuberous roots:** A portion of a root swells for food or water storage, e.g. sweet potato.

- Roots are the places in which secondary metabolites and hormones are produced in plants. For example:

- They produce gibberellins and cytokinins. These hormones are transferred to shoots with the help of xylem and stimulate plant growth and development.

- An alkaloid, nicotine is produced in the roots of *Nicotiana tabacum (tobacco)* plant and then carried to the leaves. Nicotine accumulated in the leaves serves as a toxin against herbivores that result in nervous system disorders. It is also an insecticide.



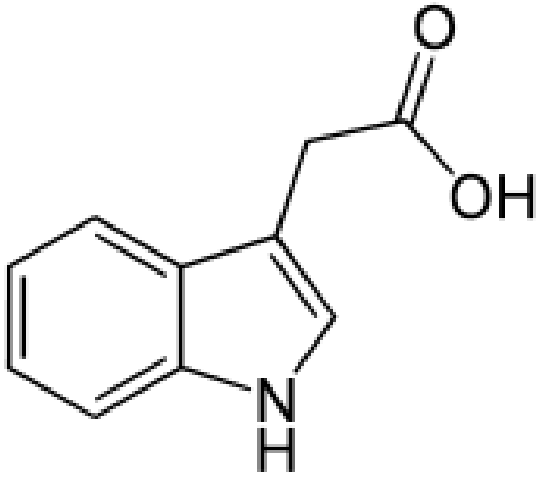
Plant Hormones

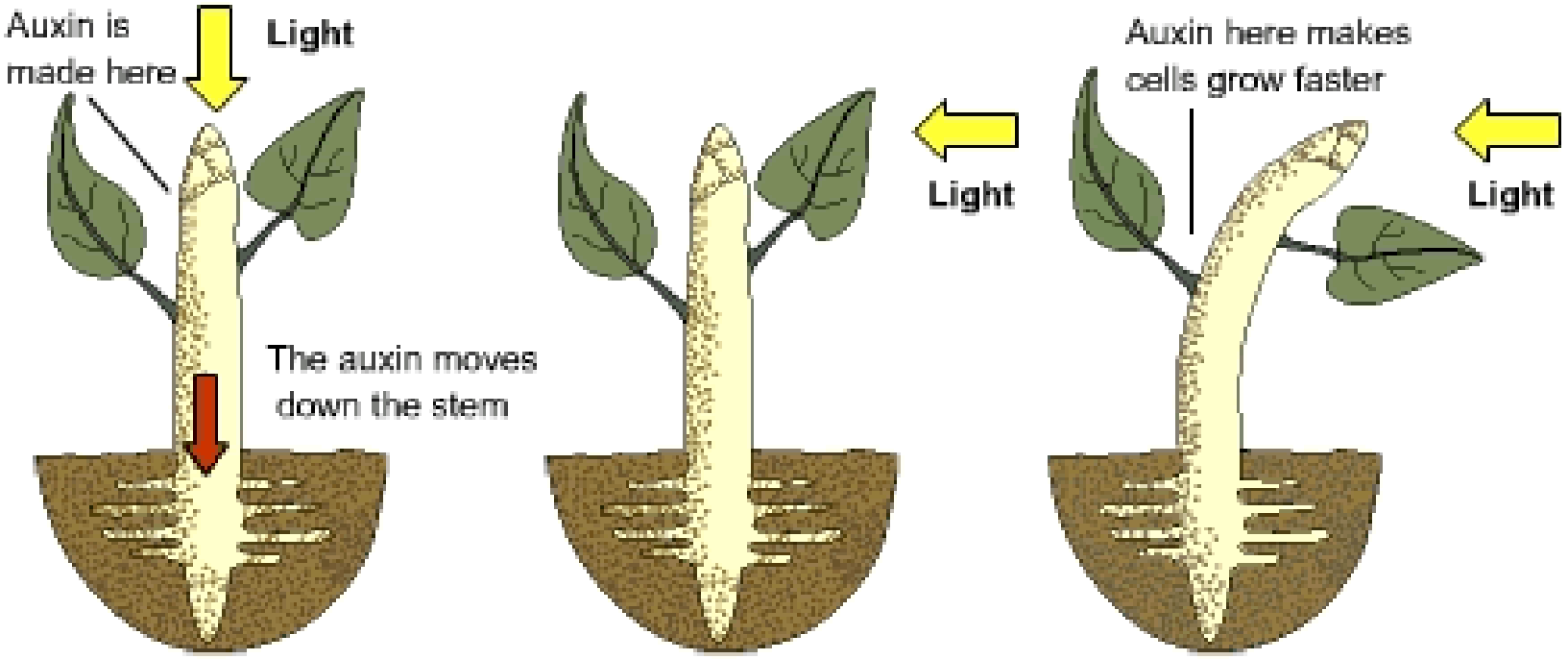
- Plant hormones are chemicals such as auxin that regulate plant growth. Plant hormones are signal molecules produced at specific locations in the plant, and occur in extremely low concentrations. The hormones cause altered processes in target cells locally and at other locations. They affect which tissues grow upward and which grow downward, leaf formation and stem growth, fruit development and ripening, plant longevity and even plant death. Hormones are vital to plant growth and, if they were to lack them, plants would be mostly a mass of undifferentiated cells.

- In general, it is accepted that there are **five major classes** of plant hormones, some of which are made up of many different chemicals that can vary in structure from one plant to the next. Each class has positive as well as inhibitory functions, and most often work in tandem with each other to regulate growth and other responses.

Auxins:

Auxins promote stem elongation, inhibit growth of lateral buds (maintains apical dominance). They are produced in the stem, buds, and root tips. Example: Indole Acetic Acid (IA). Auxin moves to the darker side of the plant, causing the cells there to grow larger than corresponding cells on the lighter side of the plant. This produces a curving of the plant stem tip toward the light, a plant movement known as phototropism.



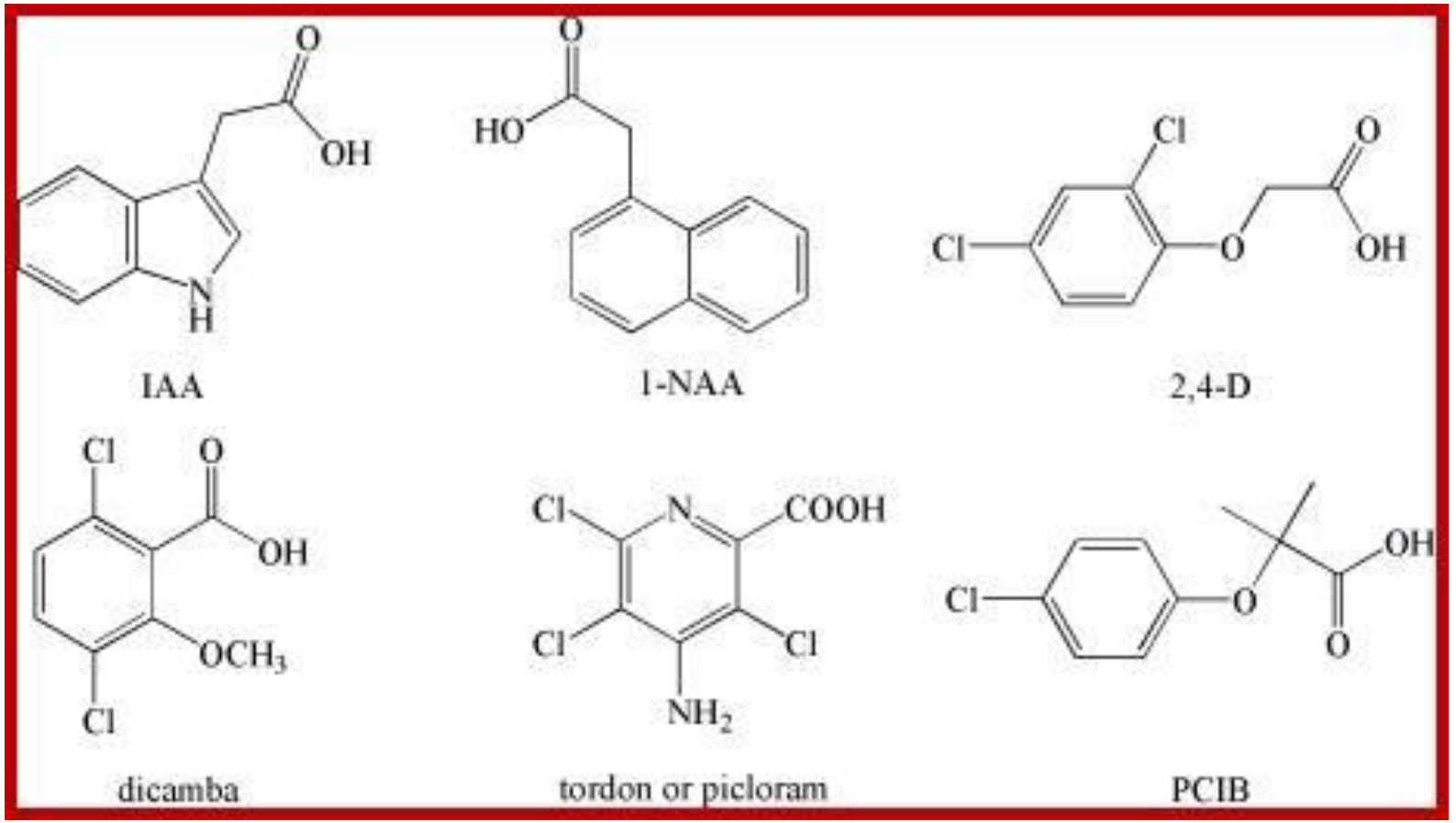


Auxin diffuses down the shoot stimulating growth.

If one side of the shoot is in the light, auxin diffuses away from the light.

The side of the shoot in the shade has more auxin, so grows faster, causing the shoot to bend towards the light.

Structures of some natural and synthetic auxins:



- Auxin also plays a role in maintaining apical dominance. Most plants have lateral (sometimes called axillary) buds located at nodes (where leaves attach to the stem). Buds are embryonic meristems maintained in a dormant state. Auxin maintains this dormancy. As long as sufficient auxin is produced by the apical meristem, the lateral buds remain dormant. If the apex of the shoot is removed (by a browsing animal or a scientist), the auxin is no longer produced. This will cause the lateral buds to break their dormancy and begin to grow. In effect, the plant becomes bushier. When a gardener trims a hedge, they are applying apical dominance.

- It also stimulates the development of fruit, inhibits falling of the leaves and the fruits, stimulates ethylene synthesis.

Cytokinins

Cytokinins work together with auxin to promote growth and development, by promoting cell division and shoot formation. They are produced in the roots and travel. They counter the apical dominance induced by auxins, promoting the development of buds. In conjunction with ethylene they promote abscission (drop) of leaves and fruit.

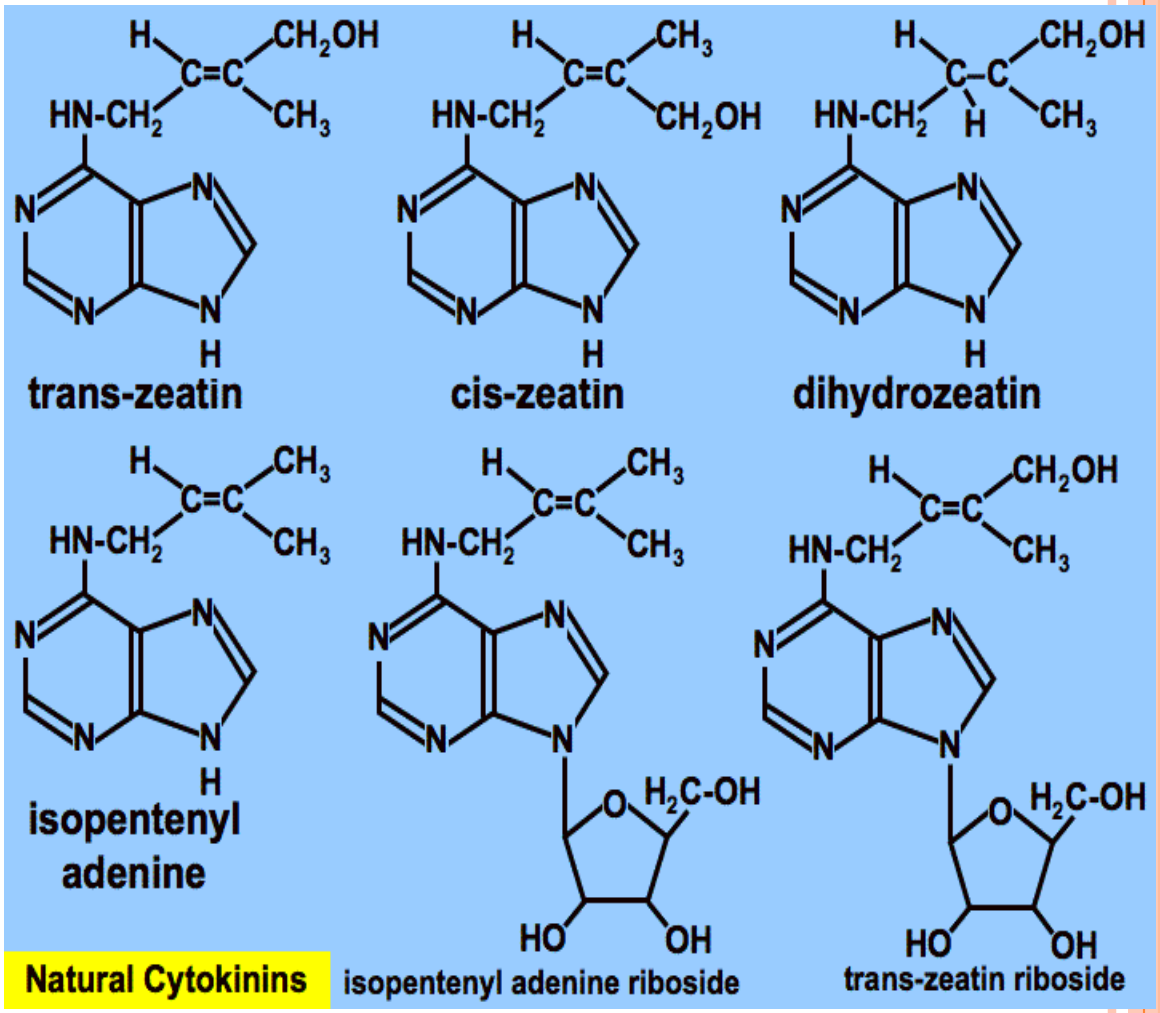
Cytokinins regulate root apical meristem size and promote lateral root elongation. They influence the development of vessels; delay aging of the leaves.

Key Concept

Cytokinins = More Mitosis

More Mitosis = More Cells

More Cells = Plant Growth



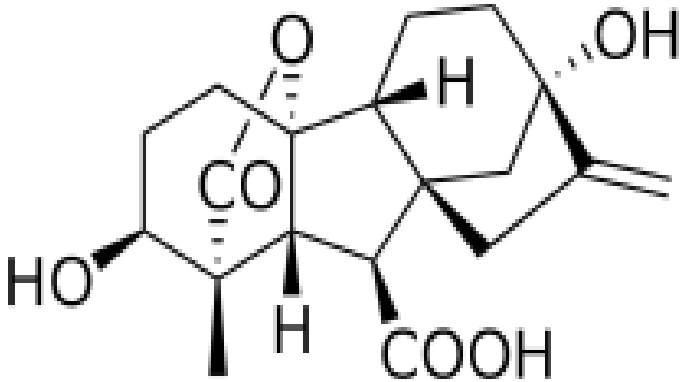
Plant treated with cytokinins

Plant not treated with cytokinins

Gibberellins

Gibberellins play an important role in germination, initiating the mobilization of nutrients stored within the seed. Absorption of water by the seed causes production of GA. They also promote the elongation of stems, flowering and cell division (growth). Gibberellins also reverse the inhibition of shoot growth and seed dormancy induced by ABA.

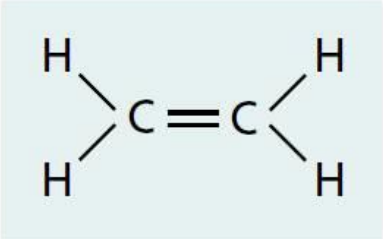
- They also stimulate flowering in some plants.



- Gibberellins are sprayed on seedless grapes to get larger fruits.

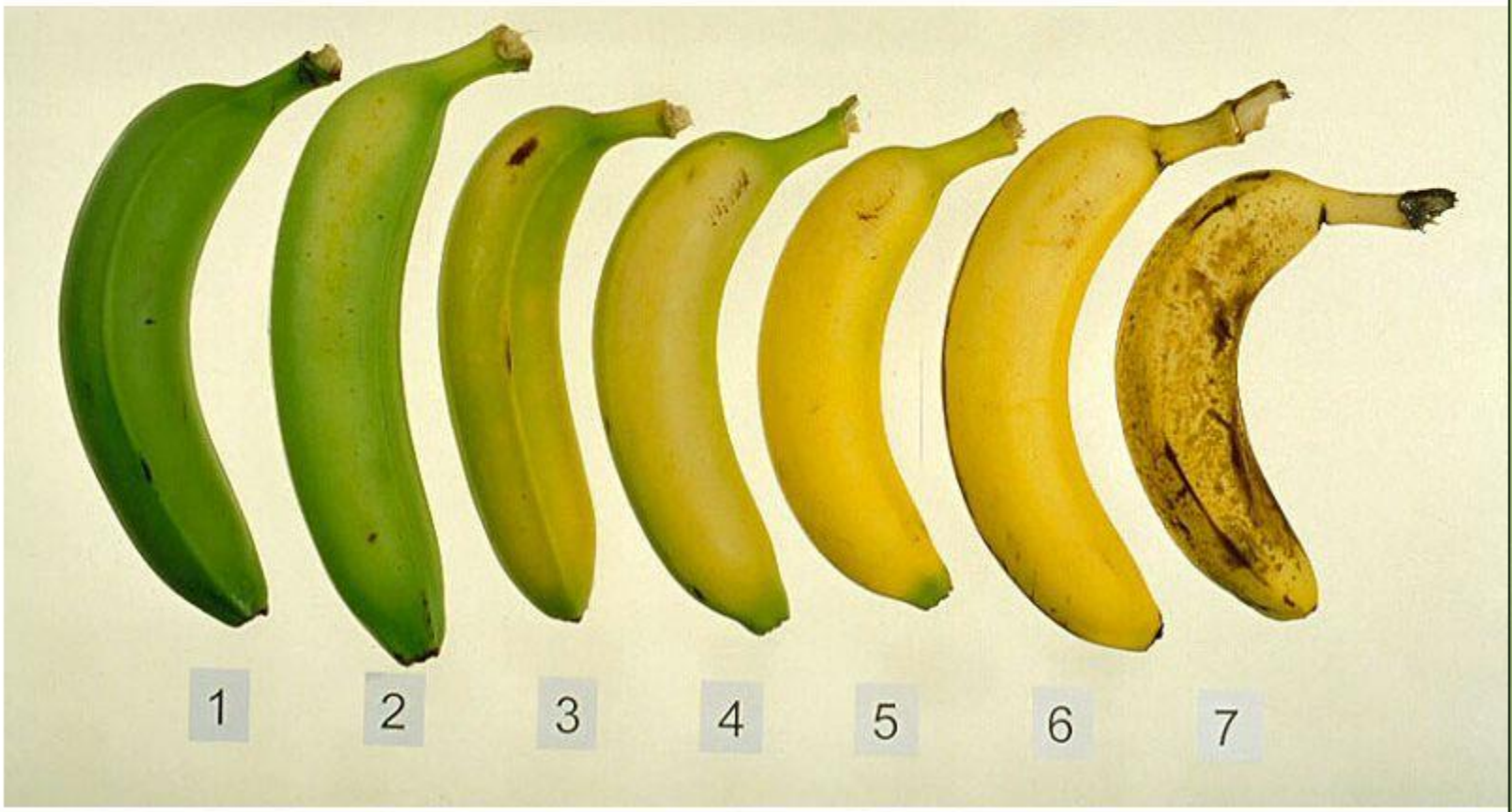
Ethylene

- Ethylene ("the ripening hormone") is a gas that promotes fruit ripening and abscission (drop) of leaves and fruit. Ethylene production increases when the seeds are mature, ensuring the fruit is released when only when the seeds are capable of germination. Fruit often releases ethylene gas as it ripens (this is why storing unripen fruit with a ripening apple will accelerate the ripening process). It also affects cell growth and cell shape; when a growing shoot hits an obstacle while underground, ethylene production greatly increases, preventing cell elongation and causing the stem to swell. The resulting thicker stem can exert more pressure against the object impeding its path to the surface. If the shoot does not reach the surface and the ethylene stimulus becomes prolonged, it affects the stem's natural geotropic response, which is to grow upright, allowing it to grow around an object.
- It also allows the perception of mechanical stress and pathogenic attacks by the plant and cause them to react.



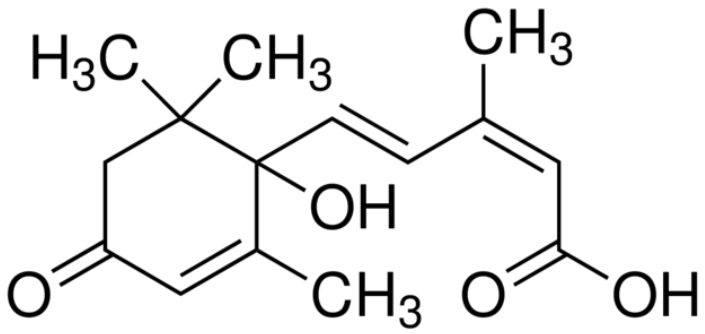
Ethylene

- Plant hormone that stimulates fruits to ripen



Abscisic acid (ABA)

- Abscisic acid (also called ABA) is one of the most important plant growth regulators. In general, abscisic acid inhibits growth / germination. Abscisic acid induces bud and seed dormancy, preventing germination during winter. As summer approaches abscisic acid dissipates, but this occurs slowly and it takes some time for it's effects to wear off. This prevents seeds from germinating on warmer winter days and ensures they only germinate once the temperature is consistently warmer. Abscisic acid also prevents seeds from germinating within the fruit, slows growth in more "mature" parts of the plant and closes stomata (tiny pores on the undersides of the leaves) in response to a lack of water.



Germination

Growth to Maturity

Flowering

Fruit Development

Abscission

Seed Dormancy

Gibberellin						
Auxin						
Cytokinins						
Ethylene						
ABA						

Cytokinin

Induce growth of shoot

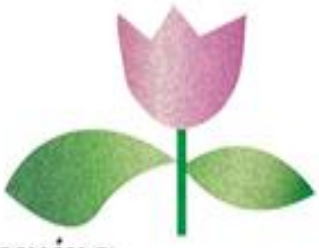
Auxin

Promote root initiation

Gibberellin

Stimulate cell elongation

Florigen



Trigger blossoming