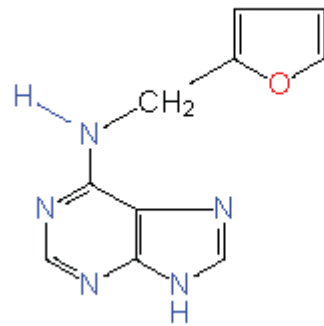
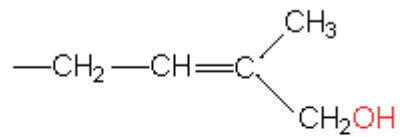
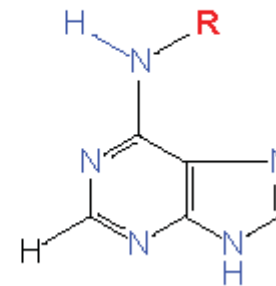


Cytokinins



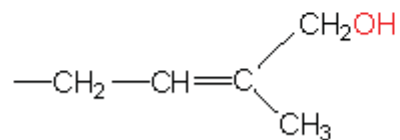
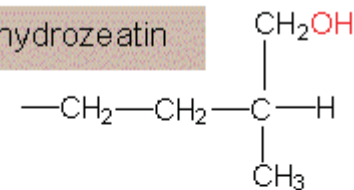
kinetin:
6 - (2 - furfuryl -
7 - amino purine)

cytokinin
(basic structure)



zeatin

dihydrozeatin





Discovery of cytokinins

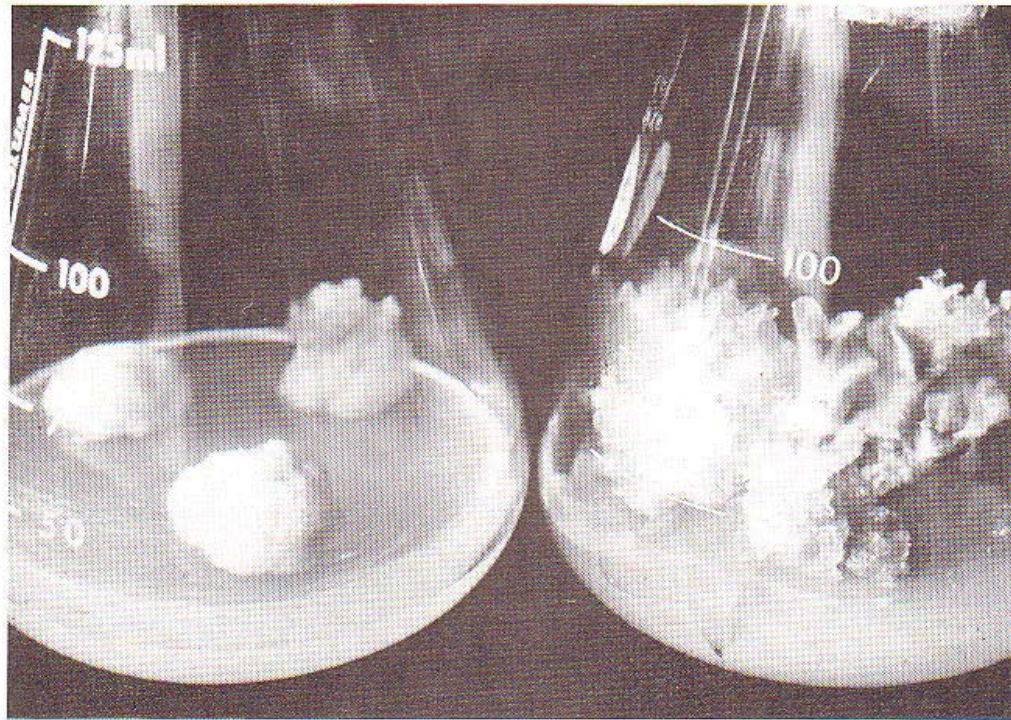
- Gottlieb Haberlandt in 1913 reported an unknown compound that stimulated cellular division.
- In the 1940s, Johannes van Overbeek, noted that plant embryos grew faster when they were supplied with coconut milk (liquid endosperm), which is rich in nucleic acids.
- In the 1950s, Folke Skoog and Carlos Miller studying the influence of auxin on the growth of tobacco in tissue culture. When auxin was added to artificial medium, the cells enlarged but did not divide. Miller took herring-sperm DNA. Miller knew of Overbeek's work, and decided to add this to the culture medium, the tobacco cells started dividing. He repeated this experiment with fresh herring-sperm DNA, but the results were not repeated. Only old DNA seemed to work. Miller later discovered that adding the purine base of DNA (adenine) would cause the cells to divide.
- Adenine or adenine-like compounds induce cell division in plant tissue culture. Miller, Skoog and their coworkers isolated the growth factor responsible for cellular division from a DNA preparation calling it kinetin which belongs to a class of compounds called cytokinins.
- In 1964, the first naturally occurring cytokinin was isolated from corn called zeatin. Zeatin and zeatin riboside are found in coconut milk. All cytokinins (artificial or natural) are chemically similar to adenine.
- Cytokinins move nonpolarly in xylem, phloem, and parenchyma cells.
- Cytokinins are found in angiosperms, gymnosperms, mosses, and ferns. In angiosperms, cytokinins are produced in the roots, seeds, fruits, and young leaves



Function of cytokinins

- Promotes cell division.
- Morphogenesis.
- Delay of senescence.
- Mobilization.
- Lateral bud development.

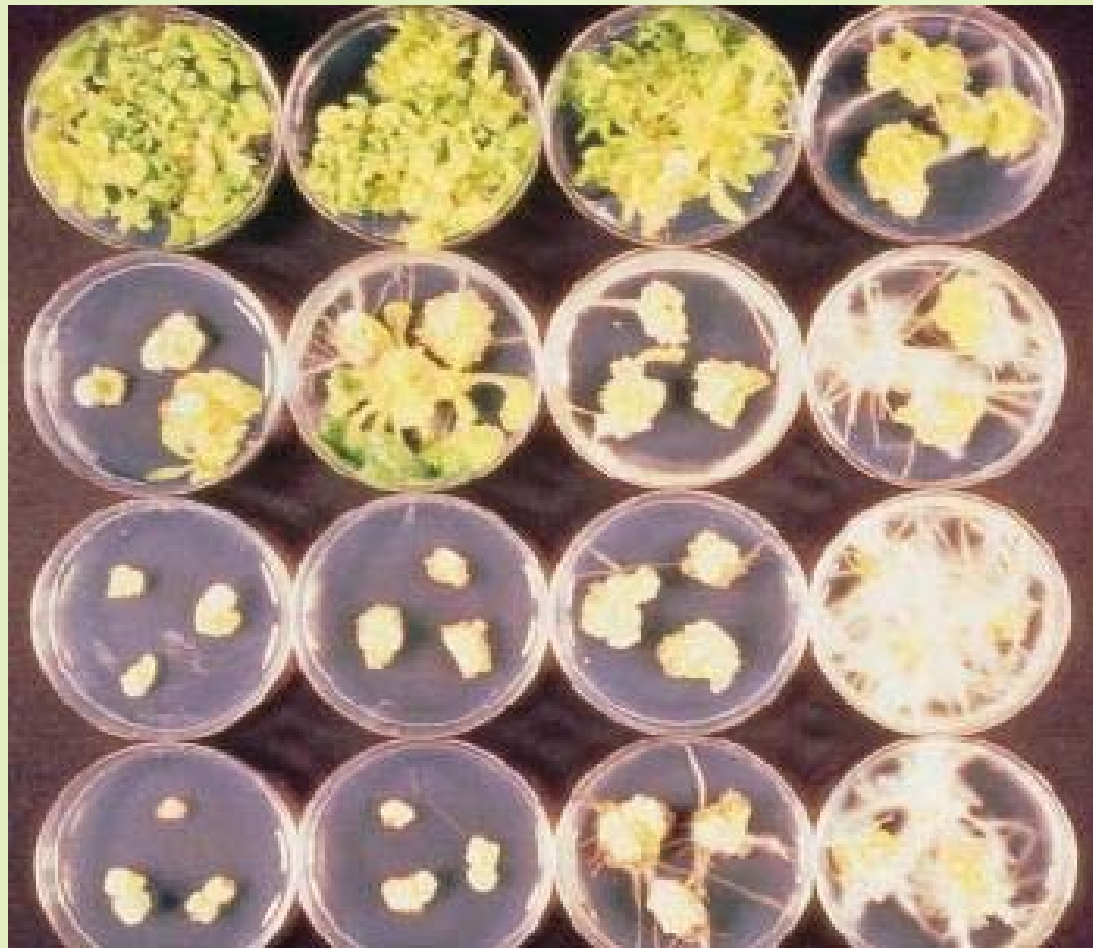
Interaction of cytokinin and auxin in tobacco callus (undifferentiated plant cells) tissue



Tissue cultures of tobacco (*Nicotiana tabacum*) callus. By altering cytokinin-to-auxin ratio, tobacco stem pith tissue may be maintained in culture as undifferentiated callus (left) or induced to differentiate and bud into plantlets (right).

From work of F. Skoog and C.O. Miller. Photo by F.H. Witham.

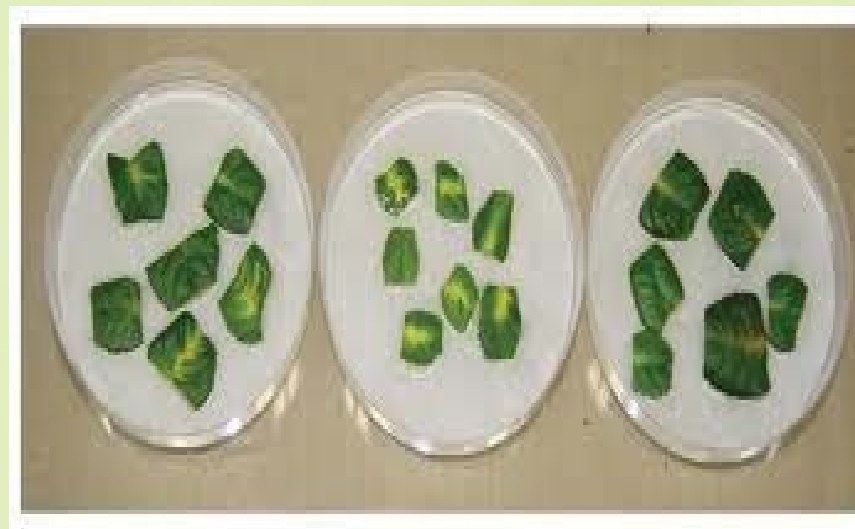
- ❖ Organogenesis: cytokinin and auxin affect organogenesis
- ❖ High cytokinin/auxin ratios favor the formation of shoots
- ❖ Low cytokinin/auxin ratios favor the formation of roots



Tobacco leaf explants cultured on media with varying concentrations of an auxin (α -naphthaleneacetic acid; NAA) and a cytokinin (6-benzylaminopurine; BAP). Concentrations of NAA are from left to right, 0, 0.01 μM , 0.1 μM , 1.0 μM ; concentrations of BAP are from bottom to top 0, 0.01 μM , 0.1 μM , 1.0 μM . At low auxin to cytokinin ratios shoot development predominates, whereas at high ratios profuse root initiation occurs. At intermediate ratios, callus is often the result.



Leaf segments of control (left), middle, and transgenic line (right) during after postharvest stress treatment

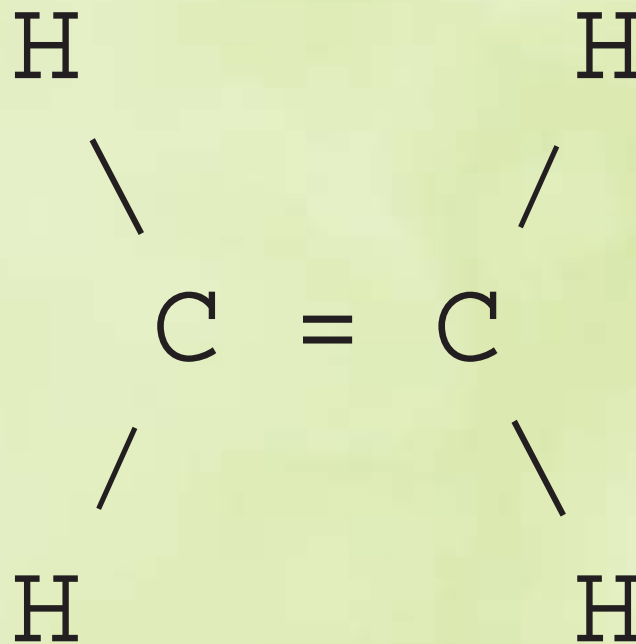




The flowers in the vase on the left side are the controls, and on the right side the flowers had been pulse-treated, for 6 h, with a mixture of GA₃, BA, and calcium ions.



Ethylene

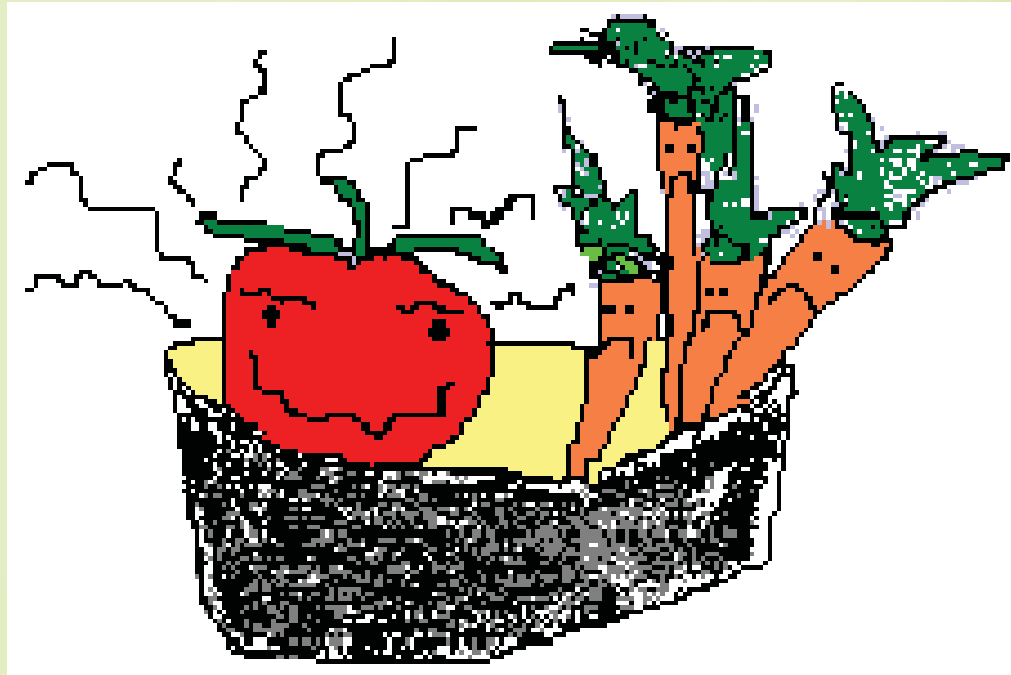




Discovery of ethylene

- In the 1800s, it was recognized that street lights that burned gas, could cause neighboring plants to develop short, thick stems and cause the leaves to fall off. In 1901, Dimitry Neljubow identified that a byproduct of gas combustion was ethylene gas and that this gas could affect plant growth.
- In R. Gane showed that this same gas was naturally produced by plants and that it caused faster ripening of many fruits.
- Synthesis of ethylene is inhibited by carbon dioxide and requires oxygen.

Ethylene Gas



- Colorless gas
- Produced in nodes of stems, ripening fruits, dying leaves



Ethylene Effects

- Dormancy
- Flowering (pineapple)
- Sex determination
- Fruit ripening



Functions of ethylene

- Gaseous in form and rapidly diffusing.
- Gas produced by one plant will affect nearby plants.
- Fruit ripening.
- Epinasty – downward curvature of leaves.
- Encourages senescence and abscission.
- Initiation of stem elongation and bud development.
- Flowering - Ethylene inhibits flowering in most species, but promotes it in a few plants such as pineapple, bromeliads, and mango.
- Sex Expression - Cucumber buds treated with ethylene become carpellate (female) flowers, whereas those treated with gibberellins become staminate (male) flowers.

Abscission layer: The Holly and the Ethylene

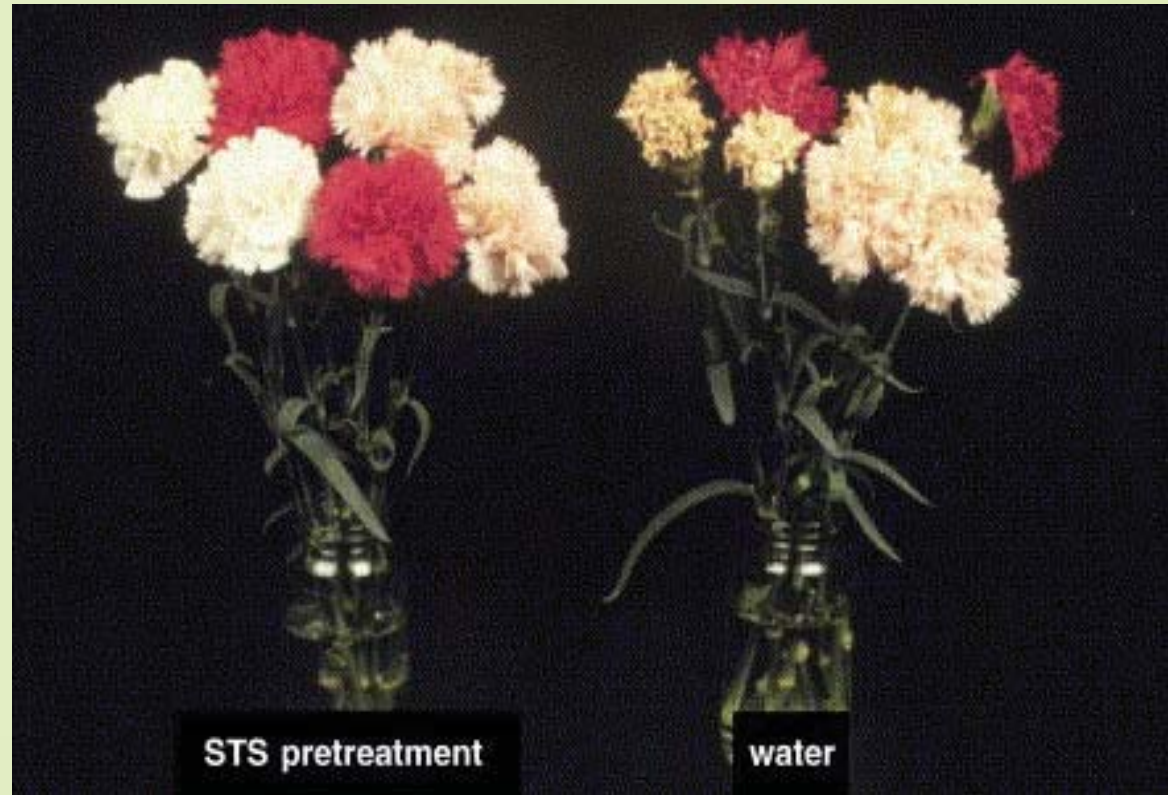




Ethylene exposure

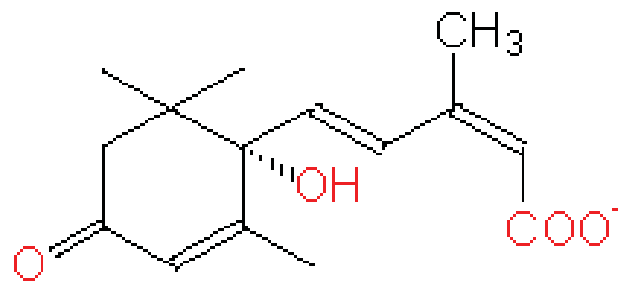
- Thickens stems
- Breaks down chlorophyll
- Weakens cell membranes
- Softens cell walls



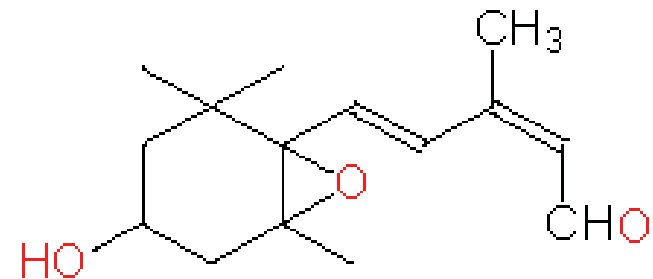


- Different varieties of carnation treated overnight with 0.2 mM STS solution. Photograph was taken after 10 days of vase life. Note that cultivar Chinera (pink colored), with reduced sensitivity to ethylene, benefits less from the STS pretreatment.

Abscisic acid



abscisic acid (ABA)



xanthoxine

- ✧ In 1940s, scientists started searching for hormone that would inhibit growth and development, what Hemberg called dormins.
- ✧ In the early 1960s, Philip Oldland confirmed that application of a dormin to a bud would induce dormancy.
- ✧ F.T. Addicott discovered that ethylene stimulates the abscission of cotton fruit, he named this substance as abscisin. (Subsequent research showed that ethylene and not abscisin controls abscission).
- ✧ Abscisin is made from carotenoids and moves nonpolarly through plant tissue.

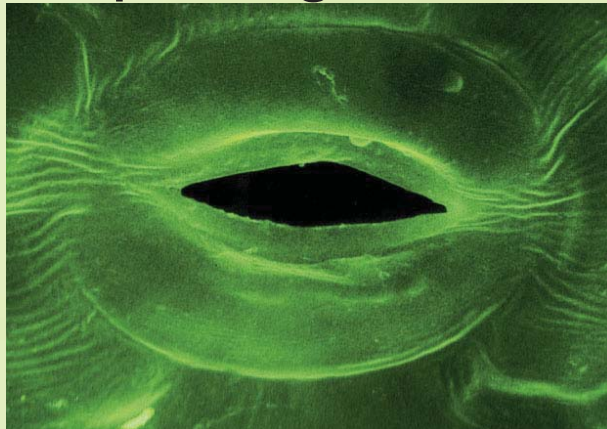


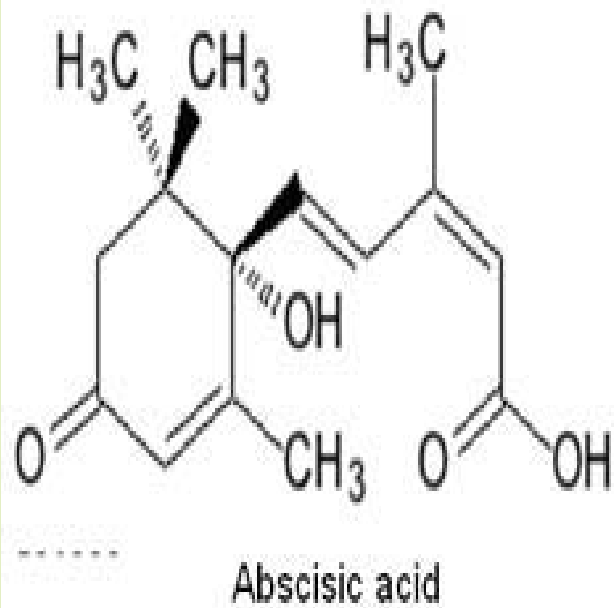
Functions of abscisic acid

- General growth inhibitor.
- Bud and seed dormancy.
- Overcoming apical dominance
- Causes stomatal closure.
- Produced in response to stress.

Abscisic Acid

- Abscisic acid is produced chiefly in mature green leaves and in fruits.
 - suppresses bud growth and promotes leaf senescence
 - also plays important role in controlling stomatal opening and closing





- transgenic *Arabidopsis* overexpressing *ABA2* with elevated ABA levels promote delay of seed germination and tolerance to salt.

Seed quality

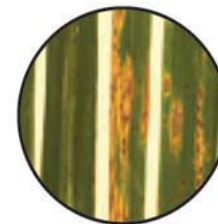
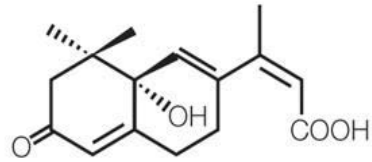
Dormancy



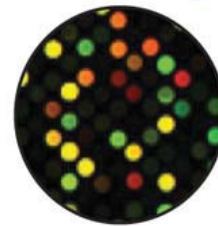
Germination



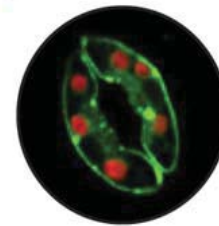
Development



Biotic stress response



Gene expression



Stomata aperture

Environmental stress tolerance