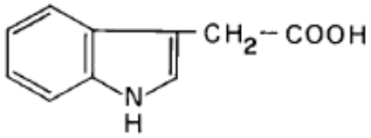
Auxins

- *Nature*

Indole-3-acetic acid (IAA) is the main auxin in most plants.



INDOLEACETIC ACID

IAA precursors: e.g., indoleacetaldehyde

other compounds: e.g., phenylacetic acid

various conjugates: e.g., indoleacetyl aspartate, 4-chloro-IAA

"for example." It is short for the Latin exempli gratia

- *Sites of biosynthesis*
- Leaf primordia
- young leaves
- developing seeds

- *Transport*
- cell to cell
- mainly in the vascular cambium and the procambial strands (but probably also in epidermal cells)
- Transport to the root probably also involves the phloem

- *Effects*

❖Cell enlargement
❖Cell division
❖Vascular tissue
❖ Root initiation
❖Tropistic responses
❖Apical dominance
❖Leaf senescence
❖Leaf and fruit abscission
❖Fruit setting and growth
❖Assimilate partitioning
❖Fruit ripening
❖Flowering
❖Growth of flower parts
❖Promotes femaleness in dioecious flowers

Gibberellins

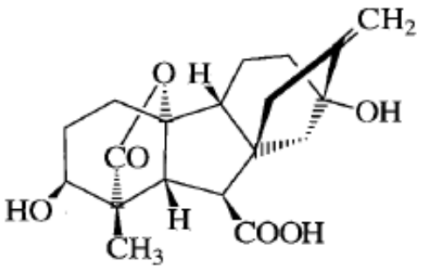
- *Nature*

based on the entgibberellane structure

over 125 members

the most widely available compound: GA3

the most important GA: GA1



GIBBERELLIN A_1 or GA_1

- *Sites of biosynthesis*

- young tissues of the shoot
- developing seed

Their biosynthesis starts in the chloroplast and subsequently involves membrane and cytoplasmic steps

- *Transport*

Some GAs are probably transported in the phloem and xylem. However thetransport of the main bioactive polar GA1 seems restricted

- *Effects*

- Stem growth
- Bolting in long day plants
- Induction of seed germination
- Enzyme production during germination
- Fruit setting and growth
- Induction of maleness in dioecious flowers

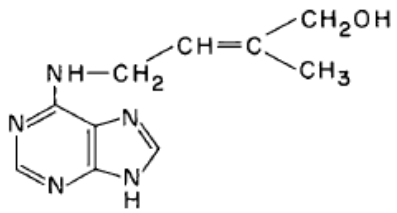
Cytokinins

- *Nature*

adenine derivatives

ability to induce cell division in tissue culture

The most common cytokinin base in plants is zeatin



ZEATIN

- *Sites of biosynthesis*
- root tips
- developing seeds

- *Transport*

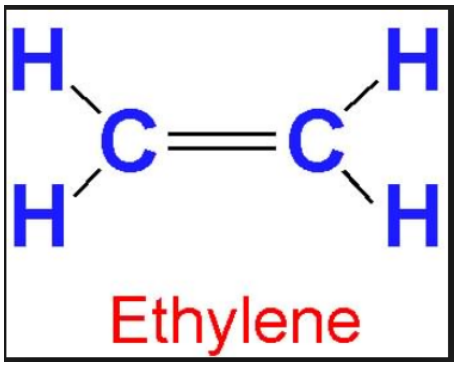
CK transport is via the xylem from roots to shoots.

- *Effects*

✓Cell division
✓Morphogenesis
✓Growth of lateral buds
✓Leaf expansion
✓Senescence
✓Stomatal opening
✓Chloroplast development

Ethylene

- *Nature*
- synthesized from methionine
- is the fruit ripening hormone
- Ethylene deficient transgenic plants grow normally
- It is the only hydrocarbon with a pronounced effect on plants



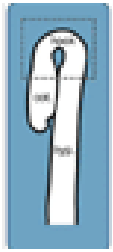
- *Sites of biosynthesis*
- most tissues in response to stress
- in tissues undergoing senescence or ripening

- *Transport*
- diffusion from its site of synthesis.

ACC can, however, be transported and may account for ethylene effects at a distance from the causal stimulus

Effects

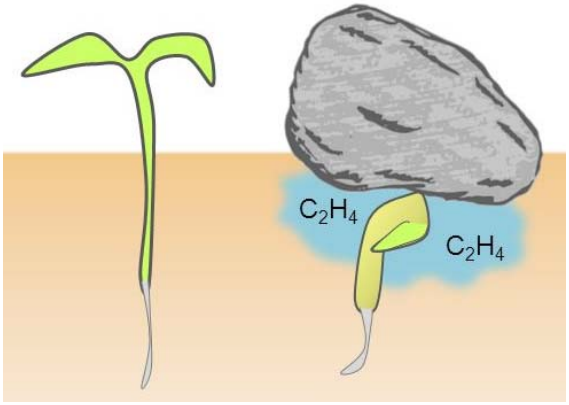
- The so called *triple response* (a decrease in stem elongation, a thickening of the stem and a transition to lateral growth) a
- Maintenance of the apical hook in seedlings (*apical hook—a structure of dicotyledonous plants shaped by the bended hypocotyl that eases the penetration through the covering soil*).
- Stimulation of numerous defense responses in response to injury or disease.
- Release from dormancy.
- Shoot and root growth and differentiation.
- Adventitious root formation.
- Leaf and fruit abscission.
- Flower induction in some plants
- Induction of femaleness in dioecious flowers
- Flower opening.
- Flower and leaf senescence.
- Fruit ripening



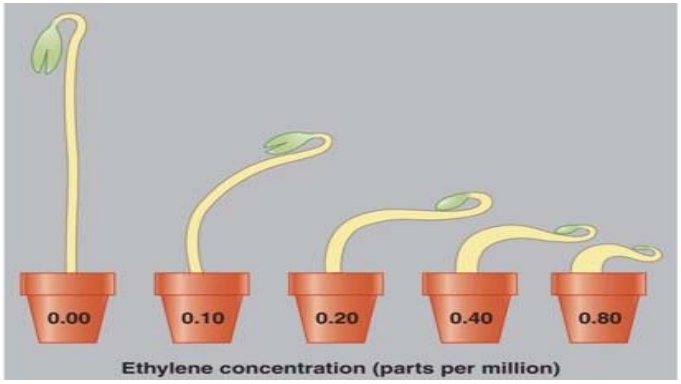
Dimitry Neljubow, in 1901, observed that peas grown in the laboratory were abnormally:

- Short
- Thick
- Curled

The lab had gas lamps that produced ethylene gas, resulting in the "triple response."

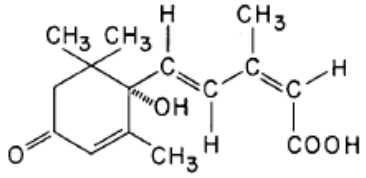


- Ethylene induces **triple response**, which allows growing shoot to avoid obstacles (rock in ground)
  - Consists of slowing of stem elongation, thickening of stem (making it stronger), and horizontal growth (curvature)
  - Resumes vertical growth when

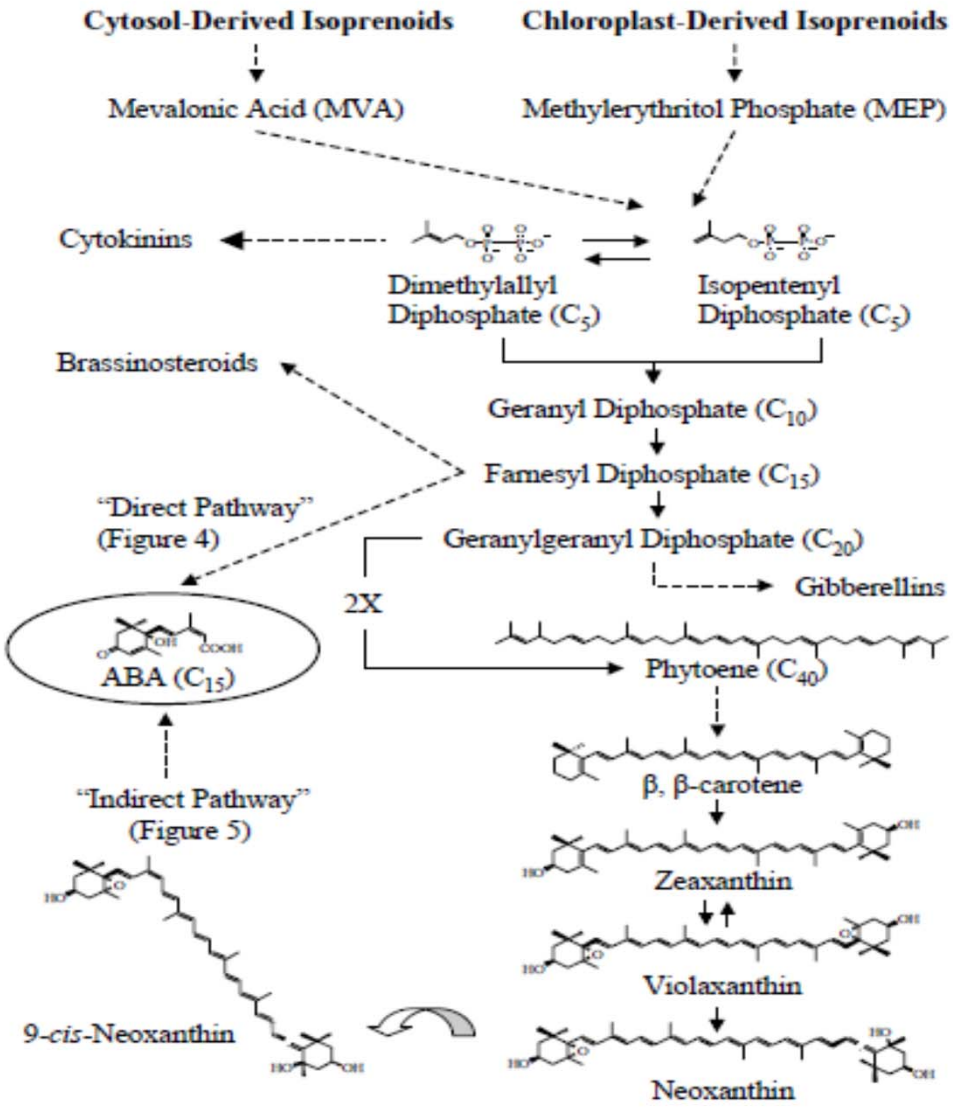


Abscisic Acid

- *Nature*
- Its name is rather unfortunate.
- "abscisin II " + "dormin“
- little role in either abscission or bud dormancy
- become thought of as an inhibitor.
- ABA appears to act as much as a promoter!



ABSCISIC ACID


Cytosol-Derived Isoprenoids
Chloroplast-Derived Isoprenoids
Mevalonic Acid (MVA)
Methylerythritol Phosphate (MEP)
Cytokinins
Dimethylallyl Diphosphate (C_5)
Isopentenyl Diphosphate (C_5)
Brassinosteroids
Geranyl Diphosphate (C_{10})
Farnesyl Diphosphate (C_{15})
"Direct Pathway" (Figure 4)
Geranylgeranyl Diphosphate (C_{20})
Gibberellins
2X
ABA (C_{15})
Phytoene (C_{40})
β, β-carotene
"Indirect Pathway" (Figure 5)
Zeaxanthin
Violaxanthin
9-*cis*-Neoxanthin
Neoxanthin

- *Sites of biosynthesis*
- Roots
- mature leaves
- Seeds are also rich in ABA

- *Transport*
- ABA is exported from roots in the xylem and from leaves in the phloem

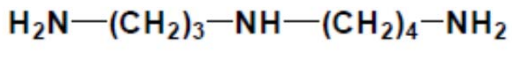
- *Effects*

- Stomatal closure
- Inhibits shoot growth
- Protein synthesis
- Counteracts the effect of gibberellin
- Some aspects of dormancy
- Response to wounding

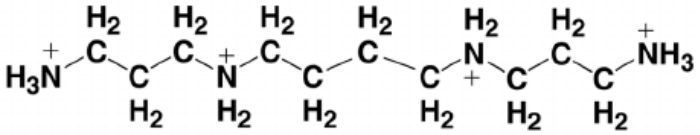
Plant proteinase inhibitors (PIs), which function in the regulation of proteolysis and inhibition of uncontrolled proteolysis, have been suggested to play a significant role in plant responses to biotic stress. The defensive capacities of plant PIs rely on inhibition of proteases present in insect guts or secreted by microorganisms, causing a reduction in the availability of amino acids necessary for their growth and development

Polyamines

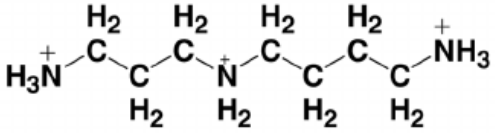
- *Nature*
- are a group of aliphatic amines
- derived from the decarboxylation of the amino acids arginine or ornithine.
- The conversion of the diamine putrescine to the triamine spermidine and the quaternaryamine spermine involves the decarboxylation of S-adenosylmethionine.



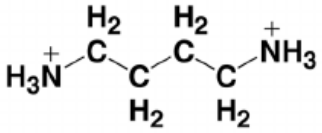
SPERMIDINE



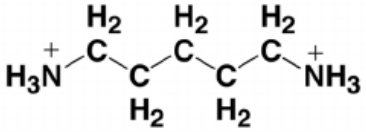
spermine



spermidine



putrescine



cadaverine

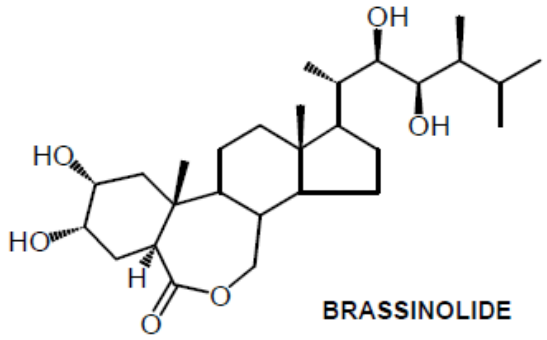
- *Sites of biosynthesis*

It appears that polyamines are present in all cells rather than having a specific site of synthesis

- *Transport*

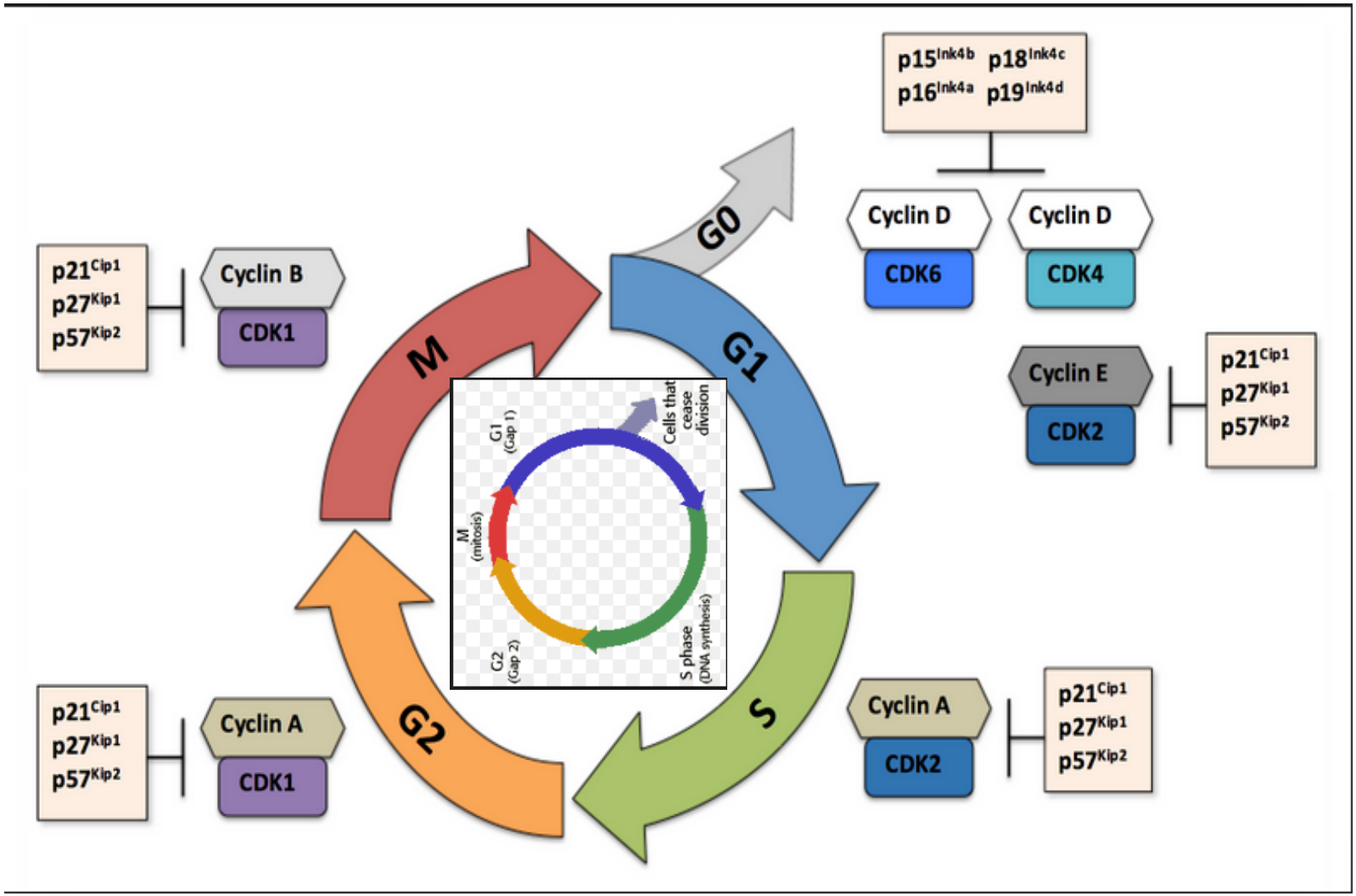
- *Effects*
- *Polyamines have a wide range of effects on plants and appear to be essential for plant growth, particularly cell division and normal morphologies*

Brassinosteroids



BRASSINOLIDE

- *Effects*
- *Cell Division.*
- *Cell elongation.*
- *Vascular differentiation.*
- *Fertility.*
- *Inhibition of root growth and development.*
- *Promotion of ethylene biosynthesis and epinasty.*

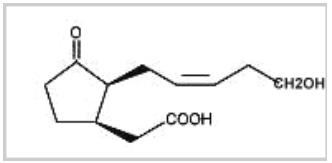

p15Ink4b p18Ink4c
p16Ink4a p19Ink4d
G0
Cyclin D
CDK6
Cyclin D
CDK4
G1
Cyclin E
CDK2
p21Cip1
p27Kip1
p57Kip2
S
Cyclin A
CDK2
p21Cip1
p27Kip1
p57Kip2
G2
Cyclin A
CDK1
p21Cip1
p27Kip1
p57Kip2
M
Cyclin B
CDK1
p21Cip1
p27Kip1
p57Kip2
G1 (Gap 1)
Cells that cease division
S phase (DNA synthesis)
G2 (Gap 2)
M (mitosis)

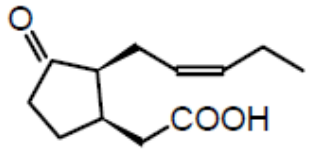
- Expansins comprise a large gene super-family which codes for small (225–300 amino acid residues) cell wall proteins (Fukuda 2014; Sampedro and Cosgrove 2005).
- Expansins have the ability to non-enzymatically trigger a pH dependent relaxation of the cell wall which loosens and softens it thus enabling cell expansion. It has been noted that due to the action of expansins, growing plant cell walls extend faster at low pH (4.5), a phenomenon which Rayle and Cleland (1992) preferred to call acid growth.
- besides pH, the action of expansins can also be influenced by several other factors including environmental factors (Brummell et al. 1999) such as flooding (Vreeburg et al. 2005) or submergence (Lee and Kende 2001) and hormones like abscisic acid, indole-3-acetic acid (Zhao et al. 2012), auxins (McQueen-Mason et al. 1992), brassinosteroids (Park et al. 2010), cytokinins (Downes and Crowell 1998) and ethylene (Belfield et al. 2005).

- Xyloglucan is intimately associated with cellulose microfibrils by hydrogen bonding, thus protects the cell wall from collapsing due to osmotic stress. In addition to this structural function, xyloglucan also has a role in the regulation of cell enlargement during plant growth. Auxin, a hormone coordinating plant development, induces the degradation of xyloglucan into smaller oligosaccharides, which results in the loosening of the cellulose-xyloglucan network and allows the turgor driven expansion of the cell wall.
- The strong hydrogen bonding between cellulose and xyloglucan makes the extraction of xyloglucan from the cell wall difficult.
- Enzymatic degradation of the xyloglucan by xyloglucanases could potentially improve the overall hydrolysis of lignocellulosic substrates by enabling cellulases to hydrolyze the cellulose polymer more efficiently.

Jasmonates

- *Nature*
- are represented by jasmonic acid (JA) and its methyl ester.
- They are named after the jasmine plant.
- There is also a related hydroxylated compound that has been named tuberonic acid.





JASMONIC ACID

- *Biosynthesis*
- Jasmonic acid is synthesized from linolenic acid
- jasmonic acid is most likely the precursor of tuberonic acid

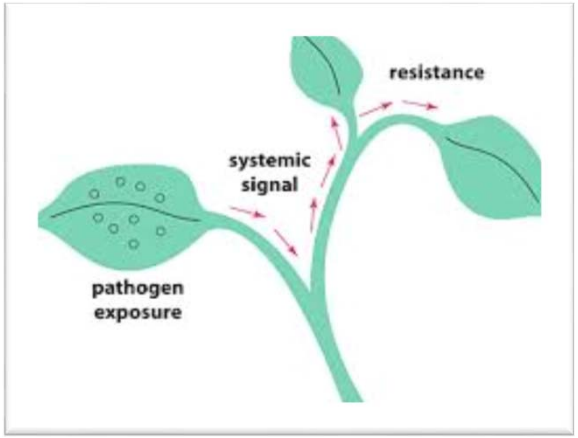
- *Effects*
- Jasminates play an important role in plant defense.
- Jamonates inhibit many plant processes.
- They promote senescence, abscission, tuber formation, fruit ripening, pigment formation and tendril coiling.
- JA is essential for male reproductive development of *Arabidopsis*.

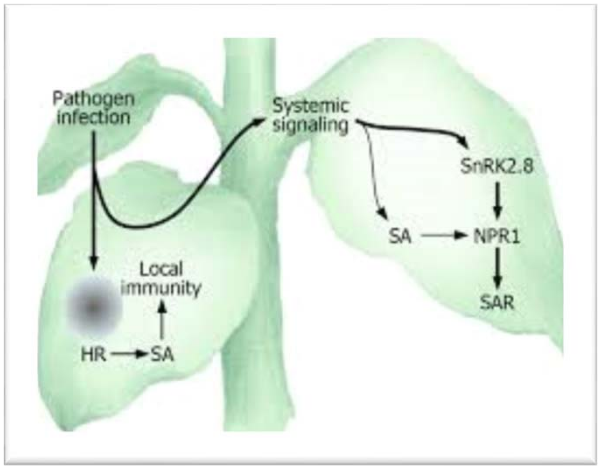
Salicylates

- *Biosynthesis*
- *biosynthesized from the amino acid phenylalanine*

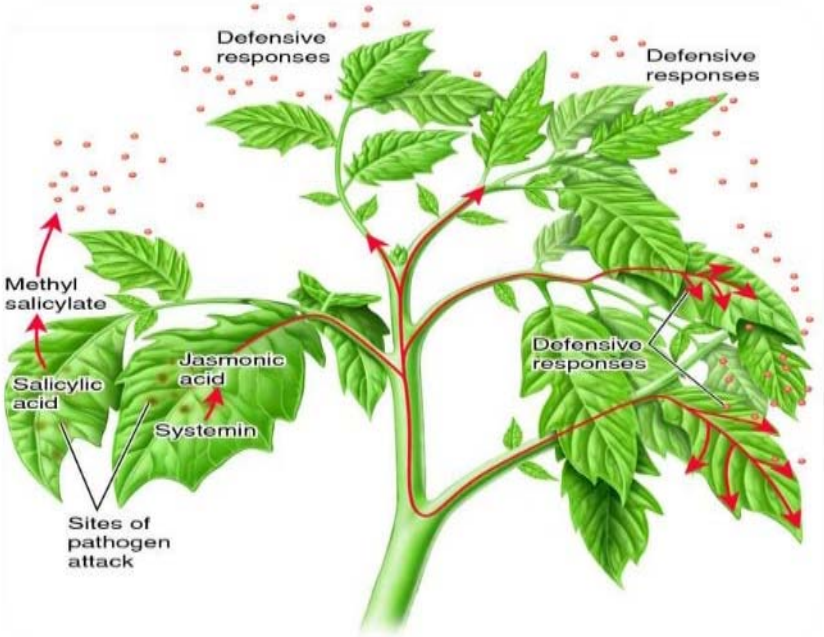
- *Effects*
- plays a main role in the resistance to pathogens.
- SA is the calorigenic substance.
- enhances flower longevity, inhibits ethylene biosynthesis and seed germination, blocks the wound response, and reverses the effects of ABA.

The term “pathogenesis-related proteins” means a group of proteins induced in a plant in response to fungal, bacterial, viral, and viroid diseases, as well as to some chemicals.





SYSTEMIC ACQUIRED RESISTANCE



Submitted to : Dr. KP Singh
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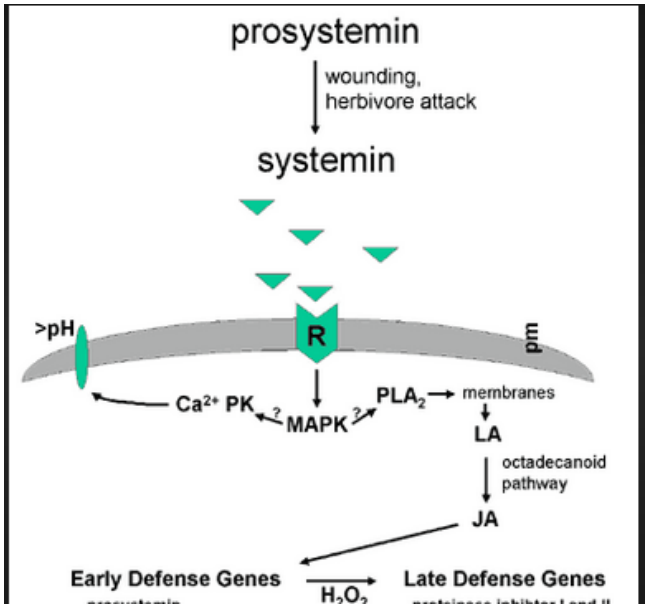
Ph.D (Plant Pathology)
Id : 43970

Signal Peptides

- *Nature*
- started with the discovery of systemin.
- Since then, over a dozen peptide hormones that regulate various processes involved in defense, cell division, growth and development and reproduction have been isolated from plants, or identified by genetic approaches



- *Effects*
- The activation of defense responses.
- The promotion of cell proliferation of suspension cultured plant cells.
- The determination of cell fate during development of the shoot apical meristem.
- The modulation of root growth and leaf patterning in the presence of auxin and cytokinin.
- Peptide signals for self-incompatability.
- Nodule formation in response to bacterial signals involved in nodulation in legumes.

Are the More-Recently-Discovered Compounds Plant Hormones?

Two decades ago there was a heated discussion as to whether a compound had to be transported to be a plant hormone, and could ethylene therefore be a plant hormone. To this Carl Price responded: "Whether or not we regard ethylene as a plant hormone is unimportant; bananas do…"[3]. Hormones are a human classification and organisms care naught for human classifications. Natural chemical compounds affect growth and development in various ways, or they do not do so. Clearly brassinosteroids fit the definition of a plant hormone, and likely polyamines, jasmonates salicylic acid and signal peptides also can be so classified. Whether other compounds should be regarded as plant hormones in the future will depend on whether, in the long run, these compounds are shown to be endogenous regulators of growth and development in plants in general.