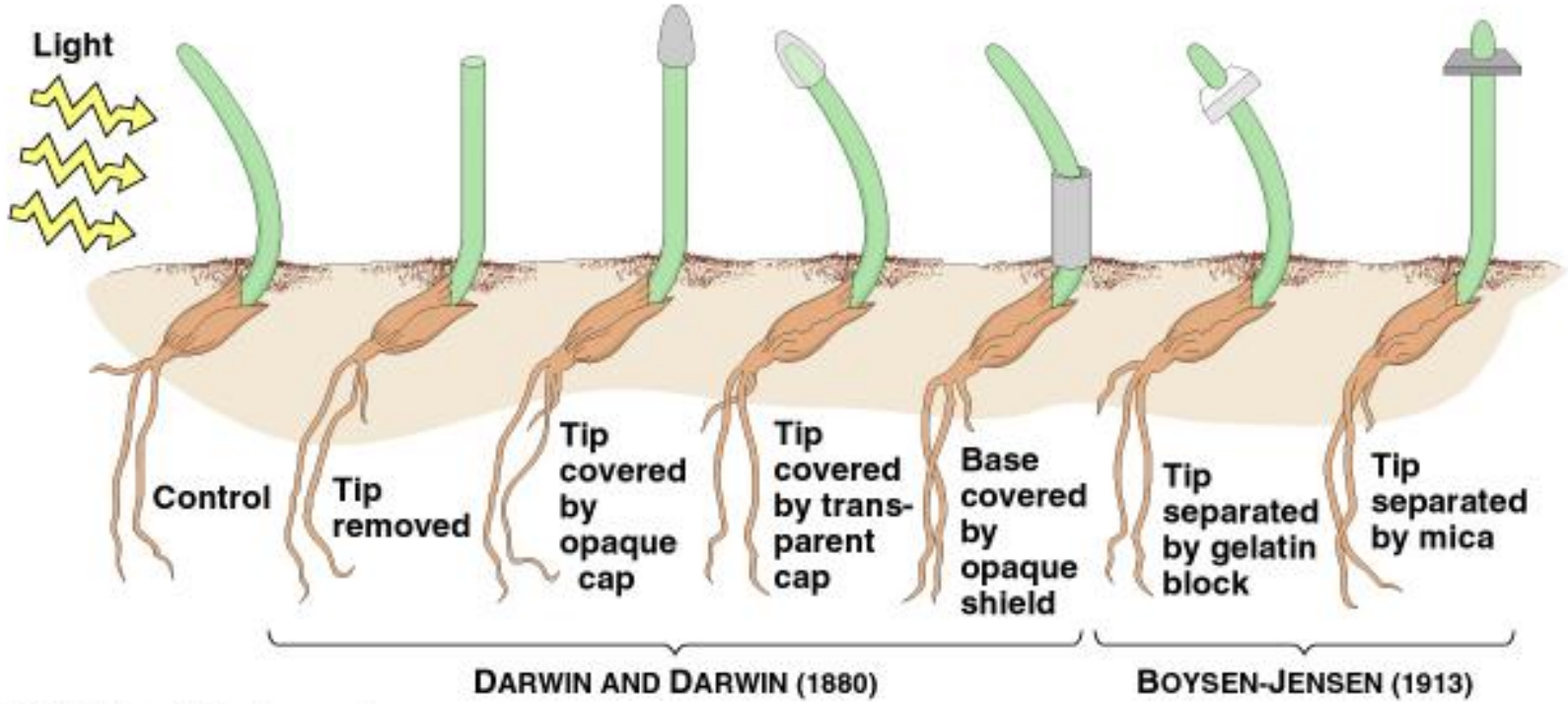
# Plant Growth Regulators

**Plant Growth Regulators - control growth, development and movement**

# EARLY EXPERIMENTS ON PHOTROPISM SHOWED THAT A STIMULUS (LIGHT) RELEASED CHEMICALS THAT INFLUENCED GROWTH

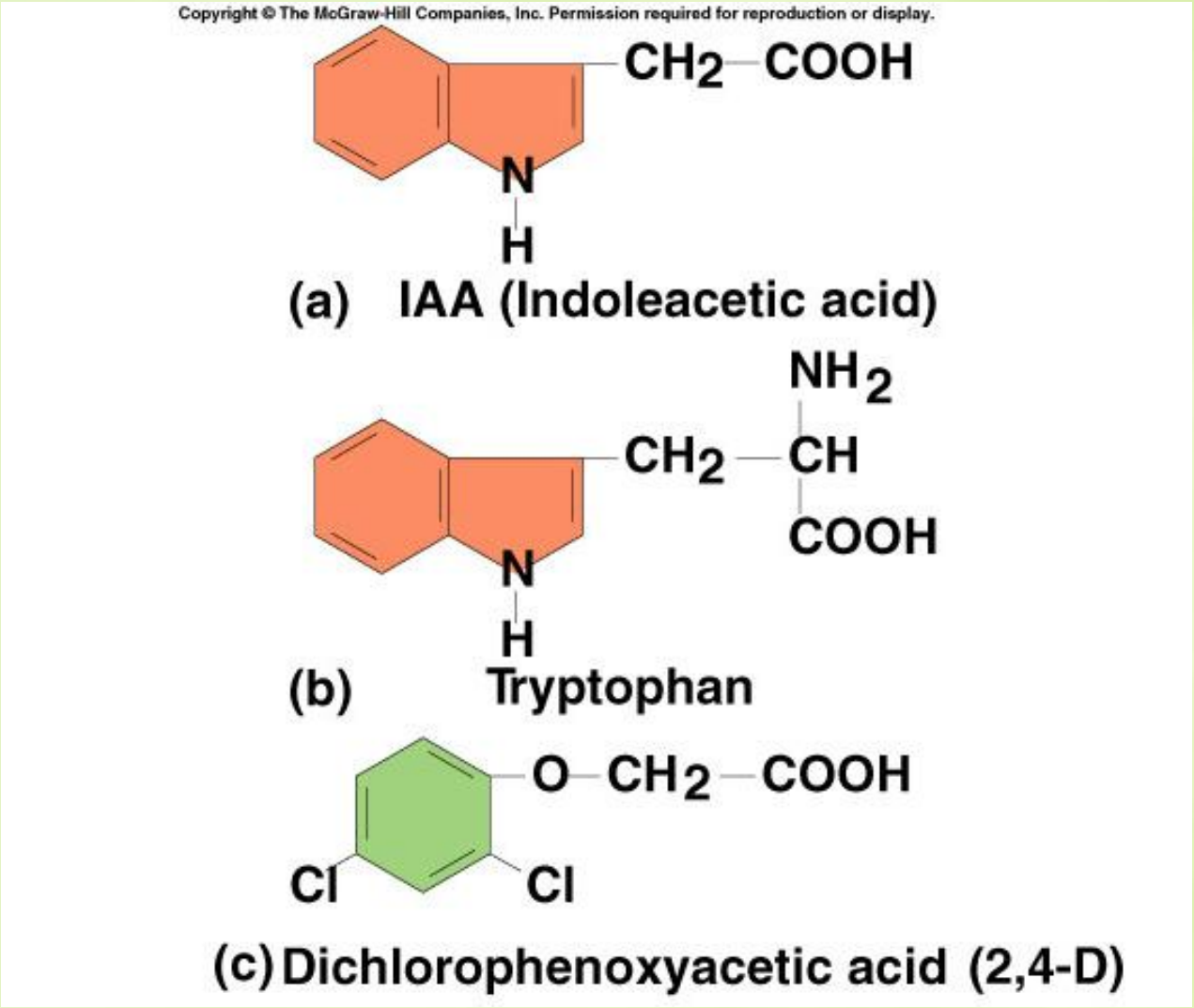



**Results on growth of coleoptiles of canary grass and oats suggested that the reception of light in the tip of the shoot stimulated a bending toward light source.**

# General plant hormones

- **Auxins** (cell elongation)
- **Gibberellins** (cell elongation + cell division - translated into growth)
- **Cytokinins** (cell division + inhibits senescence)
- **Abscisic acid** (abscission of leaves and fruits + dormancy induction of buds and seeds)
- **Ethylene** (promotes senescence, epinasty, and fruit ripening)

# Auxins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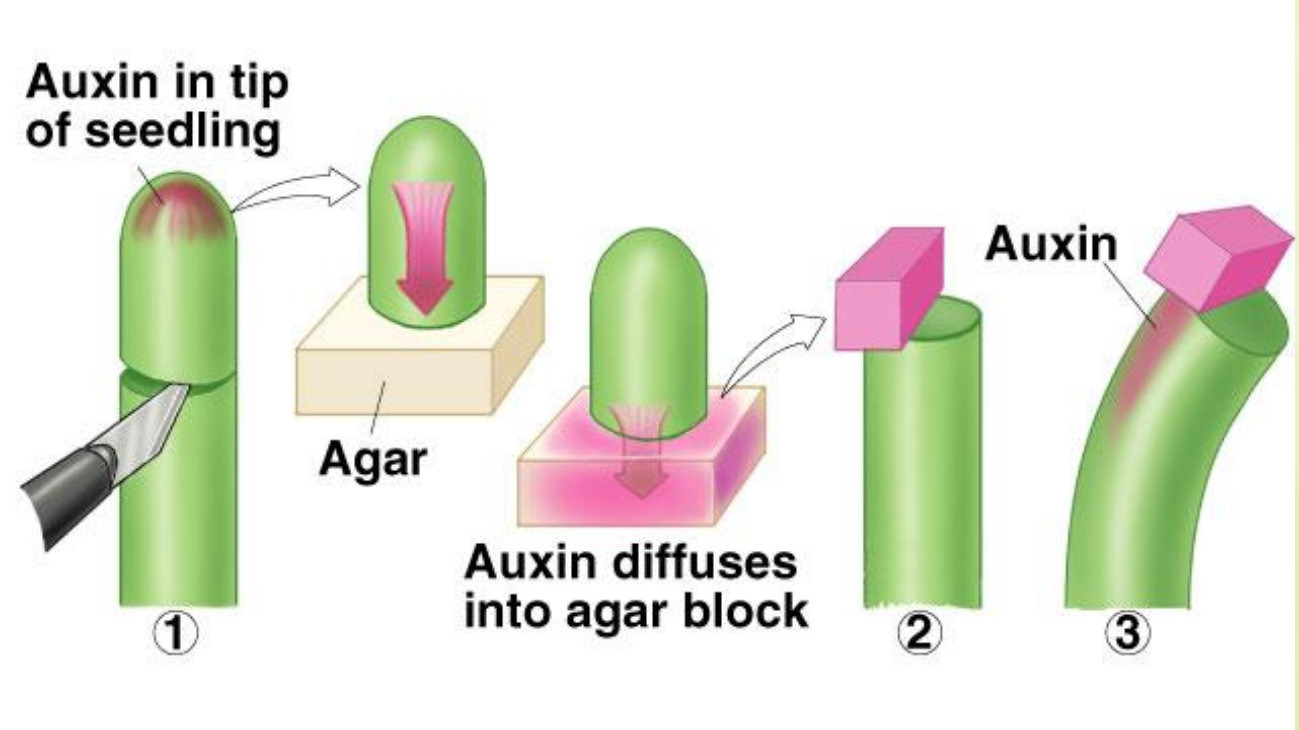
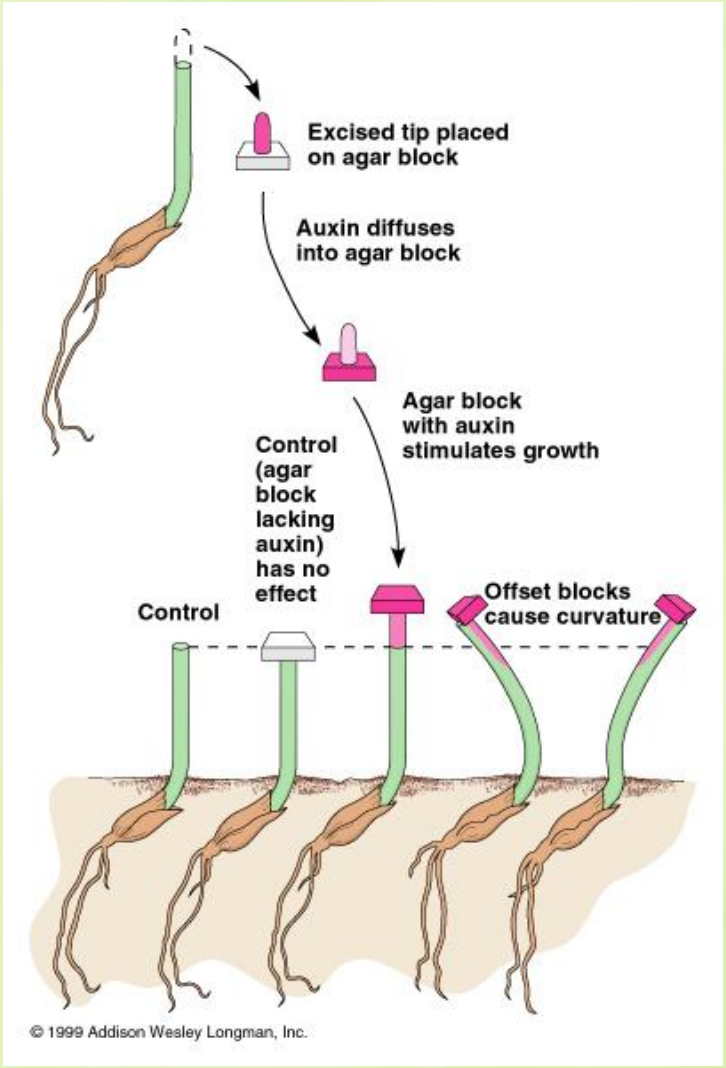
CH2 COOH
N
H
(a) IAA (Indoleacetic acid)
NH2
CH2 CH
COOH
N
H
(b) Tryptophan
O CH2 COOH
Cl
Cl
(c) Dichlorophenoxyacetic acid (2,4-D)

- Auxin increases the plasticity of plant cell walls and is involved in stem elongation.
- Arpad Paál (1919) - Asymmetrical placement of cut tips on coleoptiles resulted in a bending of the coleoptile away from the side onto which the tips were placed (response mimicked the response seen in phototropism).
- Frits Went (1926) determined auxin enhanced cell elongation.

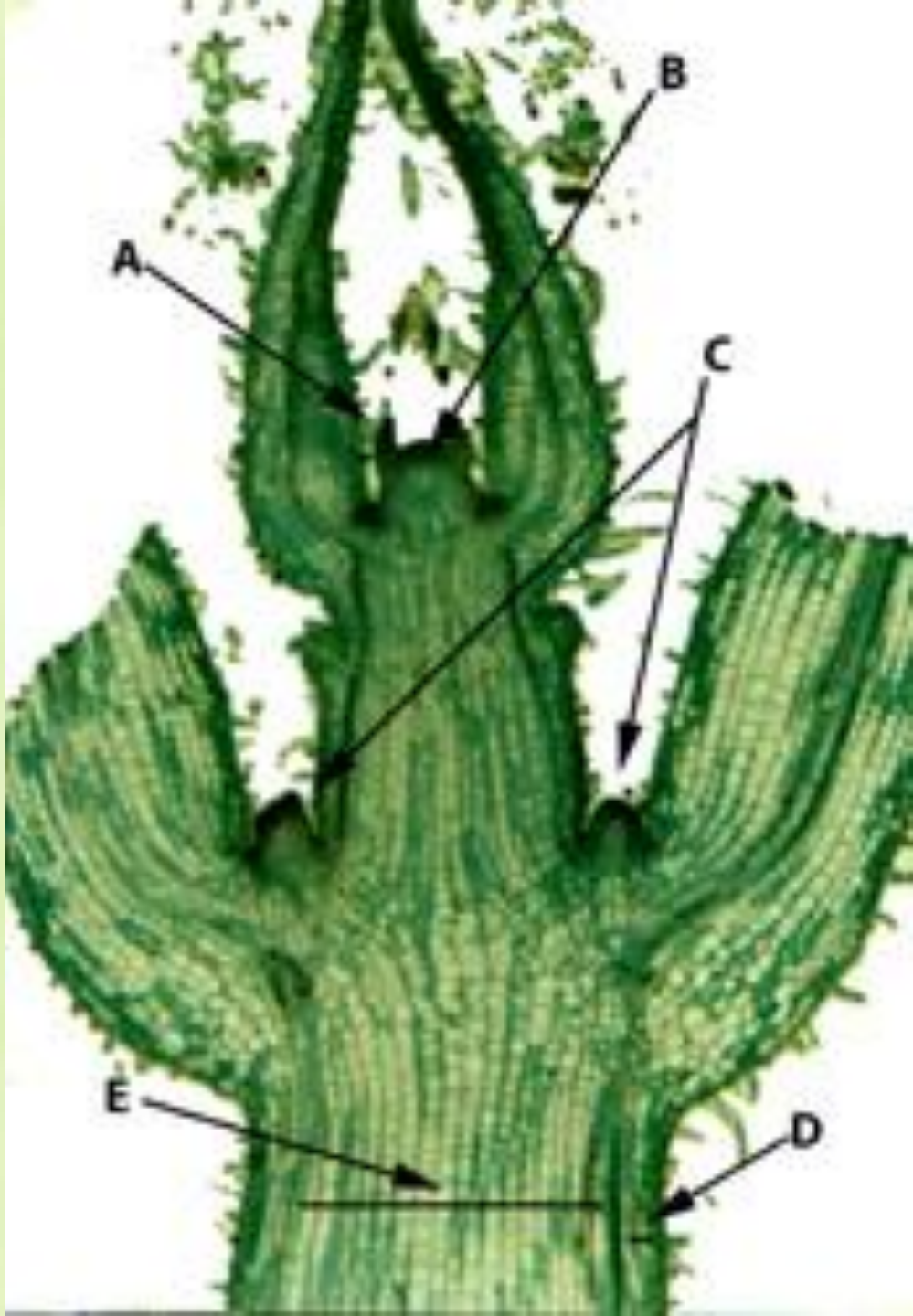


# Demonstration of transported chemical

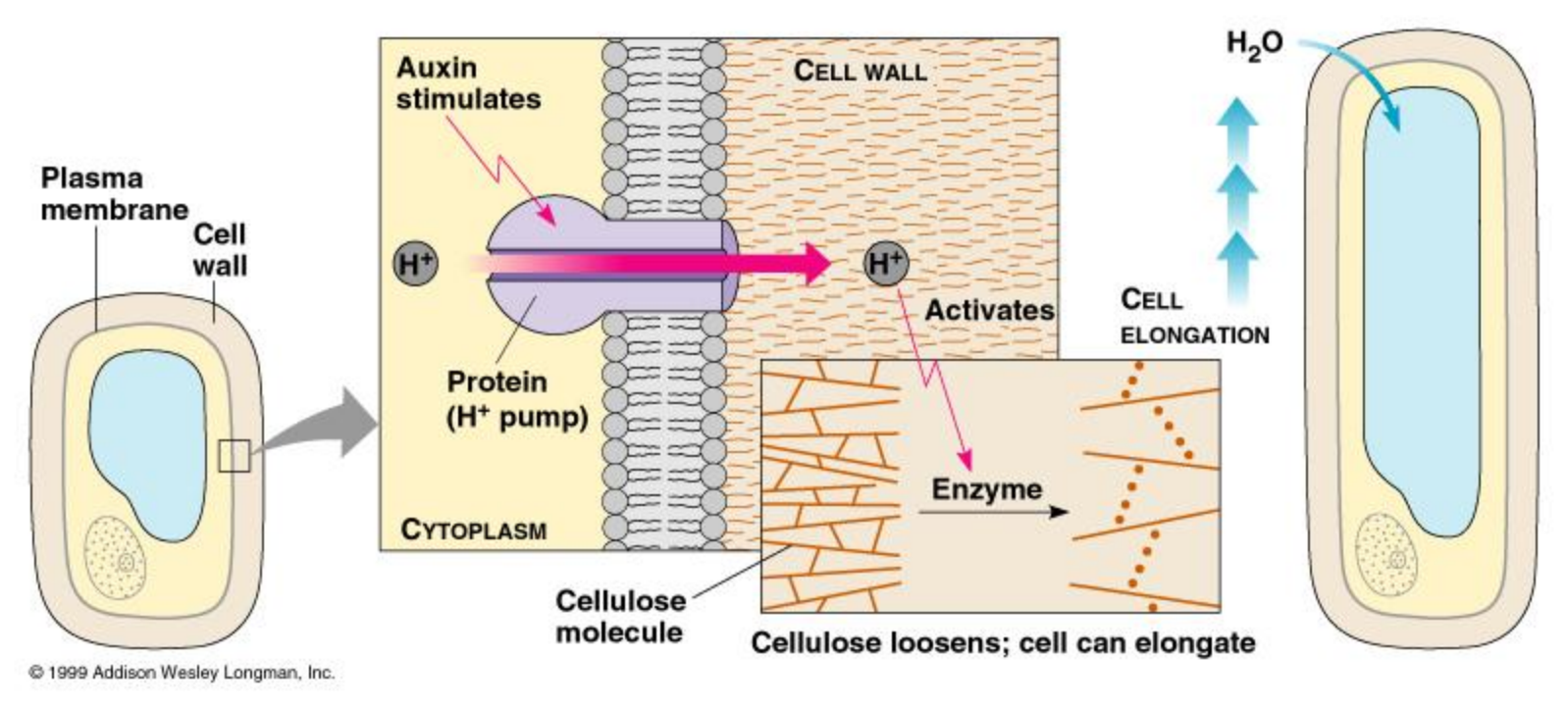


# Auxins

- Stem elongation
- Produced in tips of stems (“B” in photo)
- Migrate from cell to cell in stems



# Loosening of cell wall



# Phototropism – ability to bend towards light

- Auxins - responsible for plants bending towards light.
- Auxins - move down shaded side of the stem and cause cells to elongate

# Gravitropism (geotropism) – plant response to gravity

- Auxins – responsible for plant response to gravity

- Auxins – move to lowest side and cause stem tissue to elongate – stem curves upwards

# Root development

- Auxins encourage root development in cuttings
- Some plants produce plenty of auxins to make rooting cuttings easy
- Other plants need synthetic auxins such as IBA

# Auxin

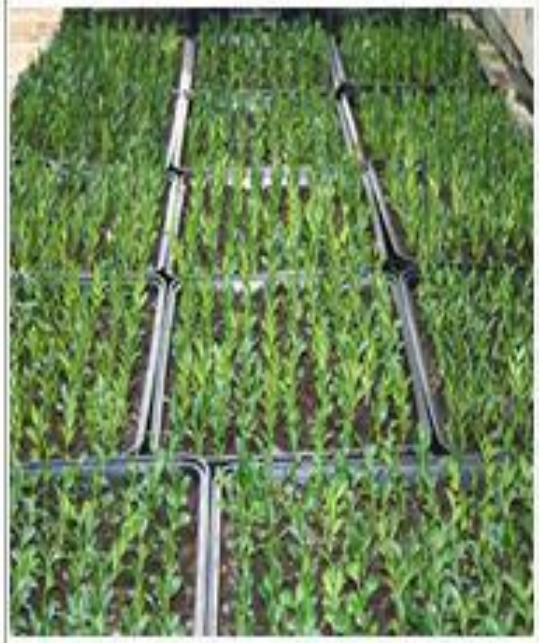
- Synthetic auxins
  - ❖widely used in agriculture and horticulture
    - ❖prevent leaf abscission
    - ❖prevent fruit drop
    - ❖promote flowering and fruiting
    - ❖control weeds
  - ❖ Agent Orange - 1:1 ratio of 2,4-D and 2,4,5-T used to defoliate trees in Vietnam War.
    - ❖Dioxin usually contaminates 2,4,5-T, which is linked to miscarriages, birth defects,leukemia, and other types of cancer.

# Additional responses to auxin

- abscission - loss of leaves
- flower initiation
- sex determination
- fruit development
- apical dominance

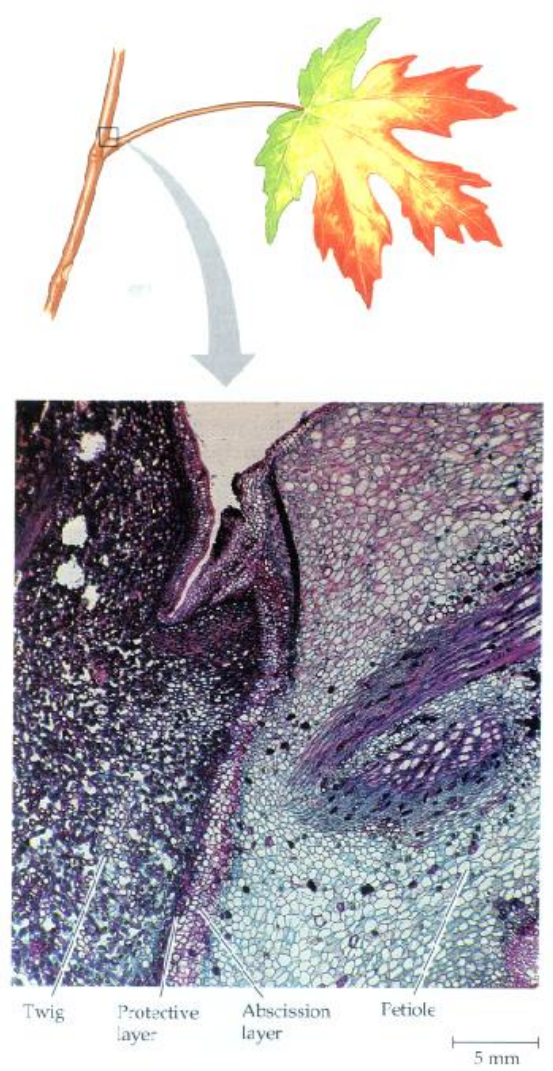
| | | |
|---|---|---|
| 1 | Cell divisions and enlargement Eg. cambial growth in diameter | .IAA + GA |
| 2 | Tissue culture | Shoot multiplications (IBA and BAP),callus Growth (2,4,-D), root multiplication IAA and IBA (1-2 mg) |
| 3 | Breaking dormancy and Apical dominance | NAA |
| 4 | Shortening internode | Apple trees (NAA) (dwarf branch-fruit) |
| 5 | Rooting of cuttings | (10-1000 ppm - NAA, IAA, phenyl acetic acid) |
| 6 | Prevent lodging | NAA- develop woody and erect stem |
| 7 | Prevent abscission | Premature leaf, fruit, flower fall (NAA, IAA and 2,4-D) |
| 8 | Parthenocarpic fruit | Grapes, banana, orange - (IAA) |
| 9 | Flower initiations | Pine apple -uniform flowering - fruit ripening (NAA). Delay flowering (2,4-D) |
| 10 | Weed eradications | 2,4,D and auxin compounds |

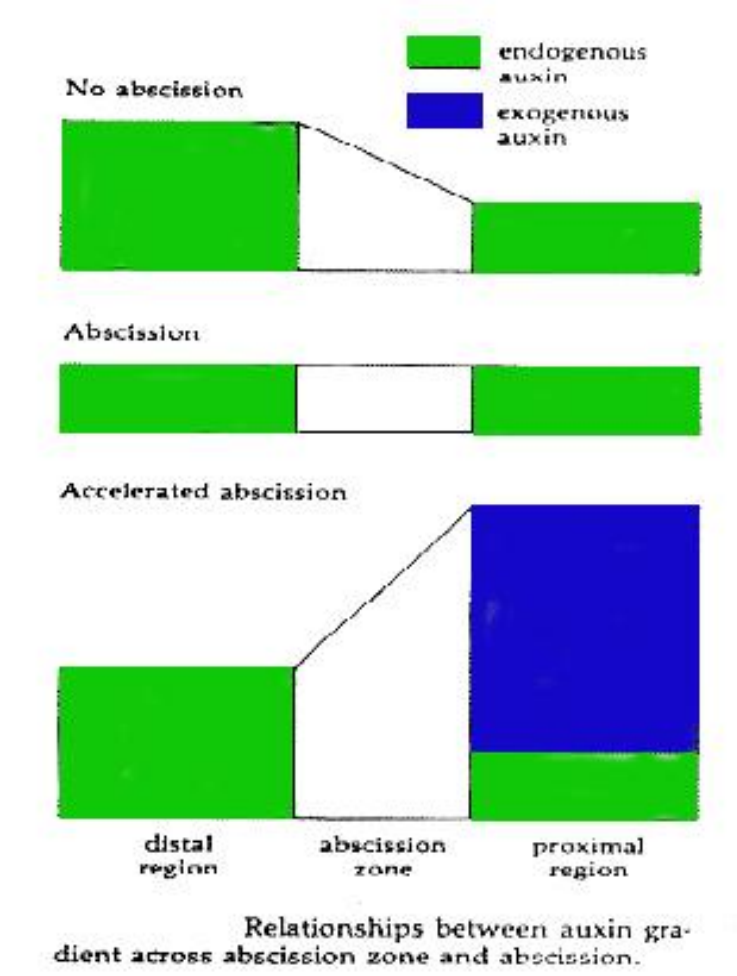
Preventing fruit abscission



Tissue culture: Callus growth and Shoot multiplication

# Control of abscission by auxin



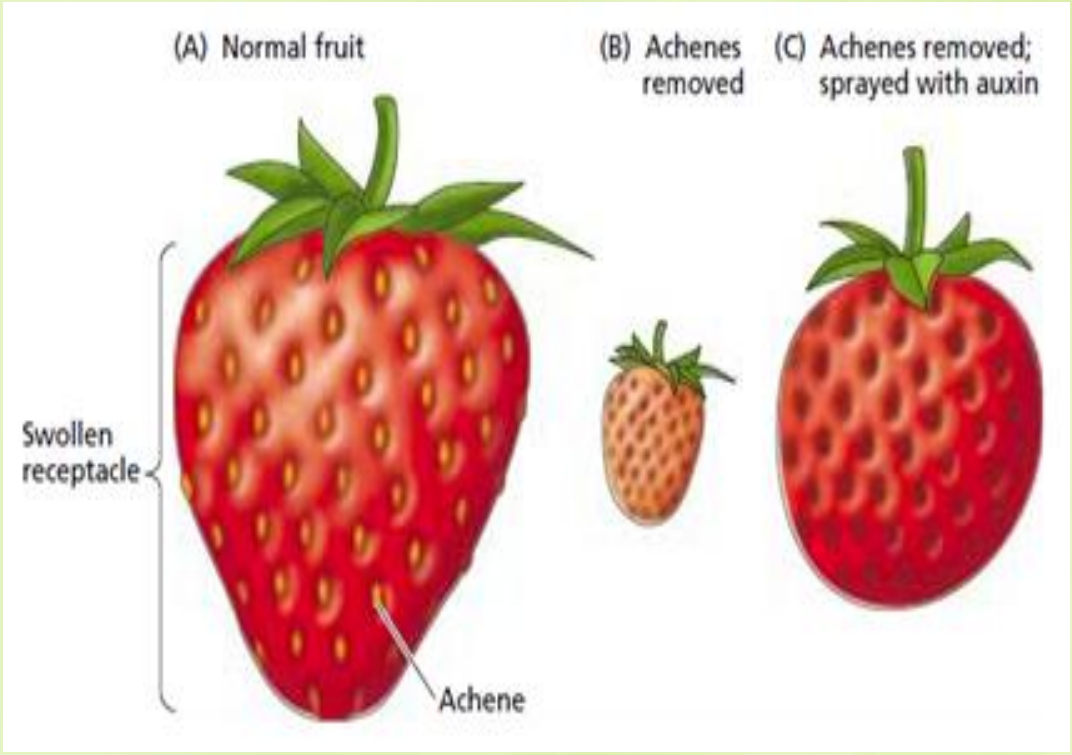

Relationships between auxin gradient across abscission zone and abscission.

# Apical Dominance

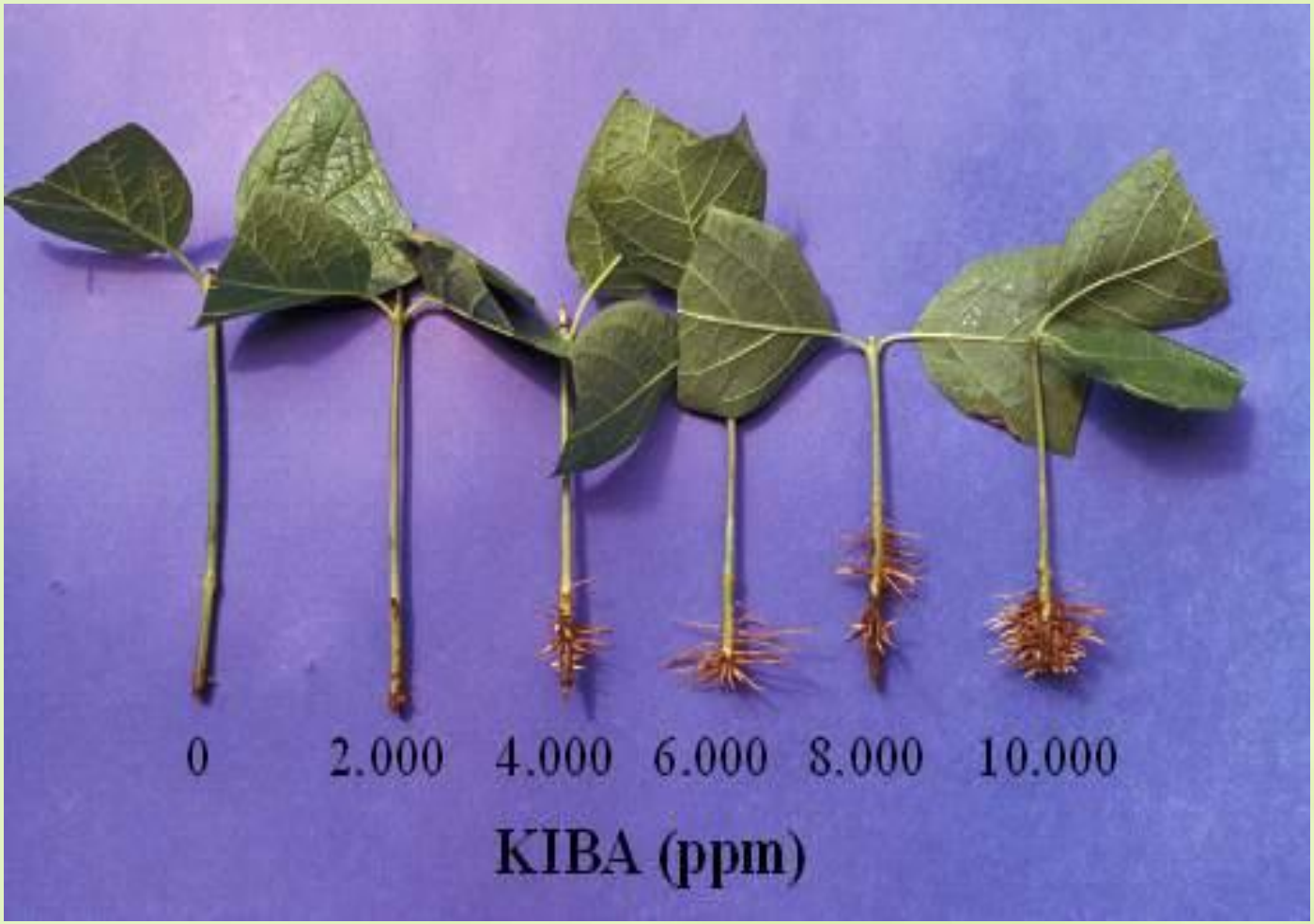
- Lateral branch growth are inhibited near the shoot apex, but less so farther from the tip.
- Apical dominance is disrupted in some plants by removing the shoot tip, causing the plant to become bushy.

# Pinching

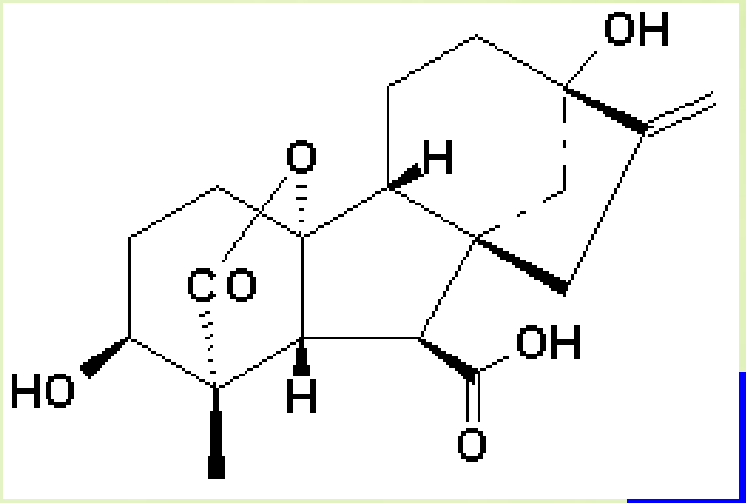
- Pinching = removing the terminal bud
- Pinching - stops flow of auxins down the stem and allows side shoots to develop
- Produces bushy, well-branched crops

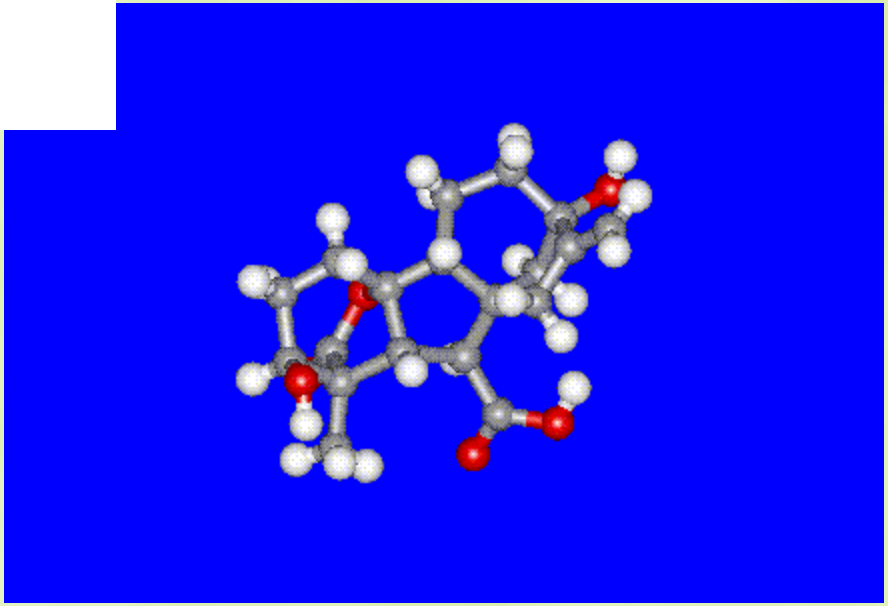



- Above describes the effect of auxin on strawberry development. The achenes produce auxin. When removed the strawberry does not develop (Raven, 1992).


0
2.000
4.000
6.000
8.000
10.000
KIBA (ppm)

# Gibberellin



# Effects of Gibberellins

- Cell elongation.
  - GA induces cellular division and cellular elongation; auxin induces cellular elongation alone.
  - GA-stimulated elongation does not involve the cell wall acidification characteristic of auxin-induced elongation
  - Breaking of dormancy in buds and seeds.
  - Seed Germination - Especially in cereal grasses, like barley. Not necessarily as critical in dicot seeds.
- Promotion of flowering.
- Transport is non-polar, bidirectional producing general responses.

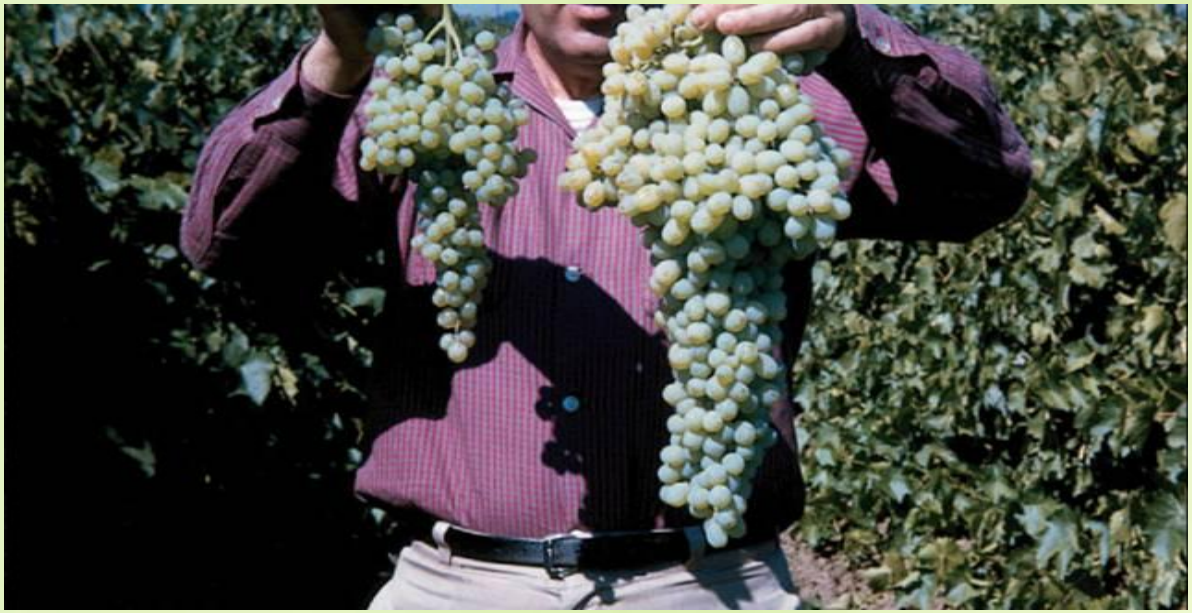
# Gibberellins

- Cell elongation and cell division
- Stimulate development of flowers (as in “gibbing” camelias)
- Cause internodes to stretch
- Produced in stem and root apical meristems, seed embryos, young leaves

# Internode Elongation

- Gibberellins cause internodes to stretch in relation to light intensity.
- High light intensity = no stretch
- Low light intensity = long internodes.  Leaves are raised to capture light

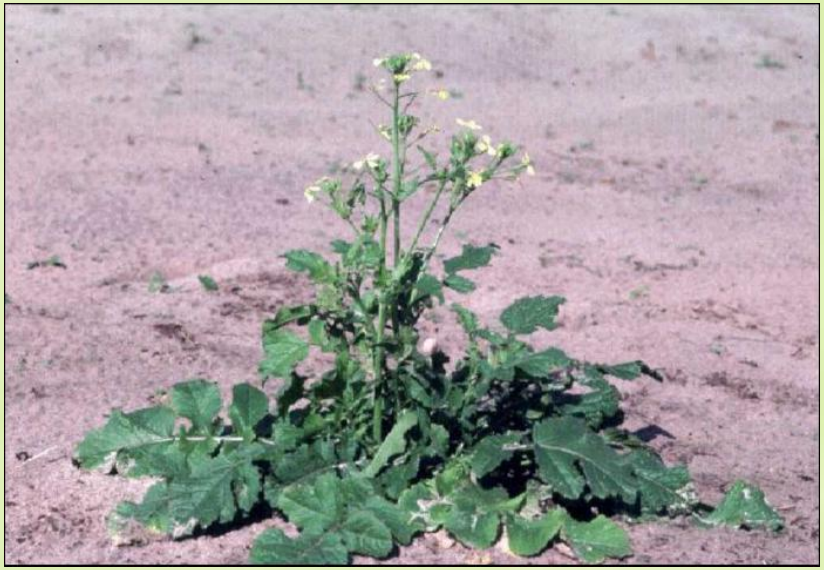
# Gibberellins and Fruit Size



# Wild Radish – Rosette & Bolt

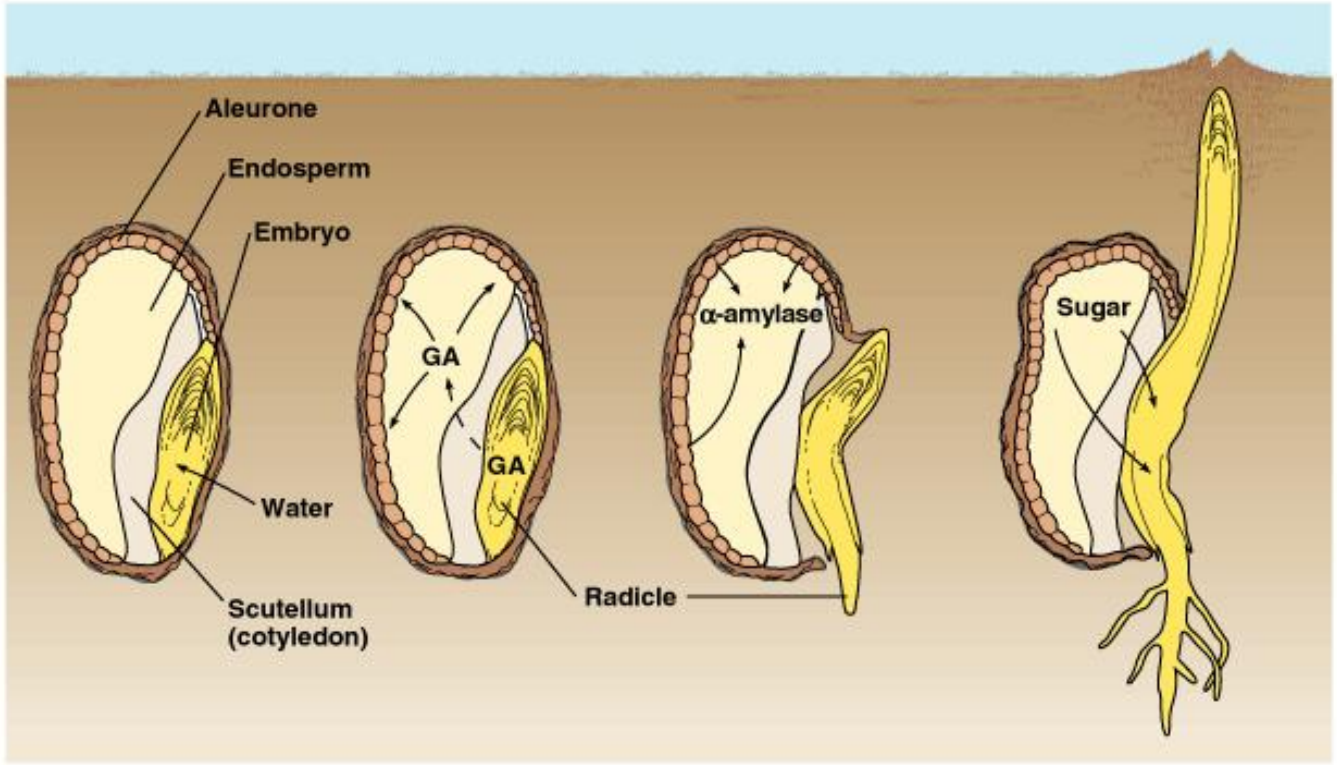
## A FLOWERING ANNUAL

YEAR ONE



YEAR ONE

# Mobilization of reserves



The effects of paclobutrazol, an inhibitor of gibberellin biosynthesis, on shoot growth and flowering of poinsettia

Dwarf Tall

High yielding semi-dwarf rice has reduced endogenous gibberellin

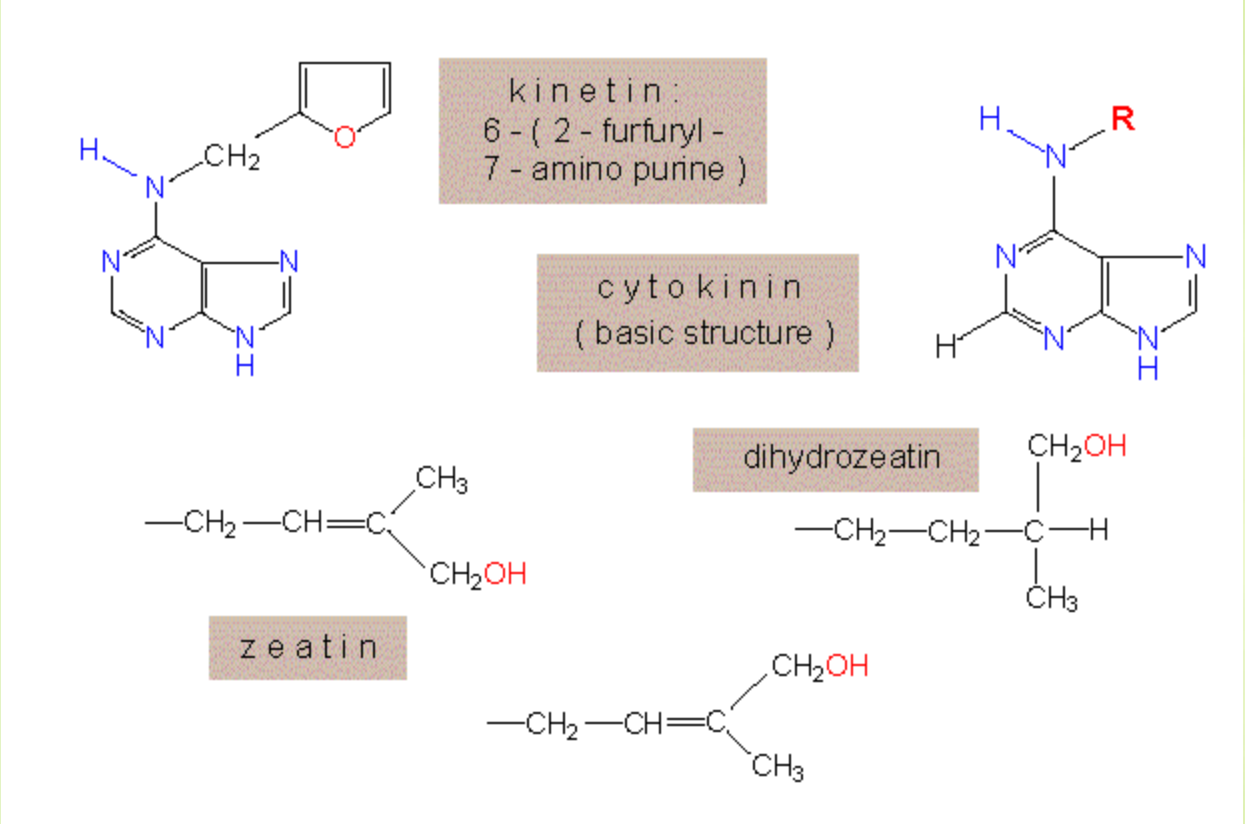

Fewer flowers and larger fruit

Delayed fruit harvest

Increased fruit size

GAs are used commercially to increase fruit size in table grapes and to regulate citrus flowering and rind maturation

# Cytokinins


kinetin :
6 - ( 2 - furfuryl -
7 - amino purine )
cytokinin
( basic structure )
dihydrozeatin
zeatin

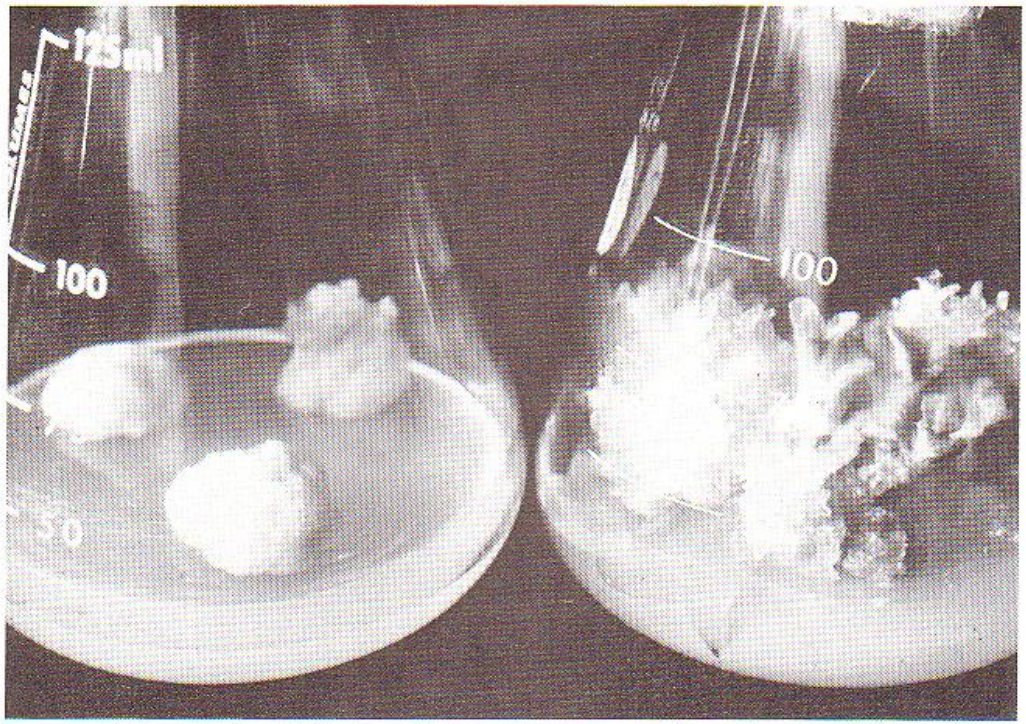
# Function of cytokinins

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

# Cytokinins

- Cytokinins, in combination with auxin, stimulate cell division and differentiation.
  - most cytokinin produced in root apical meristems and transported throughout plant
    - inhibit formation of lateral roots
      - auxins promote their formation

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

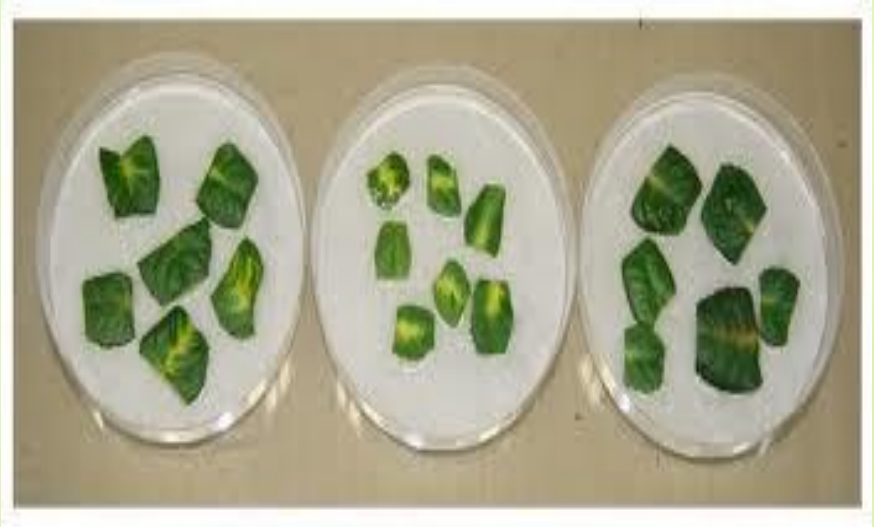


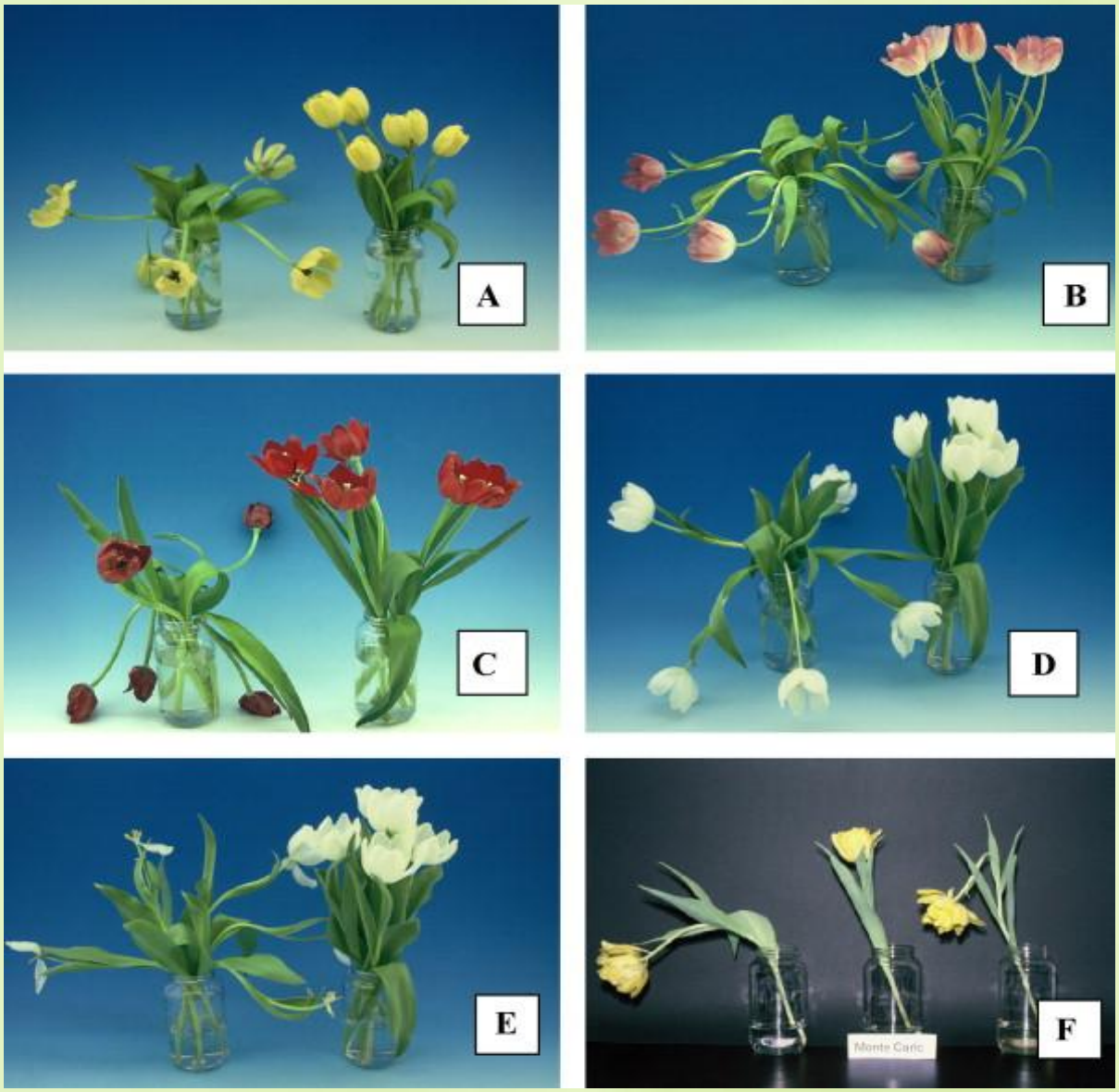

Tissue cultures of tobacco (*Nicotiana tabacum*) callus. By altering cytokinin-to-auxin ratio, tobacco stem pith tissue may be maintained in culture as undifferentiated callus (left) or induced to differentiate and bud into plantlets (right).

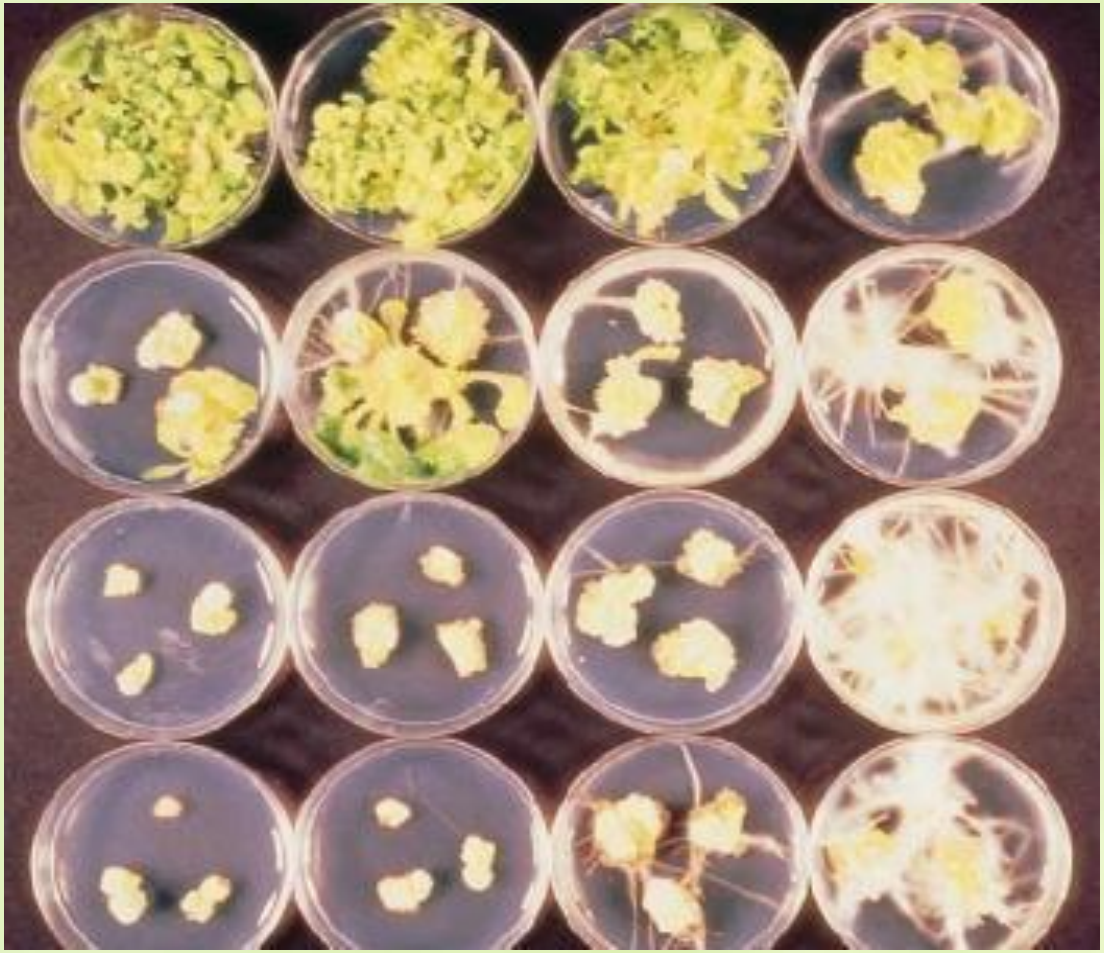
*From work of F. Skoog and C.O. Miller. Photo by F.H. Witham.*

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

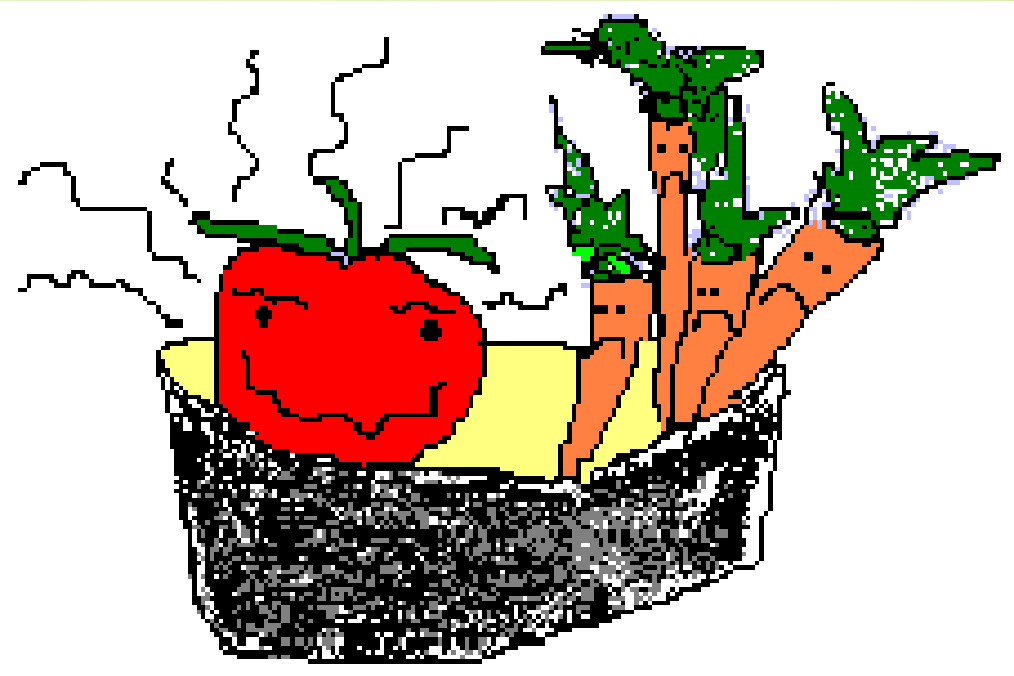
Leaf segments of control (left, middle) and transgenic line (right) during after postharvest stress treatment




A
B
C
D
E
F



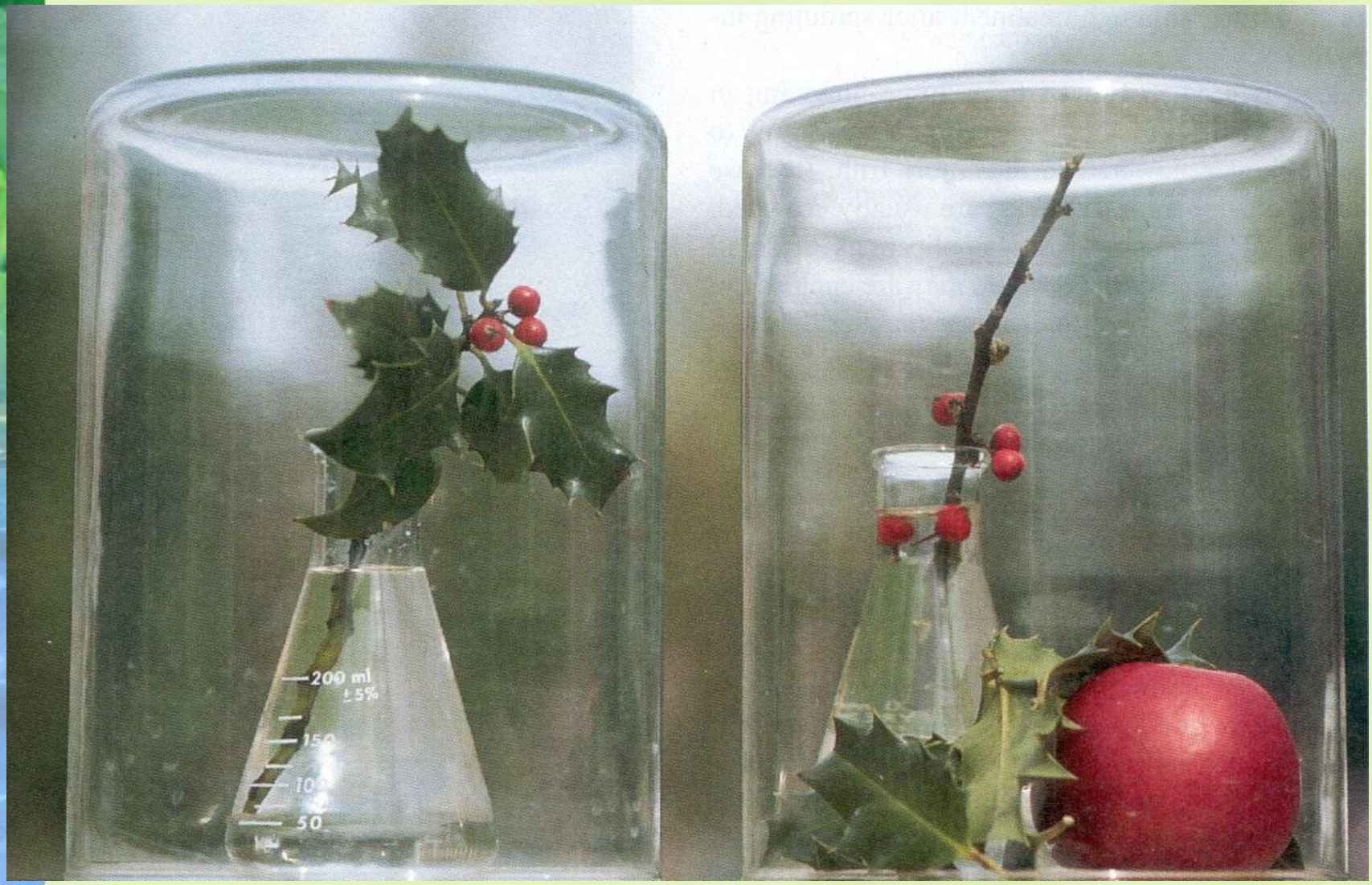
# Ethylene Gas



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


DEGREENED

# The Holly and the Ethylene

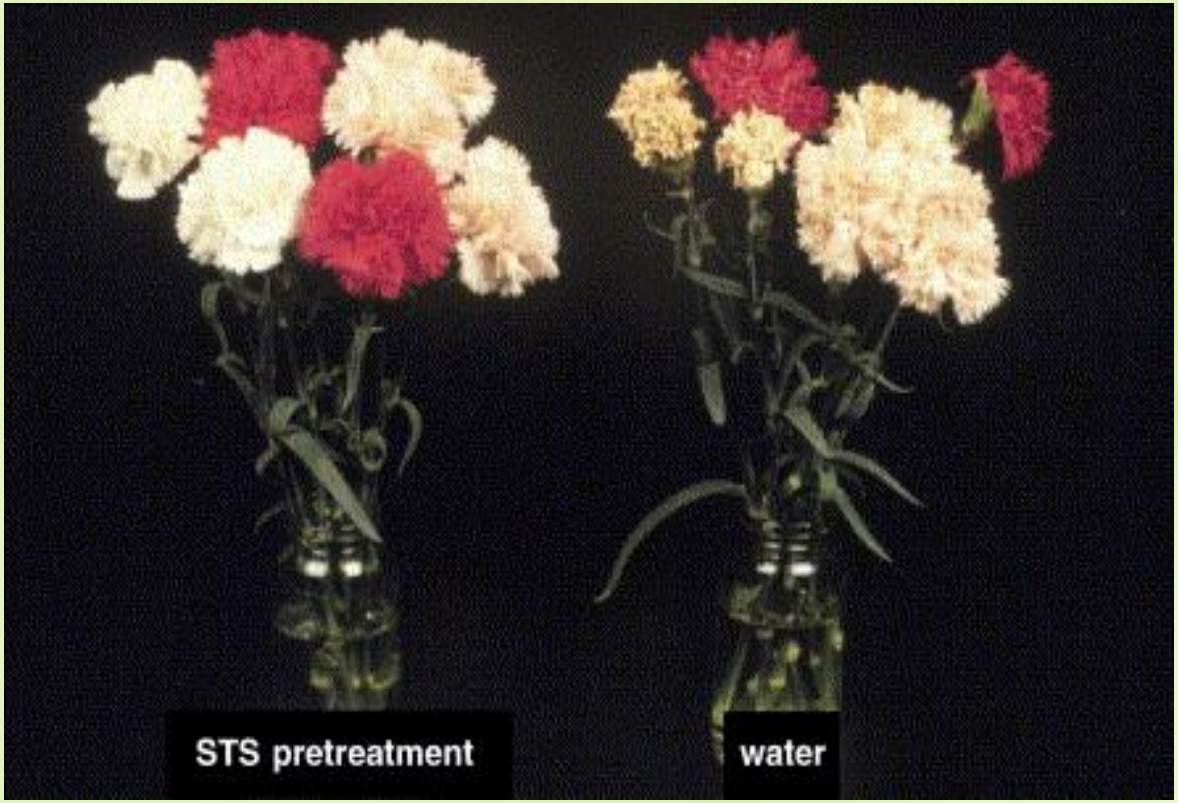


# Functions of ethylene

- 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.

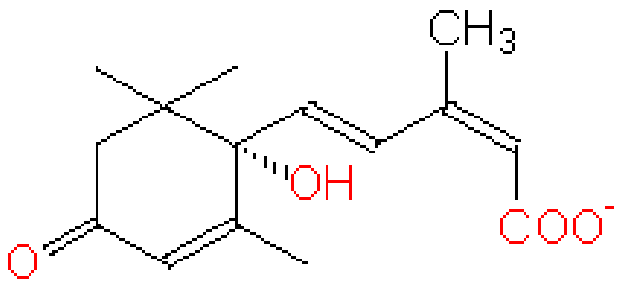
# Ethylene exposure

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

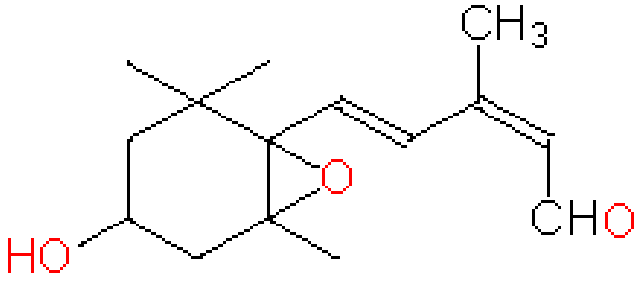



- Different varieties of carnation treated overnight with 0.2 mM STS solution. Photograph was taken after 10 days of vase life. Note that cultivar Chinera (pink colored), with reduced sensitivity to ethylene, benefits less from the STS pretreatment.

# Abscisic acid




abscisic acid ( ABA )



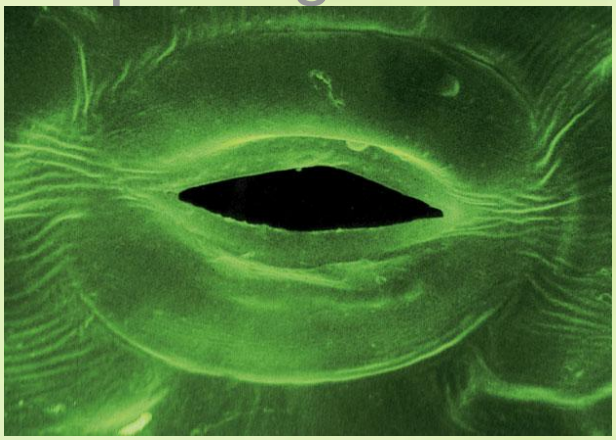

xanthoxine

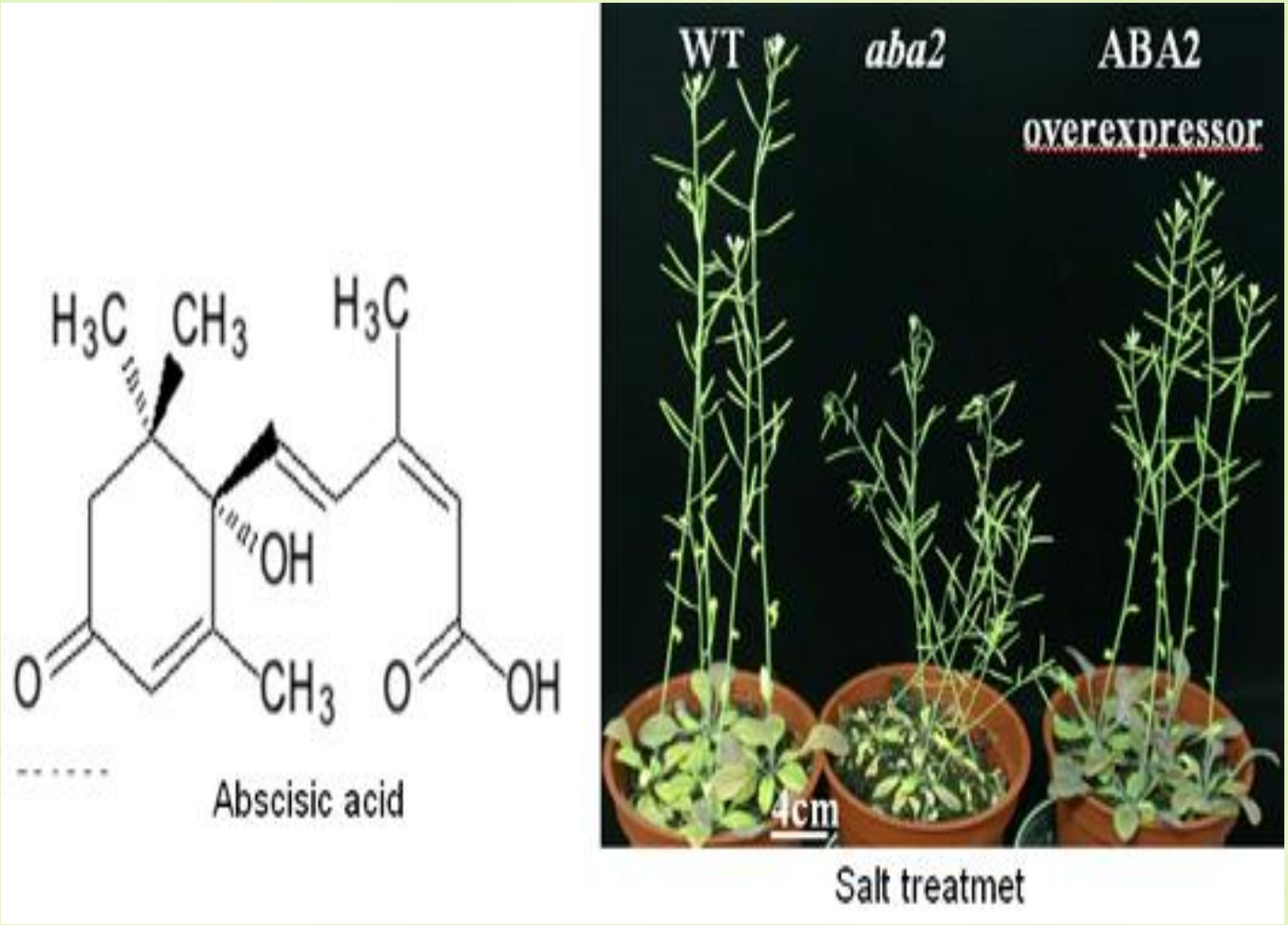
# Functions of abscisic acid

- General growth inhibitor.
- Causes stomatal closure.
- Produced in response to stress.

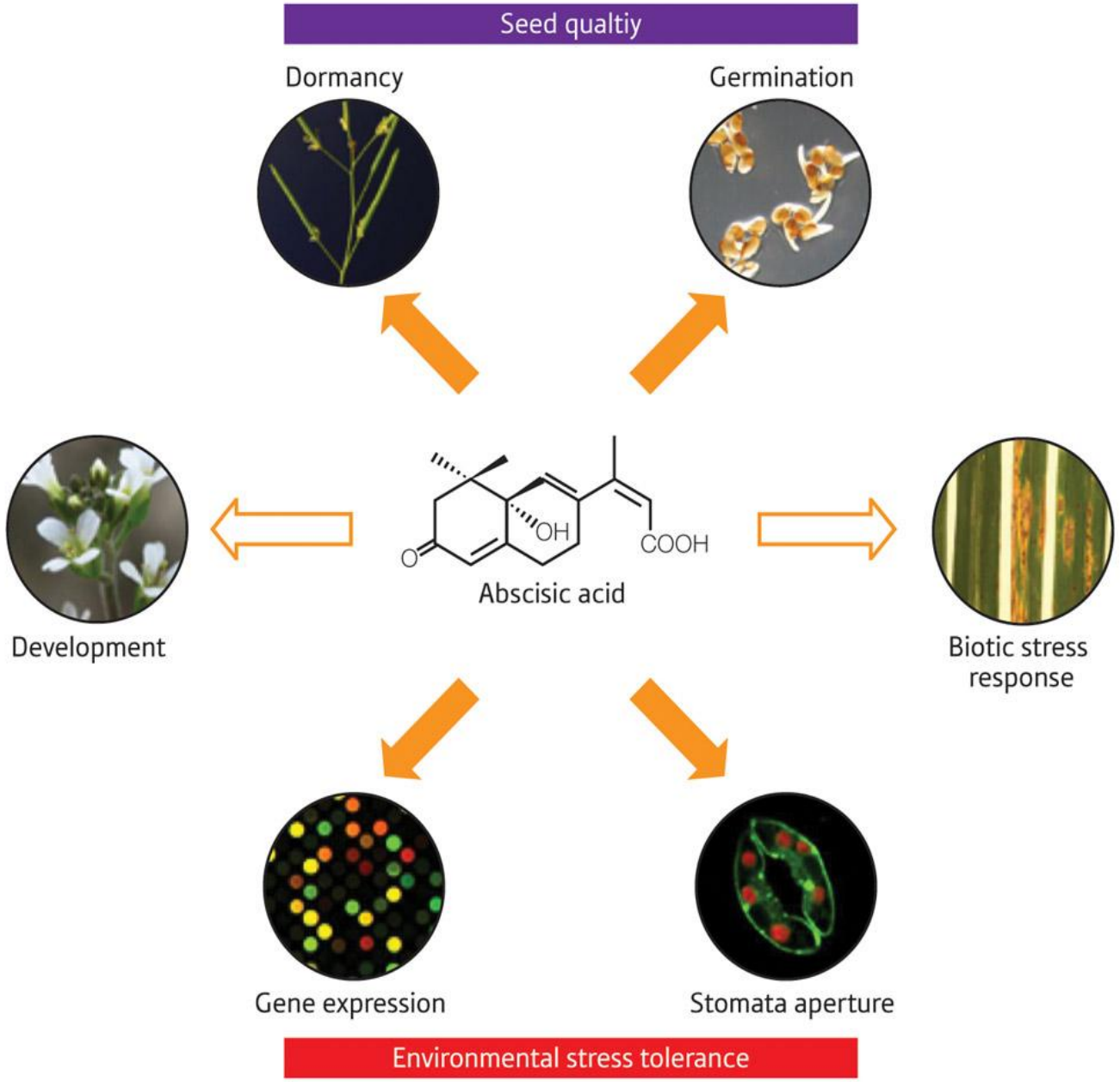
# Abscisic Acid

- 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 qualtiy
Dormancy
Germination
Development
OH
COOH
Abscisic acid
Biotic stress response
Gene expression
Stomata aperture
Environmental stress tolerance