Regulation of Plant Growth by Plant Hormones

Plant hormones

- The 5 main groups of plant hormones
    - Auxin
    - Cytokinins
    - Ethylene
    - Abscisic Acid
    - Gibberellins
- *Brassica rapa*, a model plant species for experimentation
- Design and begin group GA experiments

Hormones

Greek *horman* = to stimulate

Substance or chemical that is transported and causes specific physiological effects

Hormones in plants

- Hormones can have effects on the cells that produce them and, after transport, at the target cells or tissues
- Hormones can have inhibitory rather than stimulatory effects
- 5 main groups based on chemical structure

Auxin

Production

- Shoot tips
- Developing seeds

Some known actions

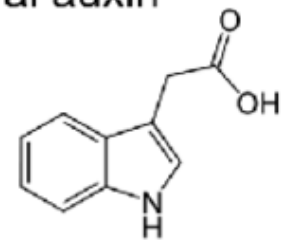
- Establishment of polarity of root-shoot axis during embryogenesis
- Cell elongation
- Cell differentiation
- Apical dominance
- Lateral root formation and adventitious root formation
- Fruit formation

Auxins

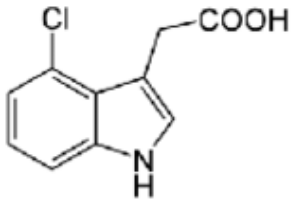
- On the molecular level, all auxins are compounds with an aromatic ring and a carboxylic acid group.
- The most important member of the auxin family is indole-3-acetic acid (IAA), which generates the majority of auxin effects in intact plants, and is the most potent native auxin.

Auxins

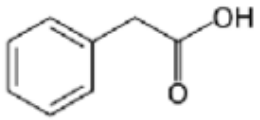
Natural auxin



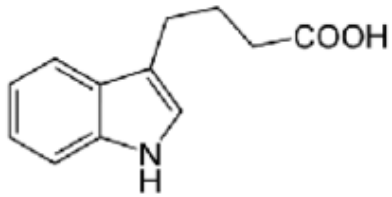
IAA



4-Cl-IAA

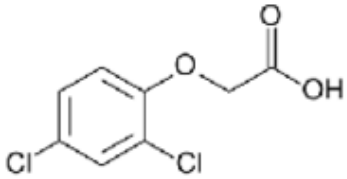


PAA

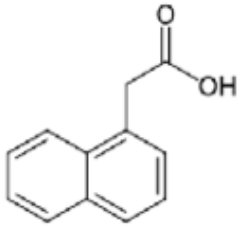


IBA

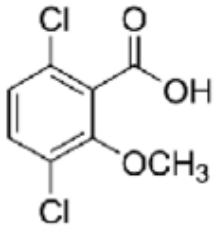
Synthetic auxin



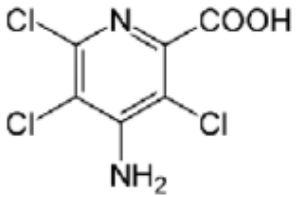
2,4-D



NAA

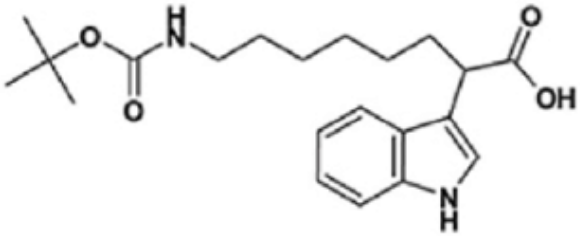


Dicamba

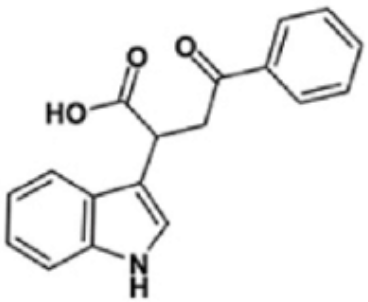


Picloram

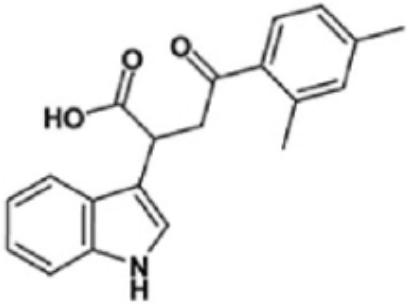
Anti-auxin



BH-IAA

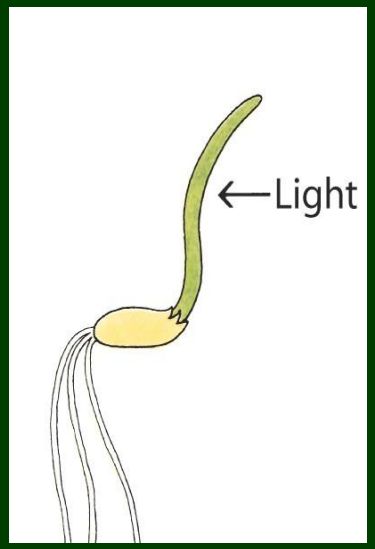


PEO-IAA

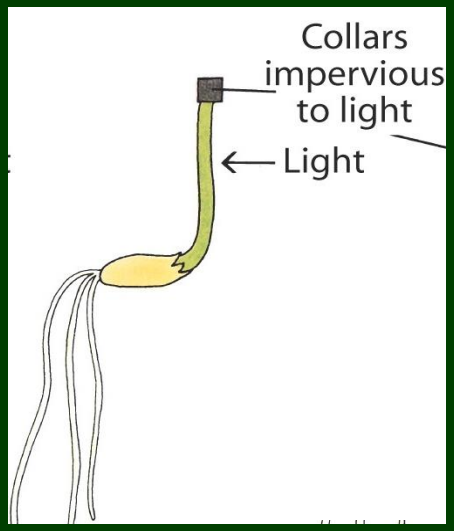


Auxinole

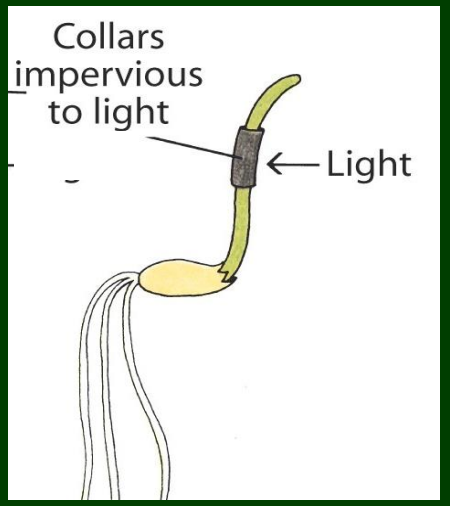
Darwins' (Charles and son) experiment



Under normal conditions, shoot tips bend towards the light



Without light on the tip, no bending



When not at tip, collar doesn't prevent bending

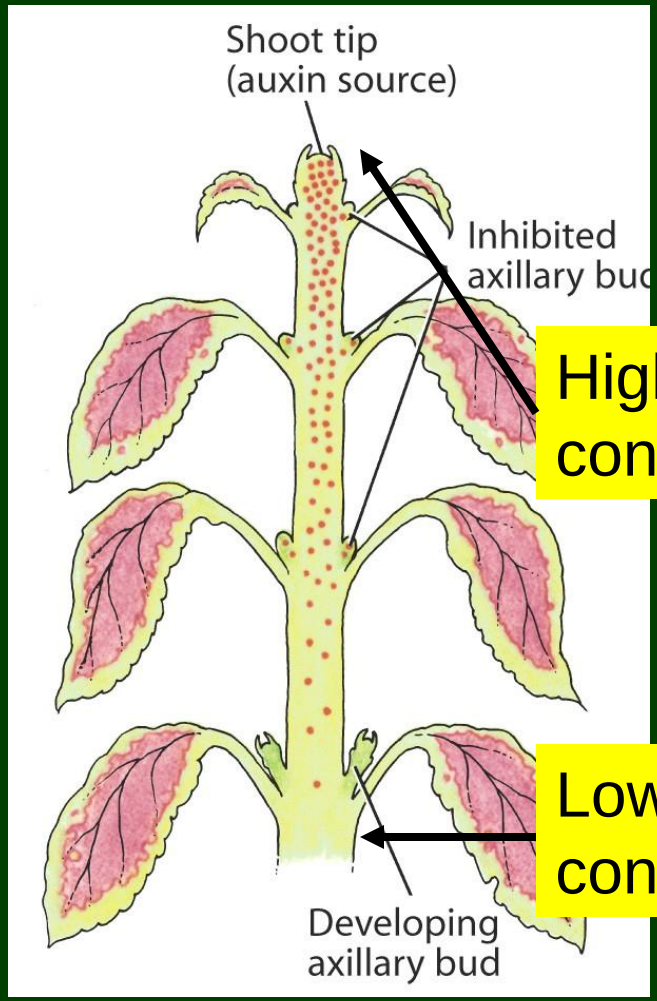
Conclusion: Light is sensed at the tip, but response not at tip

New hypothesis: A substance or chemical is transported

Auxin later isolated from shoot tips and established to be involved in cell elongation

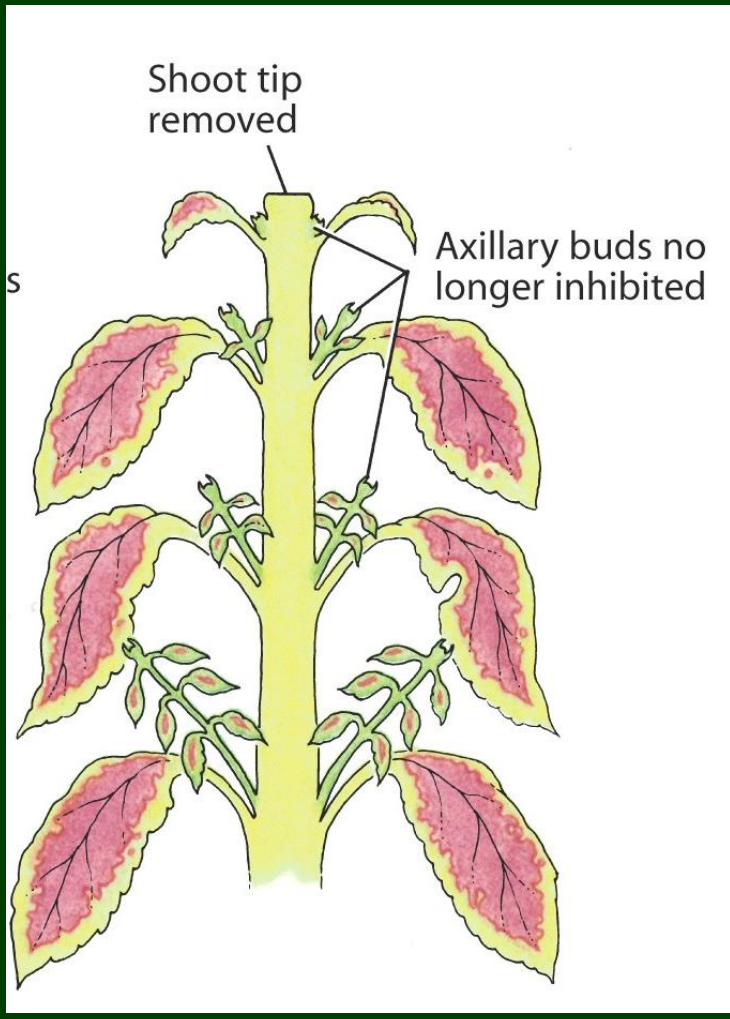
Drawings depicting seedlings of *Zea* (Poacae family)

Evidence for the role of auxin in apical dominance



High auxin concentration

Low auxin concentration



Drawings depicting *Coleus* (Lamiaceae family)

Evidence for the role of auxin in adventitious root formation

With synthetic auxin

Without synthetic auxin

Adventitious roots growing from stem tissue

Saintpaulia (Gesneriaceae family)
African violet plant

Evidence for the role of auxin in formation of fruit and structures of similar function

(*e.g.* receptacle in strawberry)

Normal conditions

All achenes removed

Band of achenes removed

Without seed formation, fruits do not develop. Developing seeds are a source of auxin.

What do you expect?

Not shown: Auxin replacement restores normal fruit formation and can be used commercially to produce seedless fruits

However, too much auxin can kill the plant and thus synthetic auxins used commercially as herbicides

Fragaria (Rosaceae family)

Cytokinins

Production

- Primarily root tips

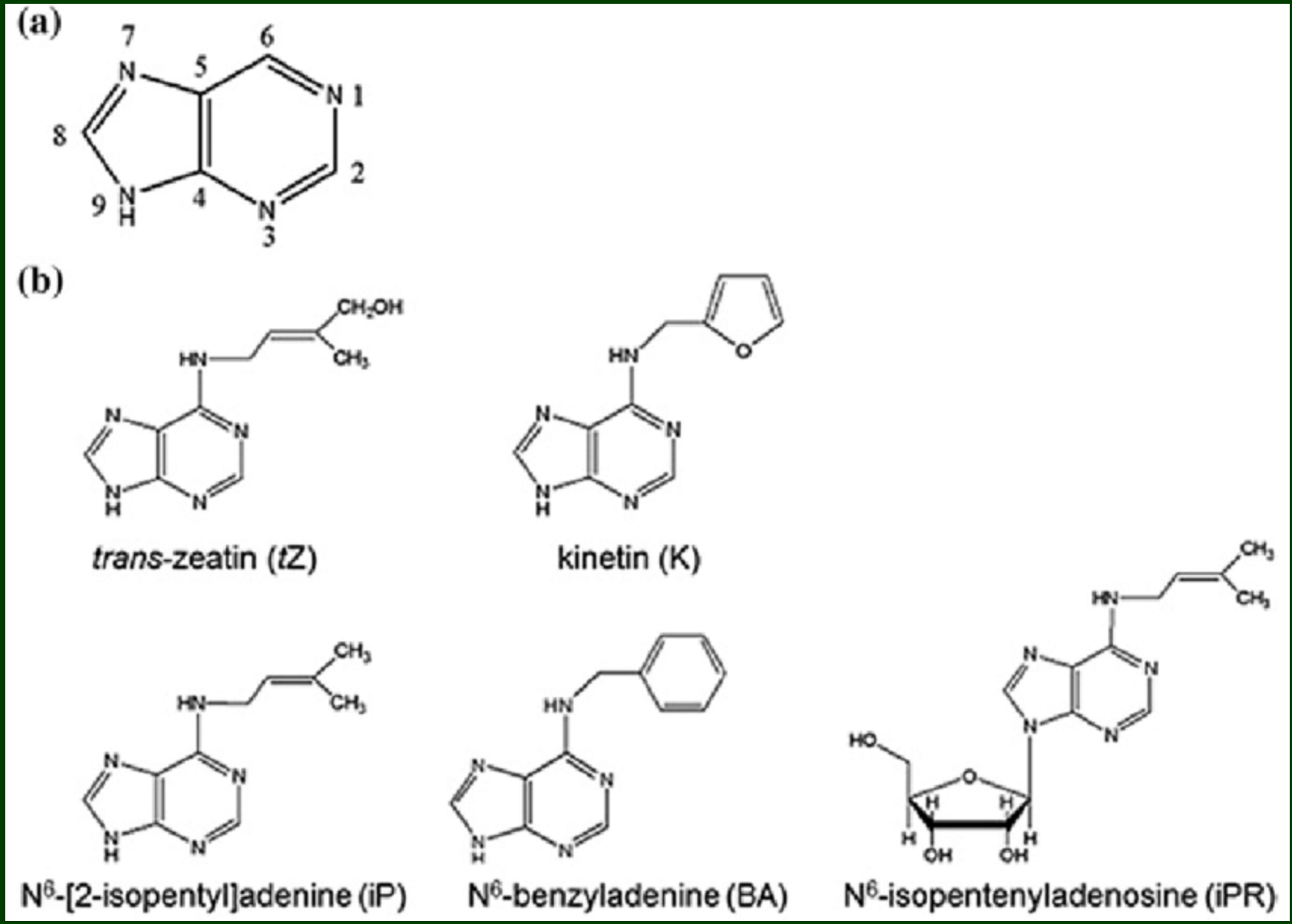
Some known actions

- Cell division (cytokinesis)
- Promote branching of axillary buds
- Delay leaf senescence

Cytokinins

- Cytokinins are plant-specific chemical messengers (hormones) that play a central role in the regulation of the plant cell cycle and numerous developmental processes.
- Cytokinins were discovered by F Skoog, C Miller, and co-workers during the 1950s as factors that promote cell division (cytokinesis).

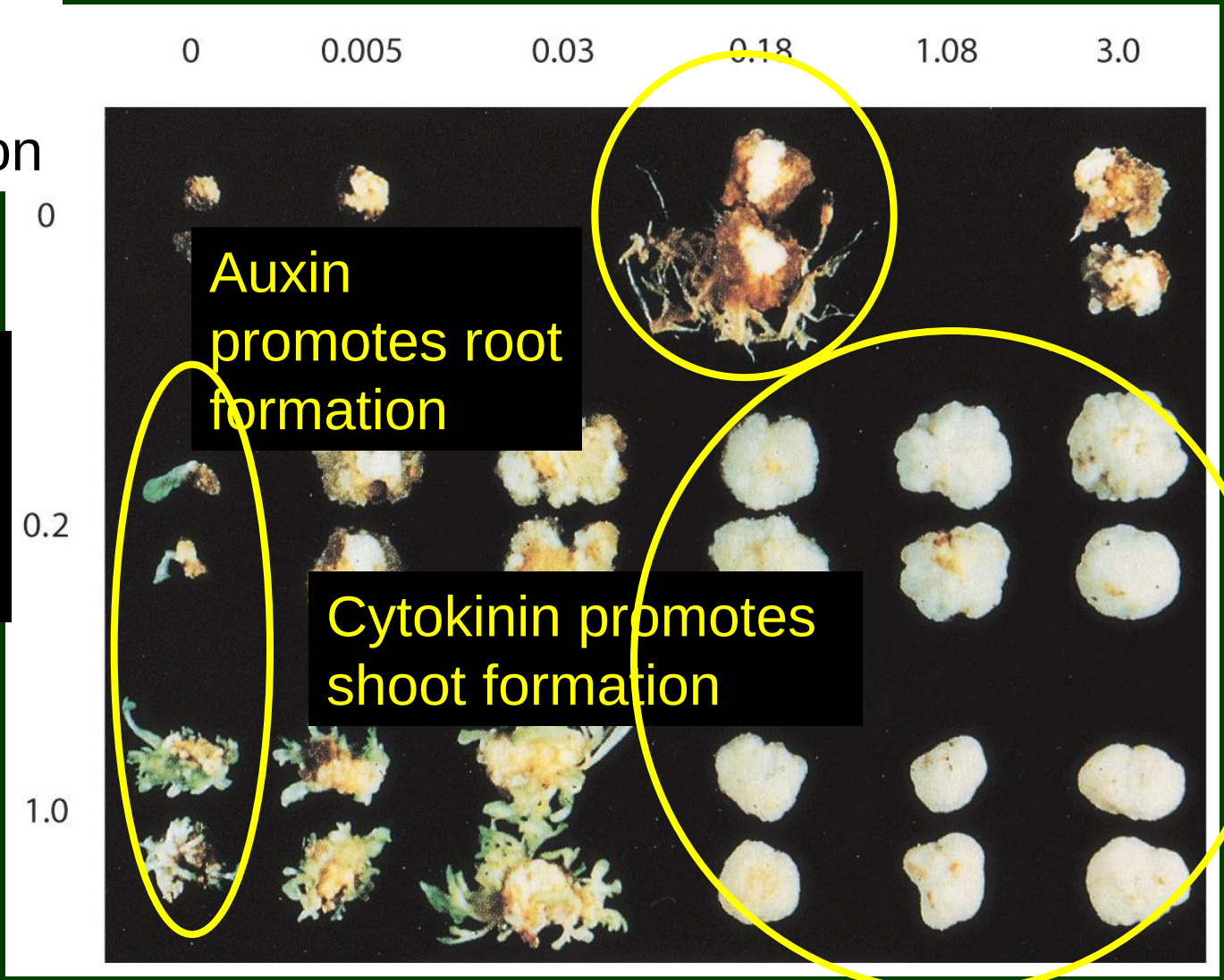
Cytokinins


(a)
(b)
trans-zeatin (tZ)
kinetin (K)
N6-[2-isopentyl]adenine (iP)
N6-benzyladenine (BA)
N6-isopentenyladenosine (iPR)

Cytokinin and auxin
complexity of plant-hormone effects and interactions

Increasing auxin concentration

Increasing Cytokinin concentration



Lack of differentiation when both are present

Callus of *Nicotiana* (Solanaceae family)

Cytokinin delays leaf senescence (ageing and reabsorption of aged organs)

Transgenic Untreated

Genetic modification to increase cytokinin biosynthesis

Nicotiana (Solanaceae family)

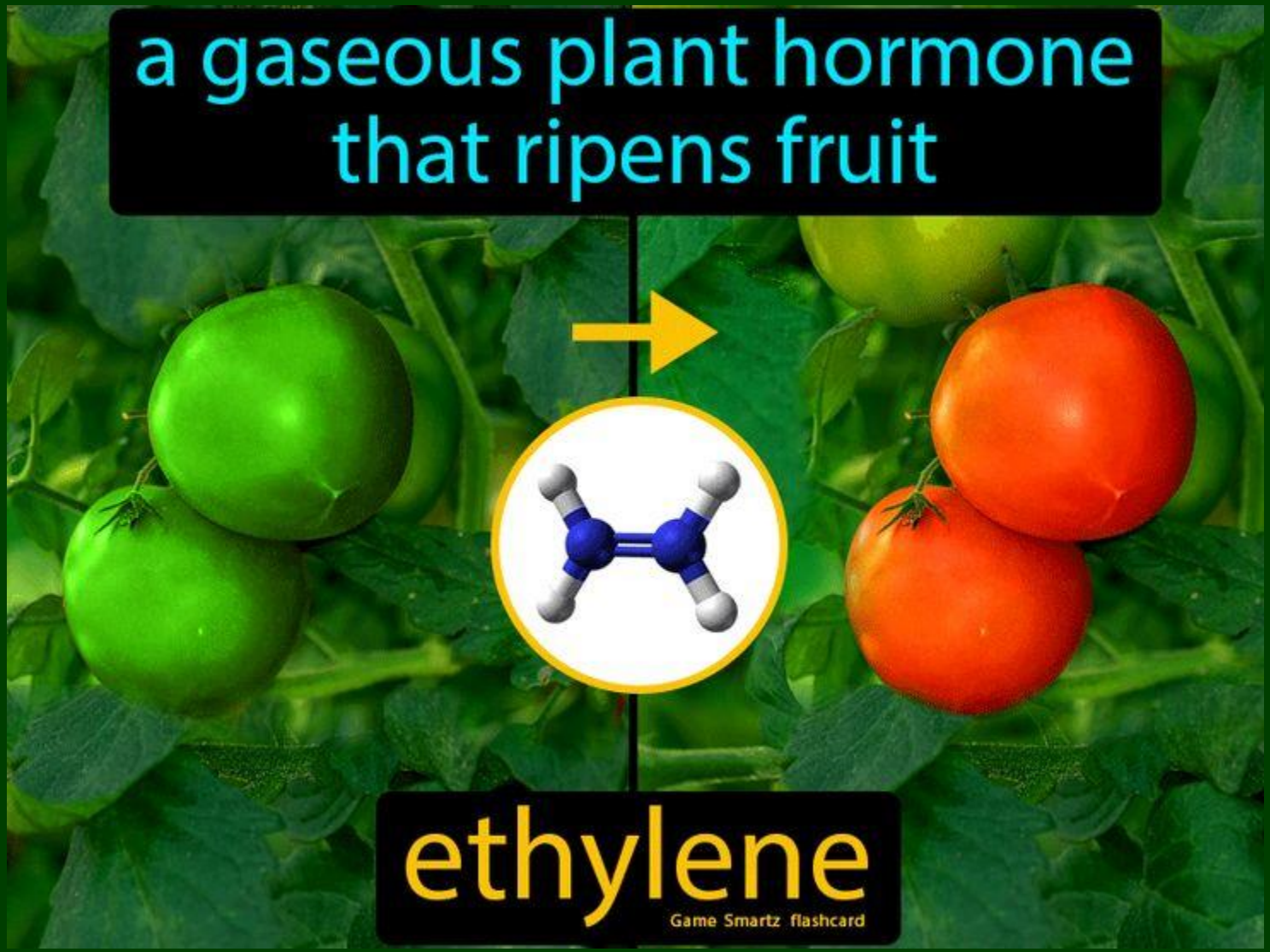
Ethylene

Production

- In most tissues under stress, senescence, or ripening

Some known actions

- Fruit ripening
- Leaf and flower senescence
- Leaf and fruit abscission (controlled separation of plant part from the main body)
- Floral sex determination in monoecious species, promote female


a gaseous plant hormone that ripens fruit
ethylene
Game Smartz flashcard

Experimenting with plant response to ethylene commercial uses

Mutated ethylene receptor

Normal ethylene receptor levels

Both are 100 days after picking

Lycopersicon (Solanaceae family)

Experimenting with plant response to ethylene commercial uses

Mutated ethylene receptor

Normal ethylene receptor levels

8 days after pollination

Petunia (Solanaceae family)

Abscisic Acid (ABA)

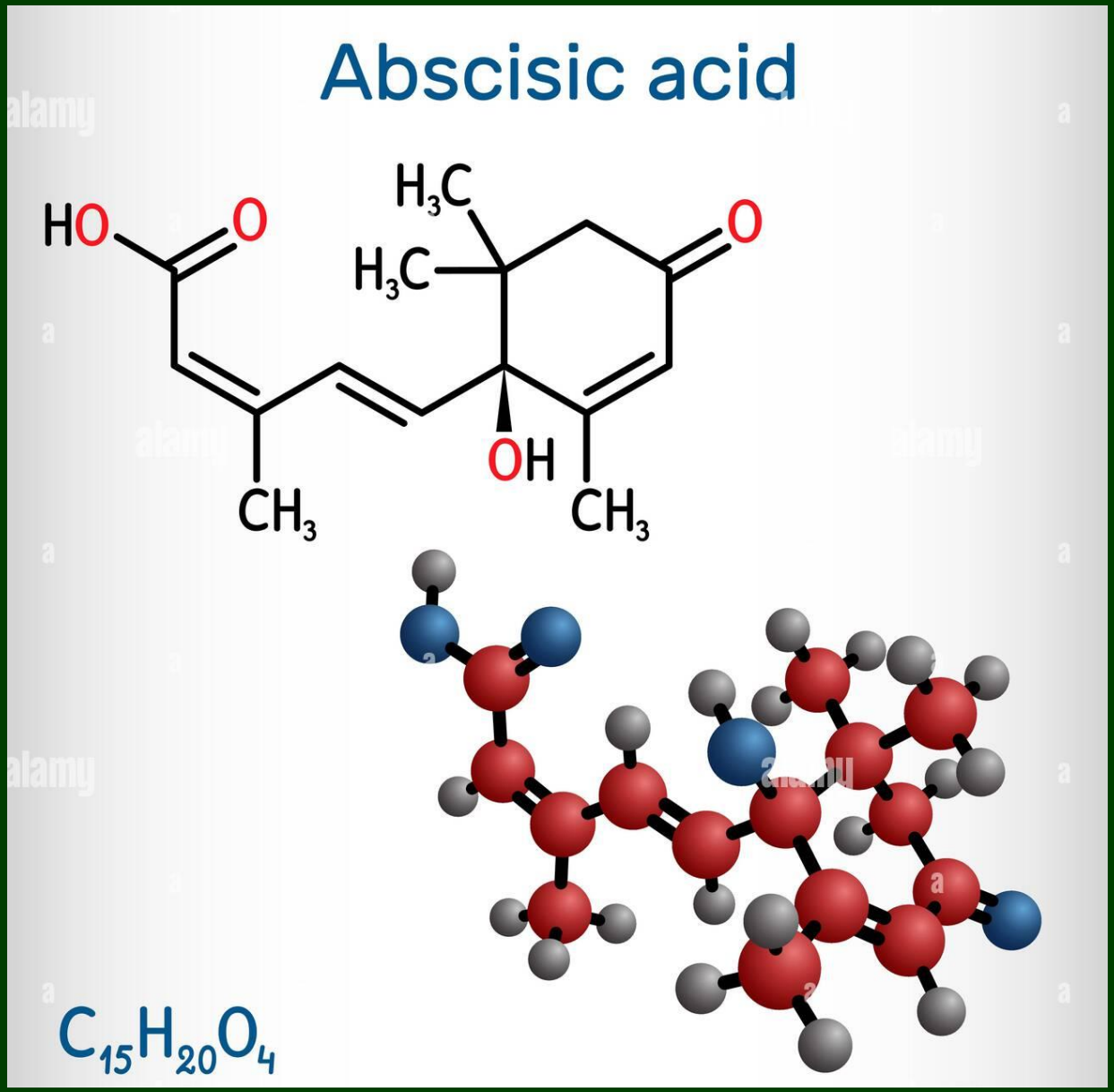
Production

- Mature leaves, especially under stress
- Roots, then transported to shoots

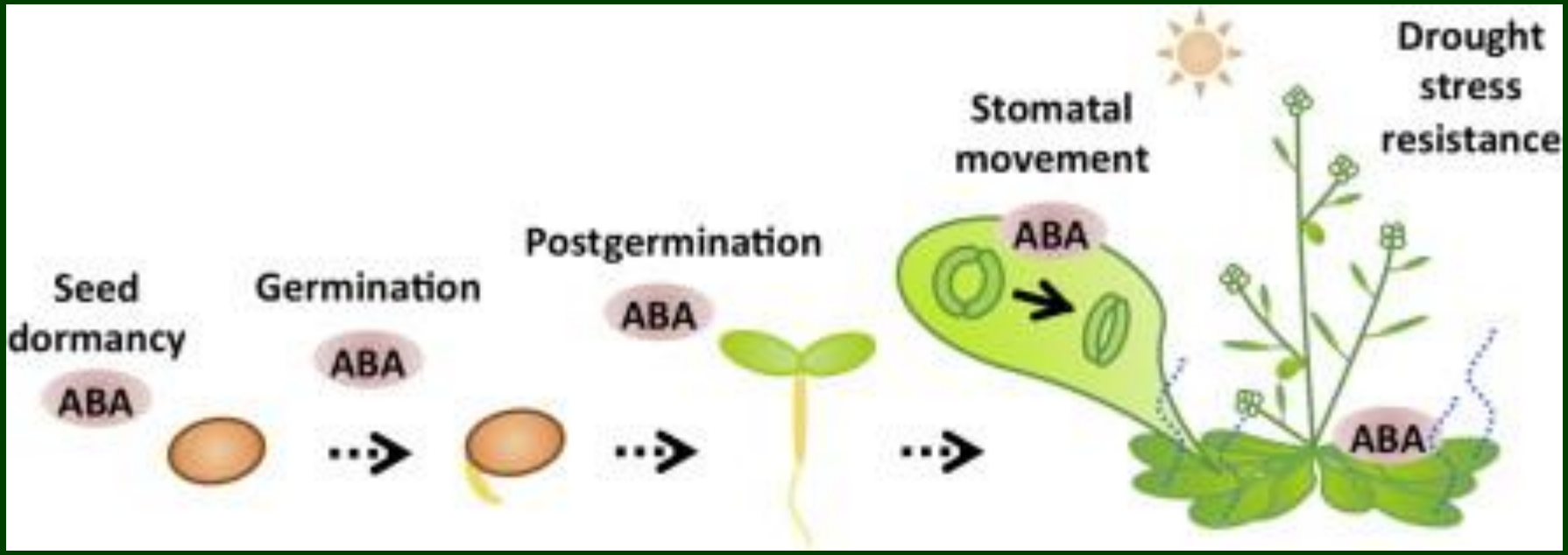
Some known actions

- Stress response
- Stimulate stomatal closure
- Inhibit premature germination of seeds
- Embryogenesis
- Seed dormancy maintenance

ABA chemical structure



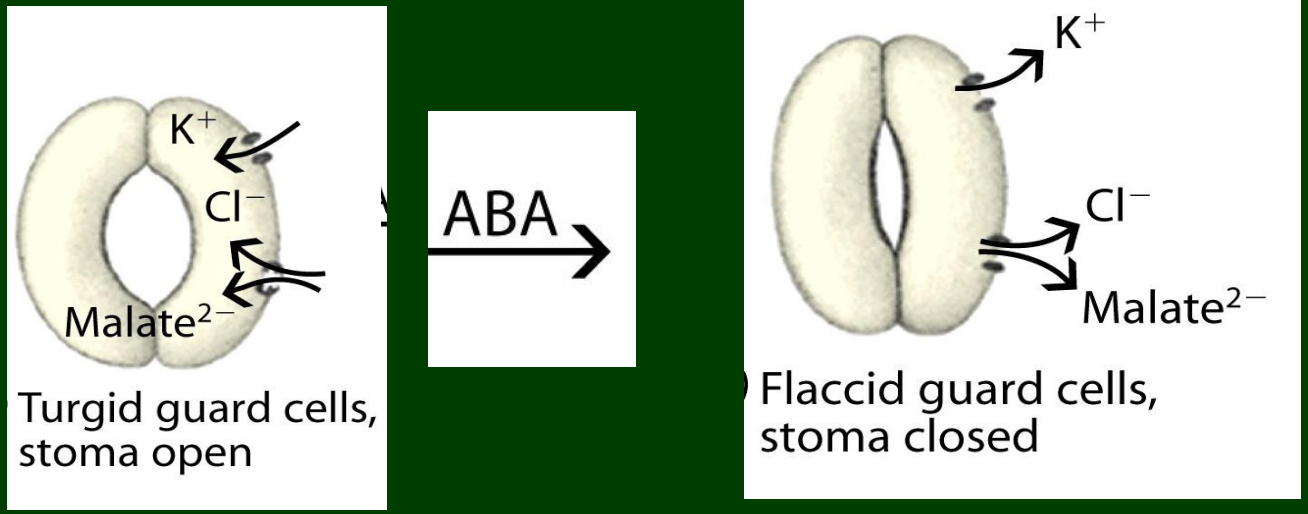
Abscisic Acid (ABA)



ABA induces stomatal closure

a simplified diagram

More about guard cells and experiments with guard cells coming up in a couple of weeks



Solutes (*e.g.* potassium and chloride ions) accumulate in guard cells causing water to accumulate in guard cells, making them turgid

ABA is one signal that causes guard cells to release solutes and thus release water, making them flaccid and closing the stoma (pore) between them

Guard cell response to ABA is one topic of research in the Outlaw lab at FSU

Gibberellins

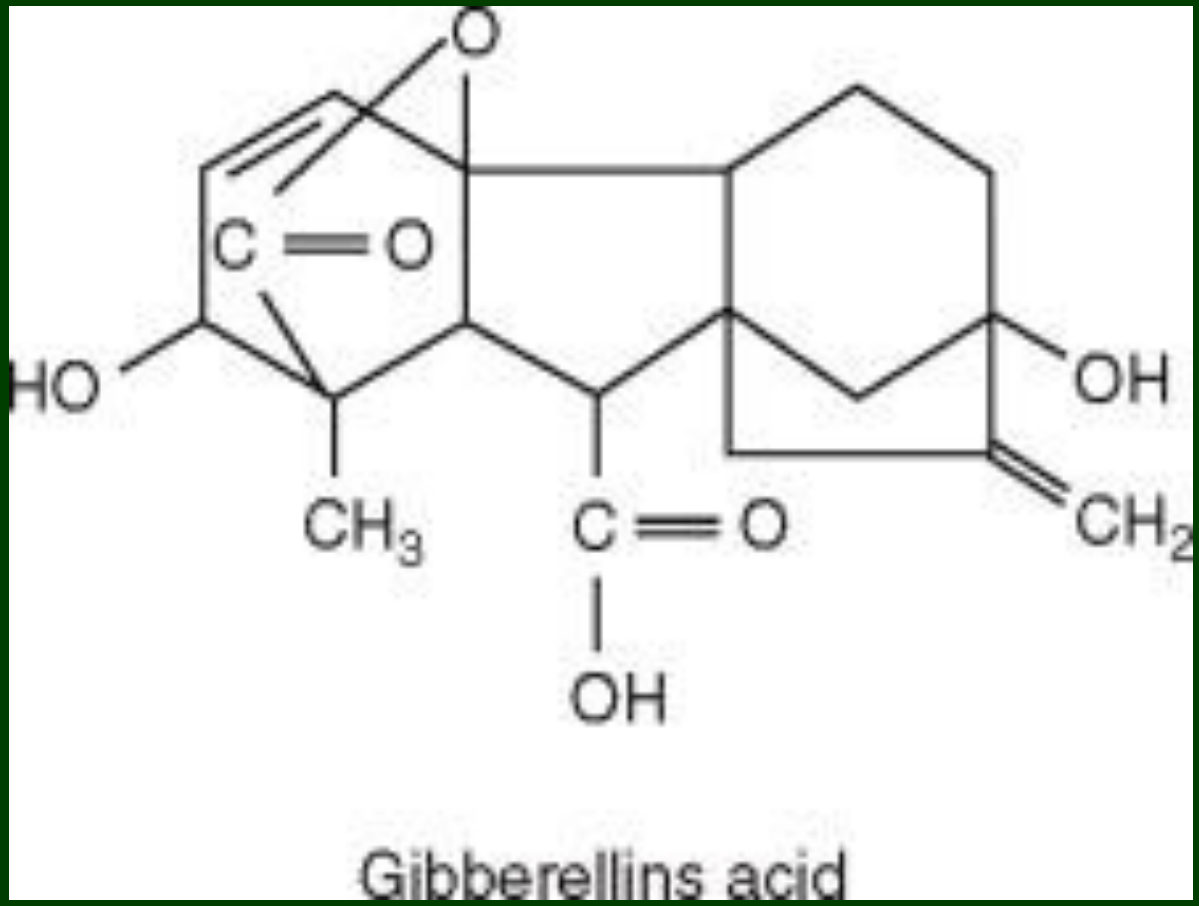
Gibberellic acid (GA)

Production

- In young, developing shoots and seeds

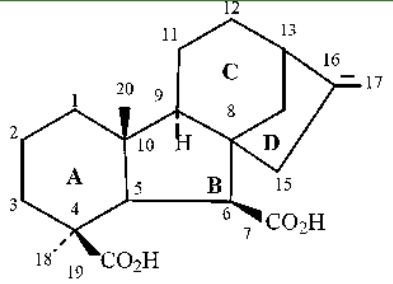
Some known actions

- **Cell elongation**
- Cell division
- Stimulate seed germination
- Stimulate flowering
- Stimulate fruit development

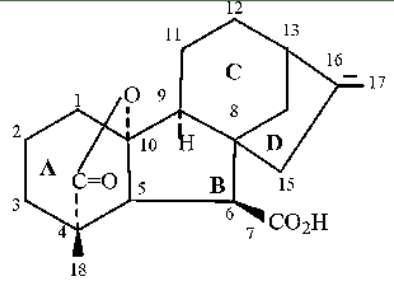


Gibberellins acid

A

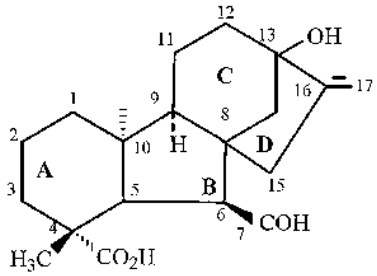


GA-C_{20} skeleton

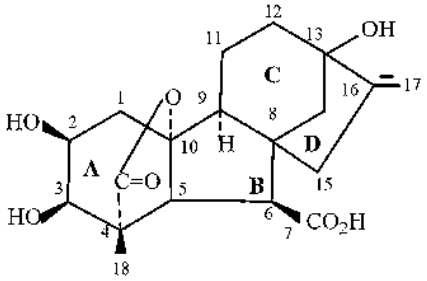


GA-C_{19} skeleton

B

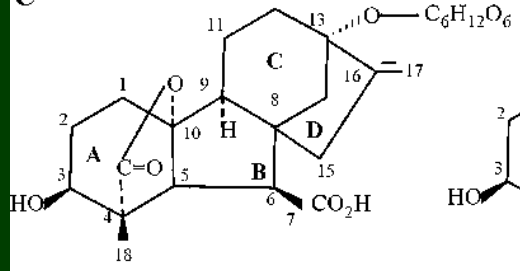


GA_{12}-aldehyde

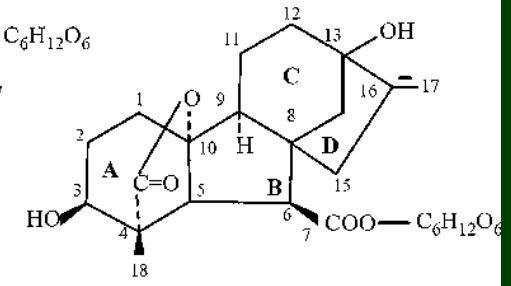


GA_8

C

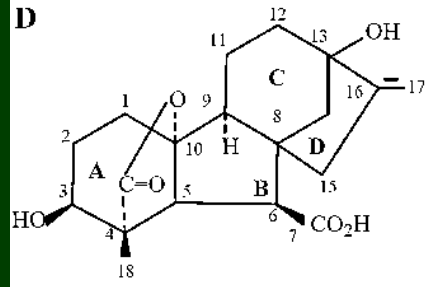


GA_1-13-*O*-glucoside

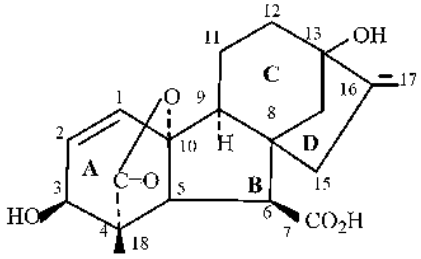


GA_1-glucosyl esther

D



GA$_4$



GA$_3$

GA effect on cabbage internode elongation

Commercial use of GA

Without GA

With GA

Larger fruits that are easier to clean are attractive in markets

Thompson seedless grapes (*Vitis* (Vitaceae family)