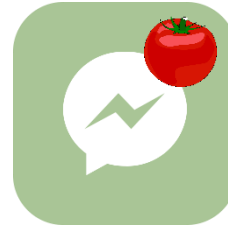


Sessile Networking: Plant Chemicals as Messengers



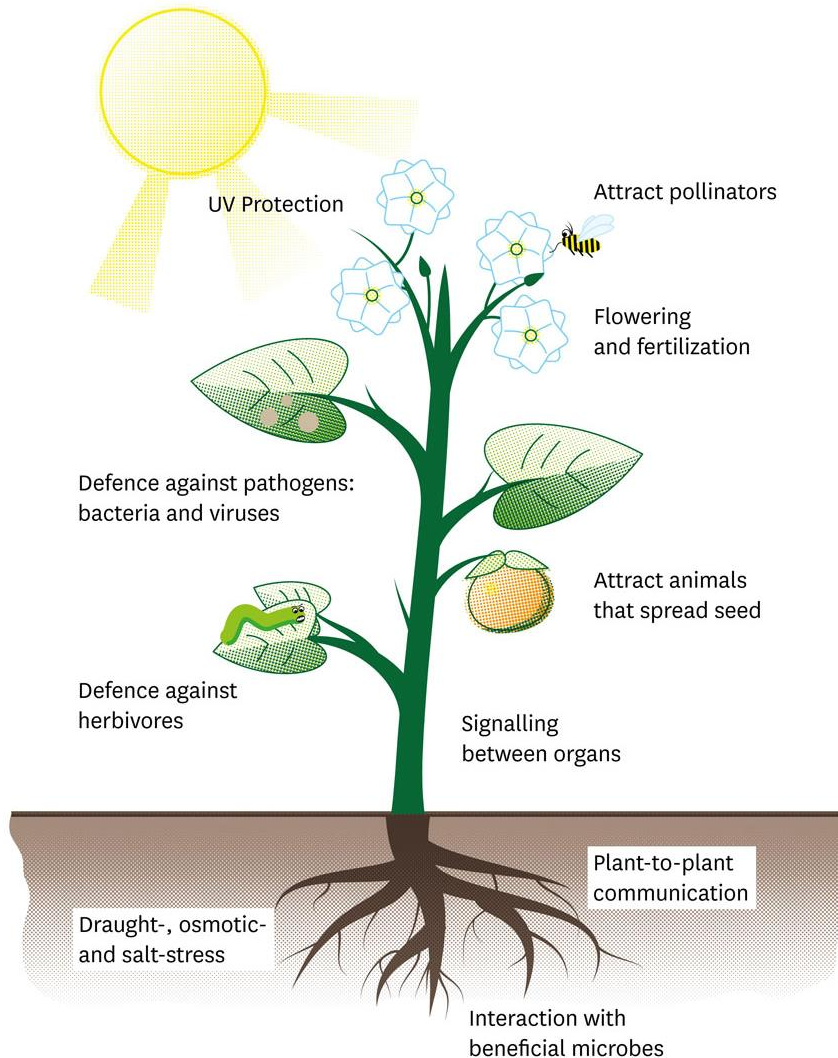
Sonali Roy
Plant Chemical Biology Seminar

Overview of this talk

- What are Phytochemicals?
- Importance of plant chemicals to plant growth, development and survival.
- What are Phytohormones?
 - Auxin – Biosynthesis, Signaling, Physiological roles

Characteristics of a Sessile Lifestyle

The most overused first-sentence of plant science paper abstracts (probably)
“Plants are sessile organisms”.



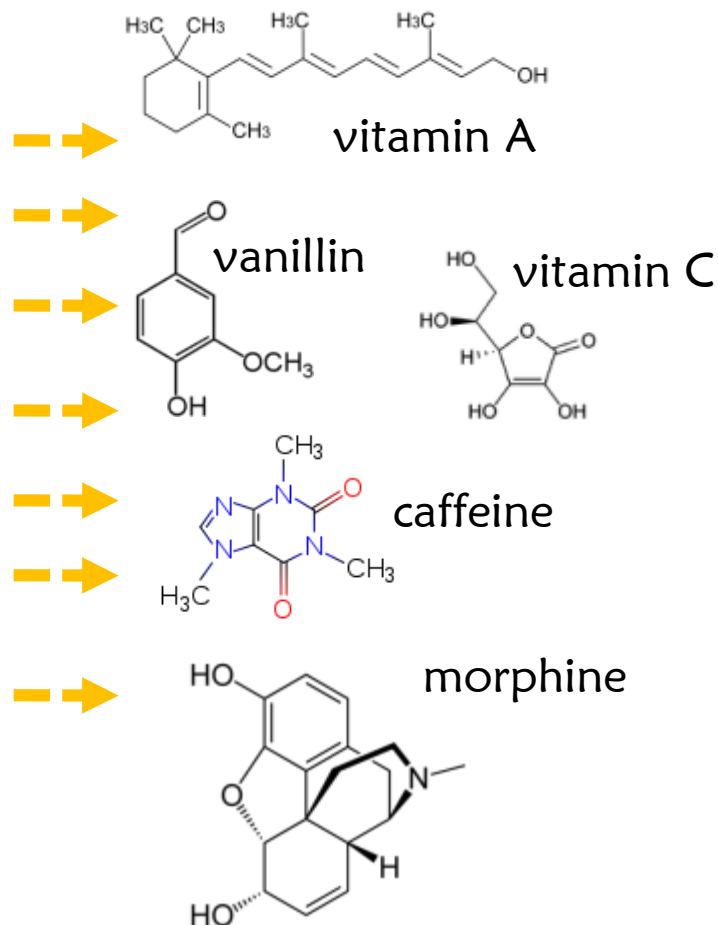
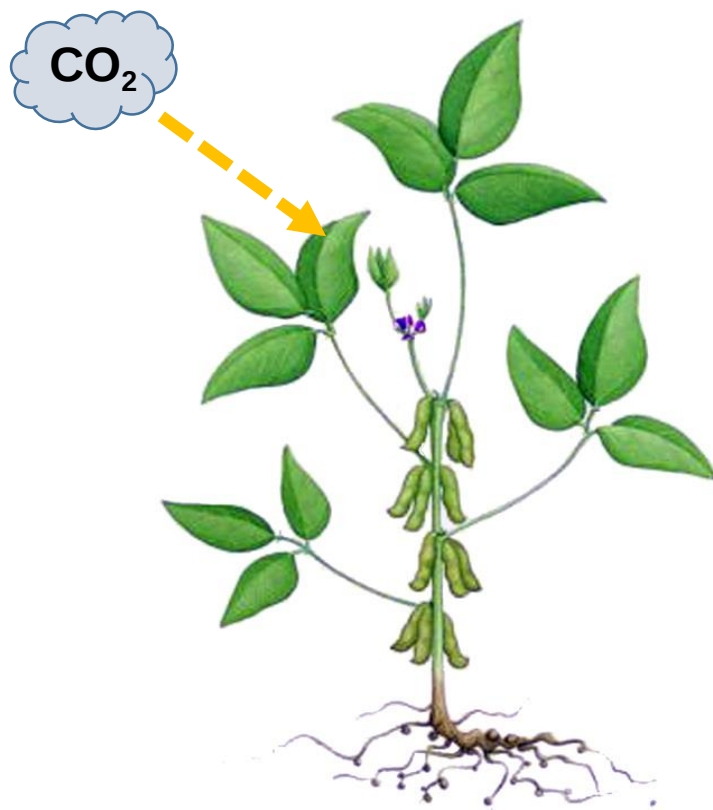
“**Sessility** is the biological property of an organism describing its lack of a means of self-locomotion.”

Cannot Move

1. To find food and nutrients
2. To escape high temperature and stress
3. To evade pathogens, herbivores.
4. To interact with beneficial organisms

Plants have an arsenal to chemicals to overcome Sessility

Plant chemicals or '**Phytochemicals**' are biologically active chemical substances naturally produced in plants.



Can you identify the major plant chemical in these objects?

Caffeine: World's most widely consumed psychoactive drug

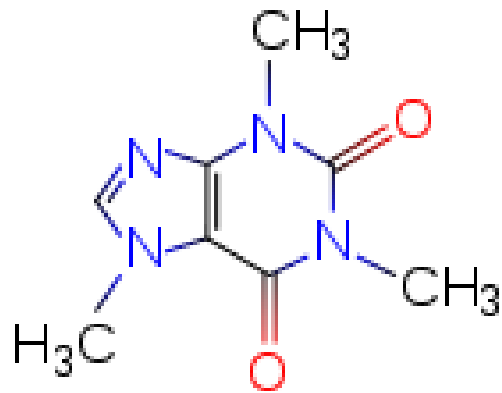
Coffea arabica

Origin: Africa (First used in Yemen)

Extracted from: Berry

Cost: \$4.13/Lb

Use: Flavor, Medicinal



Caffeine



Vanilla is a flavoring derived from orchids of the genus *Vanilla*

Vanilla planifolia

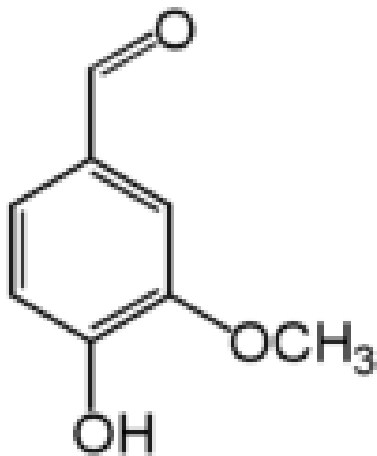
‘Vaina-illa’ or little pod

Origin: Mexico

Extracted from: Pod

Cost: \$300/Lb

Use: Flavor, Perfumes



Vanillin



Salicin: Willow bark extract used as a remedy for aches

Salix spp.

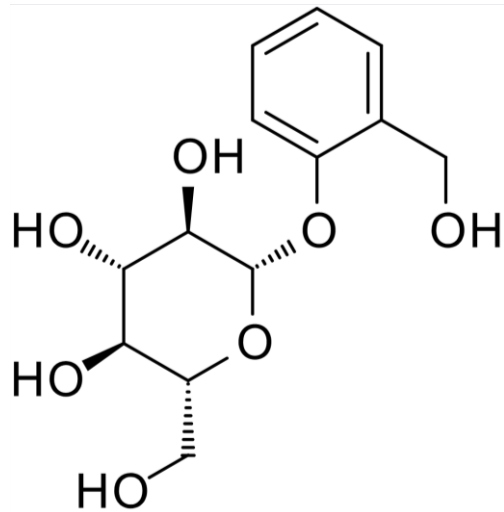
Origin: Egypt

Extracted from: Bark

Cost: \$0.01/tablet

Use: Medicinal

(Synthetically derived form is Aspirin)



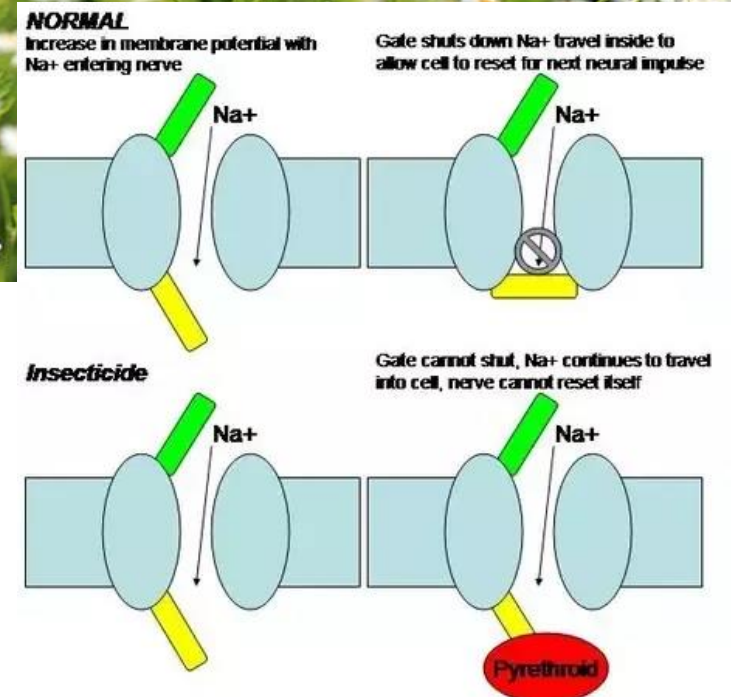
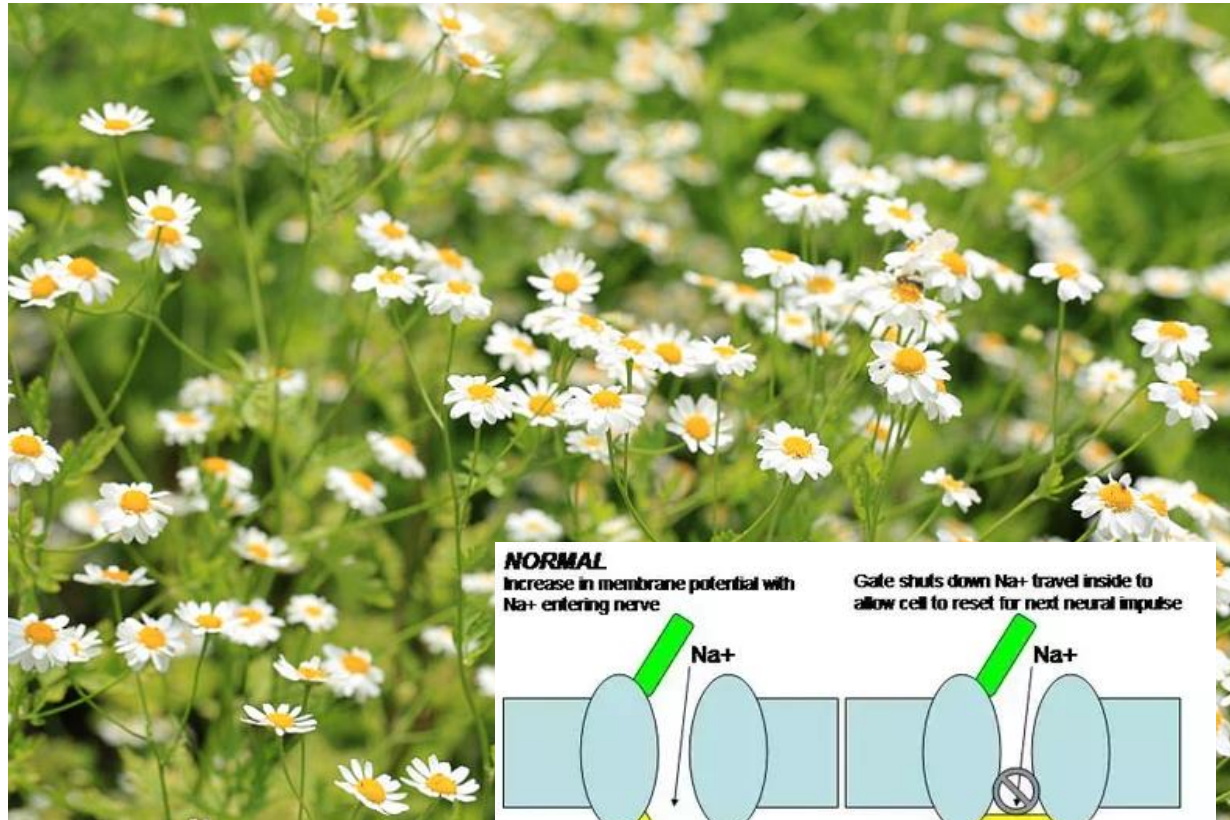
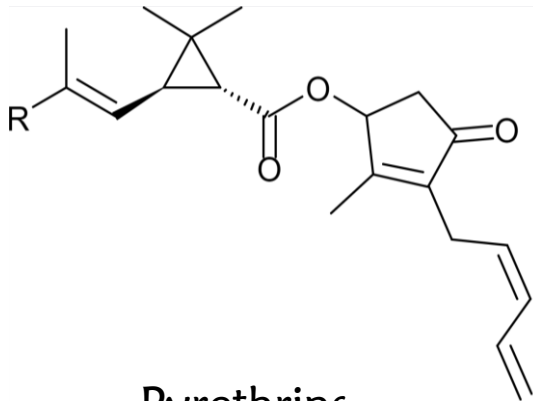
Salicin



Pyrethrins: Nature's organic pesticide

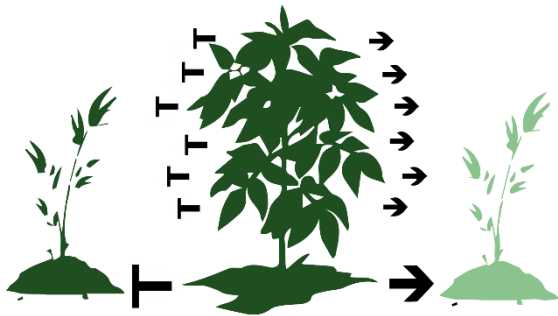
*Chrysanthemum
cinerariifolium*

Origin: Europe, Asia
Extracted from: Flowers
Cost:
Use: Insecticides



Phytochemicals act as signals

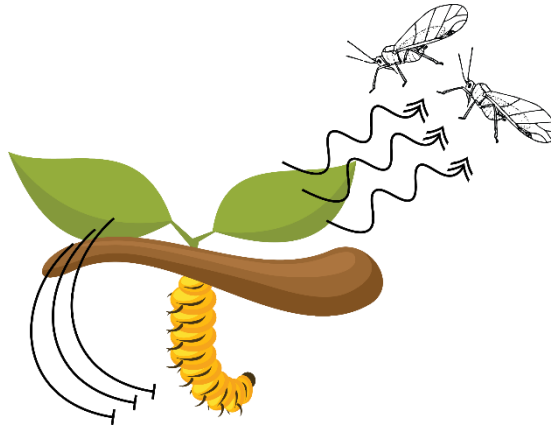
Plant-Plant Communication (Allelochemicals)



An Allelochemical positively or negatively influences the germination, growth, survival, or reproduction of a neighboring organism

- Probiosis (Promote)
- Antibiosis (Antagonize)

Plant-Microbe/Insect communication



- Defense (Chemicals that deter pathogens and herbivores – Methyl salicylate)
- Mutualism (Chemicals that attract beneficial organisms – Luteolin)

Within the plant



- Long distance signaling.
- Cell-to-cell signals

Phytochemicals are intermediate products of plant metabolism

Primary Metabolism

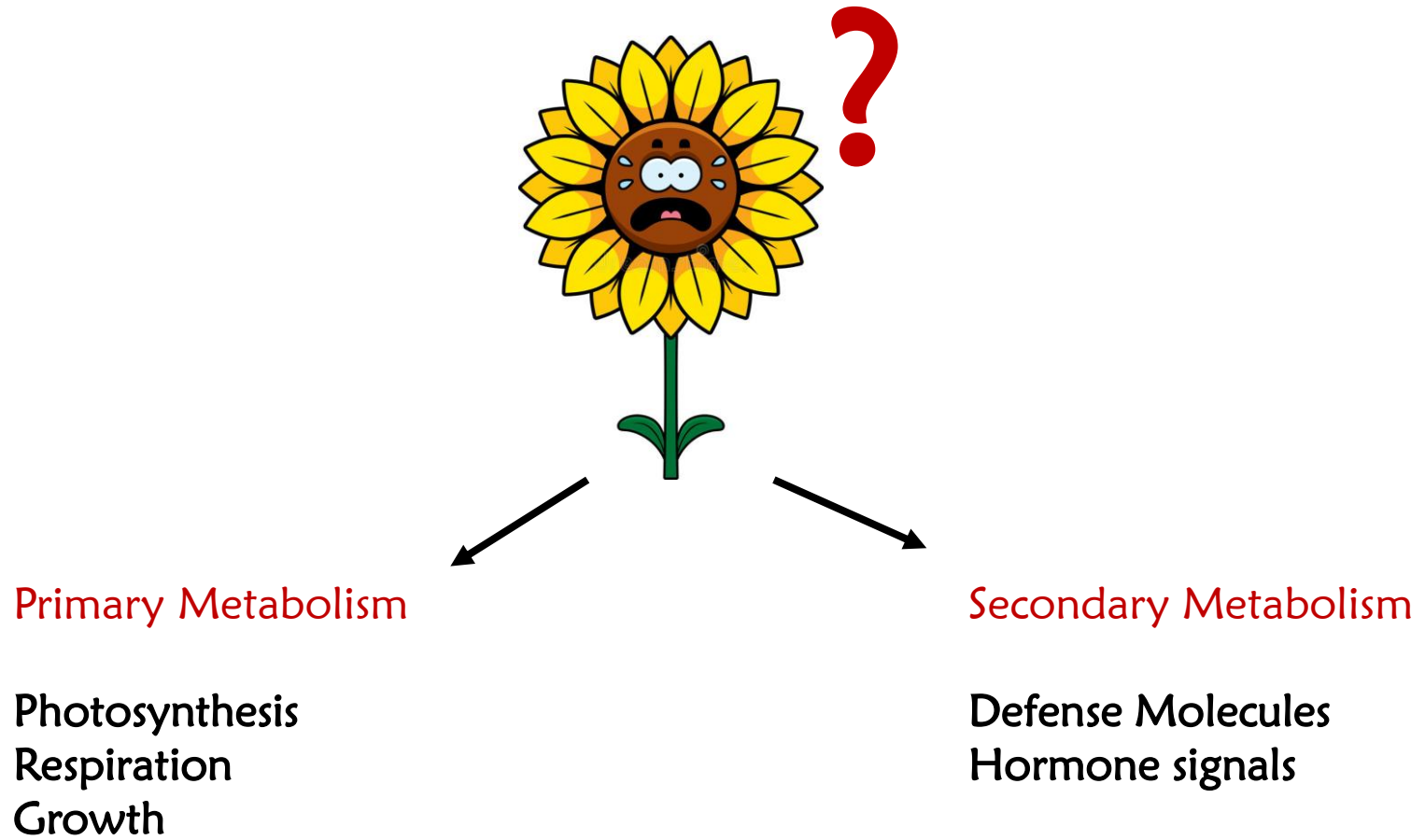
1. Comprises all metabolic pathways that produce compounds essential to the plant's survival (Photosynthesis, respiration).
 - Directly involved in the growth and development of the organism (amino acids, nucleosides, carbohydrates).
2. Common to all organisms.
3. Produced in large quantities.

Secondary Metabolism

1. Produces metabolites that aid in the growth and development of plants but are not required for the plant to survive.
 - Play a role in plant defense and regulation of primary metabolic pathways.
2. Specialized chemicals, produced in certain organisms.
3. Produces chemicals in smaller quantities.

True or False?

When attacked, do plants prioritize primary or secondary metabolism?



True or False?

When attacked, do plants prioritize primary or secondary metabolism?

Constitutively activated defense responses

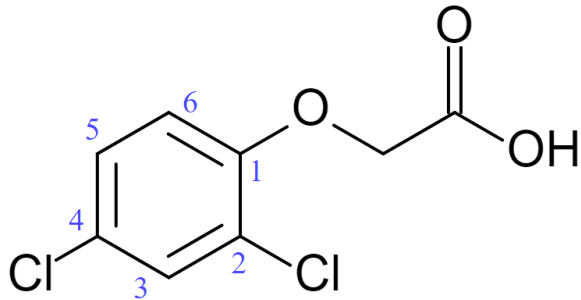


- Smaller (impaired growth)
- Higher cell death (lower survival rates)
- Reduced seed production (impaired reproduction)

Can you name a plant chemical in a herbicide?

Auxins: Synthetic forms of hormones are used as herbicides

*Synthetic mimic of
natural auxins*



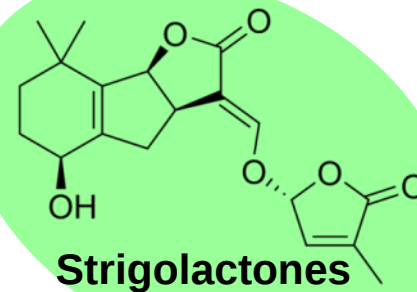
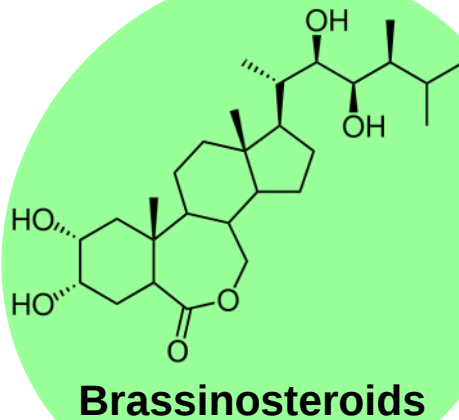
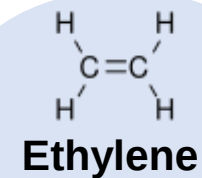
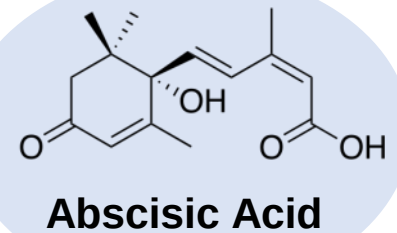
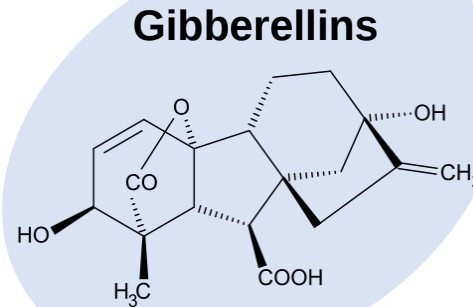
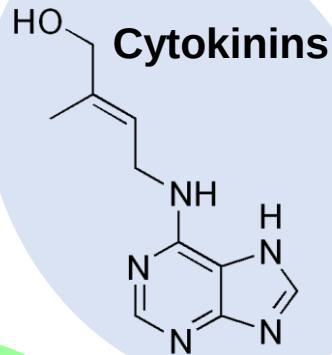
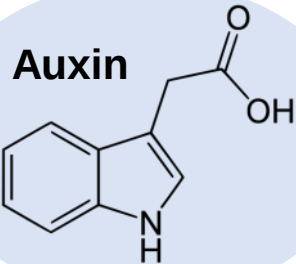
2,4-Dichlorophenoxyacetic acid



Kills plants by causing uncontrolled growth

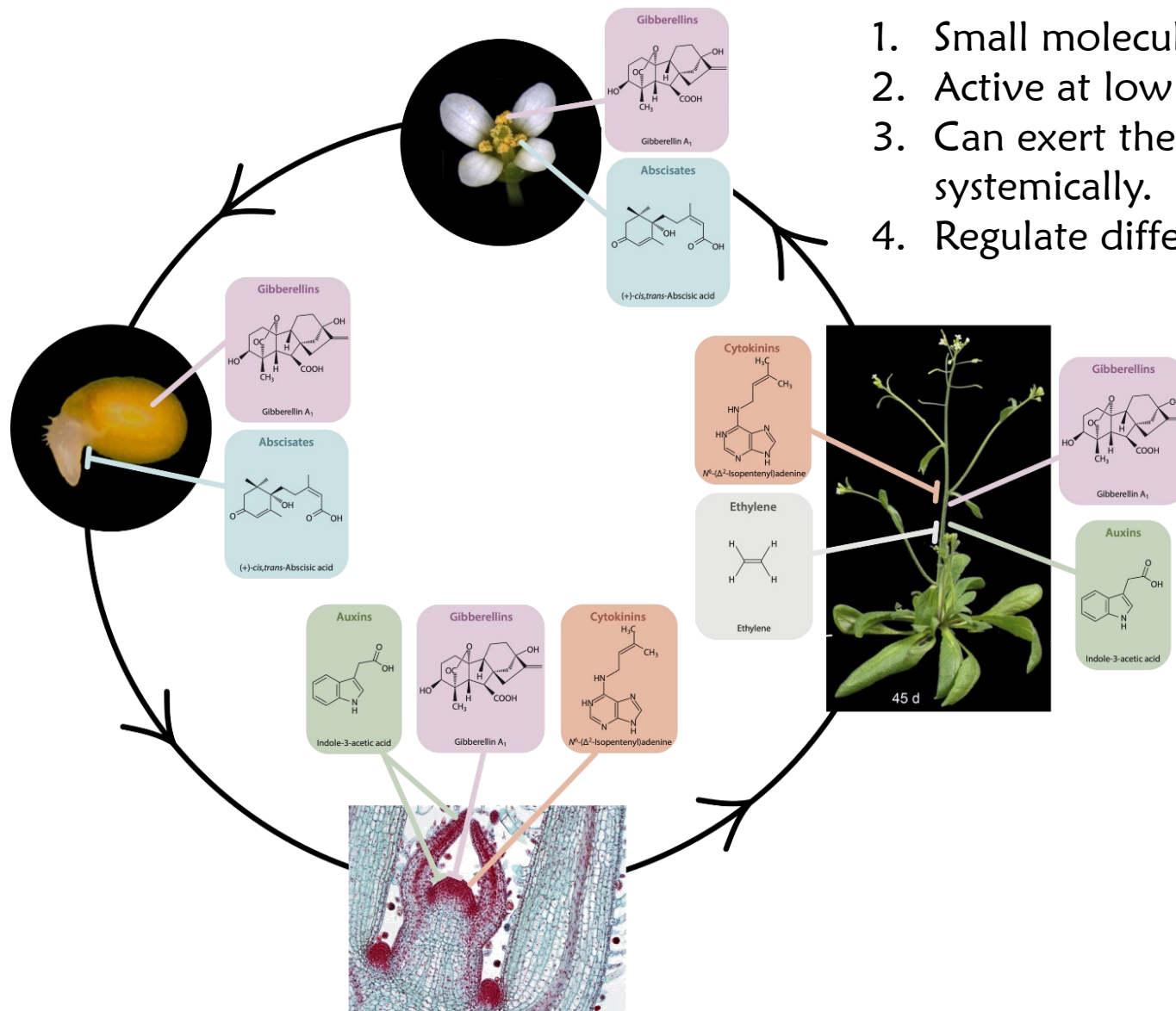
What are Phytohormones?

Phytohormones are plant chemicals that regulate cellular activities (division, elongation and differentiation), pattern formation, organogenesis, reproduction, sex determination, and responses to abiotic and biotic stress.

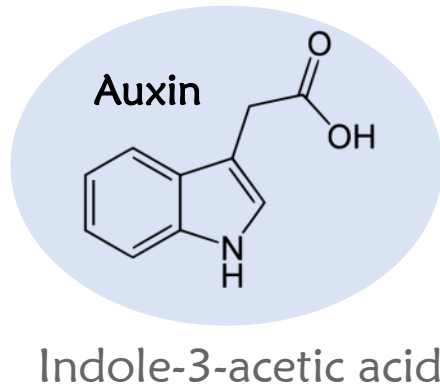


Phytohormones coordinate plant growth and development

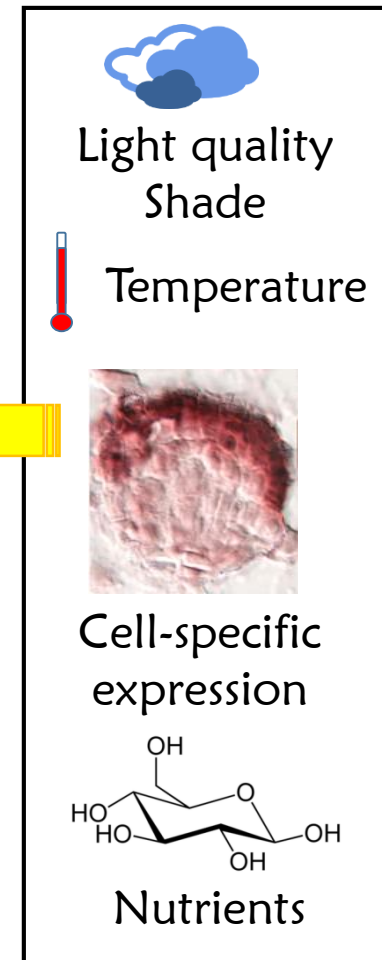
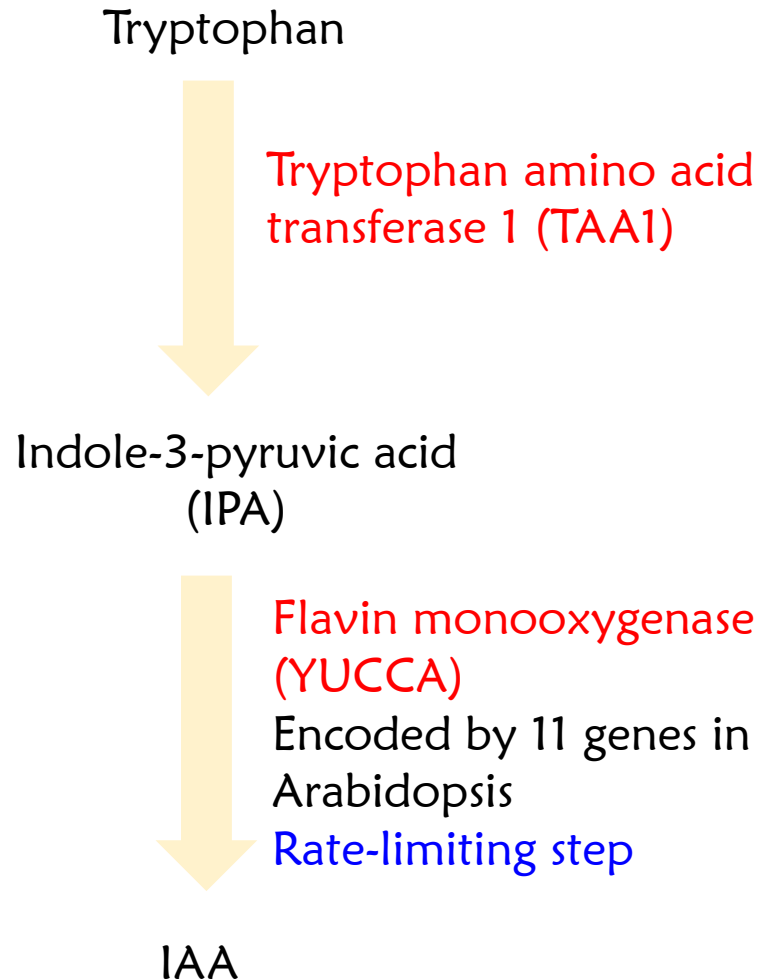
1. Small molecules.
2. Active at low concentrations
3. Can exert their effects locally or systemically.
4. Regulate different plant processes.



Most auxin in plants is synthesised by a two-step IPA pathway

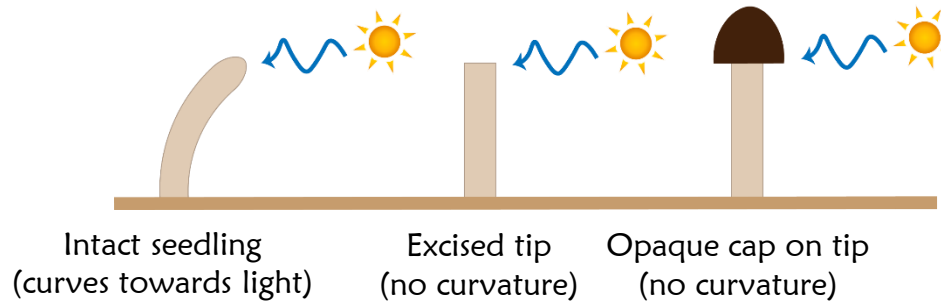
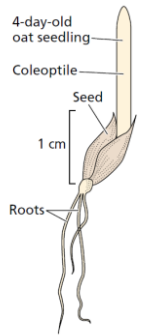


The IPA pathway is a conserved two-step pathway. The activity level of the two enzymes are regulated in diverse ways



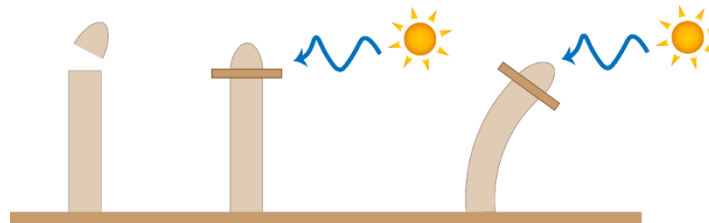
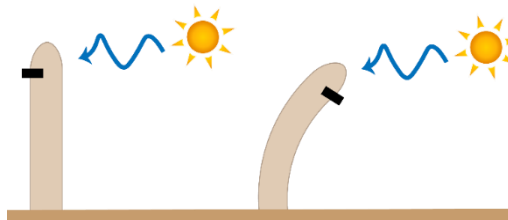
Discovery of Auxin

Darwin(s) (1880)



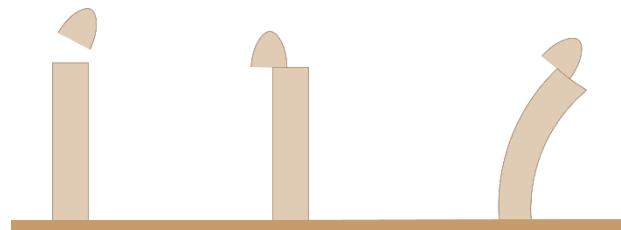
Growth stimulus is produced in the coleoptile tip.

Boysen-Jensen (1913)



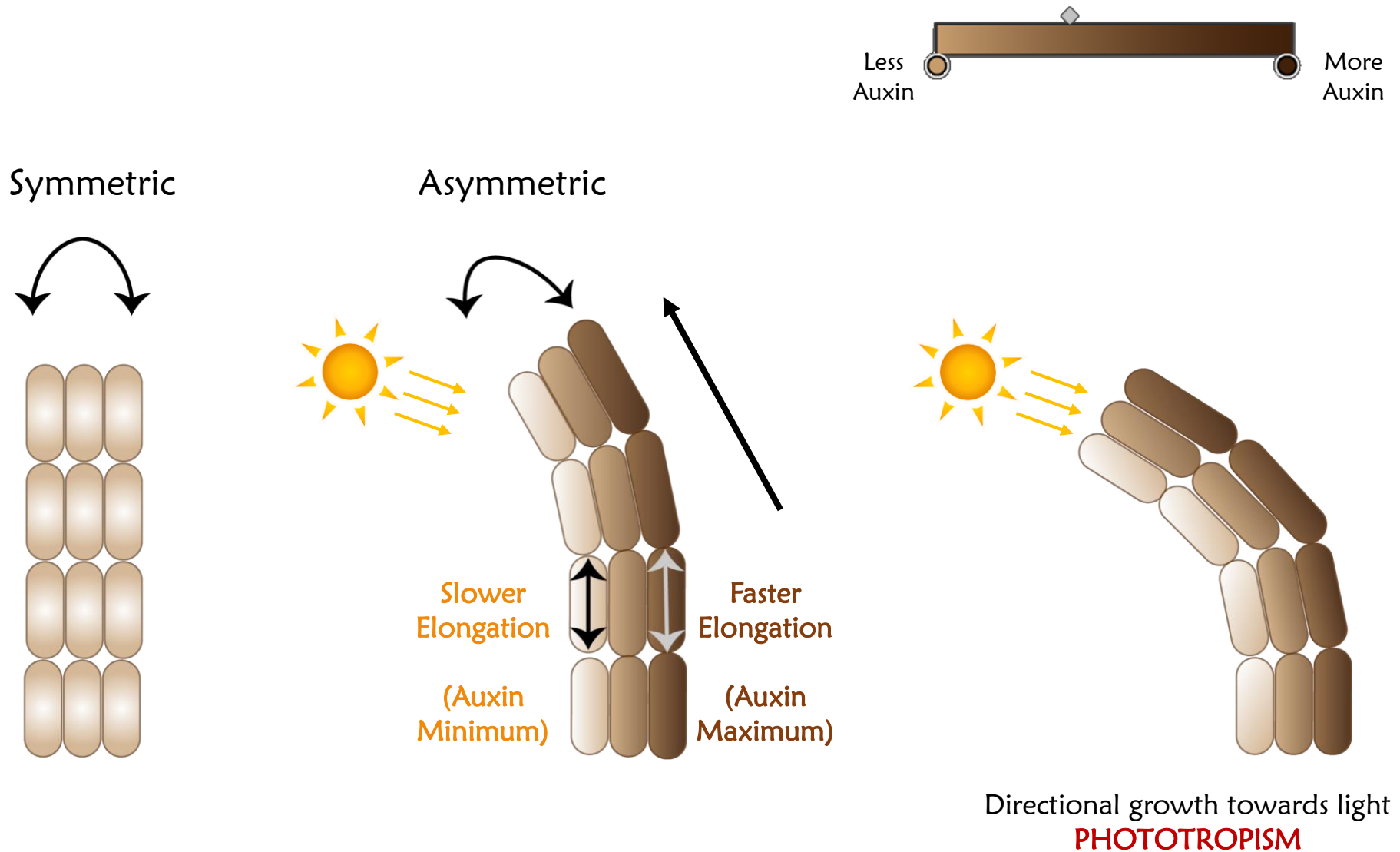
Growth stimulus is water soluble.

Paal (1919)

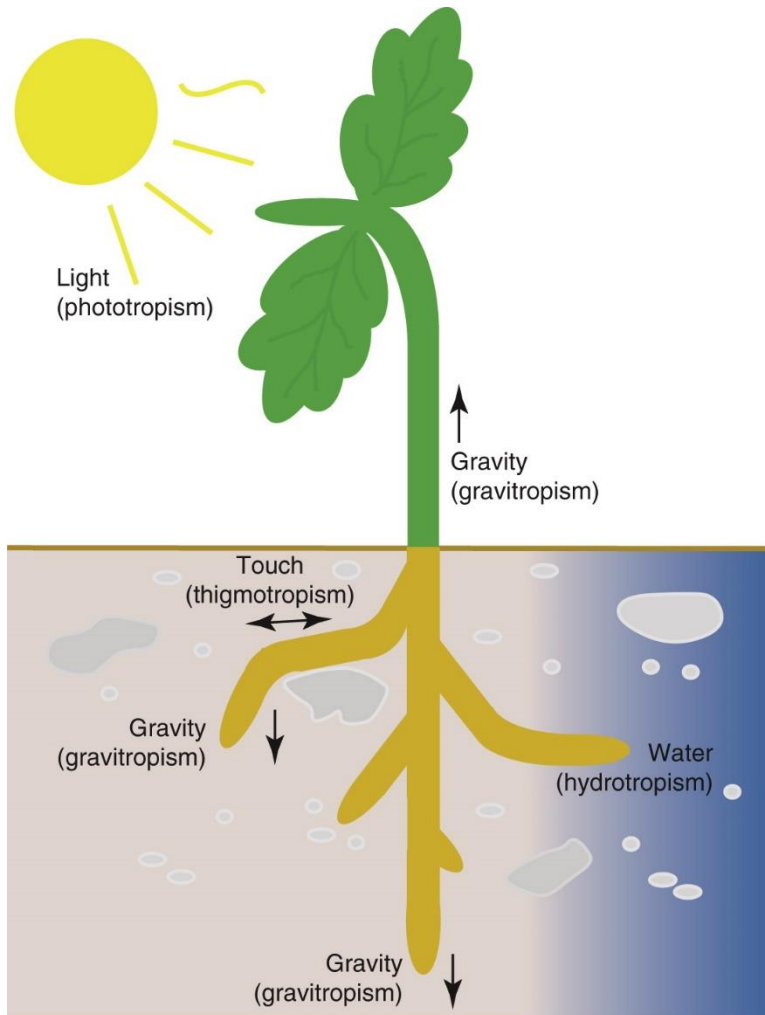


Growth stimulus is chemical in nature.

Auxin promotes cell expansion in shoots

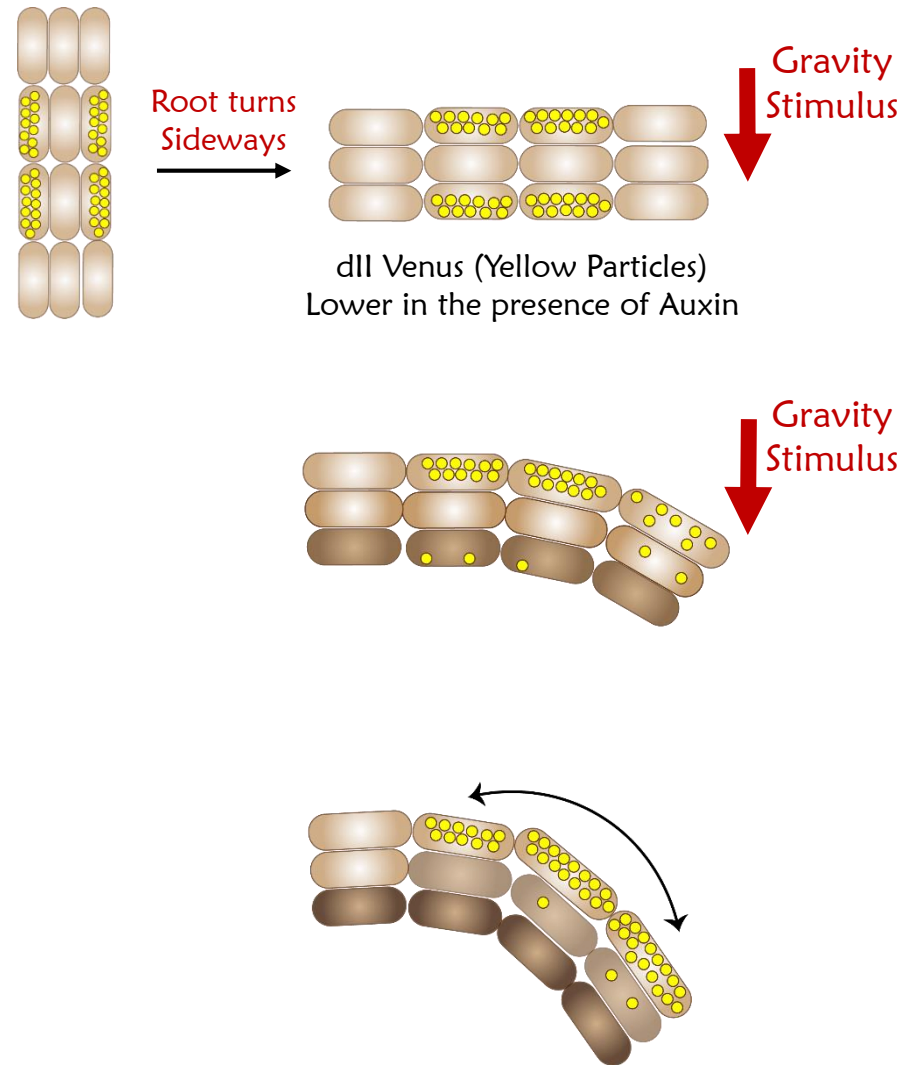


Auxin inhibits cell expansion in roots



Current Biology

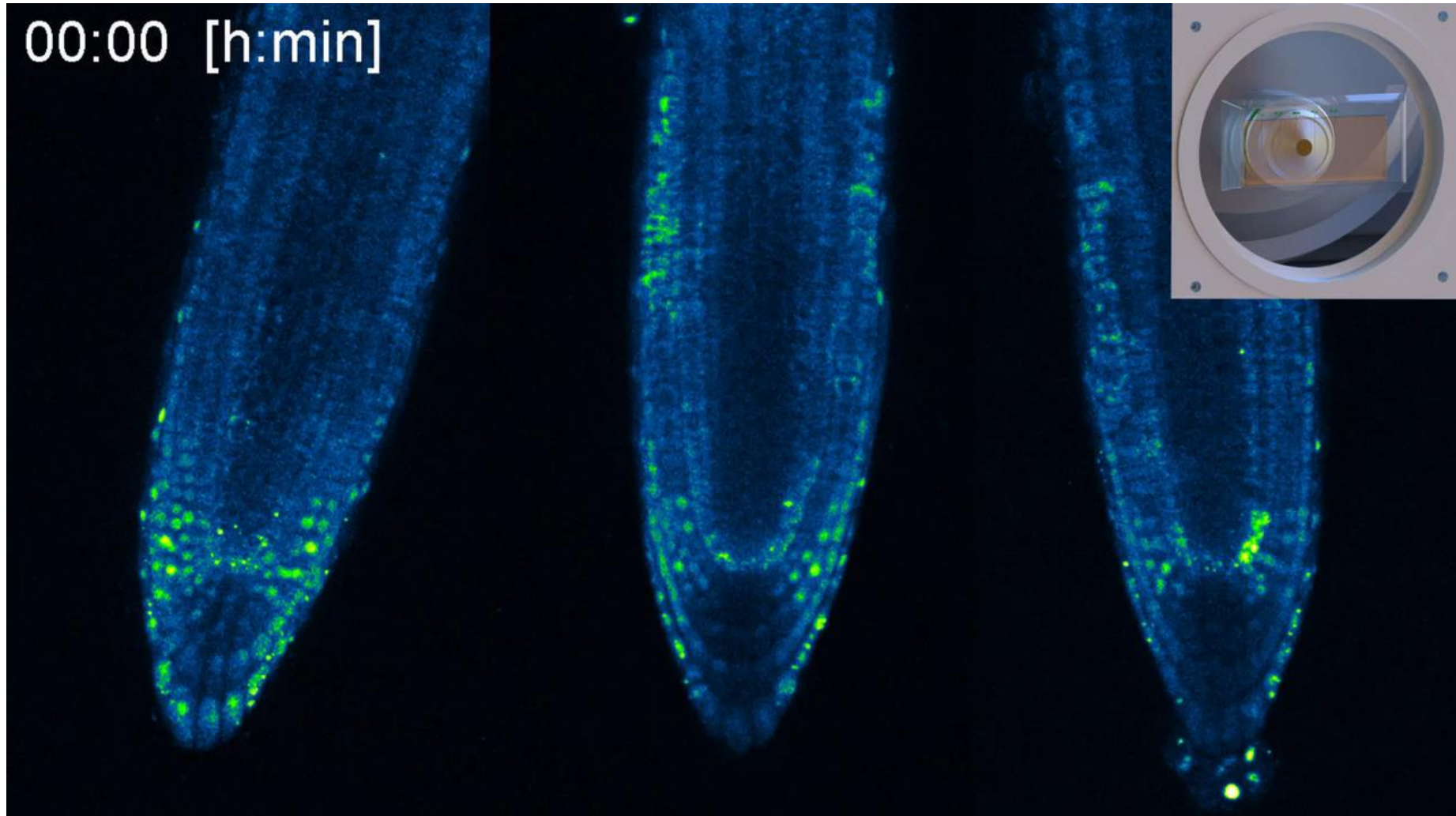
Plant tropisms, Simon Gilroy, 2009, Current Biology



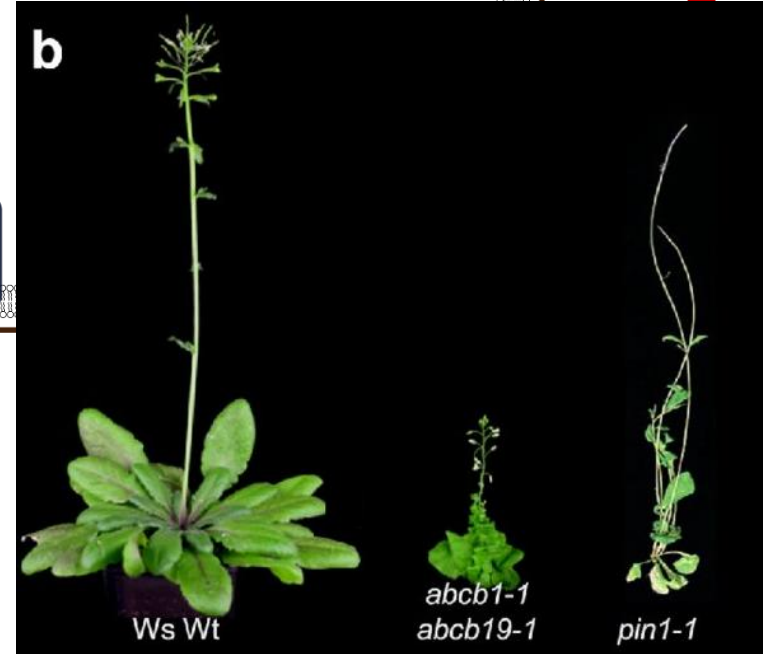
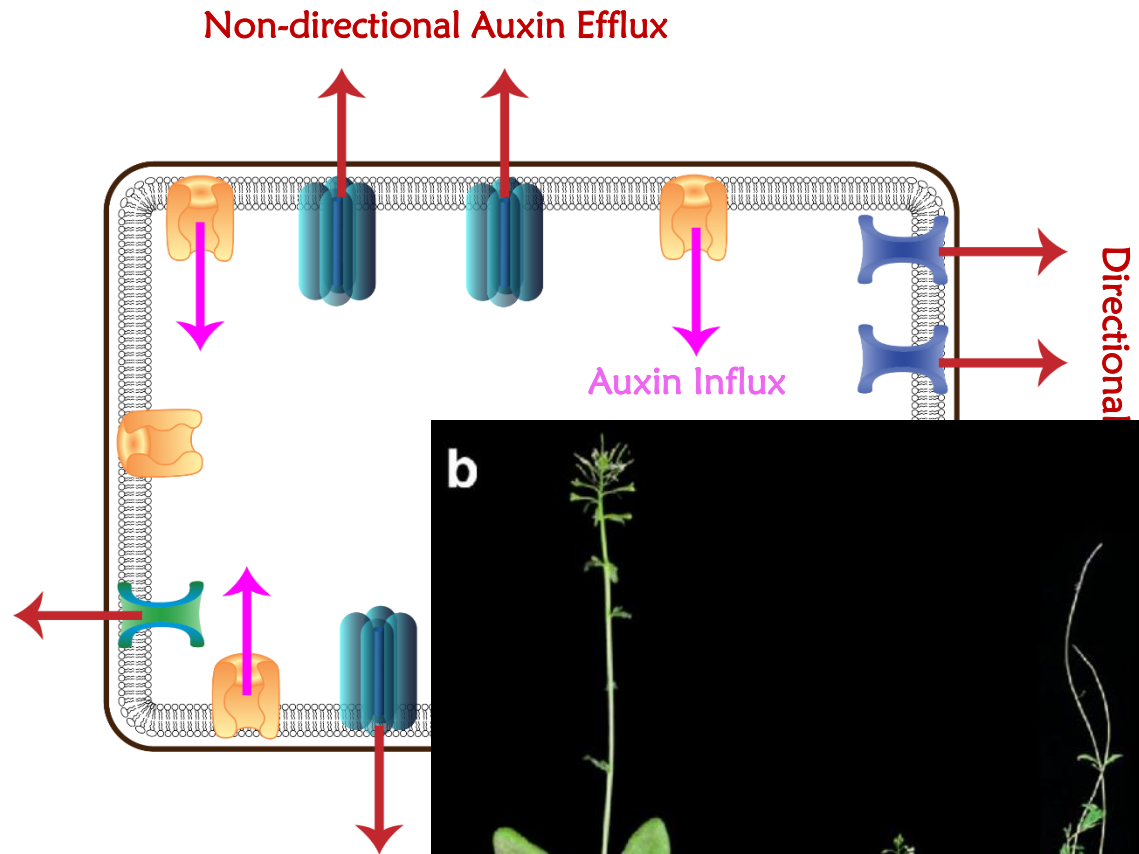
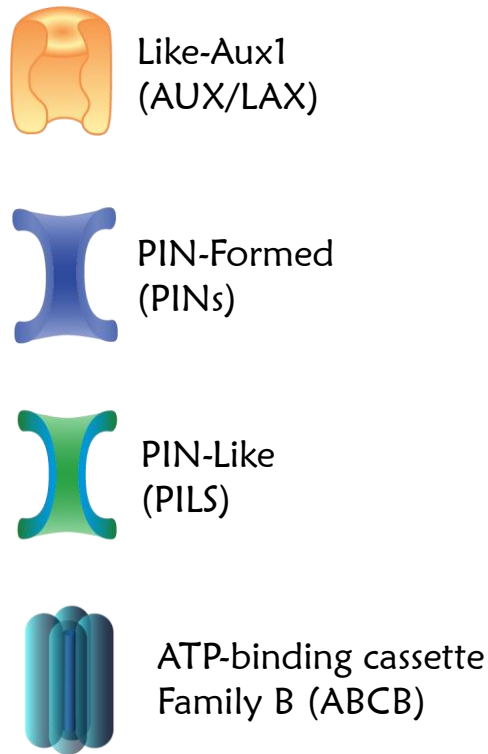
Directional growth towards gravity
GRAVITROPISM

Auxins control directional movements

Higher **VENUS (Yellow particles)** expression = Less Auxin = Cell Elongation

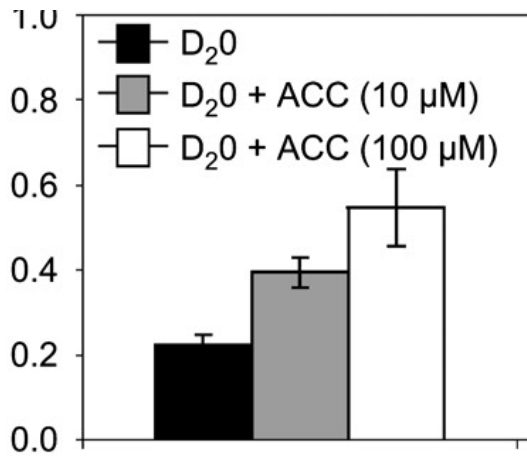


Polar Auxin Transport is an active process that contributes to tropic movements

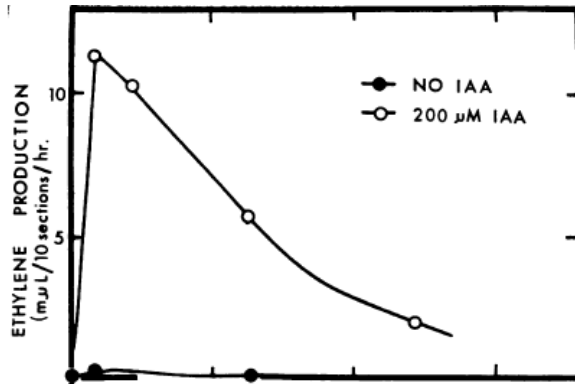


Auxin does not work alone

Auxins act synergistically with Ethylene



Ethylene promotes auxin synthesis



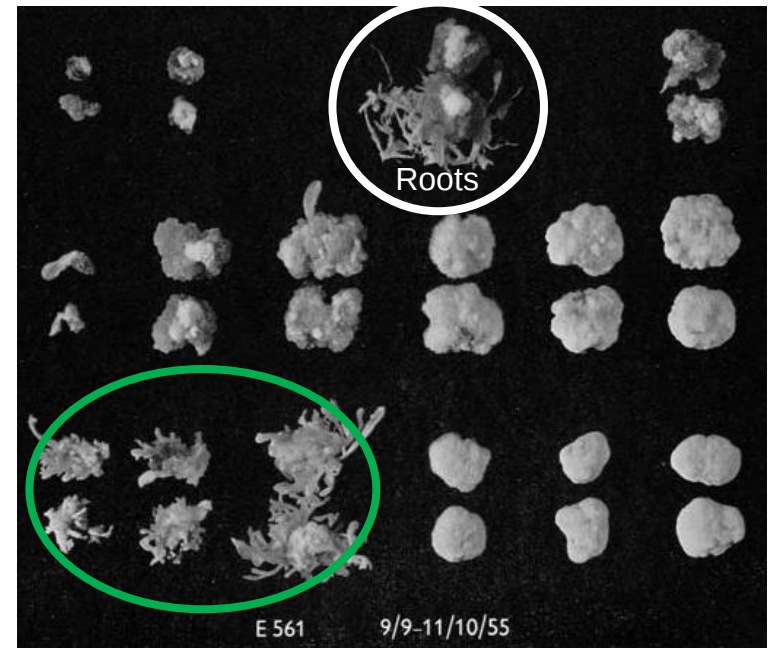
Auxin stimulates ethylene production

Auxin antagonizes Cytokinin Function



Increasing [Auxin]

Increasing [Cytokinin]



Auxin exploitation by microbes: Agrobacterium



The first written record of crown gall disease, on grape, dates from 1853

Fridiano Cavara (1897) found that a bacterium causes crown gall in grape

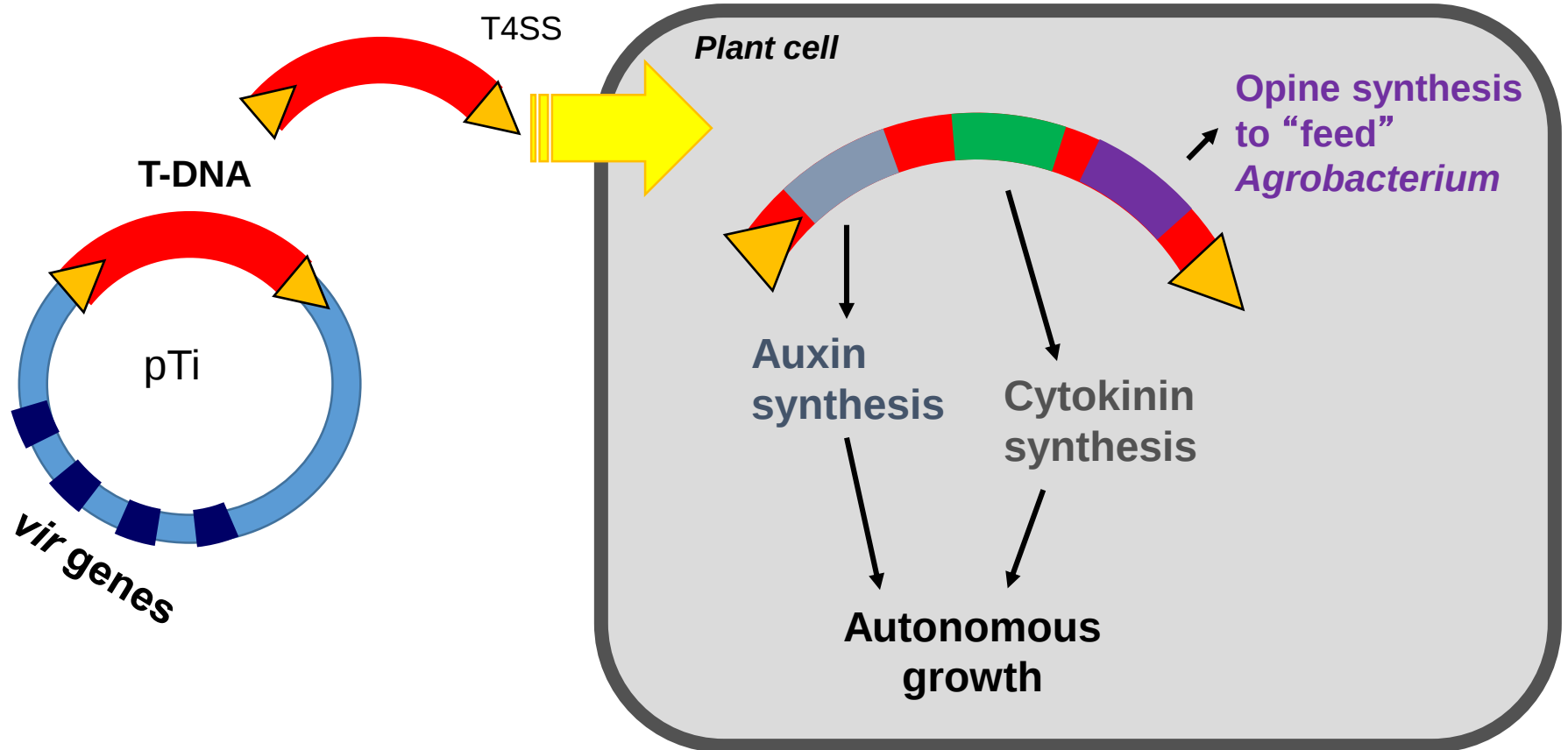


Crown gall induces growths at wound sites and severely limits crop yields and growth vigor

Teaching Tools in Plant Biology: A Really Useful Pathogen - Agrobacterium. *The Plant Cell*

[Edward L. Barnard](#), Florida Department of Agriculture and Consumer Services, Bugwood.org; [Mike Ellis](#), Ohio State University; [University of Georgia Plant Pathology Archive](#), University of Georgia, Bugwood.org; [Wikimedia commons](#)

Auxin exploitation by microbes: Agrobacterium



vir = Virulence genes

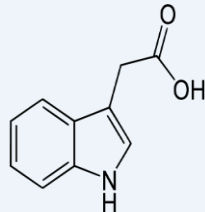
T-DNA = Transfer DNA

T4SS = Type IV Secretion System

Peptide Hormones

Small molecule hormones

- **Chemical Structure-** Derived from amino acids (e.g., Indole-3-acetic acid), isoprenoids (e.g., Benzyl amino purine), lipids (e.g., Methyl Jasmonate)
- **Biosynthesis-** End products of a cellular metabolic pathway



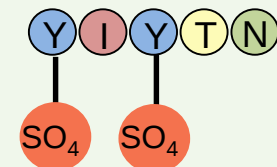
Auxin (IAA)

Similarities

- Regulate growth and development even at minute concentrations
- Can act long distance
- Commonly require membrane receptors for recognition
- Activity may require secondary group modifications (e.g., hydroxylation)

Peptide hormones

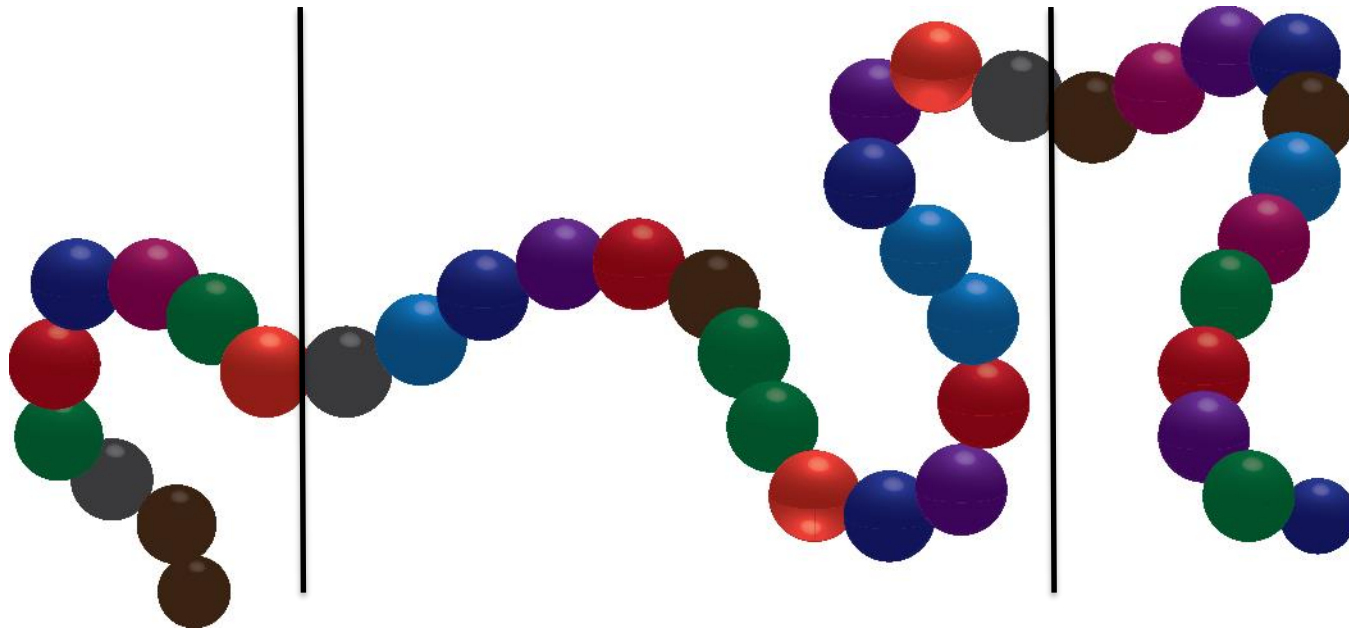
- **Chemical Structure-** Derived from polypeptide chains
- **Biosynthesis-** Transcribed ribosomally from a single gene



Phytosulfokine peptide

Peptide Hormones

- 5 - 65 amino acid residues
- Active at very low concentrations.
- Serve as receptor ligands



N-TERMINAL SIGNAL PEPTIDE

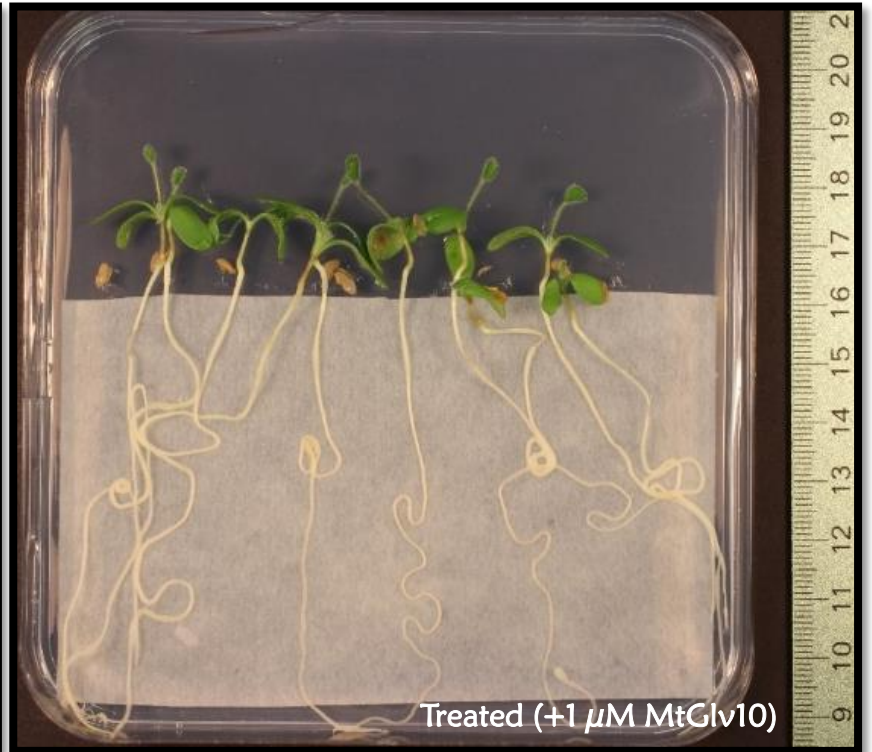
- Directed to the Endoplasmic reticulum, Golgi secretory pathway

VARIABLE REGION

C-TERMINAL SIGNALLING PEPTIDE

- May contain different post-translational modifications

Peptide Hormones



Summary

- Plants use chemicals to deal with changes in their environment
- Phytochemicals are typically products of secondary metabolism but they can regulate primary metabolic activities.
- Phytochemicals include small chemical messengers called Phytohormones which include the key hormone Auxin.