Plant Growth and Development

- Growth = irreversible increase in mass that results from cell division and cell expansion
- Development = sum of all the changes that progressively elaborate an organism's body
- Indeterminate growth = grow as long as organism is alive (ex. plant stem)
- Determinate growth = stop growing after reaching a certain size (ex. animals, flower, leaf)

Growth Cycles

Growth Cycle	Description	Example
Annuals	Life cycle within a year or less →dies after a growing season, seeds grow into new plants	Impatients, Geraniums, Bergonia

Growth Cycle

Growth Cycle	Description	Example
Biennial	•Life spans generally 2 years •Live through winter between its vegetative growth (1st spring) and flowering (2nd spring) •But we don't leave beets/carrots in ground long enough to see them flower	Beets, carrots 

Growth Cycle

Growth Cycle	Description	Example
Perennials	•Live many years •Death usually from infection or environmental trauma rather than old age	Woody plants- Trees, shrubs, Herbaceous- grass, hydrangeas, rose bushes, yellow & white daisies

Plant Responses to Stimuli

The Private Life of a Carnivorous Plant

http://www.youtube.com/watch?v=ktIGVtKdgwo

Canivorous plants!

- Consume insects or protozoans
- Darwin wrote the first account in 1875
- Live in soil with low nitrogen
- Sticky and use digestive enzymes

Of Mice and Plants

- ***Nepenthes rajah*** **(Nepenthaceae)**
- **pitcher plant (passive trap)**
- Holds 3.5L of water
- 2.5L of digestive liquid
- **Consumes mammals and birds**
- Endemic to Borneo
- Endangered

The **pitcher plant** is an excellent example of a **passive trap**. The plant has tall leaves that are tapered like a glass or bottle. Water and digestive enzymes collect inside these leaves forming a reservoir at the bottom. Insects are attracted to the plant and enter the top of a leaf. As the insect proceeds down the inside of the leaf, small hairs inside the plant that point downward direct the insect further and further into the center. The sides of the leaf are also coated with a waxy, slippery substance. Eventually, the insect will fall into the water and drown. As the insect decomposes, it releases nutrients that feed the plant.
http://www.ehow.com/how-does_5270668_do-carnivorous-plants-capture-insects.html

Venus Fly Trap

- Plants that have **active traps** include the most famous carnivorous plant, the Venus fly trap. The end of each of the fly trap's leaves look like two oval lobes joined in the middle, trimmed with eyelash-like points. On the surface of each oval lobe, there are three trigger hairs.

- **When an insect lands on the lobe and touches the hairs, the lobes fold closed around the insect**. The points form a tiny cage that traps the insect alive. For the trap to be sprung, the trigger hairs must be touched multiple times. That way the plant knows that what is in the trap is alive. **Digestive enzymes are then released into the trap** to finish the job.

Sundew Plant Tendrils

- Carnivorous plants that have passive and active traps include the sundew plant. At the end of each leaf, the sundew plant has a cluster of thin tendrils stretching in all directions.

- **Each tendril is tipped with a drop of sticky nectar. Insects that are attracted to the nectar land on the leaf and get stuck in the tendrils. This is the passive trap.** But that's not the end of the story.

- As the insect struggles, signals are transmitted to **the plant through the tendrils, which begin to bend in, surrounding the insect and digesting it.** This is the active trap and makes it impossible for the insect to escape.

- http://www.youtube.com/watch?v=Eyoa9m_Ghqo

Nastic Movement

- Stimulated response that is non-directional
- Examples:
- 1) mimosa: touch stimulus→ closes leaves, but no change in directions
- 2) venus fly trap: touch stimulus →closes the trap, not changing in direction

- ** sunflower facing towards the sun is a directional response → not a nastic movement

Turgor Response

- Rapid movement of plants in response to a stimuli brought about by changes in turgor pressure

- Plant cells filled with water are rigid, with high turgor pressure. When water content is low, the cells are limp and turgor is low.

- Touching a Venus fly trap causes a sudden loss in turgor in special cells which become limp and causes leaflets to close quickly.

Tropism

- Directional growth response to unequal stimulation from the external environment, resulting in curvatures of whole plant organs toward or away from stimuli

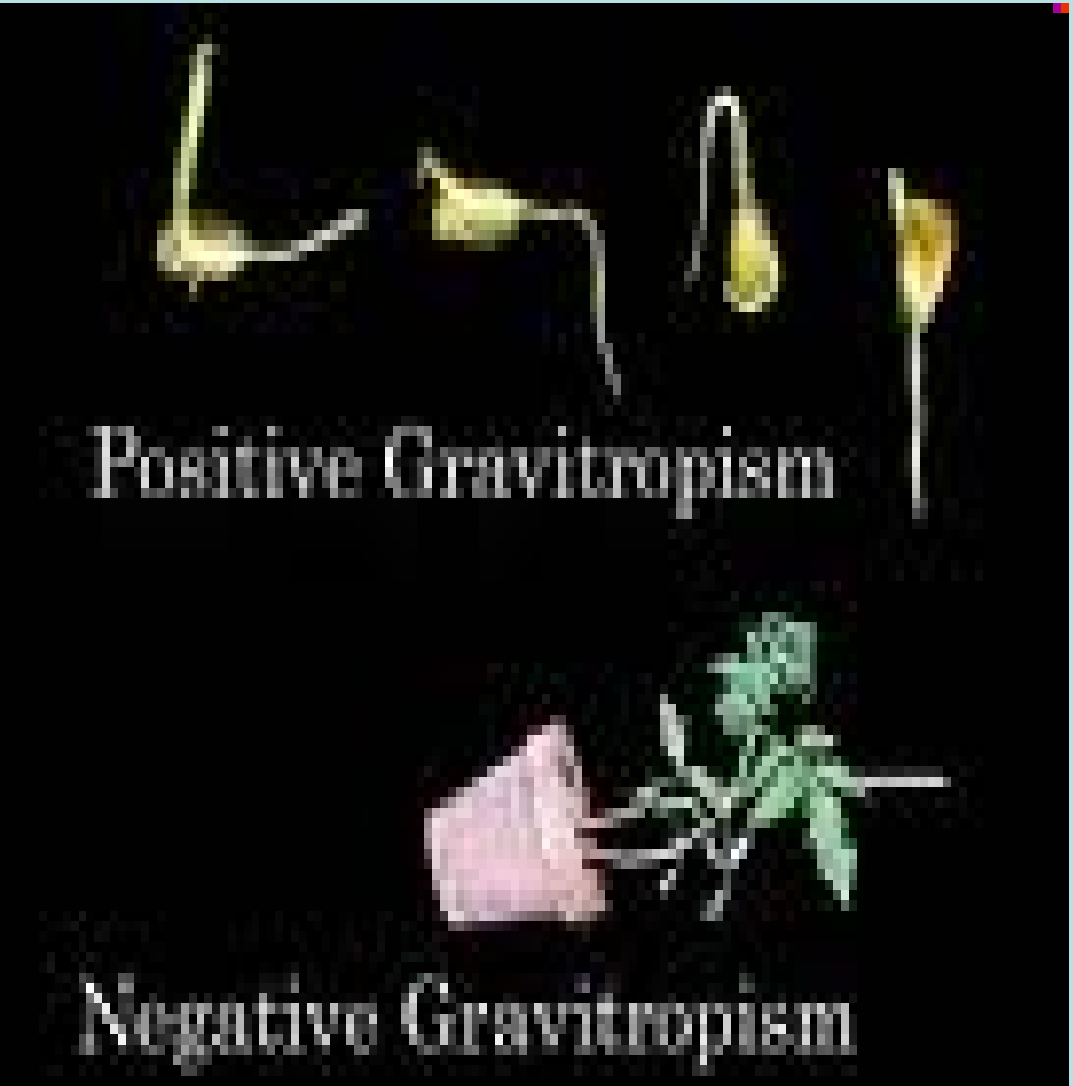
- Positive tropism = growth toward stimulus
- Negative tropism = growth away from stimulus

Types of Tropism

Tropism	Stimulus	Positive Response	Negative Response
Phototropism	Light	Stem, leaf	Roots
Gravitropism	gravity	Roots	Stem
Thigmotropism	Touch	Vine	Most plants

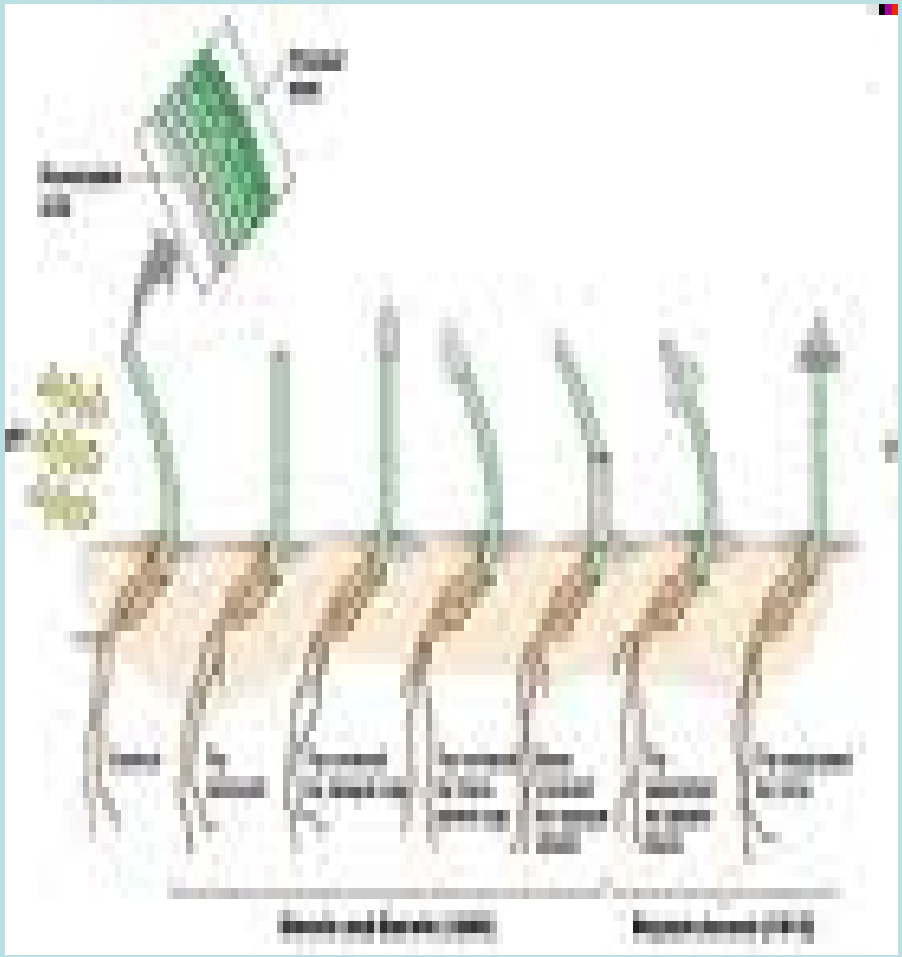
Phototropism

Gravitropism



Thigmotropism

Darwin and Boysen-Jensen Experiments



Darwin & Darwin (1880)

1)Planted seedlings with light coming from one direction →plant bends towards light

2) Removed the tip →no bending

3) Tip covered with an opaque cap →no bending

4) Tip covered with a transparent cap →bending

Conclusion: tip is responsible for sensing light

Boysen-Jensen (1913)

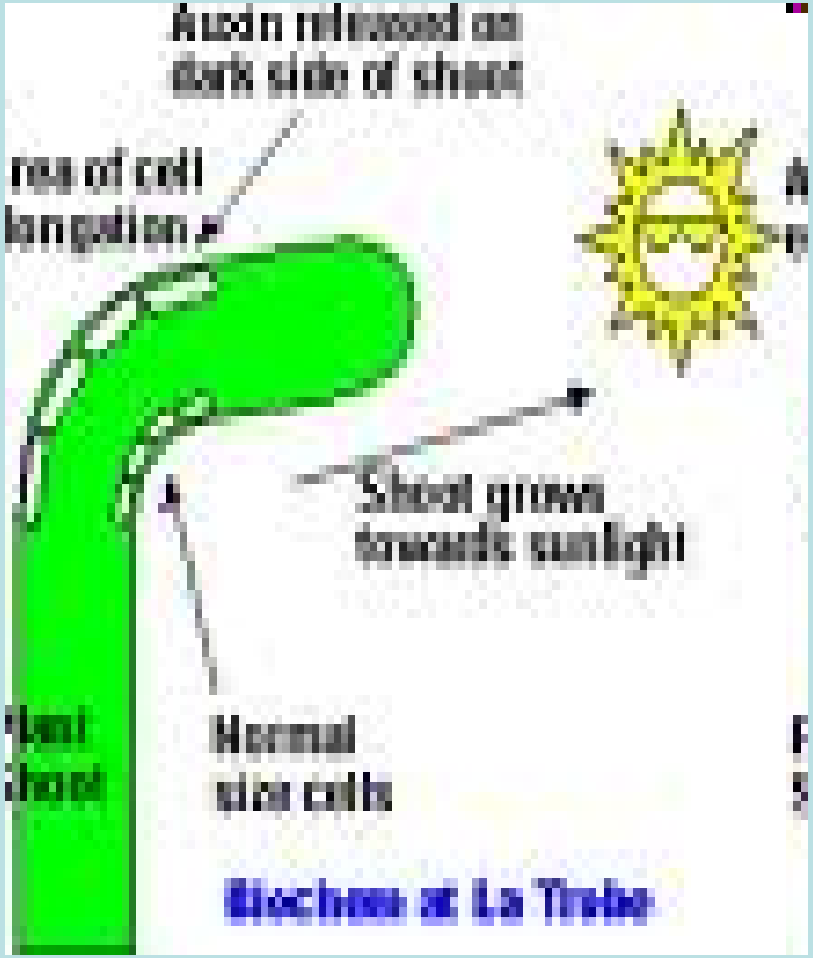
- 1) placed a gelatin barrier between tip and rest of shoot (allowing chemicals to pass) → bending
- 2) placed an impermeable barrier (mica) between tip and rest of shoot → no bending
- Conclusion: chemical message passed to the elongating region, resulting in bending

Phototropism and Auxin

- Auxin accumulates on the shaded side of the stem →causing the cells to elongate→stem bends toward the light

- If the plant is turned around, the stem bends in the other direction as it grows (the first curve remains)

Auxin


Auxin released on
dark side of shoot
Shoot grows
towards sunlight
Normal
size cells
Biochem at La Trobe

Statoliths and Gravitropism

- Statolith =organelle that contains a great quantity and density of starch
- Accumulate in the lower part of cells of roots due to gravity
- Cause auxin to build up at the lower part of cells
- Too much auxin inhibits cell growth in roots
- Slows growth on lower side but rapid elongation of cells on upper side →roots curve down

Plant Growth and Hormones

Internal Regulation of Plant Growth and Development

- When environmental conditions are optimal plants can grow to their maximum height.
- This includes: light, nutrients, moisture and warmth.

Hormonal Control of Plant Growth

- Some History…
- Charles Darwin and his son wanted to find out what caused grass seedlings to grow.
- Seeds normally grow towards a light source, but grass seeds have an opaque capsule that does not let light through…so what makes the seedling grow?

Experiment

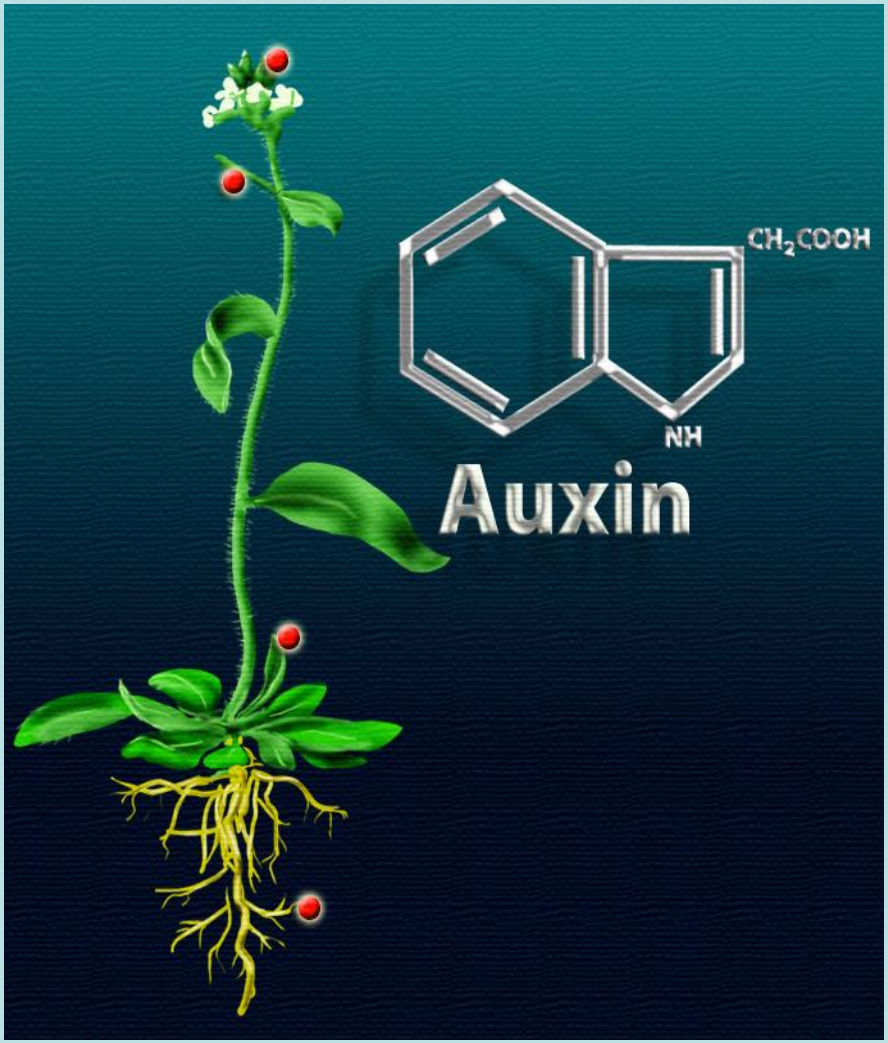
- In 1926 Frits Went found out through a series of experiments that a chemical enhanced plant growth.
- Auxin – from the Greek word ‘auxein’, which means to increase.

Other Observations

- People observed that a rice plant infected with a fungus *Gibberella fujikoroi grew abnormally tall. The fungus had something in it.*
- In 1935 scientists were able to isolate the chemical compound and named it gibberellic acid.
- When you apply the compound gibberellic acid that is not infected with the fungus it causes it to grow abnormally tall.

What is a hormone?

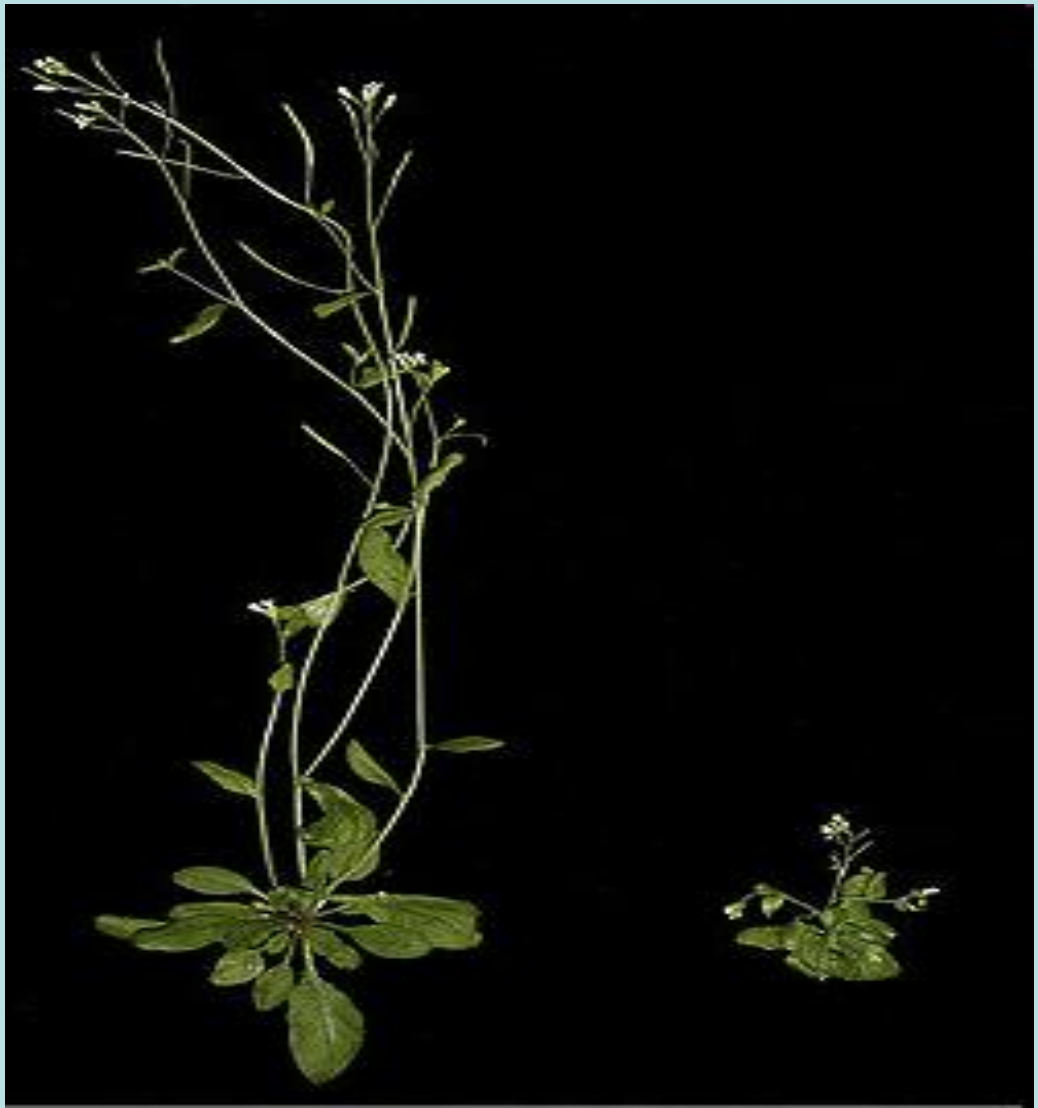
- Hormone = a compound that is produced by one part of the body and transported to other parts, where it binds to a specific receptor and triggers responses in the target cells


CH2COOH
NH
Auxin

Auxins

Classification	Promoter
Site of production	Apical meristem
Cell (division, elongation, differentiation)	Promote cell elongation vascular tissue development
Fruit	Delay ripening
Abscission (leaf drop)	Inhibit leaf drop before leaf ages, but promote leaf drop afterwards
Senescence (aging)	-----
Application	Prevent ripe fruit from falling off trees →gives farmers extra time to harvest

Auxin signal-transduction mutant (right)



Cytokinins

Classification	Promoter
Site of production	In actively growing tissue
Cell (division, elongation, differentiation)	Cell division and differentiation (mitosis)
Fruit	----
Abscission (leaf drop)	----
Senescence (aging)	Delays aging
Application	Spray cut flowers with cytokinins →keep them fresh for a longer time, inhibiting aging

“CytoSpray”

- Nitrozime
- high content of naturally occurring plant hormones such as **cytokinins, auxins, giberellins**
- stimulates whatever stage of growth plants are in,

Gibberellins

Classification	Promoter
Site of production	Apical meristem
Cell (division, elongation, differentiation)	Promote division, elongation, increase stem length
Fruit	----
Abscission (leaf drop)	----
Senescence (aging)	----
Application	**Japanese rice plants with a fungus infection producing too much Gibberellin→ rice plants grew very tall →fell over and badly damaged** **Commercial crops increase fruit size**

Effect of Giberellin on cannabis sprout

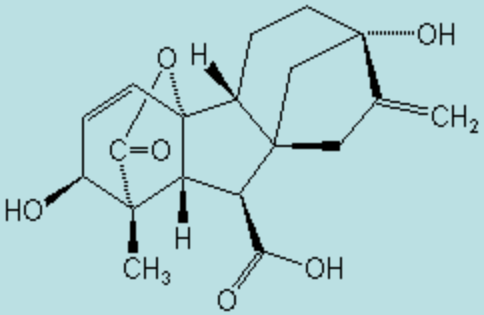
Ethylene (gas)

Classification	Inhibitor
Site of production	Ripening fruit, damaged tissue
Cell (division, elongation, differentiation)	Inhibit elongation
Fruit	Promote ripening, can stimulate other plants to ripen (ex. green banana ripen quickly when left beside oranges)
Abscission (leaf drop)	Speed up dropping of leaves
Senescence (aging)	Aging of plant tissues
Application	Pick fruits before ripening (do not spoil during shipping) and apply artificial ethylene before sale

Abscisic acid (ABA)

Classification	inhibitor
Site of production	In mature green leaves, fruits, root caps
Cell (division, elongation, differentiation)	Inhibit growth of axillary buds, inhibit seed germination, Blocks the action of growth promoting hormones
Fruit	Promote ripening
Abscission (leaf drop)	Promote leaf drop
Senescence (aging)	promote
Application	Better colour in fruit

Gibberellins



-Promote cell enlargement

-Promote uptake of starch tissue by embryos in germinating seeds

-Stimulate the vascular cambium to produce secondary phloem in woody plants

-Promote ‘bolting’ rapid elongation of the flower stem in plants

-Overall, stronger and taller plants.

-Used in commercial crops to increase fruit size and cluster in grapes.

-Delay ripening of citrus fruits.

Cytokinins (cytokinesis – cell division after mitosis)

- Promote cell division and cell differentiation.
- Delay the aging of leaves and fruit

Oligosaccharins

- Stimulate the plant to produce an antibiotic in response to attacks by fungi or bacteria.
- This allows the plant to grow to its full potential.

Growth Inhibitors

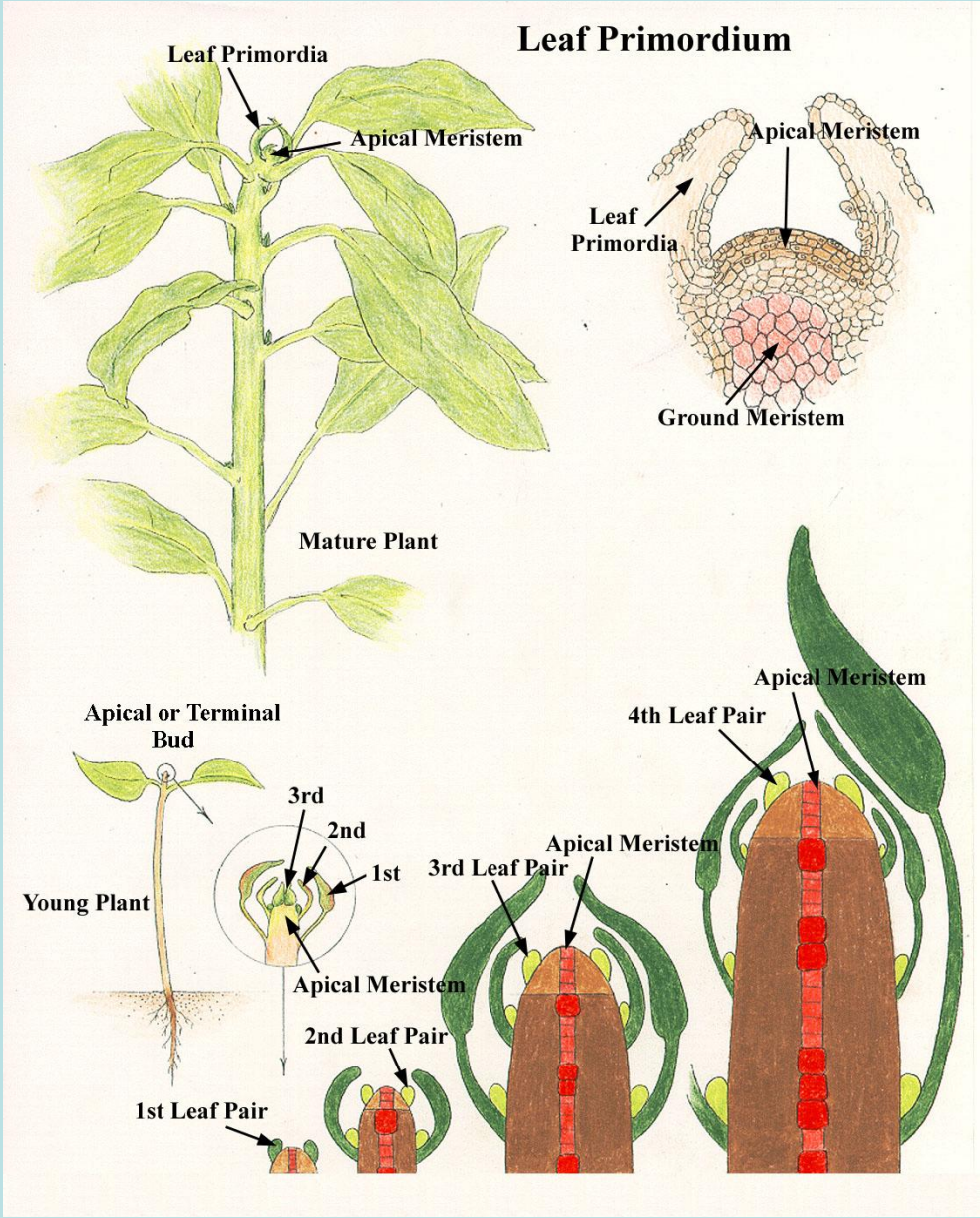
- Abscisic Acid (ABA)
  - Stop the stomata from opening, therefore blocking the intake of carbon dioxide.
  - Inhibit seed germination
  - Block the action of growth promoting hormones
  - Promote the shedding of leaves and fruit

Ethylene – is a **gaseous** hydrocarbon

- Speeds up fruits to ripen and sweeten
- Speed up the dropping of leaves
- The production of ethylene gas can stimulate other plants to ripen.
- Agricultural uses: tomotoes are picked early when they are green and ethylene is applied to artificially ripen the tomotoes to red.

Seed Germination Video

- http://www.youtube.com/watch?v=d26AhcKeEbE&feature=related


Leaf Primordium
Leaf Primordia
Apical Meristem
Apical Meristem
Leaf Primordia
Ground Meristem
Mature Plant
Apical Meristem
4th Leaf Pair
Apical or Terminal Bud
3rd
2nd
1st
Young Plant
Apical Meristem
3rd Leaf Pair
Apical Meristem
2nd Leaf Pair
1st Leaf Pair