**Hormones: communicating with chemicals**

History- discovery of plant hormone

Concepts of hormones

6 Major plant hormones

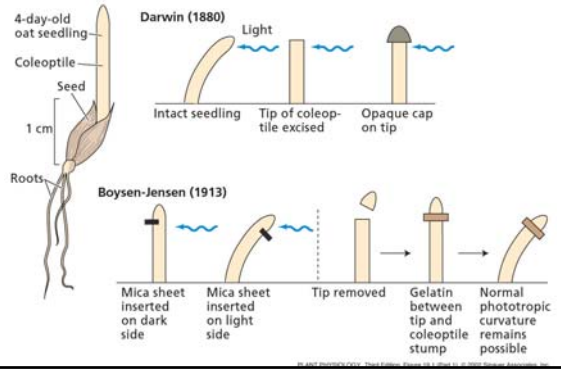
Balance of hormones regulate growth & development.

Environmental signals can cause changes in hormone levels.

Physiological effects- **what** changes does each hormone induce?

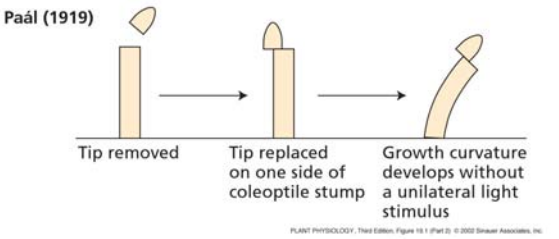
Signal transduction- **How** does each hormone induce the response?

19-1. History: **Discovery of a growth substance (hormone- auxin)**

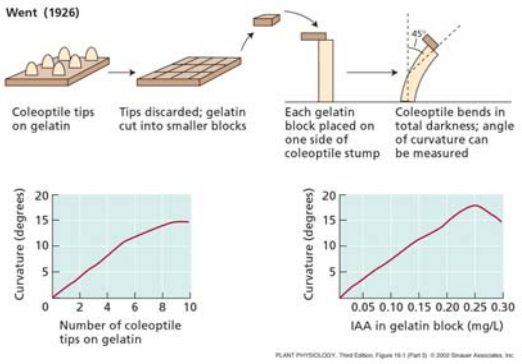



Growth substance is produced at one location and then transported to other parts of the plant.

No light




Curvature was dependent on the conc of chemical (auxin)




**Form and function of multicellular organisms depend on efficient communication among cells and organs. Communication depends on chemical signals.**

**Concepts**

1. **Hormones are chemical signals that facilitate intercellular communication**.
   Made in certain tissues and transported to target tissues.
   Act at very low conc.
2. **Level of hormones is regulated**.
   By Rate of biosynthesis
   Rate of degradation, and
   Transport
   Life time of chemical messenger is limited.
3. **Developmental/Environmental signals cause changes in hormonal balance**.

Environment cues ---> change [Hormone] --> response

Developmental cues --> change hormone levels

**Growth Regulation by Hormones**

**6 types of hormones**:

1. Auxin: Stimulates cell elongation
2. Gibberellin (GA): Broad functions , e.g. cell elongation, germination
3. Cytokinin: induce cell division
4. Abscisic Acid [ABA]: suppresses growth, "stress" hormone
5. Ethylene: causes fruit ripening, abscission
6. Brassinosteroid: BR

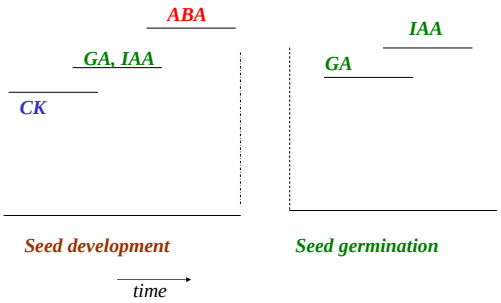
**Other signaling molecules**:

Jasmonic Acid (JA): made in response to wounding

Salicylic Acid (SA): aspirin, made in response to pathogen infection

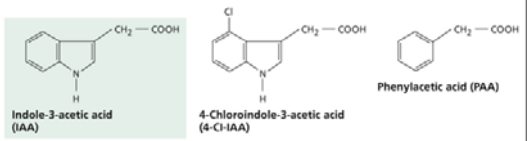
Systemin

## Hormones during seed development and germination




19-2. Taiz. Principal auxin in plants is IAA

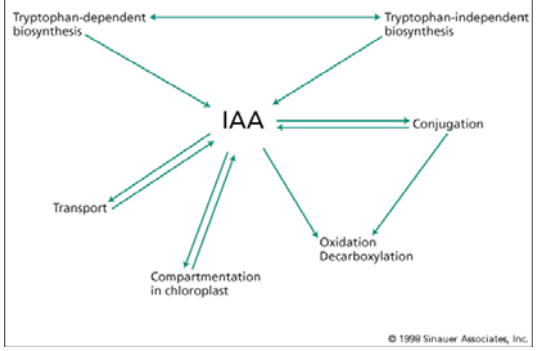
Synthesized in shoot meristem, young leaves, developing fruits



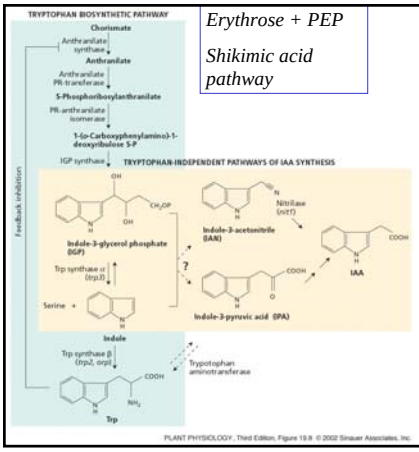



19-12: Taiz 1998. **What controls auxin levels?**

Steady state levels of auxin depends on synthesis, degradation, transport and compartmentation.





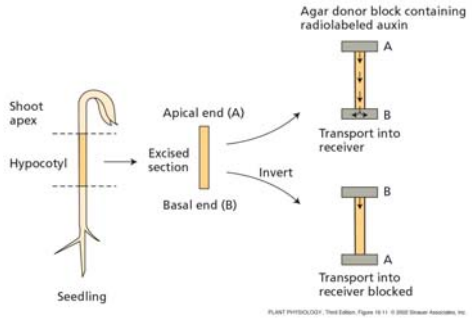

*Erythrose + PEP*

*Shikimic acid pathway*

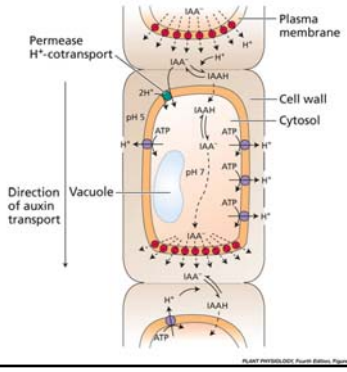
*Auxins are **synthesized** from primary metabolites via multiple pathways*

*Auxin is degraded by multiple pathways*

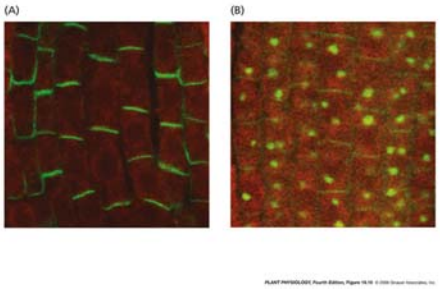
19-11. Taiz. auxin is transported in a polar fashion.




## How? Model of polar auxin transport

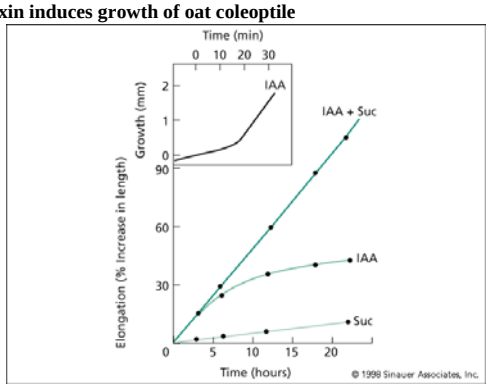


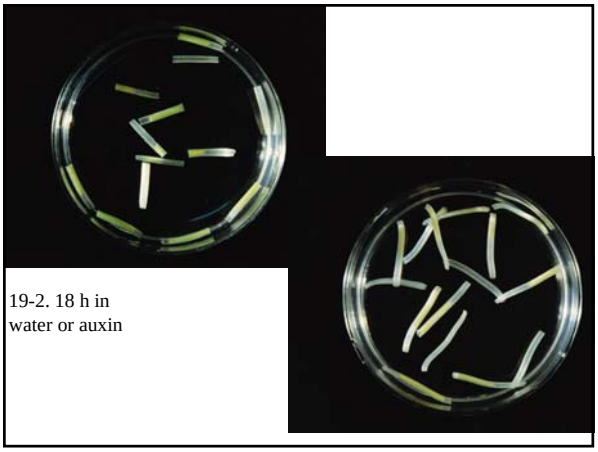
A. PIN1 localizes to lower end of root cells.
B. BFA causes PIN1 accumulation in intracellular




# Actions of Auxin
# Cell elongation

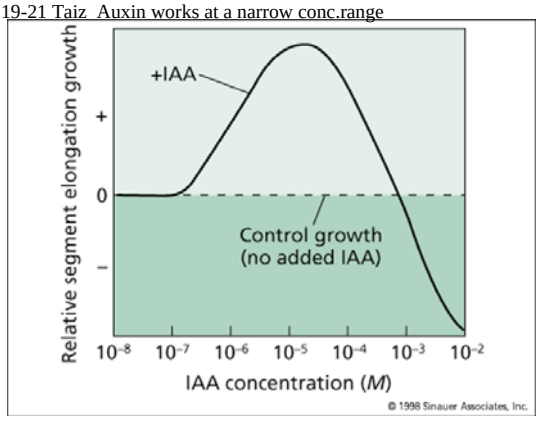
19-20 Taiz. What does auxin do?
**Auxin induces growth of oat coleoptile**



19-2. 18 h in
water or auxin

19-21 Taiz Auxin works at a narrow conc.range




**Auxin effects**:

Stimulate cell elongation

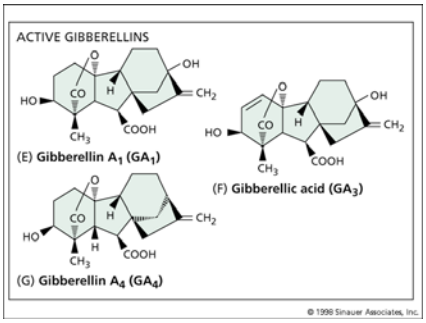
Phototropism

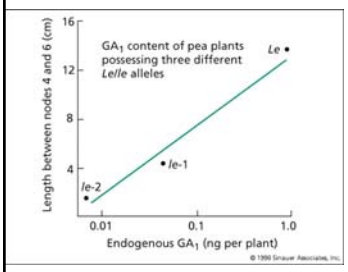
Gravitropism

**How does auxin cause these changes?**

Mode of action: [later]

# Gibberellic Acid
GA



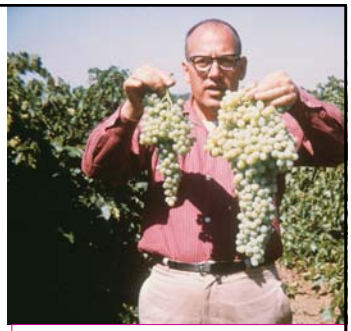

20-1. Taiz. **Gibberellic Acid**

Synthesized in shoot tip and root tip

20-9. Stem elongation correlates with GA level

Barley: GA stimulates food breakdown in seed germination

Bolting involved in Flowering

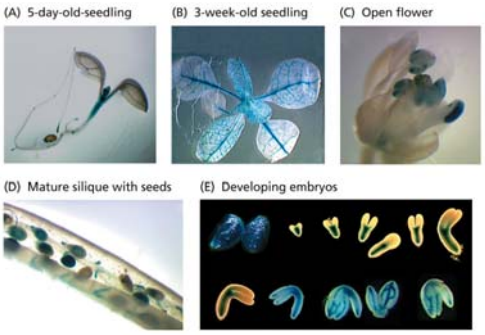


*GA increase stalk length, thus grapes grow bigger.*

*GA induce cabbage to bolt & flower*

# Sites of GA synthesis

GAI promoter::Gus




***Making beer with GA***

1. ***Malting of barley***

*Seeds are germinated (+GA) and then dried & pulverized.*
*Malt contains starch-degrading enzyme & partially digested starch*

2. ***Mashing****: water is added*
*Starch –amylase → maltose (disaccharide) - → glucose*

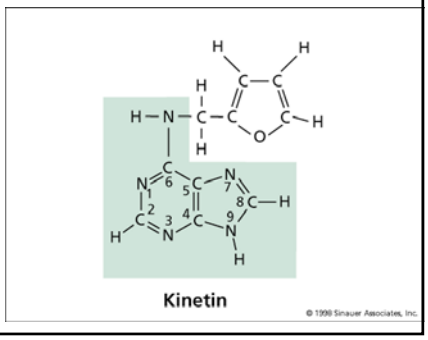
*Boiled to stop the reaction.*

3. ***Fermentation***

*Glucose ---+ yeast---> ethanol*

# Cytokinin

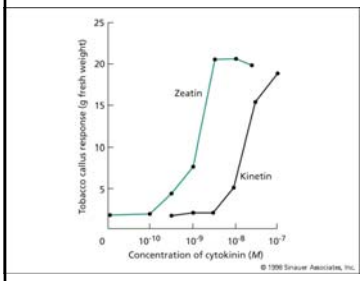
*Adenine ring*



21-1 **Cytokinin** is produced in root apical meristem

21-7

cytokinins regulate cell division




Initiate chloroplast development

Enhance cotyledon expansion

Delay senescence

# Abscisic Acid ABA

*Seed maturation*

*Stress*

**ABA levels depend** *on*
*Synthesis in leaves (chloroplast)*

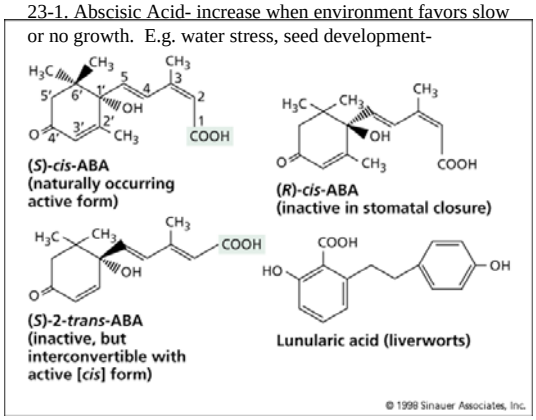
*Distribution within mesophyll cell*

*Import from roots.*

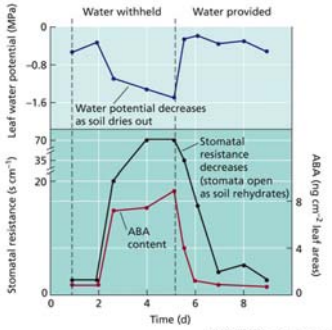
*Degradation*

*Export*

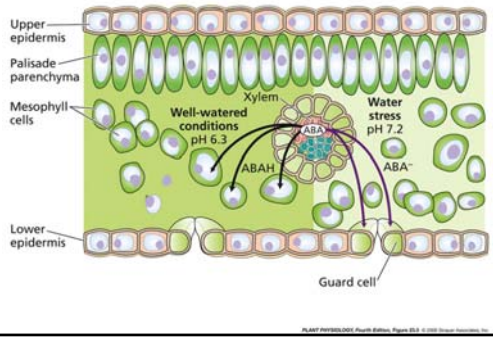
23-1. Abscisic Acid- increase when environment favors slow or no growth. E.g. water stress, seed development-




# ABA increase in response to water stress




# Import of ABA via xylem to leaves




ABA needed for seed development and inhibits premature germination

Mutant of ABA synthesis

Seeds germinate prematurely

*Vp14 maize*

## ABA levels depend on

*Synthesis in leaves (chloroplast)*

*Distribution within mesophyll cell*

*Import from roots.*

*Degradation*

*Export*

## Ethylene

$H_2C=CH_2$

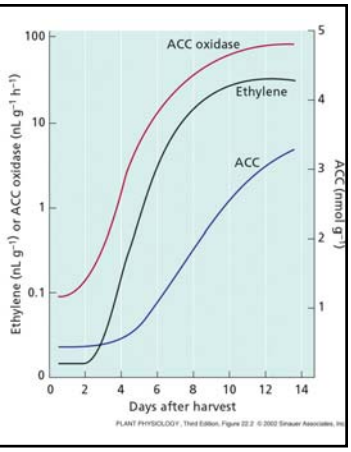
## Ethylene gas

Environmental stress promote ethylene biosynthesis.

•Senescence

•Fruit ripening

•Shortening of dark-grown seedling




***Ethylene induces responses in seedlings*** *(dark). Ethylene is synthesized when seedlings encounter mechanical pressure.*

Hypocotyl thickens
Bent apical hook

*Once seedling emerges above ground, the response to ethylene is repressed.*

Ethylene resistant mutant, etr1 is tall and cotyledons open

from Kende 2001 PP.