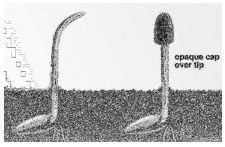
Chapter 44:
Plant Responses to the Environment

Chemical Regulation of Plant 'Behavior':

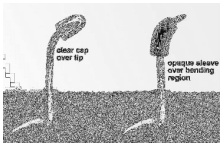
(Plant) Hormone: Chemicals produced in one location and transported to other locations where they exert an effect

Discovery of Plant Hormones:

1) Charles and Francis Darwin (late 1800's)



Tip of coleoptile detects light

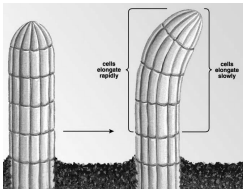


Bending region does not detect light

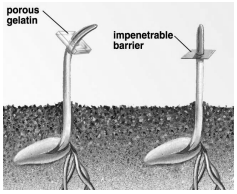
∴ The tip transmits information about light direction to bending region

Discovery of Plant Hormones:

2) Peter Boysen-Jensen (early 1900's)



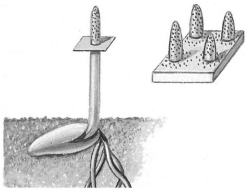
Bending = Unequal elongation of cells



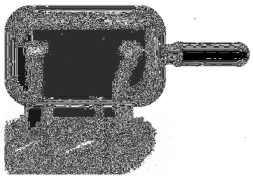
Chemical produced in tip and moves down shaft

Discovery of Plant Hormones:

3) Fritz Went (1920's)
   - Identified the chemical responsible for stem bending



Allowed chemical to enter agar block



When agar block placed on stump, cells elongated

Chemical = Auxin ('to increase')

Plant Hormones:

1) Auxins:
   - Effect elongation of cells in shoots/roots
   - Promote differentiation of vascular tissue
   - Promote development of fruit
   - Suppress lateral bud formation (Apical dominance)
2) Gibberellins
   - Promote elongation of cells in stem
   - Stimulate flowering, seed germination, bud sprouting
3) Cytokinins
   - Promote cell division in plant tissues (e.g. bud sprouting)
   - Stimulate plant metabolism
   - Prevent plant aging (e.g. leaves)

Plant Hormones:

4) Ethylene (Gas at room temperature):
   - Promotes fruit ripening
   - Stimulates cell walls to form abscission layers

5) Abscisic Acid:
   - Promotes survival in unfavorable environmental conditions
     - ❖Maintains bud/seed dormance
     - ❖Regulates stomata size

Apples give off ethylene gas naturally.

Hormonal Regulation of Plant Life Cycle:

Germination:

A) Abscisic Acid (AA) maintains seed dormancy
- ↓ metabolism of embryo
- Must be removed before germination can occur:
  - Desert Plants - Water (AA washed away)
  - Temperate Plants - Hard freeze (AA broken down)

B) Gibberellin stimulates germination
- Initiates synthesis of enzymes that release energy from endosperm / cotyledons

Hormonal Regulation of Plant Life Cycle:

Seedling Development:

A) Auxin controls orientation of seedling

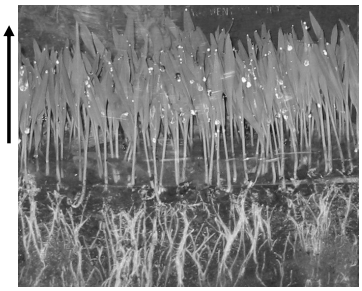
Phototropism = Directional growth with respect to light

Gravitropism = Directional growth with respect to gravity

- Shoots stimulated to grow towards light (+ phototropism) and away from gravity (- gravitropism)
- Roots stimulated to grow away from light (- phototropism) and towards gravity (+ gravitropism)
- Shoot/Root growth depends on localized [Auxin]

Phototropism vs Gravitropism

Shoots: Against gravity, towards light

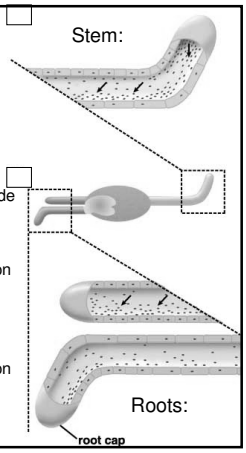


Roots: Towards gravity, away from light

Auxin Regulation:

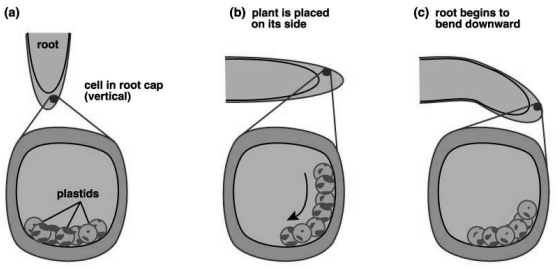
Roots/Stem:

- Auxin produced by shoot tip
- Auxin collects in root/shoot shaft:
  - Vertical = evenly distributed
  - Non-vertical = collects on lower side
- In shoots:
  - ↑ [Auxin] = stimulate cell elongation
  - ↓ [Auxin] = inhibit cell elongation
- In roots:
  - ↓ [Auxin] = stimulate cell elongation
  - ↑ [Auxin] = inhibit cell elongation



Detection of Gravity:

Starch-filled plastids (aka Statoliths) allow plants to sense gravity



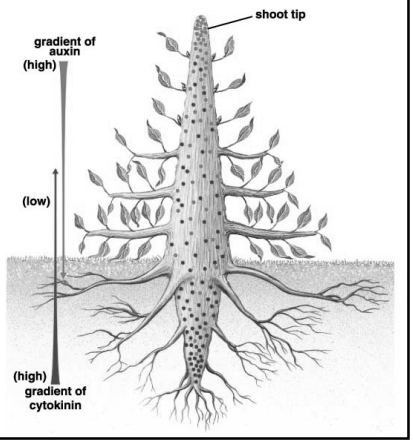
(Figure 43.2)

Hormonal Regulation of Plant Life Cycle:

Maturation:

A) Auxin and Cytokinin influence branch growth
- Auxin alone maintains apical dominance
  - Produced in shoot tip
  - Inhibits growth of lateral buds
- Auxin + cytokinin stimulates lateral buds
  - Cytokinin produced in roots
  - Bud sprouting progresses from bottom to top of stem

Hormonal Control of Lateral Bud Formation:



(Figure 43.3)

Hormonal Regulation of Plant Life Cycle:

Maturation:

A) Auxin and Cytokinin influence branch growth
- Auxin alone maintains apical dominance
  - Produced in shoot tip
  - Inhibits growth of lateral buds
- Auxin in the presence of cytokinin stimulates lateral buds
  - Cytokinin produced in roots
  - Bud sprouting progresses from bottom to top of stem

B) Auxin stimulates root branching
- Stimulates pericycle cells to divide

Control of Flowering:

- The timing of flowering is critical (time for seed production)
- Reliable environmental cue = Length of Day
  - ❖ Longer Days = Spring/Summer; Shorter Days = Fall/Winter

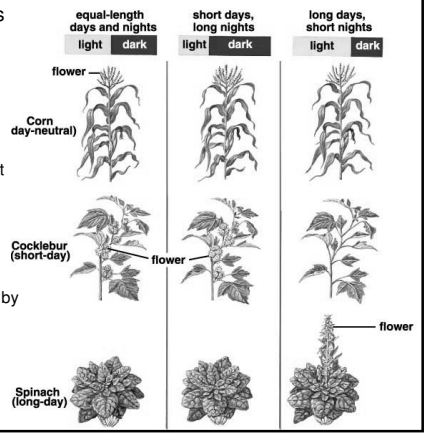
Plant Classifications:

A) Day-neutral Plant:
- Flower when physiologically ready, regardless of day length

B) Long-day Plant:
- Flower when day longer than critical value
  - Spinach > 13 hours daylight

C) Short-day Plant:
- Flower when day shorter than critical value
  - Cocklebur < 15 hours of daylight

Daylength Effects on Flowering:



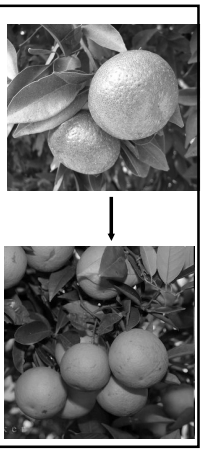
Plants detect sunlight via Phytochromes

Florigens: Hormones produced by leaves that signal buds to flower

(Figure 43.4)

Development of Fruit:

- **Developing seeds produce auxin and /or gibberellin**
  - ❖ Stimulates ovary to produce fruit (cells multiply; store starch)
- **Mature seed releases auxin surge**
  - ❖ Triggers ethylene release (ripens fruit)
    - ➢ Color changes from green to red / blue / yellow
    - ➢ Texture changes from hard to soft
    - ➢ Taste changes from bitter to sweet



Senescence and Dormancy:

- Autumn → Uneaten fruit dropped; leaves shed
- Senescence = rapid aging (of leaves/fruits/flowers)
  - Culminates in formation of abscission layer

Hormonal Control:

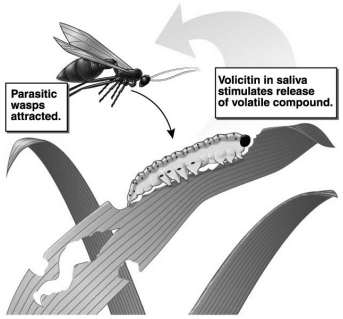
1. Auxin/Cytokinin maintains fruit/leaves
2. Auxin levels drop off (leaf/fruit)
3. Ethylene released
   - Initiates enzyme production (petiole breakdown)
4. Abscisic acid enforces bud dormany

Chemical Communication in Plants:

- Tobacco plants produce salicylic acid (aspirin) to fight off viral infections
  - Plants relay infection to neighboring plants via chemical cues

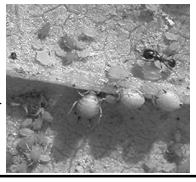
Chemical Communication in Plants:

- Corn plants call in predators to attack caterpillars feeding on them via chemical cues



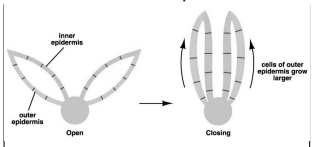
Wasp parasitism

- Tiny wasp species are often parasites on crop pests.
  - ❖Often used as biocontrol.



What About Rapid Plant Responses?

Answer: Some plant utilize 'nerve-like' impulses



1) Fly triggers sensory hairs
2) Cells of outer epidermis pump H+ ions into cell wall
3) Enzymes activated; weaken cell walls
4) Water enters cell; cells swell (43%)
5) Leaves 'pushed' close
   * Energetically costly (Don't Tease!)