

Growth

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11

Growth

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A single fiddlehead of a tropical tree fern (*Acrostichum spathuloides*). As the fern frond (leaf) matures, the fiddlehead uncoils and expands into a beautiful, leafy structure.

Photosynthesis

- Energy for most cellular activity involves adenosine triphosphate (**ATP**).
 - ❖ Plants make ATP using light as an energy source.
 - Take place in **chloroplasts** and other green parts of the organisms.



Carbon Dioxide

- Carbon dioxide reaches chloroplasts in the mesophyll cells by diffusing through the stomata into the leaf interior.
 - ❖ Use of fossil fuels, deforestation, and other human activities have added excess carbon dioxide to the atmosphere.
 - May enhance photosynthesis.
 - Plants may counter-balance by developing fewer stomata.

Water

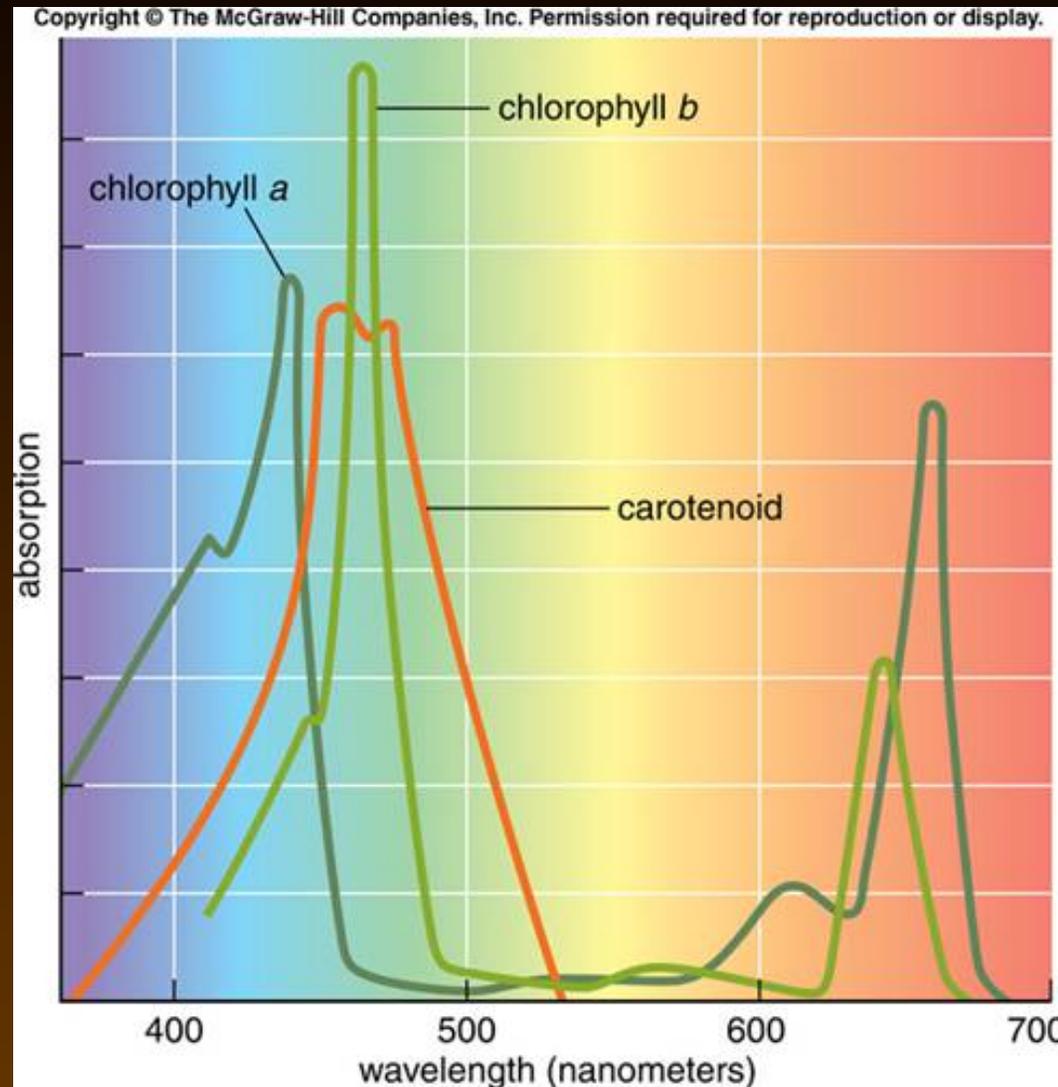
- Less than 1% of all the water absorbed by plants is used in photosynthesis.
 - ❖ Most of the remainder is transpired or incorporated into plant materials.
- If water is in short supply, stomata usually close and thus reduce the supply of carbon dioxide available for photosynthesis.

Light

- About 40% of the radiant energy received on earth is in the form of visible light.
 - ❖ Leaves commonly absorb about 80% of the visible light reaching them.
 - Light intensity varies with time of day, season, altitude, latitude, and atmospheric composition.
 - Considerable variation in the light intensities necessary for optimal photosynthetic rates.

Light Dependent Reactions - In Depth

- Each pigment has its own distinctive pattern of light absorption.



Chlorophyll

- Several different types of chlorophyll.
 - ❖ Most plants contain both **chlorophyll a** (blue-green) and **chlorophyll b** (yellow-green).
 - Other pigments include **carotenoids** (yellow and orange) **phycobilins** (blue or red), and several other types of chlorophyll.
 - About 250-400 pigment molecules group as a **photosynthetic unit**.

Respiration

- Do plants burn glucose like us?
- Respiration is essentially the release of energy from glucose molecules that are broken down to individual carbon dioxide molecules.



Nutrients, Vitamins, and Hormones

- **Nutrients** - Substances that furnish the elements and energy necessary to produce organic molecules.
- **Vitamins** - Most are organic molecules of varied structure that participate in catalyzed reactions, mostly by functioning as an electron acceptor or donor.
 - ❖ Synthesized in cell membranes and cytoplasm.

Nutrients, Vitamins, and Hormones

- Genes also dictate the production of **hormones**.
- Because some effects of vitamins are similar to those of hormones, they are sometimes difficult to distinguish.
 - ❖ The term **Growth Regulator** has been applied to compounds that have effects on plant development similar to those of hormones and vitamins.

Plant Hormones

- Auxins

- ❖ Auxin production occurs mainly in **apical meristems, buds, and young leaves.**
- ❖ Plant response varies according to concentration, location, and other factors.
 - **Promotes cell enlargement, stem growth, and delays development processes such as fruit and leaf abscission and fruit ripening.**

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Plant Hormones

- **Gibberellins (GA)**

- ❖ Named after the fungus that produced it (*Gibberella fujikuroi*).
- ❖ Most GA produced by plants are inactive, apparently functioning as precursors to active forms. More than 110 known kinds.
 - Most dicots and a few monocots grow faster with an application of GA.

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Plant Hormones

- Gibberellins are involved in nearly all the same regulatory processes in plant development as auxins.
 - ❖ Appears to lower the threshold of growth.
 - Several commercial growth retardants can be used to block GA synthesis.

Plant Hormones

- Cytokinins

- ❖ Regulate cell division.
- ❖ Synthesized in root tips and germinating seeds.
- ❖ If present during the cell cycle, cytokinins promote cell division by speeding up the progression from the G₂ phase to the mitosis phase.
- ❖ Can prolong the life of vegetables in storage.

Plant Hormones

- **Abscissic Acid**

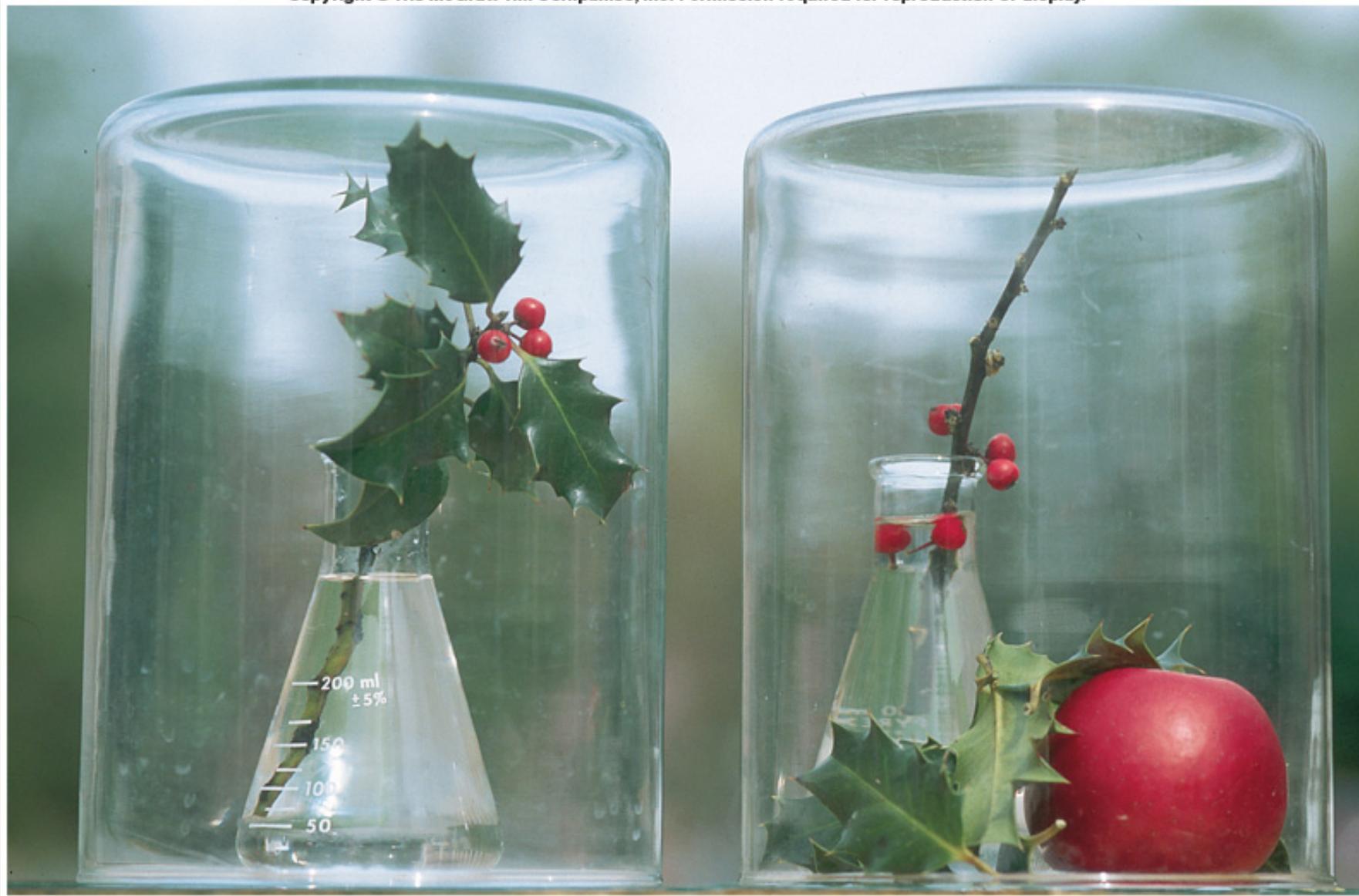
- ❖ Has inhibitory effect on the stimulatory effects of other hormones, and thus on plant growth.
- ❖ Synthesized in plastids.
 - Particularly common in fleshy fruits.
 - Prevents seeds from germinating while still on the plant.
 - Has little influence on abscission.

Plant Hormones

- **Ethylene**

- ❖ Produced by fruits, flowers, seeds, leaves, and roots.
- ❖ Produced from amino acid **methionine**.
- ❖ **Used to ripen green fruits.**
 - Production almost ceases in the presence of oxygen.

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Using Ethylene Gas to Ripen Fruits

- <http://www.youtube.com/watch?v=H2atn8YD9UE>
- http://www.youtube.com/watch?v=I1tdZh9PI_8

Plant Hormones

- Other Compounds

- ❖ Oligosaccharides

- Released from cell walls by enzymes - influence cell differentiation, reproduction, and growth in plants.

- ❖ Brassinosteroids

- Have gibberellin-like effects on plant stem elongation.

Hormonal Interactions

- **Apical Dominance**

- ❖ Apical dominance is the suppression of the growth of lateral or axillary buds.
 - Believed to be brought about by an auxin-like inhibitor in a terminal bud.
 - If cytokinins are applied in appropriate concentration to axillary buds, they will begin to grow, even in the presence of a terminal bud.

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Hormonal Interactions

- **Senescence**

- ❖ Senescence is the breakdown of cell components and membranes, eventually leading to the death of the cell.
 - Some studies have suggested certain plants produce a senescence factor.

- **Other Interactions**

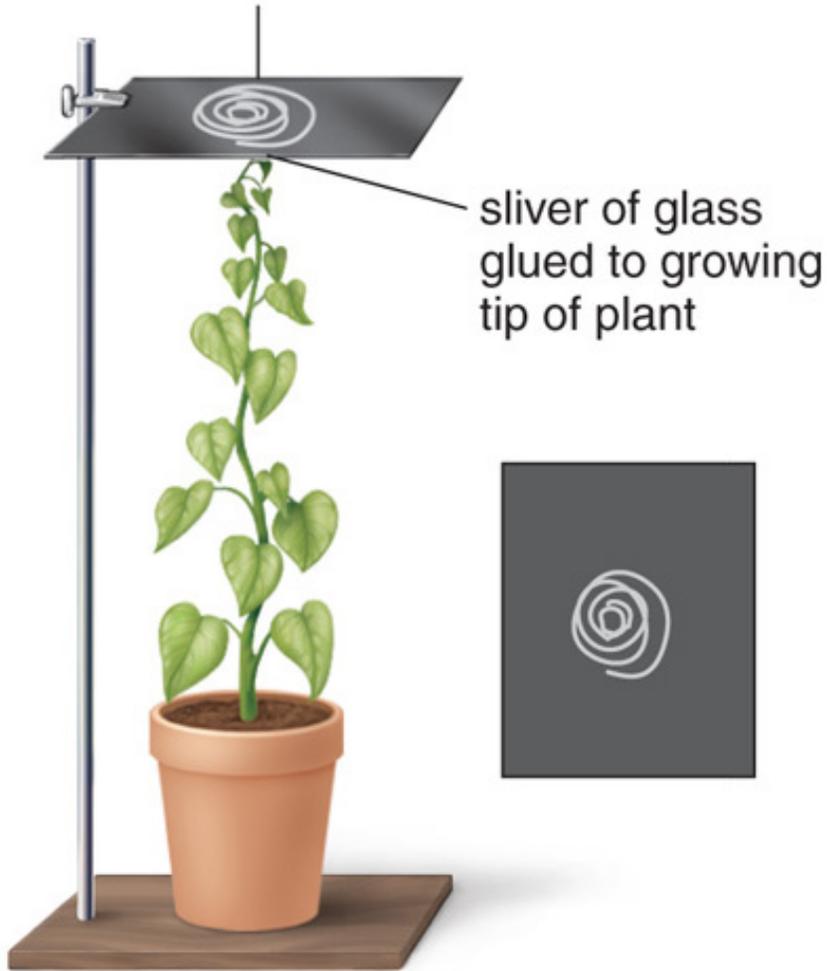
- ❖ Root and shoot development regulated by auxins and cytokinins.
- ❖ Seed germination regulated by gibberellins.

Plant Movements

- **Movements From Internal Stimuli**
 - ❖ **Nutations** - Slight spiraling
 - ❖ **Nodding** - Side-to-side oscillations
 - ❖ **Twining** - Very defined spiraling
 - ❖ **Contraction** - Contractile roots
 - ❖ **Nastic** - Non-directional
 - **Epinasty** - Permanent downward bending

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paper blackened
with carbon



sliver of glass
glued to growing
tip of plant

tip spirals as it grows,
tracing its pattern on the paper

Charles Darwin's
demonstration of
nutations (spiraling growth).

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Plant Movements

- ❖ <http://plantsinmotion.bio.indiana.edu/plantmotion/starthere.html>

Plant Movements

- **Phototropism**

- ❖ **Positive** - Growth towards a light source.
- ❖ **Negative** - Growth away from a light source.
 - Different light intensities bring about different phototropic responses.

- **Gravitropism**

- ❖ Growth responses to the stimulus of gravity.
 - Primary plant roots are positively gravitropic, while shoots forming the main axis are negatively gravitropic.

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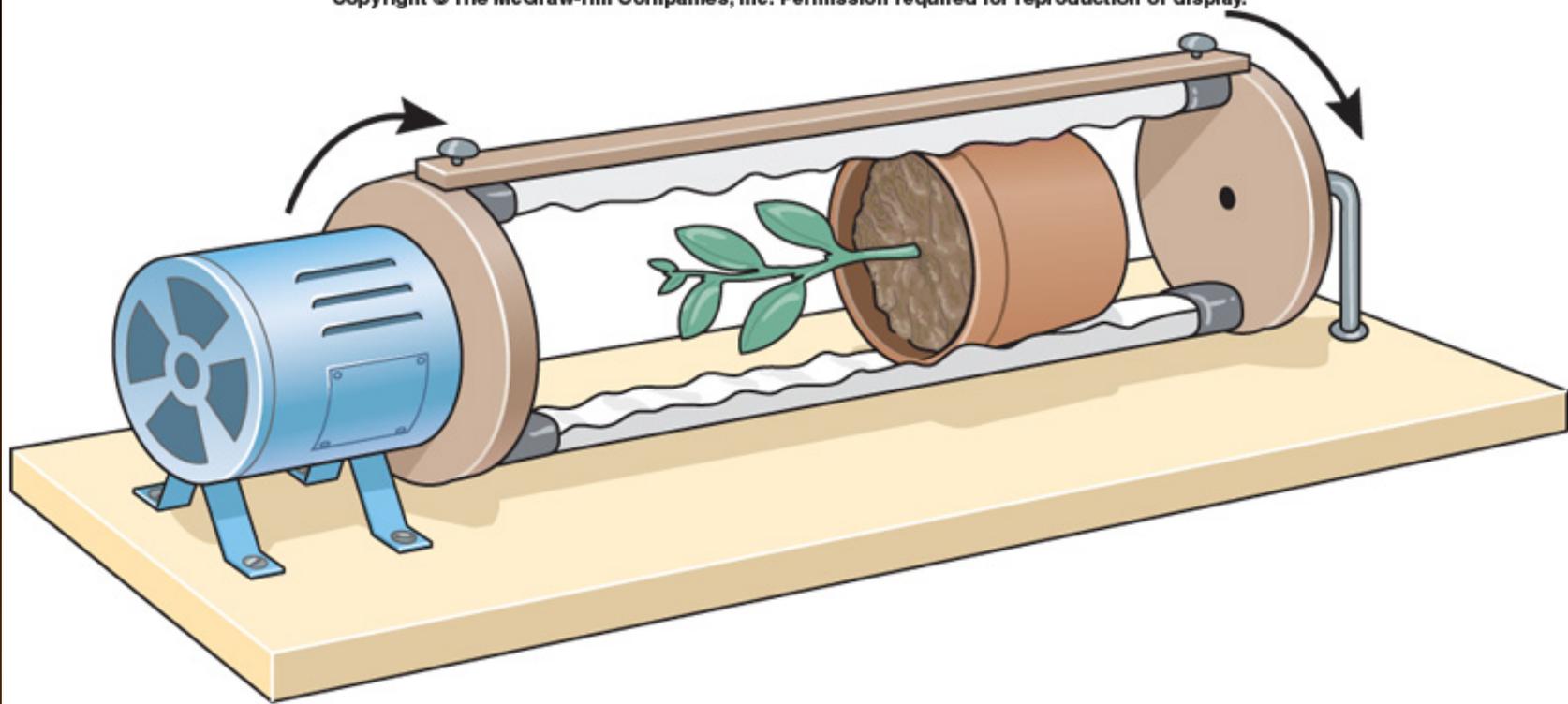


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Clinostat

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Plant Movements

- Other Tropisms

- ❖ Thigmotropism - Physical Contact.
- ❖ Chemotropism - Chemicals
- ❖ Thermotropism - Temperature
- ❖ Traumatotropism - Wounding
- ❖ Electrotropism - Electricity
- ❖ Skototropism - Dark
- ❖ Aerotropism - Oxygen

Sensitive Plant

<http://www.youtube.com/watch?v=0o18UUSJgQA>



B.

Plant Movements

- **Turgor Movements**

- ❖ Turgor movements result from changes in internal water pressures and are often initiated by contact with objects outside of the plant.
 - Turgor contact movements are not confined to leaves.
 - Many flowers exhibit movements of stamens and other parts facilitating pollination.

Turgor Movements

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A.

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B.

Plant Movements

• Circadian Rhythms

- ❖ Members of the Legume Family exhibit movements in which leaves or petals fold in regular daily cycles.
 - Fold in the evening and unfold in the morning.
- ❖ Controlled by a biological “clock” on approximately 24 hours cycles.
 - Appear to be controlled internally.

Prayer plant time lapse

- <http://www.youtube.com/watch?v=cRToxjXhbso>



- <http://www.youtube.com/watch?v=LOaD0RNpovo>



Plant Movements

• Solar Tracking

- ❖ Leaves often twist on their petioles and, in response to illumination, become perpendicularly oriented to a light source.
 - Heliotropisms - Growth is not involved.
 - Should be phototorsion.

• Water Conservation

- ❖ Many grasses have special thin-walled cells that lose their turgor and roll up or fold during periods of insufficient water.

Why do these leaves have holes in them?



Plant Movements

- Taxes

- ❖ **Taxic Movement** refers to movement involving either the entire plant, or their reproductive cells.

- In response to a stimulus, the cell or organisms, propelled by a flagella or cilia, moves toward or away from the stimulus.

- Chemotaxic - Chemicals

- Phototaxic - Light

- Aerotaxic - Oxygen Concentrations

Photoperiodism

- **Photoperiodism** refers to the fact that day length is directly related to the onset of flowering in many plants.
 - ❖ **Short-Day Plants** will not flower unless the day length is shorter than a critical period.
 - ❖ **Long-Day Plants** will not flower unless periods of light are longer than a critical period.

Photoperiodism

- ❖ **Intermediate-Day Plants** will not flower if the days are too short, or too long.
- ❖ **Day-Neutral Plants** - Will flower under any day-length, provided they have received the minimum amount of light necessary for normal growth.

Red received less than 8.5 hours of light.

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A.



B.

Temperature and Growth

- Each plant species has an optimum temperature for growth which may vary with a plant's growth stage, and a minimum temperature, below which growth will not occur.
 - ❖ Lower night temperatures often result in higher sugar content in plants and may also produce greater root growth.
 - ❖ Growth of many field crops is roughly proportional to prevailing temperatures.

Dormancy and Quiescence

- **Dormancy** - Period of growth inactivity in seeds, buds, bulbs, and other plant organs even when environmental requirements are met.
- **Quiescence** - State in which a seed cannot germinate unless environmental conditions normally required for growth are present.
 - ❖ Lodgepole Pines