PowerLecture:
Chapter 30
Plant Nutrition And Transport
Section 30.0: Weblinks and InfoTrac

See the latest Weblinks and InfoTrac articles for this chapter online or click highlighted articles below (articles subject to change)

- Section 30.0: Remediation Technologies Development Forum
- Section 30.0: Phytoremediation Research
- Section 30.0: Edenspace Systems Corp.
- Section 30.0: Waste Lands—The Threat of Toxic Fertilizer
- Section 30.0: Aberdeen to Cap Old Munitions with Sand. *Superfund Week,* Nov. 25, 1994.
- Section 30.0: Plants Proving Their Worth in Toxic Metal Cleanup. Anne Simon Moffat. *Science,* July 21, 1995.

How Would You Vote?

The following is the question for this chapter. See national results below.

- Should genetically engineered plants be used in phytoremediation?

Impacts, Issues: Leafy Clean-Up Crews

- J-Field – once military disposal site of old chemical weapons - harmful organic substances, particularly TCE, seeped into the groundwater
- Today, military and EPA are trying to repair the site using hybrid poplar trees
- Trees take up TCE, cleaning groundwater

Impacts, Issues: Leafy Clean-Up Crews

- Phytoremediation – cleaning blighted regions using plants to take up toxic substances
- Toxins, once taken up by the plant, are degraded in cells or released into air where it breaks down faster than in groundwater
- Some plants store toxins in tissues, allowing toxins to be disposed of with the plants

Impacts, Issues: Leafy Clean-Up Crews

- Genetically engineered plants that tolerate higher toxin levels may offer better options for use in phytoremediation

Section 30.1: Weblinks and InfoTrac

See the latest Weblinks and InfoTrac articles for this chapter online or click highlighted articles below (articles subject to change)

- Section 30.1: NRCS Soils
- Section 30.1: Something to Grow On
- Section 30.1: Essential Elements for Plant Growth
- Section 30.1: Plant Stress
- Section 30.1: Surviving the Dust Bowl
- Section 30.1: Knop's Solution Is Not What It Seems (hydroponics exercises). David Hershey. *Science Activities,* Fall 2001.
- Section 30.1: Small Farms, Externalities, and the Dust Bowl of the 1930s. Zeynep Hansen et al. *Journal of Political Economy,* June 2004.

Carnivorous Plants

- Capture animals to supplement their nutrient intake
- Venus flytrap lures insects with sugary bait; closes on victim
- Cobra lily lures insects down a one-way passage

Plant Nutritional Requirements

- Nearly all plants are photoautotrophs
- Require carbon dioxide, water, minerals
- Many aspects of plant structure are responses to low concentrations of these vital resources in the environment

Soil

- Minerals mixed with humus

- Minerals come from weathering of rock
- Humus is decomposing organic material

- Composition of soil varies
- Suitability for plant growth depends largely on proportions of soil particles

Three Soil-Particle Sizes

- Sand
  - Largest particles
- Silt
  - Medium-sized particles
- Clay
  - Finest particles

Humus

- Decomposing organic material
- Nutrient rich
  - Negatively charged organic acids help humus attract positively charged minerals
- Absorbs water and swells; shrinks as it releases water
  - Helps to aerate soil

Optimal Soil for Plant Growth

- Loam
  - Roughly equal proportions of sand, silt, and clay

- 10 to 20 percent humus

Soil Horizons

- O horizon
- A horizon - topsoil
- B horizon - less organic material, more minerals
- C horizon - no organic material

Macronutrients

Mineral elements that are required above 0.5 percent of the plant's dry weight

Carbon Nitrogen Magnesium
Hydrogen Potassium Phosphorus
Oxygen Calcium Sulfur

Micronutrients

Elements that are required in trace amounts for normal plant growth

Chlorine Zinc
Iron Copper
Boron Molybdenum
Manganese

Leaching

- Removal of nutrients from soil by water that percolates through it
- Most pronounced in sandy soils
- Clays are best at holding onto nutrients

Section 30.2: Weblinks and InfoTrac

See the latest Weblinks and InfoTrac articles for this chapter online or click highlighted articles below (articles subject to change)

- Section 30.2: Roots—The Hidden Half of Growth

- Section 30.2: Mycorrhizas Webpage

- Section 30.2: Nitrogen Fixation Gallery

- Section 30.2: Out of Thin Air (nitrogen fixers). David Wolfe. *Natural History,* Sept. 2001.

Root Structure & Absorption

- Roots of most flowering plants have:
  - Endodermis - surrounds vascular cylinder
  - Exodermis - just below surface
- Both layers contain a Casparian strip
  - Controls the flow of water and nutrients

Casparian Strip

Root Hairs

- Extensions from the root epidermis

- Greatly increase the surface area available for absorption

Root Nodules

- Swelling on the roots of some plants
- Contain nitrogen-fixing bacteria
- Bacteria convert nitrogen gas to forms that plants can use

Mycorrhizae

- Symbiosis between a young plant root and a fungus

- Fungal filaments may cover root or penetrate it
- Fungus absorbs sugars and nitrogen from the plant
- Roots obtain minerals absorbed from soil by fungus

Section 30.3: Weblinks and InfoTrac

See the latest Weblinks and InfoTrac articles for this chapter online or click highlighted articles below (articles subject to change)

- Section 30.3: Transport of Water and Minerals in Plants

- Section 30.3: Cohesion-Tension Mechanism of the Ascent of Sap

- Section 30.3: Transporting Water in Plants. Martin Canny. *American Scientist,* Mar.–Apr. 1998.

Water Use and Loss

- Plants use a small amount of water for metabolism
- Most absorbed water lost to evaporation through stomata in leaves
- Evaporation of water from plant parts is transpiration

Water Transport

- Water moves through xylem
- Xylem cells are tracheids or vessel members
- Both are dead at maturity

Cohesion-Tension
Theory of Water Transport

- Transpiration creates negative tensions in xylem
- Tensions extend downward from leaves to roots
- Hydrogen-bonded water molecules are pulled upward through xylem as continuous columns

Transpiration
Drives Water Transport
Replacement Water is Drawn in through Roots

The Role of Hydrogen Bonds

- Hydrogen bonds attract the hydrogen of one water molecule to the -OH group of another
- Hydrogen bonds make water cohesive; water molecules stick together inside the narrow xylem walls as the molecules are pulled upward

Section 30.4: Weblinks and InfoTrac

See the latest Weblinks and InfoTrac articles for this chapter online or click highlighted articles below (articles subject to change)

- Section 30.4: Desert Plant Survival
- Section 30.4: Eastern Mojave Vegetation
- Section 30.4: How Plants Conserve Water. *Applied Genetics News,* July 2001.
- Section 30.4: The Unthirsty 100 (plants that require less summer water). *Sunset,* Oct. 1988.

Osmosis and Wilting

- Water responds to solute concentrations; moves osmotically into plant cells
- When water loss is balanced by osmotically induced movement inward, plant is erect
- If water concentration of soil drops, inward movement stops, plant wilts

Cuticle

- Translucent coating secreted by epidermal cells
- Consists of waxes in cutin
- Allows light to pass though but restricts water loss

Stomata

- Openings across the cuticle and epidermis; allow gases in and out
- Guard cells on either side of a stoma
- Turgor pressure in guard cells affects opening and closing of stomata

Control of Stomata

- Close in response to water loss
- ABA binds to receptors on guard cell membranes
- Calcium ions flow into cells
- Chloride and malate flow from cytoplasm to extracellular matrix
- Potassium ions flow out
- Water moves out of guard cells

Stomata

- Pollutants clog stomata

CAM Plants

- Most plants are C3 or C4 plants
  - Stomata open during day and photosynthesis proceeds
- CAM plants are better at water conservation
  - Stomata open at night and carbon dioxide is fixed
  - Next day, stomata remain closed while carbon dioxide is used

Section 30.5: Weblinks and InfoTrac

See the latest Weblinks and InfoTrac articles for this chapter online or click highlighted articles below (articles subject to change)

- Section 30.5: Michigan Maple Syrup Association

- Section 30.5: Sweet Success in Texas (biochemical aspects of the ripening of sugarcane). Steve Miller. *Agricultural Research,* Apr. 1992.

Phloem

- Carry organic compounds
- Conducting tubes are sieve tubes
  - Consist of living sieve-tube members
- Companion cells
  - Lie next to sieve tubes
  - A type of parenchyma
  - Help load organic compounds into sieve tubes

Transportable Organic Compounds

- Carbohydrates are stored as starches
- Starches, proteins, and fats are too large or insoluble for transport
- Cells break them down to smaller molecules for transport
  - Sucrose is main carbohydrate transported

Transport through Phloem

- Driven by pressure gradients
- Companion cells supply energy to start process

Loading at Source

- Small soluble organic compounds loaded into phloem

Translocation

- Fluid pressure is greatest at a source
- Solute-rich fluid flows away from the high-pressure region toward regions of lower pressure

Pressure

- Honeydew exuding from an aphid after part of the insects mouth penetrates a sieve tube (p520)

Unloading at a Sink

- Region where compounds are being stored or used
- Solutes are unloaded into sink cells and water follows

Interdependent Processes