Notes

Biology 103, Spring 2008
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Week 4 **Reading:** Chapter 42, sections 4-6

Topic: Plant transport systems

Note: If you have not taken Bi 102, use the links under "Useful Websites" to learn about osmosis, diffusion, and active transport, processes which are part of plant transport systems.. These concepts are sometimes difficult, but the animations on the websites help students learn them more quickly and easily.

Main concepts:

- Vascular tissue forms the pipelines of a plant, and is used to transport water, dissolved minerals, and dissolved sugars.
- Xylem tissue transports water and dissolved minerals from roots to leaves, using some active transport, but mostly passive processes.
- Phloem tissue transports dissolved sugars up or down a plant, using active transport and osmosis.
- Plants require large amounts of eight nutrients: carbon, hydrogen, oxygen, nitrogen, phosphorous, potassium, magnesium, and calcium. Other nutrients, such as manganese, copper, sulfur, selenium, and boron are required in very small amounts.
- Carbon and oxygen are obtained from the air. The rest of the required nutrients are from water and minerals dissolved in the water.
- Microbes in the soil form symbiotic relationships with root cells which benefit plants by helping them acquire scarce nutrients.
  - Fungal mycorrhizae help plants absorb minerals, especially phosphorous.
  - Nitrogen-fixing bacteria convert nitrogen compounds into forms that plants can absorb.
- Transpiration (water transport) involves three processes: absorption at the roots, capillary action in the xylem, and evaporation at the leaves.
  - Roots acquire dissolved minerals in a four-step process:
    - Active transport into the root hairs, which moves minerals against their concentration gradient.
    - Diffusion through the cortex cells and into the pericycle.
    - Active transport out of the pericycle cells and into the vascular cylinder.
    - Diffusion into the xylem.
  - Capillary action, which draws water up the xylem vessels.
    - Cohesion: water molecules are polar and are attracted to each other.
    - Adhesion: water molecules also stick to other polar substances, such as the walls of xylem vessels.
    - Both phenomena tend to draw water up narrow vessels. The highest a column of water can rise before gravity overcomes the forces in the hydrogen bonds involved is 32 feet.
  - Evaporation: contributes to the Cohesion-Tension theory
    - Cohesion creates a "water chain" up the xylem vessels.
    - Evaporation at the leaf surface removes water molecules, lowering the water concentration in the leaf.
    - More water rises by osmosis.
    - Evapo-transpiration is controlled by the opening and closing of the stomata of the leaf. Stomata open in response to light and low carbon dioxide levels in the leaf. They close in response to water loss.
- The pressure-flow theory is the current explanation of how plants transport sugars.
  - Pressure-flow takes advantage of osmosis to move sugars in any direction the plant needs.
  - Source: Sugars are made in the photosynthetic cells of the leaf.
  - Sink: Sugars are stored in the roots, and sometimes in the stems, fruits, or leaves of a plant.
  - Active transport is used to pump sugars from the source cells into the phloem cells.
  - Once a phloem cell is loaded with sugar, water moves in by osmosis. This raises pressure in the cell.
  - Osmotic pressure moves the sap (sugar dissolved in water) toward the sink (roots, fruits, or other place that the sugars will be stored).
  - Sugars move into sink cells and enter the cells by diffusion. The sugar molecules are linked together to make starch, which is less soluble in water. This keeps the concentration of sugar low in the cell, to keep the diffusion gradient high.

- The same process can be used to move sugars out of sink cells to other cells that need sugars for energy. Starch can be broken apart into sugar again, and the sugars can then be pumped into the phloem cells by active transport.

Common misconceptions:

- Students sometimes compare plant transport to animal circulatory systems. It's important, though, to remember that there is no systematic circulation involved. Most water molecules take a one-way trip up the xylem vessels. Those that move into phloem by osmosis may be circulated, but this is a by-product of the main process, which moves sap in one direction or another in the phloem. Sap is moved from source to sink, and does not circulate.
- Students are familiar with the idea that sugars are made in the leaves and stored in the roots. They sometimes forget, though, that the stored sugars must be moved to cells that need them. They may also not realize that sugars are stored in other parts of the plant besides the roots.

Reading notes:

- List and describe the four steps of mineral acquisition that occur in the roots.
- Refer to figure 24-18, and explain the role of the Casparian strip.
- Describe how fungi and bacteria help plants absorb nutrients.
- Read the "Earth Watch" section, and summarize how plants help regulate water distribution on land.
- Define "cohesion" and "tension." Explain how cohesion and tension help draw water up the xylem.
- Explain how pressure differences created by transpiration at the leaves help draw water into the roots.
- Describe how light, carbon dioxide, and water loss control the function of the guard cells.
- Explain how aphids helped scientists study how phloem transports sugars.
- Define "source" and "sink," and use these terms to describe how the pressure-flow process works. Use Figure 24-25 as a guide.
- Read the last section on evolutionary connections. List some ways in which roots, leaves, and stems may have been adapted to different purposes.

Useful websites:

- If you need to review osmosis and active transport:
  - "Active Transport" http://www.brookscole.com/chemistry_d/templates/student_resources/shared_resources/animations/ion_pump/ionpump.html is an animation of the Sodium-Potassium pump found in the membranes of nerve cells. It's a good introduction to the concept.
  - "Diffusion and Osmosis" http://www.phschool.com/science/biology_place/labbench/lab1/intro.html has a series of interactive lessons on material movement.
- Animations of transport in plants:
  - "Guard cell function" http://www.phschool.com/science/biology_place/labbench/lab9/stomamov.html is a simple animation of how stomata open and close.
  - "Transpiration" http://www.phschool.com/science/biology_place/labbench/lab9/concepts1.html is a guided tutorial with simple animations.
  - "Transpiration" http://www.kscience.co.uk/animations/transpiration.htm is a very simple animation of water moving through plant tissue.
  - "Sucrose transport" http://www.tvdsb.on.ca/westmin/science/sbioac/plants/sucrose.htm is a simple animation that demonstrates the pressure-flow model.