Phloem Loading

Amanda DeWit
Fred MacDonald
Joy Hein
Matt Tuche

Motivation

It is the first process that a plant takes in providing itself nutrients. It is the fist signal provided by the leaves to other organs of the plant. It is what is needed to make a plant grow.

- Source to sink relationships
  - Consumption of plant leaves
    - Leafy vegetables
    - Tobacco leafs
  - Leaves make photoassimilates
    - Maple syrup
    - Fruit production
      - In general all edible parts of a plant depend on sucrose production
- Transformation from sink to source
- Half-mature leaves stops importing sucrose and start exporting it
  - A one way transformation
  - If it is unable to make its own food then it dies
    - Young albino leaves grafted to stems die after reaching maturity because they are unable to make sucrose
- Some avenues of sucrose travel are not open during a leaf's sink phase
  - Small veins in a leaf are not developed enough

The Main Question:

Why is photoassimilate travel only unidirectional when a leaf goes from a sink to source?

- Sink phase:
  - Sucrose travels from source leaves (mature) to sink leaves (young).
    - Through the vascular bundle (veins)
    - Certain size veins do not transport sucrose
- Source phase
  - Once it matures the vascular bundle operates in one direction only (carrying photoassimilates to other parts of the plant)
    - All of the veins within the lamina participate

Leaf Vascular Bundle Cross Section

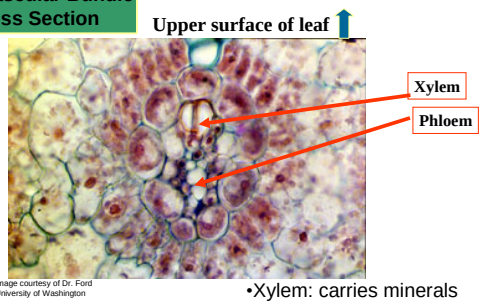
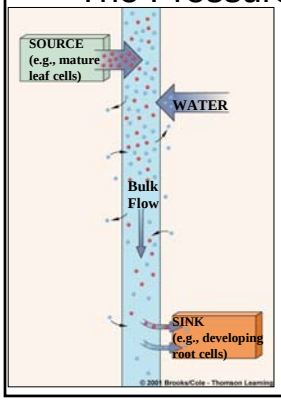


Image courtesy of Dr. Ford
University of Washington

•Xylem: carries minerals and water to all parts of the plant

Phloem: carries sucrose to all parts of the plant

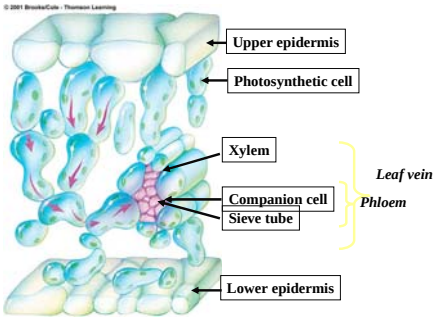
The Pressure Flow Process



- **Build-up of pressure at the source and release of pressure at the sink causes source-to-sink flow.**
- **At the source phloem loading causes high solute concentrations.**
- **Ψ decreases, so water flows into the cells increasing hydrostatic pressure.**
- **At the sink Ψ is lower outside the cell due to unloading of sucrose. Osmotic loss of water releases hydrostatic pressure. Xylem vessels recycle water from the sink to the source.**

Slide courtesy of Dr. E. Ford
University of Washington

Sucrose Path From Source Leaf



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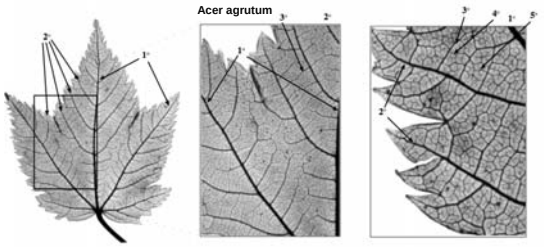
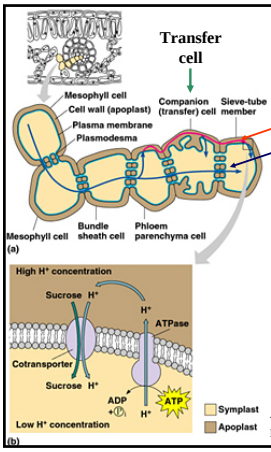
Vein Orders



- Vascular bundles (veins) are designated by size
  - Large veins can be seen (easily) by the eye
    - Called 1st, 2nd and 3rd order veins
    - They sit on top of mesopyhll and are surrounded by parenchyma cells
    - Sucrose diffuse to cells within sink leaf while moving
  - Smaller veins (4th and beyond)
    - Not involved in the translocation process

3rd order veins create islands, and eventually branch into smaller veins. 4th order veins are not mature at this point and cannot import sucrose

Images courtesy of Leaf architecture Working Group and Bioscience



Sugar produced at a source must be loaded into sieve-tube members.

Sucrose follows a combination of two routes:, apoplastic in solution outside the cells, symplastic through the cells.

Some plants have *transfer cells,* modified companion cells with numerous ingrowths of their walls that increase the cells' surface area and enhance solute transfer between apoplast and symplast.

Physiological transport accumulates sucrose in sieve-tube members to two to three time the concentration in mesophyll cells. Proton pumps power this transport by using ATP to create a H^+ gradient.

Active transport is the primary mechanism for apoplastic

Image and slide courtesy of Dr. Ford University of Washington

What Does the Author think?

- There is very few studies on phloem loading
- Four different hypothesis on loading. Each one deals in either symplastic or apoplastic travel

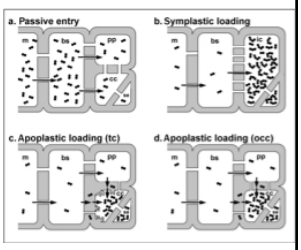


Diagram courtesy from Bioscience

Robert Turgeon

- Professor in the department of plant biology at Cornell University
- Primary investigator of the 5th International Conference on Plasmodematal Biology
- Additional research of phloem loading:

(links to some of the related phloem loading publications available from http://www.plantbio.cornell.edu/people.php?netID=ert2).