

Through Thick and Thin

Objective

Students will show that water rises higher in narrow tubes. They will generalize that tubes in trees must be of relatively small diameter in order to raise water so high.

Materials (for each team of students)

- celery stalk
- food dye
- container sized to allow celery to sit in solution of food dye for several days
- knife

Xylem, Phloem and Early Experiments

There are two kinds of conducting tissue in plant stalks and trunks: xylem and phloem. Xylem cells are dead by the time they begin to function. They are arranged as hollow cylinders connected end to end to form long tubes reaching from the root tip to every part of the stem, shoot and flower. A second set of conducting tissue remains alive as it does its job. This is the phloem which carries food from the leaf "factories" down to the roots.

If the phloem, which is located in the bark outer layer of the trunk is removed from a tree, the roots die in a few days. But the leaves do not immediately wilt. They continue to function for several days. When the roots of the tree die and can no longer take up water the leaves begin to die. In 1727, Stephen Hales reported removing a ring of bark from a tree and finding shriveled fragmented bark at the edge below the cut but swollen lumpy bark above it. (Rev. Stephen Hale; *Vegetable Staticks*) It looked like material was accumulating at the edge above the cut but had drained away from the region below it. Earlier in 1679, Marcello Malpighi reported a similar experiment and found this bark change did not happen when there were no leaves on the tree. (Marcello Malpighi: *Anatome Plantarum*) So it was discovered that the xylem carries water *up* the trunk and phloem transports food down.

Explore

Make a fresh cut across the base of a stalk of celery. Place it in a container of water colored with food dye (red). What happens to the leaves after a day or so? (They will be fringed in red) Cut across the celery stem and look at it through a hand lens. Can you find tiny red vessels which carried the food color? Can you dissect out a single tube from the length of celery stem?

Explain

The movement of food, water and minerals within a plant with conducting tissues is called translocation. Water and minerals are transported in xylem, whereas dissolved food is transported in phloem. Most scientists think that the best explanation (called the tension-cohesion mechanism) for how water climbs up the xylem vessels of huge rainforest trees is that, in part, it's pulled up. Heat from the sun evaporates water at the mouth of the stomata. This causes water cohering to the evaporating molecule to move up to the stomata entrance. The remaining water down through the whole column of dead xylem tubes is placed under tension, and is pulled up the tube. More water comes in through the root tips at the bottom. Understanding adhesion and cohesion of water is fundamental to understanding how this unbroken column of water can sometimes go 300 feet up into the air. When the tubular vessels are small enough, molecular attractions pull water upward against the force of gravity. Larger tubes have too much water in the center, too far from the tube, to produce as strong a set of adhesive forces.