2) Counter-current transport of fluids and entropy generation in tree trunks

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Trees are ably to pump water and mineral components from soil to the leaves along their trunks which could be of 1-110 m height (giant sequoia). The mechanisms of the heat and mass exchange in plants are still unclear. The accepted mechanisms are active water suction by the root hairs via osmotic mechanism (bottom pump) and water evaporation in the leaves heated by the sun (top pump). Some additional mechanisms as direct water leakage from leaf veins could be added for the upward flow enhancing. The downward motion of the concentrated solution of sugars and other assimilated produced in the leaves (photosynthesis)

$$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6H_2O$$

is governed by osmosis-driven flow (Münh hypothesis).

The upward and downward transports are coupled and based on the mass and heat balance equations. In the experimental conditions the roots compartment can be substituted by a water vessel, while the tree crown can be substituted by a porous volume of any polymer material or gypsum. Such constructions are used for air moistening at home and office.

In this project, the student will familiarize with long-range fluid transportation in plants and irreversible thermodynamics in the mass transfer due to hydrostatic and osmotic pressure drops. The project will be carried out according to the following steps:

1. Analysis of balance equations for the long-distance fluid flow in a bunch of capillary tubes of the tree trunk.
2. Derivation of the expression for entropy generation accounted for the pressure-driven fluid flow, osmosis and water evaporation and its analysis.
3. Numerical computations of fluid transport along the tree trunks of different height and ambient conditions (atmospheric pressure, temperature, humidity).
4. Understanding nonequilibrium thermodynamics of the long-range fluid transport in trees.