Osmotic flows in plant leaves
– how leaf morphology influences sugar transport efficiency

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Plants produce sugars inside their leaves to provide energy and materials for survival and growth. Inside the leaves, sugars are taken up into the conduits of the phloem vascular system (Fig. 1). The increased sugar concentration attracts water by osmosis and the resulting hydrostatic pressure difference drives a bulk flow of sap towards other parts of the plant. Münch described the basics of this mechanism for long-distance transport already in 1930, however, there are still open questions about how sugars are loaded into the phloem conduits and how the network structure of leaf venation facilitates high sugar export rates.
We are developing analytical models for sugar loading and export from basic building blocks of the venation network. With the help of these models we can identify important parameters and dimensionless numbers, that characterize the efficiency of the system. From this we infer typical length scales and geometric features, which we compare to data of leaves found in the literature and from recent experiments.

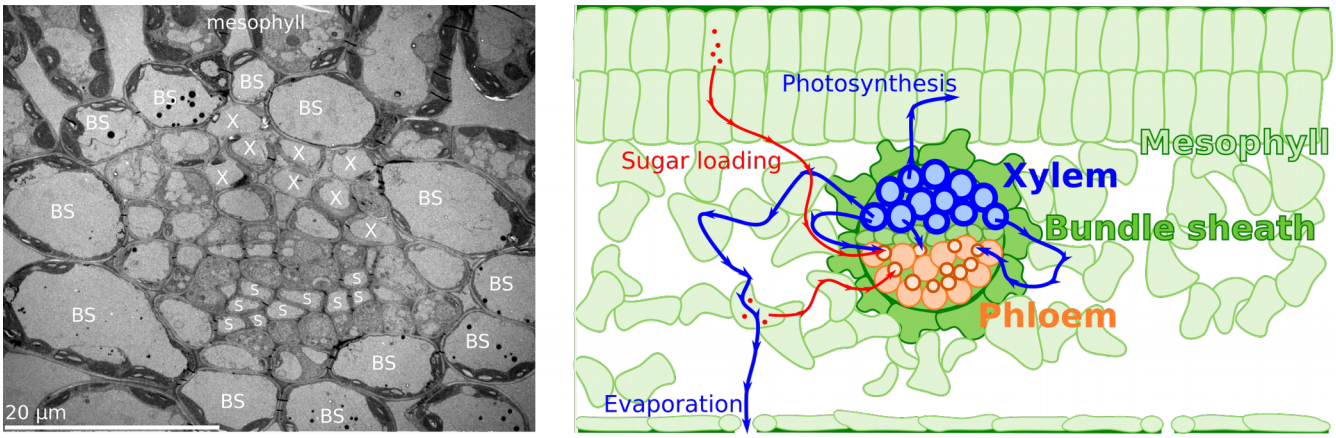

Fig. 1: Pathways of sugar and water inside a plant leaf: **Water** from the xylem conduits (X) is evaporated from the lower side of the leaf, delivered to mesophyll cells for photosynthesis, as well as osmotically taken up into the sieve elements (S) of the phloem tissue. **Sugar,** produced in the mesophyll cells surrounding the veins, is loaded into the phloem to be exported from the leaf to other parts of the plant. Left: Transmission electron microscopy image showing the cross section of a vein of a plant leaf. Right: Schematic cross section of a plant leaf, highlighting the conducting tissues (xylem and phloem) inside a vein.