

# **X-ray imaging of water-conducting pathways and water transport in xylem vessels of vascular plants**

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## **Abstract**

The xylem vessels of vascular plants are responsible for the transport of water and minerals. They have highly redundant xylem bundles and bypass ability. Direct visualization of water-conducting pathways and sap flow in xylem vessels is important for understanding the biophysical features of vascular plants and their sap transport. The 3D morphological structures of xylem vessels and sap transport in various vascular plants were visualized using advanced bio-imaging techniques such as synchrotron X-ray micro-imaging and X-ray CT techniques. In these experimental studies, gold nano particles (AuNPs) were used as tracer particles to measure velocity information of sap flows in xylem vessels. The hydrophilically surface-treated AuNPs transmit pit membranes of plants without destroying the surrounding tissues. In addition, the water-refilling speeds in individual xylem vessels are virtually unaffected by the seeding of the AuNPs, when the uptake rates of the AuNPs solution and distilled water are quantitatively compared. Real-time observation of sap flows in vascular plants under *in vivo* condition is helpful to understand the basic mechanism of water transport in xylem vessels of crops. Some typical results on the sap flows in the xylem vessels of rice and maize samples, the water uptake through 3D xylem network of *Arabidopsis*, and the ionic effects on water transport will be discussed.