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Scaling of phloem structure and optimality of sugar transport in conifer needles KAARE H. JENSEN, Technical University of Denmark, HENRIK RONELLENFITSCH, Max Planck Institute for Dynamics and Self-Organization, JOHANNES LIESCHE, University of Copenhagen, N. MICHELE HOLBROOK, Harvard University, ALEXANDER SCHULZ, University of Copenhagen, ELENI KATIFORI, University of Pennsylvania — The phloem vascular system facilitates transport of energy-rich sugar and signalling molecules in plants, thus permitting long-range communication within the organism and growth of non-photosynthesizing organs such as roots and fruits. The flow is driven by osmotic pressure, generated by differences in sugar concentration between distal parts of the plant. The phloem is an intricate distribution system, and many questions about its regulation and structural diversity remain unanswered. Here, we investigate the phloem structure in the simplest possible geometry: a linear leaf, found, for example, in the needles of conifer trees. We measure the phloem structure in four tree species representing a diverse set of habitats and needle sizes, from 1 cm (*Picea omorika*) to 35 cm (*Pinus palustris*). We show that the phloem shares common traits across these four species and find that the size of its conductive elements obeys a power law. We present a minimal model that accounts for these common traits and takes into account the transport strategy and natural constraints. This minimal model predicts a power law phloem distribution consistent with transport energy minimization, suggesting that energetics are more important than translocation speed at the leaf level.

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