The plant cytoskeleton as a complex network

D. Breuer[1,*], A. Ivakov[2,3], S. Persson[2,3], Z. Nikoloski[1]

[1] Systems Biology and Mathematical Modeling,
Max Planck Institute of Molecular Plant Physiology, 14476 Potsdam, Germany

[2] Plant Cell Walls, Max Planck Institute of Molecular Plant Physiology,
14476 Potsdam, Germany

[3]ARC Centre of Excellence in Plant Cell Walls, School of Botany, University of Melbourne,
Parkville 3010, Victoria, Australia

[*]Corresponding Author: breuer@mpimp-golm.mpg.de

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Abstract

The plant cytoskeleton is a highly dynamic interconnected structure comprised of actin filaments and microtubules that transport and position cellular material. While the molecular mechanisms of cytoskeleton formation and maintenance have been characterized, little is known about the organizational principles that shape these processes on a whole-cell level.

Here, we present an imaging-based framework which enables the reconstruction of cytoskeletal networks in living cells. Using this framework we demonstrate biological relevance of the network structures in terms of short average path lengths and high robustness; properties that are desirable for efficient transport. Intriguingly, these advantageous features are temporally maintained and are also evident during complex re-arrangements of the cytoskeleton.

Moreover, we perform an extensive analysis of the optimality of the cytoskeleton. By solving (semi-definite) optimization problems we construct networks that are optimal with respect to a number of network properties and combinations thereof and compare them to the cytoskeletal network. The analysis suggests that the organization of the cytoskeleton constitutes a compromise between fast, reliable, and spatially uniform transport. Our investigation is extended to other biological and man-made transportation networks.