How mechanical inhomogeneities and mechanical feedback impact plant morphogenesis.

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Abstract

How organs shape and size are determined is still poorly understood despite much progress in developmental genetics. Strikingly, organs have a reproducible shape while their cells display highly variable behavior [1-2]. How is such cellular variability buffered at the organ level? To answer this question, we focus on Arabidopsis thaliana sepal, because each plant have a large number of almost identical sepals, which are accessible to live imaging. Moreover, sepals feature the stochastic formation of giant cells [2] leading to a highly variable cell population.
The large number of sepals in each plant makes it possible to quantify variability in sepal shape in a single plant and to screen for mutants that have more or less variable organ shapes than wild type.

We focused on mutations in genes related to the cell wall, the stiff extracellular matrix that surrounds plant cells, because of its importance in the control of growth. We studied plants affected in the three major components of the cell wall, pectin, hemicellulose and cellulose . This screen suggested that the orientation of cellulose microfibrils is the most important control of organ shape reproducibility.

Whilecellulose orientation determines the cell wall mechanical anisotropy, the guidance of cellulose deposition is in turn controlled by tissue tensions. Interestingly, differential growth triggers tensile stress in the growing sepal. We thus propose that a feedback loop from tissue mechanics to cellulose orientation has a direct influence on final organ shapes.

Bibliography:

Roeder, A. H., Chickarmane, V., Cunha, A., Obara, B., Manjunath, B. S., & Meyerowitz, E. M. (2010). Variability in the control of cell division underlies sepal patterning in Arabidopsis thaliana. PLoS Biology, 8.

Uyttewaal, M., Burian, A., Alim, K., Landrein, B., Borowska-Wykret, D., Dedieu, A., Peaucelle, A., Ludynia, M., Traas, J., Boudaoud, A., Kwiatkowska, D. & Hamant, O. (2012).

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Mechanical Stress Acts via Katanin to Amplify Differences in Growth Rate between Adjacent Cells in Arabidopsis. Cell, 149(2), 439-451.

N. Hervieux, M. Dumond, A. Sapala, A.-L. Routier-Kierzkowska, D. Kierzkowski, A. Roeder, R.S. Smith, A. Boudaoud & O. Hamant. A mechanical feedback restricts sepal growth and shape in Arabidopsis. Curr Biol 26, 1019–1028.