From variability to reproducibility: modelling the role of mechanics in the robustness of organ shape

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Résumé

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 have a highly variable behavior. To investigate how such cellular variability is buffered at organ level, we chose to study Arabidopsis thaliana sepal, because each plant has a large number of almost identical sepals displaying broad distributions of cell size.
In plants, morphogenesis is driven by internal hydrostatic pressure and controlled through the regulation of cell wall properties. Therefore, we built a model of sepal morphogenesis with only these two parameters, and in which the impact of heterogeneity in mechanical properties on final shape can be probed.

To calibrate the extent of mechanical heterogeneity, we then measured cell wall stiffness using atomic force microscopy. Stiffness appeared highly variable. Incorporating such variability in the model caused the loss of shape robustness . In order to retrieve robustness of shape, we had to introduce temporal variability in stiffness in addition to spatial variability. Next, we used this model to understand the phenotype of the *vos1* mutant displaying low sepal shape robustness. In *vos1* sepals, the variability between neighboring cells is reduced. Combining analyses of the mutant and model modifications, we reached the counterintuitive conclusion that increased spatial heterogeneity yields robust shapes.

Mots-Clés: development, mechanics, variability

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