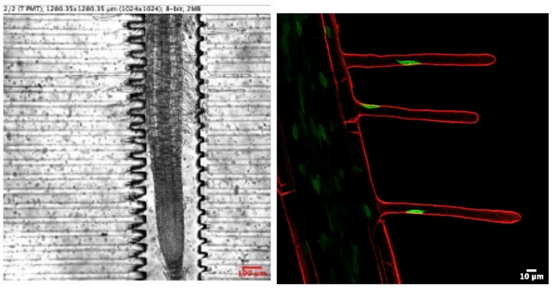
Internship/PhD in mechanobiology of the root hair

Summary of the research project:

Plant development and growth are linked to cellular shape changes, which are controlled by genetic programs but also by perception of environmental signals, including mechanical cues. While both genetic regulation and mechanical control of morphogenesis were studied independently, there is a need to explore how cellular shape-associated strain and stress can mechanically regulate gene expression during differentiation. In animals, mechanical stimuli are known effectors of differentiation. They involve propagation of mechanical forces through the cytoskeleton to the nucleus leading to a spatio-temporal chromatin remodeling and modification of gene expression. In plants, less is known about mechanotransduction from cell surface to the nucleus.

In the framework of an international interdisciplinary network supported by an HFSP grant, we propose to investigate how mechanical cues affecting cellular shape are sensed at the nuclear envelope to drive chromatin remodeling in Arabidopsis, a model plant. We will study a unique cellular model, the single root hair, the main actor of pant growth in the soil. We will analyze root hair formation and growth in WT and mutants affected in either root hair development or nuclear shape. Combining in vivo live imaging, micro-mechanical measurements (rheometry), and root hair growth in specific microfluidic chips, with channels of different shapes, we will evaluate mechanical properties of cells and nuclei, force propagation from cell surface to the nucleus during root hair development and their effect on gene expression. Data collected from live imaging, mechanical measurements, and microfluidic assays will be correlated to finite element modeling to estimate strain and stress in the system for predicting chromatin remodeling following cellular and nuclear shape changes.



A root cultured in a microfluidic device with root hairs growing in lateral channels, and nuclei labelled in green.

Internship/PhD:

The successful candidate will be in charge of the experimental physics part of the project, in particular of the micro-mechanical/microfluidic assays. She/he will be hosted in the Matière et Systèmes Complexe Laboratory (UMR 7057 CNRS and Paris-Diderot/Université de Paris), in the team of Prof. Atef Asnacios. The team has developed unique experimental setups to quantify single cell-scale passive (rheology, deformability) and active (force generation, mechanosensing) mechanical properties. Coupling these original experimental setups with fluorescence imaging, the team could in particular show the link between animal cell shape and rigidity sensing. These techniques have been recently adapted for plant cell mechanics analysis to reveal specific contributions of cytoskeleton and osmotic regulation. The successful candidate will work in team with a full time post-doc supported by the HFSP grant. She/he will also collaborate with the teams of Dr Marie-Edith Chabouté (Institut de biologie moléculaire des plantes, CNRS UPR 2357, Strasbourg, France - Cellular and molecular biology, gene expression and chromatin analyses), Dr Kentaro Tamura (Department of Botany, Kyoto University, Japan - Genetics and biochemistry), and Prof. Henrik Jönsson (Sainsbury Laboratory, University of Cambridge, United-Kingdom - Computational morphodynamics and finite element modeling).

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