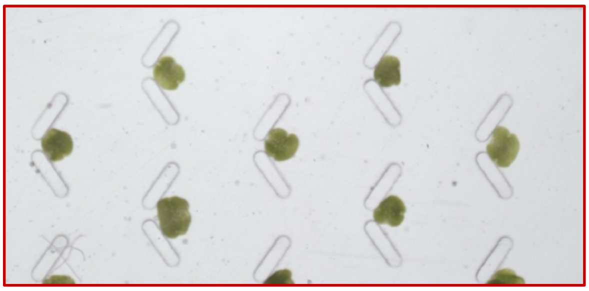
Assessing the role of plant hydraulics in morphogenesis

Host laboratory: LadHyX, Ecole Polytechnique

Contact: Arezki Boudaoud,
arezki.boudaoud@polytechnique.edu



Project description. Despite the importance of plants for life on the planet, we are still far from fully understanding how plants grow and achieve their shape, through a process known as morphogenesis. We focus on the role of tissue hydraulics in setting the pace of growth. Indeed, growth involves water uptake and water movement within tissues. We started to work on a model basal plant, *Marchantia polymorpha*, that mostly grows in two dimensions [1]. We found this plant well-suited for culture and microscopy in microfluidic chips and we developed an approach to deduce plant hydraulic conductivity of individual plants from the dynamics of volume changes upon osmotic shifts within the chip; we showed that plant growth rate correlates with hydraulic conductivity [2].

The main goal of the internship is to extend our first study [2] to smaller length scales. We have developed an approach to measure tissue deformations using particle image velocimetry. We will simplify cell-based [3] or continuous [4] hydromechanical models of plant tissues and infer their parameters from the dynamics of deformation field measured experimentally. We will compare results on wild-type plants with plants in which the expression of aquaporins, membrane water channels, is altered. Finally, we will compare patterns of hydraulic conductivity to patterns of growth rate, so as to characterise the role of conductivity in morphogenesis.

We expect to shed light on water fluxes during morphogenesis, in plants and in other multicellular systems.

Methods. We will use microfluidics [2], fluorescence microscopy, image analysis, and numerical solutions to inverse problems [5].

References

[1] Solly JE, Cunniffe NJ, Harrison CJ (2017) Regional Growth Rate Differences Specified by Apical Notch Activities Regulate Liverwort Thallus Shape. Curr Biol 27: 16–26.

[2] Laplaud V, Muller E, Demidova N, Drevensek S, Boudaoud A (2024) Assessing the hydromechanical control of plant growth. Journal of the Royal Society Interface 21: 20240008.

[3] Long Y, Cheddadi I, Mosca G, Mirabet V, Dumond M, Kiss A, Traas J, Godin C, Boudaoud A (2020) Cellular Heterogeneity in Pressure and Growth Emerges from Tissue Topology and Geometry. Curr Biol 30: 1504–1516.

[4] Oliveri H, Cheddadi I (2024) Hydromechanical field theory of plant morphogenesis. http://arxiv.org/abs/2409.02775

[5] Lorenzetti E, Municio-Diaz C, Minc N, Boudaoud A, Fruleux A (2024) Inferring reaction-diffusion parameters from imperfect FRAP, unpublished.