Mechanics of stomata opening : role of microfibril orientation and clamping.

Academic Year: 2026–2027
Supervisors: L. Tadrist (loic.tadrist@univ-amu.fr)
Host Laboratory: Institut des Sciences du Mouvement UMR7287, SBI Team
Location: Aix-en-Provence (IUT Aix campus)
Duration: 4 - 6 months
Salary: Yes
Recommended Level: M1 or M2 in Mechanical Engineering / Physics
Required Skills: Computational fluid mechanics, Aeroelasticity, Thermodynamics, Heat transfers

Summary

Stomata are microscopic pores on the leaf surface, formed by pairs of specialized **guard cells**, which regulate gas exchange (CO_2 uptake) and water loss (transpiration) in plants. The opening of stomata is driven by **turgor pressure**: when guard cells absorb water, their cell walls—reinforced by radially oriented **cellulose microfibrils**—expand anisotropically, causing the cells to bow outward and create an opening. This process is tightly controlled by environmental signals (e.g., light, humidity, CO_2 levels) and the biomechanical properties of the guard cell walls, including microfibrillar alignment and cuticle anchoring.

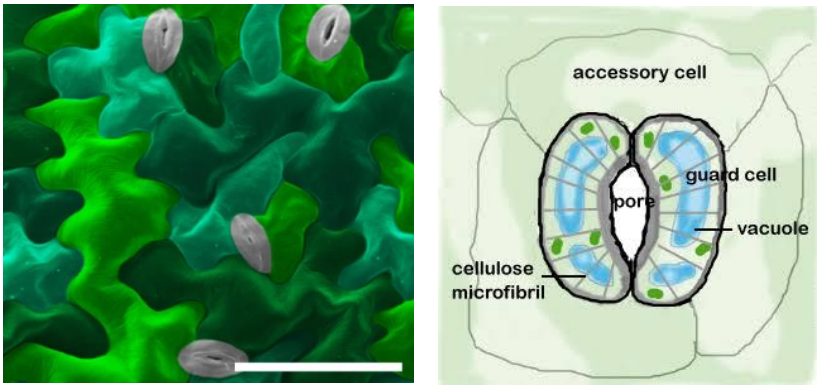

Figure 1: left: Stomatal distribution on the cuticle of a leaf. from Bidhendi et al, Nature Comm. 2023. Right: schematics of guard cells.

This internship focuses on investigating the biomechanical mechanisms governing the opening of stomatal guard cells, with a particular emphasis on two key questions:

1. **Does the orientation of cellulose microfibrils play a critical role in facilitating stomatal opening?**
2. **Are the anchoring conditions of guard cells to the cuticle significant for their functionality?**

Building on last year's successful development of a functional prototype, this project aims to fabricate and test new prototypes to experimentally address these questions. The prototypes will simulate the macroscale behavior of guard cells, allowing for precise manipulation of structural parameters such as microfibrillar alignment and cuticle attachment.

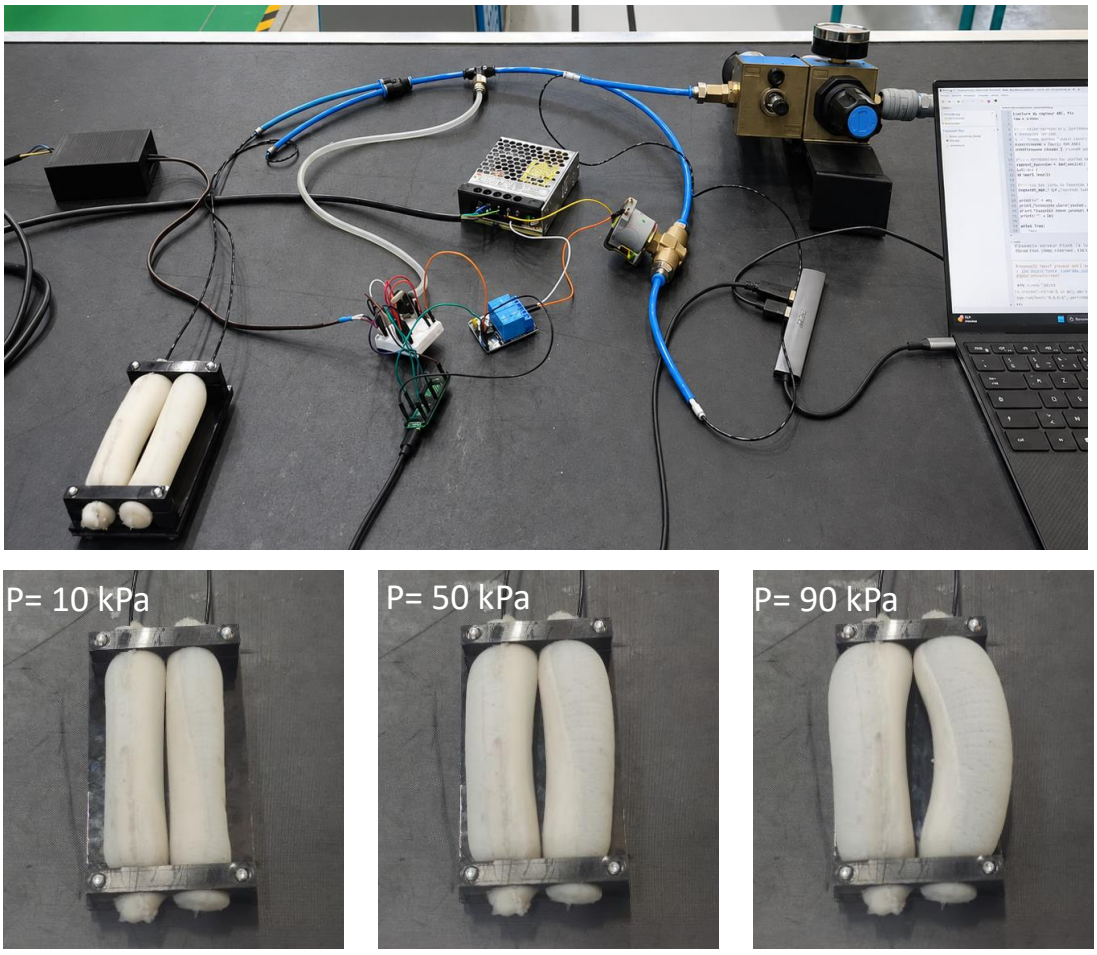

Figure 2: Prorotype of stomatal opening (Tadrist's Lab).

Internship Tasks:

1. Designing and producing refined prototypes to replicate guard cell mechanics at a macroscopic scale.
2. Conducting controlled experiments to evaluate the impact of microfibril orientation and cuticle anchoring on stomatal dynamics.
3. Analyzing biomechanical data to correlate structural features with functional outcomes.
4. Write a scientific article by summarizing experimental results.

This internship may be fully experimental or coupled with some finite element modelling. This internship may give potential PhD opportunity.

Work Environment:

The Institut des Sciences du Mouvement (ISM) is a multidisciplinary research unit. The laboratory's research focuses on the study of locomotion in living organisms from various perspectives. The Bio-Inspired Systems (SBI) team at ISM aims to study principles and strategies derived from biological systems to inspire and design innovative technological systems.