Funded PhD/Engineer Position (starting 2025)
Role of T Lymphocyte Viscoelastic and Adhesive Properties In Immune Recognition

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Project funding: ANR project CriticaliTy (Deciphering critical behaviours in T-cell mechano-activation)

T lymphocytes identify foreign antigens through physical interactions with target cells, forming an immunological synapse. The strength and spatial organization of molecular bonds within this interface determine immune response outcomes, such as whether a cytotoxic T cell should destroy or ignore a cancer cell. It is thus important to quantify the strength of the adhesion within the immunological synapse, depending on the composition and on the single-bond binding energy.

The **aims** of the projects are to:

- develop methods to measure adhesion forces between T cells and antibody-coated microbeads,
- extracting single-molecule binding energies from cell adhesion measurements,
- analyze how adhesive patches evolve over time,
- investigate how different ligand-receptor contributions (activating and co-activating molecules, adhesion molecules) combine in the immunological synapse.

We will address the following **research questions**:

- how do cellular viscoelastic properties influence adhesive interactions?
- can we reliably extract single-molecule binding energy from whole-cell measurements?
- how do adhesive patches evolve temporally, and are the important time scales related to the organization of the T cell at the interface ?
- how do different ligand-receptor bonds collectively function in T cell-target cell interactions?

During this interdisciplinary thesis with a major experimental component, we will use our micropipette-based single-cell rheometer (Fig. 1) to perform cell microindentation to (i) quantify viscoelastic properties of T cells [1-3], (ii) measure their adhesive properties to antibody-coated microbeads and various cell types. We will collaborate with immunologists (Claire Hivroz group, Institut Curie, Paris) and biologists for cell/molecular expertise and work with theoreticians to analyze mechanical measurements (David Gonzalez-Rodriguez, Univ. de Lorraine, Metz)

The **candidate** should have a background in experimental physics, bioengineering, or related fields, with experience in or willingness to learn cell culture techniques. The candidate should also have basic programming languages (e.g. Python, MATLAB, or ImageJ/Fiji) for data analysis and image processing, and strong communication skills for effective collaboration with scientists from diverse backgrounds including immunologists and theoreticians.

Duration and format: The project will be adapted to the candidate's profile - 3-year PhD thesis or 2-year research engineer position. Both tracks will involve hands-on experimental work, international conference presentations, and publication opportunities.

Please send a CV, motivation letter, academic transcripts, and contact information for two references to julien.husson@polytechnique.edu .

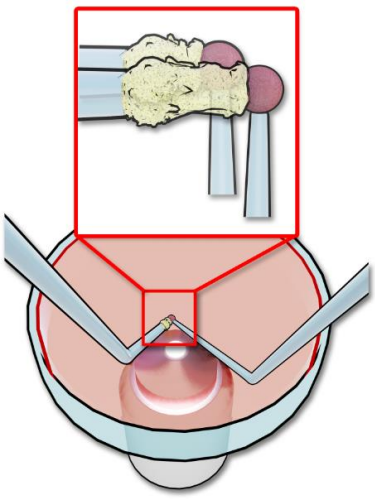

Figure 1. Single-cell rheometer. Two micropipettes are placed in a Petri dish. A flexible pipette (right) holds a microbead covered with antibodies that can adhere to or activate a leukocyte. A rigid micropipette (left) gently holds a leukocyte (inset). The base of the flexible micropipette is translated to exert a desired force on the cell. Recording the resulting cell deformation allows the measurement of cell viscoelastic properties and morphological changes.
Online example videos: https://cellmechanics.jimdofree.com/videos/

References

[1] Zak et al., Biophysical Journal 2021; doi:10.1016/j.bpj.2021.02.042.
[2] Markova et al., Biophysical Journal 2024; doi: 10.1016/j.bpj.2023.12.008
[3] Husson, MIMB, vol. 2600; doi: 10.1007/978-1-0716-2851-5_1, 2023.