M2 Internship
Mechanics of T lymphocytes

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Candidate: Student interested in experiments at the interface between physics and biology

Quantifying cell mechanical properties is important for better understanding various cellular processes. Focusing on the immune reaction at the single-cell level, we have shown that when a white blood cell (or leukocyte) contacts another cell to attack it or exchange information, the former becomes much stiffer and more viscous within minutes [1]. Studying these mechanical changes in immune cells can help scientists better understand the mechanism by which immune cells identify threats such as cancer cells. Many aspects of the mechanical properties of immune cells remain unclear and require further characterization. This internship will contribute to this characterization.

We develop tools to probe the mechanical properties of cells via microindentation, i.e. by pressing them with micrometric beads or needles. Among other parameters, we can measure the tension of the actomyosin cortex underlying the cell membrane [2], which can fluctuate over time. One question to be addressed is whether these fluctuations are used by leukocytes to sense their environment and whether they can help them to react faster to stimuli brought by other cells.

Another aspect of the internship is motivated by some of our preliminary data showing that pressing a T lymphocyte (or T cell, a leukocyte at the core of immune response) with an adhesive microsphere leads to an apparent higher stiffness of the leukocyte than when the microsphere is not adherent. This effect might be either a purely mechanical artifact due to adhesive vs. non-adhesive boundary conditions, or might be a signature of a rapid mechanical response of the cell to adhesion. We will address this question by producing sets of microbeads with controlled adhesive strength and by inhibiting specific molecular components of the cell cytoskeleton.

During this internship with a major experimental component, we will use our micropipette-based single-cell rheometer (Fig. 1) to perform cell microindentation to quantify the viscoelastic properties of white blood cells [3]. Cell and molecular biology know-how will be provided by biologists through established collaborations.

There is a possible PhD opportunity to continue this work.

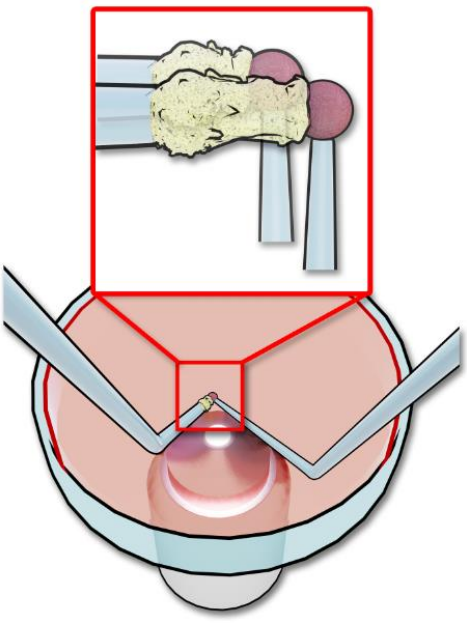

Figure 1. Single-cell rheometer. Two micropipettes are placed in a Petri dish. A flexible pipette (right) holds a microbead covered with antibodies that can adhere to or activate a leukocyte. A rigid micropipette (left) gently holds a leukocyte (inset). The base of the flexible micropipette is translated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