Internship

Mechanics of T lymphocytes

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Candidate profile: (bio-)physicist or engineer with a solid interest for experiments

Quantifying cell mechanical properties is important to better understand many 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 better understand how immune cells identify threats, such as cancer cells. Many aspects of the mechanical properties of immune cells remain unclear and need to be characterized. This internship will contribute to this characterization.

We develop tools to probe the mechanical properties of cells, mainly by pressing them with micrometric beads or needles. Depending on the shape and size of the object used to press the surface of a cell, one can probe either the cell surface or the cell interior. When probing the cell surface, one can measure the tension of the actomyosin cortex underlying the cell membrane. This cortical tension has been shown to fluctuate over time in some immune cells [2], and this internship will help confirm our preliminary data suggesting that these fluctuations also exist in T lymphocytes (or T cells). By using molecular inhibitors, we will identify the key players involved in these fluctuations in cortical tension in T cells.

Another aspect of the internship is motivated by other preliminary data of ours showing that pressing on a T cell 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 it 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 in-house micropipette-based single-cell rheometer (Fig. 1) that allows trough 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.

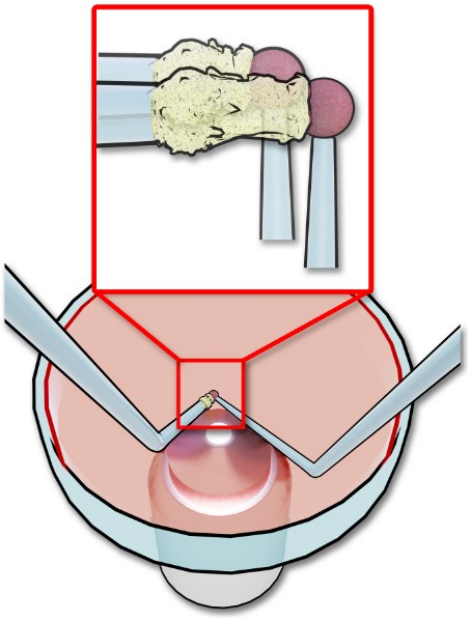

Figure 1. Single-cell rheometer. Two micropipettes are placed in a Petri dish. A flexible pipette (right) holds an microbead covered with antibodies that can adhere to or activate a leukocyte. A rigid micropipette (left) gently holds a leukocyte (inset). The base of the flexible micropipette is translated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

References

[1] Zak et al., Biophysical Journal 2021; doi:10.1016/j.bpj.2021.02.042.
[2] Laplaud et al. Science Advances 2021; doi: 10.1126/sciadv.abe364
[3] Husson, MIMB, vol. 2600; doi: 10.1007/978-1-0716-2851-5_1, 2023.