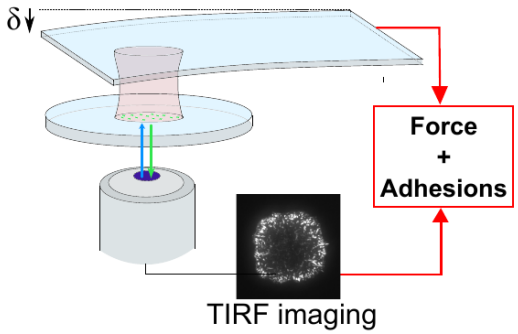
Some physical aspects of single-cell mechanosensing

Asnacios A.[1], Bimbard C.[1], Bufi N.[1], Durand-Smet P.[1], Etienne J.[2], Fouchard J.[1], Mitrossilis D.[1]

1 Université Paris-Diderot and CNRS, Sorbonne Paris Cité, Laboratoire Matière et Systèmes Complexes, UMR 7057, Paris, France
2 Université Grenoble Alpes and CNRS, Laboratoire Interdisciplinaire de Physique, Grenoble, France

As part of their physiological functions, most cells need to adapt to their mechanical environment. In particular, the rigidity of the extracellular matrix was shown to control cell traction forces, shape, and ultimately cell differentiation. In this context, most studies focused on the role of biochemical regulation in rigidity sensing.



Principle of the parallel-plates setup combining single-cell traction force measurements and evanescent wave fluorescence microscopy.

In contrast to this biochemical signaling-centered approach, our aim is to reveal the physical/mechanical phenomena involved in mechanosensing. To this end, we developed a single-cell technique allowing us to measure the traction force and speed of shortening of individual cells deflecting microplates (i.e. springs) of variable stiffness. We will show that the mechanical power invested by the cell to bend the microplates is adapted to stiffness, and reflects the response of myosin-motors to load (analogy to impedance matching) [1]. Along this line, in order to determine how fast a cell could adapt to stiffness, we designed a unique protocol allowing us to change the effective stiffness felt by a single cell in real time (~0.1 second). This technique revealed that cell contractility was instantaneously adapted to a sudden change in stiffness, indicating that a purely mechanical response to stiffness indeed does exist [2,3].

Finally, we will present the results of experiments combining single-cell traction force measurements, dynamic control of stiffness, and monitoring of adhesion complexes, and will discuss how cell shape and mechanical adaptation to rigidity could control cell fate [4].

1. Mitrossilis D, et al. (2009) Single-cell response to stiffness exhibits muscle-like behavior. Proc Natl Acad Sci USA 106(43):18243–18248.
2. Mitrossilis D, et al. (2010) Real-time single-cell response to stiffness. Proc Natl Acad Sci USA 107(38):16518–16523.
3. Etienne J, et al. (2015) Cells as liquid motors. Mechanosensitivity emerges from collective dynamics of actomyosin cortex. Proc Natl Acad Sci USA 112(9): 2740-2745.
4. Fouchard J, et al. (2014) Three-dimensional cell body shape dictates the onset of traction force generation and growth of focal adhesions. Proc Natl Acad Sci USA 111(36):13075–13080.