# Master 2 internship (2016-2017) and PhD (2017-2020) proposal

*Field: Theoretical and computational soft condensed matter physics and biophysics.*

Laboratory name: Matière et Systèmes Complexes. CNRS identification code: UMR 7057.
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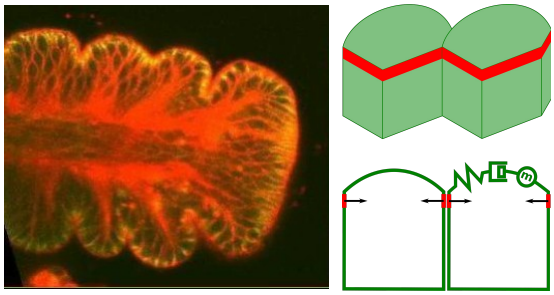
Internship location: Paris, laboratoire MSC, Bâtiment Condorcet, Université Paris Diderot.
Thesis possibility after internship: École doctorale 564, Physique en Île-de-France : EDPIF.
Internship funding: usual (legal) funding when longer than two months (ca. 500€/month).
PhD funding possibilities: 1. with École Doctorale (concours), 2. with Région Île-de-France (Institut des Systèmes Complexes), 3. with CIFRE (corporate co-funding).

## Physical modeling of a developing biological tissue

Biological tissues, especially during embryogenesis, are a fascinating example of an active material, whose mechanical and structural properties evolve continually. The evolution of these properties result in new shapes (morphogenesis). It is more and more established that mechanical stress in tissues is an essential ingredient of biological signaling: it combines with chemical signals to let tissue cells locate themselves, which affects their fate (cellular type).



*Left: apoptosis drives fold formation in Drosophila leg. Right: simple simulation with actin belt and complex cortex rheology.*

With this internship, our goal is to simulate the behaviour of a few cells in such a tissue for some precise phenomena, in collaboration with a biologist experimental team, depending on opportunities and on the candidate's preferences.

One possibility is to focus on apoptosis and on its mechanical role which has been evidenced during Drosophila leg development by a team in Toulouse (Magali Suzanne, see Ref. (1) and photo). We will use a detailed and tunable mechanical model. Our current code contains a non-trivial rheology of the cellular cortex and a dynamic evolution of cell-cell adhesion inspired by molecular mechanisms. The internship will consist in incorporating additional ingredients specific to apoptosis in order to identify those that are essential to reproduce the observed mechanical transformations.

On the long term (thesis work), internal cell mechanisms that are essential to its interaction with neighbouring cells within a tissue will be included gradually. This will be used to specify our generic continuum model (2) and to infer (3) the macroscopic rheology.

The successful candidate will either be familiar with biophysics or soft matter physics, or with applied mathematics and numerical simulations, for instance in C++ or in python and will be eager to interact with experimentalists in order to reorient the simulation ingredients.

(1) B. Monier, M. Gettings, G. Gay, T. Mangeat, S. Schott, A. Guarner, **M. Suzanne**, *Nature* (2015) **518**, 245-248

(2) S. Tlili, **C. Gay**, F. Graner, **P. Marcq**, **F. Molino**, P. Saramito, *Eur. Phys. J. E* (2015) **38**, 33-63 ; **38**, 115

(3) V. Nier, S. Jain, C. T. Lim, S. Ishihara, B. Ladoux, **P. Marcq**, *Biophys. J.* (2016) **110** (7), 1625-1635