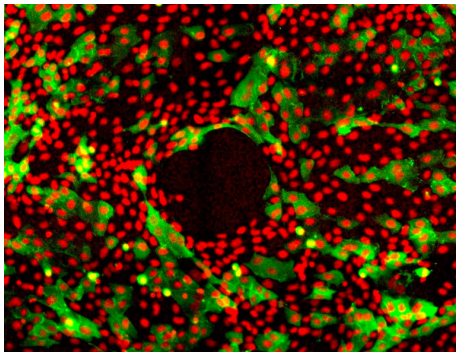
LABORATOIRE JEAN KUNTZMANN
MATHÉMATIQUES APPLIQUÉES - INFORMATIQUE

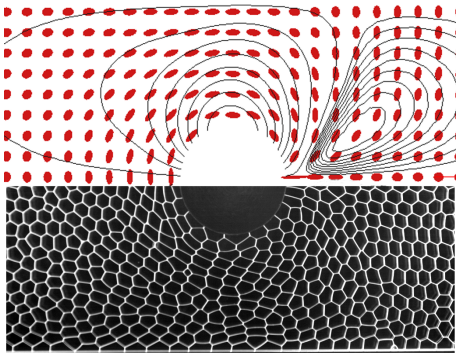
M S C

M2 internship and/or PhD thesis

Numerical modeling of living tissues

Context – Biological tissues have structures which evolve, in particular during embryo development, wound healing or tumor proliferation. Their dynamics, regulated through an interplay between genetics and mechanics, is complex. We aim at disentangling and understanding the contribution of mechanics. Does the mechanical behaviour of a tissue differ fundamentally from that of a passive material ? Can it be modelled in term of continuum mechanics, with partial differential equations ? Ultimately, will it be possible to solve dynamical equations, and compare them to experimental observations ?





Left : monolayer of cells, migrating from left to right around a circular obstacle ; nuclei are in red, and representative cells are in green.
Right : Soap froth monolayer flowing from left to right around a circular obstacle ; the experiment (bottom) is compared with numerical predictions (top).

Methods – The problem will be formulated as a system of partial differential equations. This set of equations will describe, at a macroscopic scale, the behavior of a cell tissue moving on a substrate. The behavior of the cell tissue could be described as a active viscoelastic fluid : it combines viscous fluid behavior with the elastic behavior of active individual cells in one mathematical model.

Expected results – By developing a code, based on the C++ Rheolef finite element library, we will be able to numerically solve the set of time-dependent partial differential equations. Then, numerical results will be compared to available experimental data, obtained with real cell tissues at MSC lab. in Paris. These comparisons will furnish some new ideas for improving the initial mathematical model, for instance taking into account the active behavior of cells, or to introduce the cell orientation information into the set of equations.

Keywords : partial differential equations ; finite element method ; fluid mechanics ; biology

Required skills : applied mathematics ; interaction between mathematicians and biophysicists.

Contact	Pierre.Saramito@imag.fr	+33 4 57 42 17 82	LJK (Grenoble)
	Francois.Graner@univ-paris-diderot.fr	+33 1 57 27 71 01	MSC (Paris)

References

Cheddadi et al. (2011)
Tlili et al. (2015)
Rheolef C++ library

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