M2 internship + PhD offer

Inference of an active viscoelastic model of embryonic flows *& application to the gastrulation process*

"It is not birth, marriage, nor death, but gastrulation which is truly the most important time in your life" (Lewis Wolpert)

Before gastrulation, the embryo consists of a single sheet of epithelial cells. By the end of gastrulation, the embryo is invaginated into a large fold (which will eventually become the gut) and two layers of cells (endo and ectoderm).

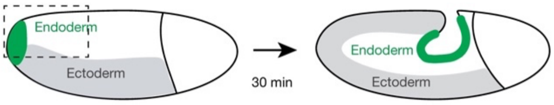

Fig. 1. Drosophila gastrulation.

A physical modelling challenge Models of the gastrulation process either consider the embryonic cell layer as an elastic material [1] (rubber-like) or as a Newtonian fluid (honey-like) material [2]. However, on the time scale of gastrulation, we believe that an intermediate, viscoelastic model would be more appropriate. The objective is to infer the viscoelastic properties of gastrulation flows, using the mid-gut invagination as a large-scale mechanical perturbation. We will benchmark our inference method against physical models of active foams, called vertex models.

Experimental data: The team develops techniques that allow the visualization of each and every cell throughout the gastrulation process of the Drosophila model system [3].

Within ongoing experiments in the team, new molecular staining shed new light on the biochemical cascades involved in gastrulation.

PhD objective: Understanding how the gastrulation process unfolds using a biomechanical model

The theoretical tools to be developed together with the recruited PhD will be instrumental in interpreting the already available data in terms of a set of relationship between cell shape, flows, and signaling at stake during gastrulation.

The teams: Supervision shared between

Jean-François Rupprecht (Centre de Physique Théorique): designs theory tools to study flows in curved environments [4,5]

Thomas Lecuit (Collège de France and Institut de Biology du Développement de Marseille Luminy) is a leader in the understanding of mechanical forces during embryonic development [3].

Collaboration with Bangalore: As part of an international collaboration with Pr. Madan Rao [1], there will be plenty of opportunities to work at the National Centre for Biological Sciences (NCBS), located in Bangalore, India.

PhD student's expected profile: We are looking for a student who enjoys coding, simulations, dealing with experimental images, and performing analytical work. We primarily target Physics students, but we are also interested in applications from talented Computer Science or Applied Maths students.

Location: We are based in arguably the most beautiful academic site in the world – the Luminy campus, next to the Calanques National Reserve.

Informal inquiries are welcome! Email us:
jean-francois.rupprecht@univ-amu.fr
thomas.lecuit@univ-amu.fr

Related publications (from the team)

1. *Active morphogenesis of epithelial monolayers, Morris*, R. G. and Rao, M. Physical Review E (2019).
2. *Geometry can provide long-range mechanical guidance for embryogenesis*, Dicko M. et al. PLOS Comput. Biol. (2017)
3. *Genetic induction and mechanochemical propagation of a morphogenetic wave.* Bailles, A., Collinet,…, T. Lecuit. Nature (2019).
4. *Alcanivorax borkumensis Biofilms Enhance Oil Degradation By Interfacial Tubulation,* M. Prasad,…, J.-F. Rupprecht, J. Fattaccioli, A. S. Utada, Science (2023).
5. *Active nematic flows on curved surfaces* S. Bell, S.-Z. Lin, J.-F. Rupprecht, J. Prost, Physical Review Letters (2022)