MASTER 2 RESEARCH INTERNSHIP

From mechanical and genetic atlases to predictive developmental landscapes of early embryos

Laboratory: Collège de France
Center for Interdisciplinary Research in Biology (CIRB)
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Supervision: Dr. Hervé Turlier herve.turlier@college-de-france.fr

Team: *Multiscale Physics of Morphogenesis* www.turlierlab.com

PhD thesis after internship: YES, recommended **Benefits:** ~500€/month

Expected profile: The candidate should be trained in **applied mathematics,** or **(bio)informatics** or **physics**, and demonstrate **excellent programming skills** (Python and C++), should have some prior knowledge of dynamical systems and a strong interest for statistical learning methods and optimisation (machine-learning, inverse problems).

Project: This master internship will address the generic question of mechanochemical interplay in developmental biology, combining statistical data analysis methods and forward biophysical modeling approaches. The goal will be to infer developmental landscapes defining embryonic cell trajectories from a fate and mechanical perspective.

Biological systems, such as early embryos or tissues, develop by a combination of mechanical events (divisions, growth, rearrangements, etc..) [**1-3**] and biochemical events (gene expression, genetic and signalling circuits, cell-cell communication etc…). Rapid progress in gene sequencing methods have allowed researchers to create cell-resolved spatiotemporal maps of gene expression in developing embryos [**4-5**]. In parallel, our team recently developed methods to create cell-resolved atlases of cell shape and mechanics of early embryos and tissues in 3D [**6-8**]. The combination of these two sets of data has the strong potential for inferring unknown feedbacks between gene expression, cell-cell signalling and cell mechanics, which are at the core of biological self-organisation. The hope is that global cell trajectories living in this high dimensional space may be mapped onto an effective 'energy landscape', from which cell dynamics may be derived [**9-10**].

This internship will aim at defining a suitable theoretical framework and adapted computational approaches to bridge the gap between gene expression and mechanics in a multicellular context. The generation of synthetic data through realistic 3D simulations will be key to the development and validation of inference methods. The continuation of this project over a PhD thesis is expected to lead to the development of novel theoretical concepts and original methods to infer systems-level developmental landscapes underlying collective cell dynamics. The work will benefit from strong and established collaborations with experimental biology teams working on several embryo species (ascidian, mouse…).

Working environment: We are committed to establishing a welcoming place for all and fostering inclusion and diversity. The student will be welcomed in renovated premises at Collège de France, into the interdisciplinary team "Multiscale physics of morphogenesis" led by Dr. Hervé Turlier and composed of ~10 researchers. She/he will be able to attend public lessons at Collège de France in biophysics and developmental biology, and will be provided access to a powerful laptop and to a high performance computing cluster fully dedicated to the team (12 GPUs, 396CPUs).

[**1**] Maître, Turlier et al. ***Nature*** 2016
[**2**] Dumortier et al. ***Science*** 2019
[**3**] Firmin et al. ***Nature*** 2023 (in press)
[**4**] Sladitschek et al. ***Cell*** 2020
[**5**] Kumar et al. ***Nat Gen*** 2023
[**6**] Ichbiah et al. ***Nature Methods*** 2023
[**7**] Ichbiah, Delbary & Turlier ***arXiv*** 2023
[**8**] Yamamoto et al. ***bioRxiv*** 2023
[**9**] Saez et al. ***Cell Systems*** 2022
[**10**] Saez, Briscoe & Rand, ***Interface Focus*** 2022