

MASTER / ENGINEERING INTERNSHIP

Mechanochemical cell-state transitions during axis formation

Measure how cell mechanics and cell state interact to shape an embryonic axis in a self-organizing 3D gastruloid.

Location: IBDM, Turing Center for Living Systems
Aix-Marseille University / CNRS, Marseille

Duration: 4–6 months, start in 2027

Team:

Physical Approaches to Cell Dynamics and Tissue Morphogenesis

Supervisors: Pierre-François Lenne and Sham Tlili
(CNRS researchers, biophysics)
Jialing Cao (PhD student)

SCIENTIFIC CONTEXT Our team studies how mechanical forces, cell fate and patterning interact to shape developing tissues, combining quantitative imaging, perturbations and biophysical modelling. During early embryogenesis, cells collectively move, rearrange and differentiate to build structures such as the heart, gut and brain. Yet the cell-scale rules linking mechanics and differentiation to tissue organization remain difficult to dissect *in vivo*, particularly in mammals.

We use gastruloids, 3D aggregates of mouse embryonic stem cells that recapitulate key features of early embryogenesis outside the embryo, including symmetry breaking, axis formation and elongation. They provide a controlled system in which cell mechanics, cell state and tissue-scale morphogenesis can be measured and perturbed together.

We recently showed that gradients of tissue surface tension can generate Marangoni-like recirculating flows that contribute to symmetry breaking and elongation. This project asks how these tissue-scale forces emerge from cell-scale adhesion, contractility, motility and differentiation state.

INTERNSHIP PROJECT The student will dissect the cell-scale mechanisms that set tissue surface tension during gastruloid axis formation. Cell doublets provide a minimal quantitative system: isolated pairs of cells will be imaged at high resolution in specifically designed microwells, and their geometry used to infer cell-cell and cell-medium surface tensions.

- culture and manipulate mouse embryonic stem cells, cell doublets and gastruloids;
- use and optimize microwell devices for cell-doublet assays and high-resolution live imaging;
- quantify cell shape, contact angles and surface/interfacial tensions from microscopy data;
- perturb adhesion and contractility using cytoskeletal drugs and mutant/reporter cell lines;
- combine quantitative data analysis and simple biophysical modelling to connect cell mechanics, cell state and tissue behaviour.

Mechanical measurements will be combined with pharmacological and genetic perturbations, together with mutant/reporter lines that report cell state. The goal is to define a mechanochemical state, how mechanical properties relate to molecular/differentiation state, and determine how it changes during axis elongation.

EXTENSION & ENVIRONMENT Depending on progress and interests, the student can relate cell-scale measurements back to tissue-scale flows and shape changes in intact gastruloids, directly connecting the doublet assay to the Marangoni-like mechanism. The project is embedded in an interdisciplinary biophysics environment combining experiment and theory, with close interactions in microfluidics, quantitative imaging, image analysis and modelling within the Turing Center (CENTURI, Marseille).

CANDIDATE PROFILE Master 1–2 or engineering-school student in biology, physics, bioengineering or a related quantitative field, curious and enthusiastic about combining experimental and analytical work. No prior biophysics experience is required; a genuine interest in quantitative approaches to developmental biology matters most. We value autonomy, careful teamwork and communication, and the motivation to develop physical and quantitative tools that help answer biological questions. The project may lead to a funded PhD position.

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