2016-14

IC-**3i** International PhD Program

PhD thesis project

2017 Call for application

Molecular Regulation of Periodic Cortical Waves of Contraction

General information

Call	2017
Reference	2016-14-MAITRE
Keyword(s)	Mammalian development; Morphogenesis; Tissue mechanics; Adhesion; Cytoskeleton

Director(s) and team

Thesis director(s)	Jean-Léon Maître
Research team	Mechanics of Mammalian Development
Research department	U934 / UMR 3215 - Genetics & Developmental Biology

Description of the PhD thesis project

The “Mechanics of mammalian development” team aims at understanding how the mammalian embryo is built. For this, we study how the forces that deform and move the cells within the embryo are produced. Usual suspects are adhesion molecules, gluing cells together, and the cytoskeleton, which can push and pull on these adhesion molecules. We use biophysical tools to measure the forces, high-resolution microscopy to observe the embryo deformation and genetics to perturb the system.

During pre-implantation development, the mammalian embryo forms the blastocyst, which is the structure embedding the embryo into the uterus. The formation of the blastocyst begins with compaction, a morphogenetic process during which blastomeres draw themselves into close contact. This is caused by the increase of contractile forces of blastomeres over a period of tens of hours. On a much shorter timescale, contractions travel periodically around the cell cortex every ~80 s. We understand very little of these periodic cortical waves of contraction. What is their mechanism of action and what is their function? The aim of the project is to characterize the molecular regulation of periodic cortical waves of contraction. We will use fast high-resolution confocal microscopy, image analysis and biophysical measurements to screen the role of candidate cortical proteins. This will reveal fundamental properties of cellular contractility, a crucial engine of early mammalian morphogenesis, and may elucidate the function of periodic cortical waves of contraction, a fascinating and poorly understood manifestation of contractility.

International, interdisciplinary & intersectoral aspects of the project

The work in the lab is generally interdisciplinary, lying at the interface between developmental and cell biology and biophysics. By studying the molecular aspects of periodic contractions, the student will address a cell biology question within a developmental context using computational and biophysical tools.
The computational aspects concerning the quantitative analysis of confocal images of periodic cortical waves of contraction will be developed in collaboration with the laboratory of Stephan Preibisch at the Berlin Institute of Medical System Biology (http://preibischlab.github.io/preibisch-labsite/).
The biophysical measurements will be supported by Fluigent, which builds microfluidic devices that are tailor-made for our experiments (http://www.fluigent.com/).

Recent publications

1. **Maître JL**, Turlier H, Illukkumbura R, Eismann B, Niwayama R, Nédélec F, Hiiragi T.
Asymmetric division of contractile domains couples cell positioning and fate specification.
Nature. 2016 Aug 18;536(7616):344-8.

2. **Maître JL**, Niwayama R, Turlier H, Nédélec F, Hiiragi T.
Pulsatile cell-autonomous contractility drives compaction in the mouse embryo.
Nat Cell Biol. 2015 Jul;17(7):849-55. doi: 10.1038/ncb3185.

3. **Maître JL**, Heisenberg CP.
Three functions of cadherins in cell adhesion.
Curr Biol. 2013 Jul 22;23(14):R626-33. doi: 10.1016/j.cub.2013.06.019.

4. **Maître JL**, Berthoumieux H, Krens SF, Salbreux G, Jülicher F, Paluch E, Heisenberg CP.
Adhesion functions in cell sorting by mechanically coupling the cortices of adhering cells.
Science. 2012 Oct 12;338(6104):253-6. doi: 10.1126/science.1225399.

5. Stockinger P, **Maître JL**, Heisenberg CP.
Defective neuroepithelial cell cohesion affects tangential branchiomotor neuron migration in the zebrafish neural tube.
Development. 2011 Nov;138(21):4673-83. doi: 10.1242/dev.071233.

Expected profile of the candidate

Candidates should have a strong interest for interdisciplinary research. Although on-the-job training will be provided, prior experience with mouse, microscopy and/or image analysis will be extremely valuable.