

EuReCa International PhD Program

PhD thesis project

2022 Call for application

Shaping of biological tissues by topological defects

General information

Call	2022
Reference	2022-02-BLANCH_BONNET
Keyword(s)	Non-equilibrium phenomena; Active liquid crystals; Morphogenesis; Collective cell migration; Microfabrication

Director(s) and team

Thesis director(s)	Carles Blanch-Mercader & Isabelle Bonnet
Research team	Physico-Chimie Curie Lab
Research department	UMR168 - Physico-Chimie Curie Lab

Description of the PhD thesis project

Monolayers of elongated cells exhibit characteristics of active liquid crystals, such as long-range orientational order and topological defects: regions where orientational order is ill-defined. During the development of organisms, topological defects are at the core of morphogenetic events and biological processes, such as protrusion formation or cell extrusion. However, the interplay between morphogenesis and topological defects remains to be elucidated.

This PhD project will combine theory and experiments to disentangle the interplay between biological active matter, topological defects, and geometry in the morphogenesis of slender structures.

First, we aim at theoretically understanding feedbacks between topological defects and geometry in the emergence of 3D shapes of active liquid-crystal surfaces.

Second, the candidate will create and analyze a minimal experimental model system, which will allow one to study correlations between order of cell monolayers and deformations on the gel layer. Combining theory and experiments will facilitate the identification of new morphogenetic mechanisms in multicellular systems, which can also open new ways to design shape-morphing materials inspired by biological systems.

This project will be developed at the Laboratoire Physico-Chimie Curie. By using interdisciplinary approaches at the interface between chemistry, biology, and physics, our unit aims at discovering the role of the physical laws on the architectures and the functions of cellular systems.

International, interdisciplinary & intersectoral aspects of the project

This PhD project sits at the interface between the physics of liquid crystals and the biology of cell migration and will combine theory and experiments. The candidate will learn and apply a set of mathematical tools, such as the active gel theory or differential geometry for the theoretical part; and cell-control techniques,



such as microfabrication or micropatterning for the experimental approach. This part will be developed in close collaboration with the company Idylle, specialized in the creation of the experimental device. They will provide state-of-the-art and ready-to-use tools for the control of the cell microenvironment.

Recent publications

1. Collective stresses drive competition between monolayers of normal and Ras-transformed cells. Moitrier S, **Blanch-Mercader C**, Garcia S, Sliogeryte K, Martin T, Camonis J, Marcq P, Silberzan P, **Bonnet I**; Soft Matter. 2019
2. Controlling Confinement and Topology to Study Collective Cell Behaviors. Duclos G , Deforet M , Yevick H G , Cochet-Escartin O , Ascione F , Moitrier S , Sarkar T , Yashunsky V , **Bonnet I** , Buguin A , Silberzan P; Methods Mol Biol. 2018
3. Cancer-associated fibroblast heterogeneity in axillary lymph nodes drives metastases in breast cancer through complementary mechanisms. Pelon F, Bourachot B, Kieffer Y, Magagna I, Mermet-Meillon F, **Bonnet I**, Costa A, Givel AM, Attieh Y, Barbazan J, Bonneau C, Fuhrmann L, Descroix S, Vignjevic D, Silberzan P, Parrini MC, Vincent-Salomon A, Mechta-Grigoriou F; Nat Commun. 2020
4. Buckling of an Epithelium Growing under Spherical Confinement. Trushko A, Di Meglio I, Merzouki A, **Blanch-Mercader C**, Abuhattum S, Guck J, Alessandri K, Nassoy P, Kruse K, Chopard B, Roux A; Dev Cell. 2020
5. Integer topological defects of cell monolayers: Mechanics and flows. **Blanch-Mercader C**, Guillamat P, Roux A, Kruse K; Phys Rev E. 2021

Expected profile of the candidate

The ideal candidate will be a physicist with proficiency in statistical physics and nonlinear physics. Prior knowledge in soft condensed matter and complex systems will be an asset. Willing to work at the interface between experiments and theory. Prior knowledge of experimental cell biology is not required.

