M2/PhD project

Laboratoire Physique des Cellules et Cancer
Institut Curie, 11 Rue Pierre et Marie Curie-75005 PARIS

Team: Biology-inspired Physics at MesoScales (https://institut-curie.org/teams/buguin_silberzan)
Supervisors: Isabelle Bonnet (isabelle.bonnet@curie.fr) / Pascal Silberzan (pascal.silberzan@curie.fr)

Bilayering of cell sheets at conflicting orientation cues

Emerging collective behaviors observed in biological tissues are largely controlled by the structure of the underlying extracellular matrix (ECM). Notably, cells can deposit oriented ECM fibers which themselves act as a guiding cue for neighboring cells and subsequently lead to the formation of large domains of common orientation in the cell sheet. In active monolayers, cell flows are generated at regions of conflicts of orientation such as topological defects. Multilayers then preferentially form at these spots, allowing to study the 2D-to-3D transition that is critical in several biological processes in embryogenesis or cancer development but whose physical mechanism is still unclear.

Our team has recently shown that aligned ECM on a surface can be mimicked by synthetic micro-patterned grooves. Such a strategy allows to build mosaic surfaces with juxtaposed domains of uniform orientation separated by a boundary recapitulating conflicts of orientation in a very controlled way compared to defects. The angle between the two orientations is one of our control parameters (see Figure below where two domains are perpendicularly oriented). Culturing a cell monolayer on such substrates can result in “crisscross” bilayers where the two layers are perpendicularly oriented. By monitoring quantitatively the formation of these bilayers in space and time, the fields of orientation or velocity can be quantitatively compared to the predictions of active matter theories developed in parallel by our collaborators in the laboratory. Other geometries can provide complementary information contributing to unravel the mechanism of formation of bilayers from a 2D monolayer as a first step in our understanding of the formation of 3D tissues.

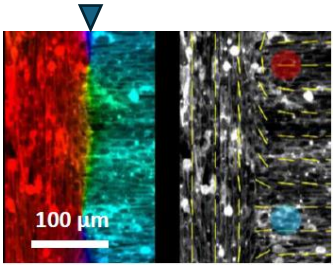

Figure: Boundary between two perpendicularly oriented monolayers. Two representations of the same field of view. On the left panel, the colors code for the cell orientations, superimposed on a phase contrast image of the monolayer. The triangle denotes the boundary. On the right, the phase-contrast image of the monolayer is superimposed with the orientation field (yellow segments) and the topological defects (blue and red dots).

Recent relevant references of the group (selection)

- Lacroix M et al.: *Emergence of bidirectional cell laning from collective contact guidance.* Nature Physics **20**, (2024) 1324
- Sarkar T. et al.: *Crisscross multilayering of cell sheets,* PNAS Nexus, **2**, (2023), pgad034
- Yashunsky V et al : *Chiral Edge Currents in Nematic Cell Monolayers* Physical Review X **12**, (2022), 041017.