M2/PhD project

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Team: Biology-inspired Physics at MesoScales (https://institut-curie.org/teams/buguin_silberzan)
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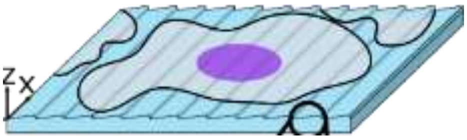
Emergence of directed cell migration on ratchet-like asymmetric cues



Directed collective cell migration is central to morphogenesis, wound healing and cancer progression. Although the molecular anisotropy of the microenvironment guides this migration in vivo, its impact on cell flow patterns remains elusive. In a previous work, we have shown that subcellular castellated microgrooves elicit a polar mode of collective migration in bidirectional "lanes" whose widths reach hundreds of micrometers. This directed form of flocking is explained by a hydrodynamic theory of active polar fluids and corresponding numerical simulations.

One can then question the behavior of the cells on surfaces that are not only anisotropic but also asymmetric. Such surfaces are obtained with grooves whose cross-section is an asymmetric triangle and not a square. By breaking the left-right symmetry, such substrates are expected to induce a displacement of active out-of-equilibrium cells in the direction perpendicular to the grooves. Such a displacement has indeed been recently observed in preliminary experiments. Yet, the mechanism of this collective rectification remains unclear.

A better understanding of this phenomenon requires a reliable mapping of the trajectories of all cells to quantitatively characterize the impact of cell-cell interactions (e.g. contacts and reorientations) in space and time. Such a task is notoriously difficult in dense monolayers because of practical limitations (cells divide, die, they can be too close to be discernable, etc..). Here, we propose to adapt a new deep neural network architecture for 2D tracking that includes temporal information. Quantities based on a statistical analysis of these trajectories on different geometries (flat, anisotropic but symmetric, anisotropic and asymmetric) will then be correlated to the rectification process to pinpoint its origin.

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.
- Duclos G et al.: *Spontaneous shear flow in confined cellular nematics*, Nature Physics. **14**, (2018), 728.
- Duclos G et al.: *Topological defects in confined populations of spindle-shaped cells.* Nature Physics **13**, (2017), 58.