

Nutrient-Mitogen availability drives Reaction-Diffusion patterning

Project description

Objective: investigate how the availability of resources, namely nutrients and mitotic factors, promote the emergence of patterns in an initially homogeneous population of cells.

Context: Spatial patterning is a central question in developmental biology, addressed by Turing's reaction-diffusion theory. Turing's hypothesis is that pattern are generated through activator-inhibitor dynamics with differential diffusion. Such mechanism is supported by empirical systems such as vegetation banding, embryonic digitation, fingerprint formation, and vascular mesenchymal self-organization.

Project: In this project, we posit that nutrient availability and mitogenic signaling form a coupled reaction–diffusion system capable of generating spatial patterns of cell density. The theoretical model, the parameters of which are all fixed experimentally, predicts a phase diagram of cell distribution as a function of nutrient and mitogenic signal availability. Three behaviors appear: population collapse under scarce resources, homogeneous proliferation under abundant resources, and cell density patterning under intermediate conditions. We experimentally confirmed these three phases under the predicted conditions.

Student Contribution: The theoretical model predict that resources availability controls the periodicity of Turing's patterning in cell density. The student will test this prediction using cells extracted form murine colon, an organ where the resource availability evolves both in time and space.

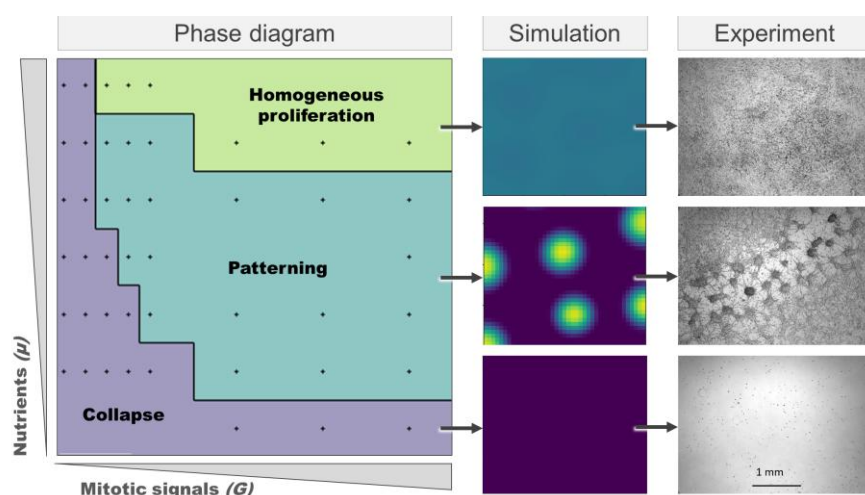


*Figure 1: **(Left)** Phase diagram, depending on nutrients and mitogenic signals. **(Middle)** Examples of simulations based on the theoretical diffusion/reaction model in the different regions of the pahse diagram: population collapse in very low resources conditions, homogeneous proliferation in saturating conditions and the emergence of Turing's patterns when nutrients become scarce. Color code represent the cell density. **(Right)** Experiments quantitatively confirm the theoretical predictions, with the emergence of periodic oscillations of cell density, in low resources conditions.*

Related Publication by the team

- Erlich & P. Recho; *Journal of the Mechanics and Physics of Solids* (2023) 178, 105342
- ME Dolega, S Monnier, B Brunel, JF Joanny, P Recho, G Cappello, *Elife* 10, e63258

Background and skills expected: The student should be either a physicist or a biologist, who would like to work at the interface between the two disciplines.

Competences acquired during the internship: Cell culture and manipulation, microfluidics, microscopy and data analysis.

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This Master internship could be followed into a PhD within the same research area: Yes