Mechanically-driven Pattern Formation in Cell Cultures

João Ramos[1], **Rui Travasso**[1], **João Carvalho**[1]

[1] CFisUC, Departamento de Física, Universidade de Coimbra

joao.r.d.ramos@gmail.com, ruit@uc.pt, jcarlos@uc.pt

Cell migration and adhesion are key in embryogenesis, vasculogenesis, angiogenesis and immune system response. In particular, durotaxis, the directed movement of a cell toward substrates of increasing rigidity, and its implications are yet to be fully understood. By studying the formation of patterns that emerge from cell-cell and cell-substrate interactions, it is possible to shed light on these underlying mechanisms. For that effect, the hybrid two-dimensional model of cell dynamics proposed by van Oers et al [1] was used. It couples a Finite Element Method (FEM), to calculate deformations of the extracellular matrix (ECM), and a Cellular Potts Model (CPM), to simulate cell movement and adhesion. The coupling is done by means of a cell traction force generation model, proposed by Lemmon and Romer [2], and by considering a durotaxis term in the Hamiltonian of the CPM. In order to explore this model, image analysis methods were adapted to classify and quantify the morphology of the emerging patterns of vasculogenesis. Results show that traction force needs to be tightly regulated for cells to form vessel networks. Furthermore, on the parameter region in which results the formation of a vascular network, cell-cell adhesion regulates the number and size of meshes, that is, by lowering cell-cell adhesion there is a decrease in the average size of meshes and an increase in the average number of meshes, until networks cease to emerge in the system.

Keywords: Cell migration; Durotaxis; Extracellular matrix; Cellular Potts model; Finite Element Method; Monte Carlo method; Pattern formation; Vasculogenesis.

REFERENCES

[1] René F. M. van Oers, Elisabeth G. Rens, Danielle J. LaValley, Cynthia A. Reinhart-King, and Roeland M. H. Merks, Mechanical cell-matrix feedback explains pairwise and collective endothelial cell behavior in vitro, *PLoS Comput Biol*, 10(8):e1003774, 2014.

[2] Christopher A. Lemmon and Lewis H. Romer, A predictive model of cell traction forces based on cell geometry, *Biophysical Journal*, 99(9):L78–L80, 2010.