Dynamics of proliferation and differentiation of stem cells

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Stem cells are a special type of undifferentiated cells that are essential for embryonic development and tissue repair. Their main quality is that they can divide to produce more stem cells or can differentiate into specialized cells, and the study of what controls the balance between proliferation and differentiation is one of the most important open questions in the field of Developmental Biology and Regenerative Medicine.

In the context of vertebrate neurogenesis, where most neurons are generated before birth, the correct interplay between self-renewal and terminal differentiation during development is key to ensure the proper function of neurogenic organs, such as the brain, the retina, and the spinal cord. It is also key to ensure proper sensory and motor functions of the adult organism, and failure in this balance results in very severe diseases.

We use a high interdisciplinary approach that combines experiments (zebrafish retina, tissue culture cells) with computational (agent-base modeling, image analysis algorithms) and theory (branching processes, nonlinear dynamics) to study how the intricate interplay between morphogenetic signals and physical cues regulate this decision-making in stem cells. The TFM proposed focuses on the effect of the force and the pressure that cells feel and how this force determines the balance between proliferation and differentiation during the formation of the zebrafish retina.

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Relevant Publications from the lab:

- The effects of Hh morphogen source movement on signaling dynamics
DG Míguez, A Iannini, D García-Morales, F Casares, Development 149 (23), dev199842 (2022)
- FGF2 modulates simultaneously the mode, the rate of division and the growth fraction in cultures of radial glia
M Ledesma-Terrón, N Peralta-Cañadas, DG Míguez, Development 147, dev189712 (2020)
- Analysis of actomyosin oscillatory dynamics using a coarse-grained model
M Hernández-Del-Valle, et al.,Frontiers in Physics 10, 881384 (2022)
- A Branching Process to Characterize the Dynamics of Stem Cell Differentiation
DG Míguez, Scientific Reports 5, 13265 (2015)