Bio-mathematical analysis of the Vertebrate embryo axis elongation (PhD thesis, Toulouse, France)

Description of the project

During embryonic development thousands of cells self-organize in a very precise and complex choreography to form the tissues and the future adult's organs. One striking morphogenetic event of the Vertebrate embryo development is the extension of its body along the antero-posterior axis. During this process cellular proliferation, migration and specification are coordinated to form the different embryonic tissues. By using live imaging of bird embryos we are able to describe the cell and tissue dynamics of Vertebrate axis elongation (1). The goal of this PhD project is to understand the cell mechanisms orchestrating the morphogenesis of the different tissues during embryo axis elongation by combining mathematical, numerical and experimental approaches. To do so the candidate will develop a unified mathematical model (based on (2)) of multi-tissues elongation in the Vertebrate, quantify the biological properties of tissues during elongation in the bird embryo and integrate the data in the model. This model will serve to highlight key aspects of the process and challenge them experimentally.

Theoretical approaches. Modeling, Continuum mechanics/Nonlinear physics, Coarse-graining, Scientific computing, Programming.

Experimental approaches. Manipulation of bird embryos, Electroporation, Microsurgery, Immunostaining, Live imaging using state of the art microscopy, Image analysis.

References

(1) Bénazéraf B, et al. Multi-scale quantification of tissue behavior during amniote embryo axis elongation. Development. 2017 Dec 1;144(23):4462–4472.

(2) A. Chertock, P. Degond, S. Hecht, J-P. Vincent, Incompressible limit of a continuum model of tissue growth with segregation for two cell populations, arXiv:1804.04090

Conditions and application

The candidate will work in a highly interdisciplinary collaborative context. Experiments will be performed at the Centre for Integrative Biology (CBI) in Toulouse under the supervision of Bertrand Benazeraf. The theoretical side will be supervised by Ariane Trescases at the Institute of Mathematics of Toulouse (IMT). The project will benefit from frequent interactions with Pierre Degond at Imperial College, London.

Candidates must have a Master degree or equivalent in mathematics or a subject with a strong mathematical component (e.g. physics, bio-physics, bio-mathematics, engineering, computer science), skills in programming and have experience and/or demonstrate a strong interest for developmental biology and experimentations in biology.

Funding: Université Fédérale Toulouse Midi-Pyrénées (three years); Start date: October 2018.

For application send a unique PDF file containing a CV, mark reports since beginning of higher education and a motivation letter with 2 reference contacts to bertrand.benazeraf@univ-tlse3.fr and ariane.trescases@math.univ-toulouse.fr