PhD project

Models for the investigation of epithelial dynamics and basal extrusion – micro and macro approaches

INSTITUTION AND DESIRED STARTING DATE:
To start around October 2019 (approximate date – quite flexible), Faculty of Mathematics, University of Vienna.

PhD SUPERVISOR:
Dr Sara Merino-Aceituno (Faculty of Mathematics, University of Vienna) – https://saramerinoaceituno.wordpress.com/

FUNDING AND DURATION: Fully funded position for 3 years (by the Vienna Science Fund).

FIELD: Mathematics (students from Physics/Computer Science background with strong mathematical education are also welcome to apply).

GENERAL DESCRIPTION OF THE PROJECT:

Epithelial tissue is pervasive in animal tissue and key to development. It is formed of a stratified layer of cells attached to a membrane called basal membrane. Cells in epithelium can undergo changes depending on gene expression and transition into mesenchymal-type cells. When cells undergo an epithelial-to-mesenchymal transition they detach from their neighbouring cells and may leave the tissue through the basal membrane in a process called **basal extrusion**. This prompts cells to migrate away from the tissue.

While basal extrusion is a well-observed phenomenon, the **mechanical factors** required for it to happen are still unknown. Understanding this is of great importance to explaining anomalies in development and the process of metastasis in cancer. However, with the current technology, it is impracticable to carry out all the laboratory experiments needed to answer this question. Building upon an existing discrete model for epithelial tissue, the goal of this PhD will be to model, simulate and investigate the possible mechanical factors involved in basal extrusion and guide experimental design.

To carry out this project, the existing epithelial model will need to be modified in different directions, following the guidance of our team of biologists. This will involve mathematical modelling, numerical simulations, comparison with experimental data, mathematical analysis of the model and also application of mathematical tools (kinetic theory) to derive continuum equations at the tissue level from the discrete cell-based model.

REFERENCES:

> On the biological side:

Slattum, Gloria M., and Jody Rosenblatt. "Tumour cell invasion: an emerging role for basal epithelial cell extrusion." Nature Reviews Cancer 14, no. 7 (2014): 495.

> On the mathematical side, the paper with the discrete model for epithelial tissue is yet to be published.

Marina Ferreira, Evangeline Despin-Guitard, Fernando Duarte, Pierre Degond and Eric Theveneau, "Interkinetic nuclear movements promote apical expansion in pseudostratified epithelia at the expense of apical constriction and apicobasal elongation." (provisional title)

> For an example of the outcome expected in terms of modelling and applications see this paper (and its supplementary information):

Peurichard, Diane, Fanny Delebecque, Anne Lorsignol, Corinne Barreau, Jacques Rouquette, Xavier Descombes, Louis Casteilla, and Pierre Degond. "Simple mechanical cues could explain adipose tissue morphology." Journal of theoretical biology 429 (2017): 61-81.

PROJECT PARTNERS:

This project is in collaboration with:

- the group of biologists led by Dr Eric Theveneau (University of Toulouse, France) - http://cbi-toulouse.fr/eng/equipe-theveneau
- mathematicians
  - > Prof Pierre Degond (Imperial College London, UK) – https://sites.google.com/site/degond/
  - > Dr Marina Ferreira (University of Helsinki, Finland) – https://marinaaferreira.wordpress.com/
  - > Dr Diane Peurichard (INRIA, Paris) – https://sites.google.com/site/dianepeurichard/home

REQUIREMENTS:

Normally, an undergraduate and master in Mathematics (an inclination to mathematical analysis is desirable, specially knowledge on partial differential equations). Students from a Physics/Computer Science background whose studies had a strong mathematical component are also encouraged to apply. Good knowledge, experience and a taste for programming and numerical simulations; willingness to work in teams that include biologists.

CONTACT:

Interested candidates please contact Dr Sara Merino-Aceituno at:
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There is no fixed deadline to applying for this position.