

Thesis proposal : Studying the visco-elastic behaviour of lymph through experimental and computational micro-fluidics (Physics/Applied Mathematics)

October 2018

Location : LIPhy, Grenoble Alpes University¹ (France) and College of Engineering, Swansea University²(UK)

This scholarship is for a **joint Swansea-Grenoble PhD**. The successful applicant will spend time at the College of Engineering, Swansea University and the Doctoral School of Physics, at Université Grenoble Alpes.

Supervision:

- M. Ismail and T. Podgorski (LIPhy, Université Grenoble Alpes, France)
- R. van Loon, D.J. Curtis and O.J. Guy (College of Engineering, Swansea University, UK)

Description

The lymphatic system returns fluid from interstitial spaces to the blood circulation and it serves as an important transport route for immune cells and antigens (see figure 1). Transport phenomena and/or breakdowns in lymphatic system performance are crucial in cardiovascular diseases, cancer, obesity, inflammatory diseases and injury resolution. However, little is actually known about transport mechanisms in this obscure system. In this project the rheological behaviour of lymph will be investigated in an effort to clarify its effect on transport through the lymphatic system. Due to the small amounts of available lymph samples, a microfluidic approach will be implemented for rheological measurements and flow characterizations in geometries that are relevant to the lymphatic system. In parallel, numerical simulations of lymphatic flows will be performed, including simulation of an actively pumping lymphatic network.

Objectives

The PhD work is based on an interplay between experimental and numerical approaches:

- To design and fabricate a small-volume micro-fluidic rheometric device.
- To interpret measurement data using computational models.
- To identify the effect of lymph mechanics through computational models of the lymphatic system.

¹<http://www-liphy.ujf-grenoble.fr>

²<http://www.swansea.ac.uk/engineering>

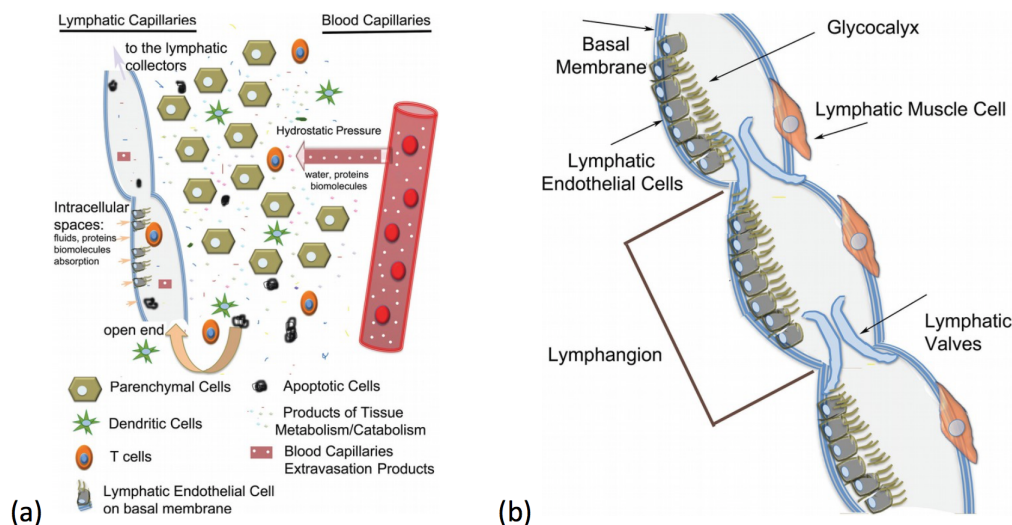


Figure 1: (a) Schematic of lymph formation; (b) Schematic of lymphatic collector (from K. C. Hansen, A. D'Alessandro, C. C. Clement and L. Santambrogio, Lymph formation, composition and circulation: a proteomics perspective, International Immunology, Vol. 27, No. 5, pp. 219-227)

The experimental work will involve the design and fabrication of microfluidic devices thanks to micro-fabrication expertise that is available in the host laboratories as well as experiments with lymph samples collected in Swansea thanks to a collaboration with the medical community. Classic and microfluidic rheological characterisation will be performed.

From the numerical viewpoint, the PhD student will use our open source Finite Element Library `Feel++` (<http://www.feelpp.org>). Such simulations will indeed be computationally extremely intensive. More generally the thesis work will combine different numerical methods with various theoretical models. More precisely, we will use the following ingredients: (i) High order discretization (ii) Fictitious domain-like methods (iii) High Performance Computing using thousands of processors. This part of the work will also be done in close collaboration with the University of Strasbourg <https://www.cemosis.fr> where the main developers of the `Feel++` Library are based (led by Christophe Prud'homme prudhomme@unistra.fr).

Required skills and qualifications:

- Ideally the candidate would be an applied mathematician and/or physicist with a strong background in either experimentation or computation (Finite Element, C++, MPI, HPC, ...). He/she should show an interest and ability to develop skills in both areas.
- As this is multi-institutional studentship with an international team of supervisors, communicative and organisational skills will be very important.

Financial support :

Université Grenoble Alpes (IDEX³/Labex Tec21⁴) and Swansea University⁵

Due to funding restrictions, this studentship is open to UK/EU citizen only.

³<http://www.univ-grenoble-alpes.fr/fr/grandes-missions/universite/grands-projets/le-projet-idx/>

⁴<https://www.tec21.fr/>

⁵<http://www.swansea.ac.uk>

How to apply

- **at Grenoble-Alpes University:**

Send a CV and a covering letter to Mourad.Ismail@univ-grenoble-alpes.fr and Thomas.Podgorski@univ-grenoble-alpes.fr.

- **at the University of Swansea:**

Apply directly on the website of the University of Swansea <http://www.swansea.ac.uk/postgraduate/scholarships/research/physics-joint-phd-studying-visco-elastic.php>