Laboratory for Interdisciplinary Physics (LIPhy, Grenoble)
140 rue de la Physique , F-38402 St Martin d'Hères

PhD thesis offer

Location : LIPhy, University Grenoble Alpes campus, St martin d'Hères, France

Context : Human Frontiers Science Program (HFSP) grant

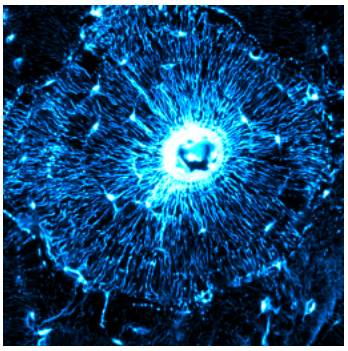
Contact : aurelien.gourrier@univ-grenoble-alpes.fr

Connectomic analysis of multiscale biological cellular networks in mineralized tissues

Your profile: you hold, or you are currently completing a **Master of Science** or **Engineering degree** in one of the following topics : **physics of complex systems**, **applied mathematics** or **medical/biological imaging** with a solid training in **image processing** and **Python programming** ?

You now wish to use your skills or develop new ones to tackle applied medical questions in an international context of scientific excellence ?

Our offer: we are currently seeking a talented PhD candidate to develop new analytical tools to better understand the role of complex cellular networks in mineralized tissues (bones & teeth). The analysis of complex networks is a fascinating field with incredibly varied applications: social networks interactions, logistic transport, telecom and computing infrastructures etc. It is also a cornerstone of neuroscience,



where biologists seek to understand the relations between measured functions and the brain organization. At the most fundamental level, this implies understanding how the topology/connectivity of the neuron network determines higher scale functions and *vice versa*. Interestingly, few people know, that there are as many cells in the human skeleton as there are in the brain and that both have a similar dendritic phenotype, i.e. are highly interconnected as seen on the fluorescence microscopy image on the left showing interconnected cells surrounding a blood capillary in a human femur. It is therefore tempting to apply similar ideas developed in the general framework of complex networks analysis to bones.

In our group (Structural & Functional Bioimaging – Optics & Imaging team) we developed a unique expertise for optical imaging of cellular networks in mineralized tissues over the recent years and we are now focusing on the image processing and analysis aspects. Together with colleagues from **McMaster University (Canada)** and the **City College of New-York (USA),** we were recently awarded a prestigious **Human Frontiers Science Program research grant** to tackle this issue.

The key aspects of this project reside in: 1) the huge number of microscopic cells and connections to consider at the organ level, resulting in a large scale dimensionality of the network graph; 2) the specific symmetries and interfaces that tend to split the network into sub-graphs depending on tissue type and 3) the connection to other (e.g. vascular) networks and surfaces, resulting in a true multiscale problem.

Your missions: *within our international collaboration framework, you will be in charge of :*

- **optimizing image processing pipelines using morphological models and machine learning tools**
- **implementing graph analysis including geometry and symmetry network characteristics**
- **proposing strategies adapted to multiscale studies, e.g. coarse-graining, wavelets...**
- **providing dynamical analysis of network evolution as a function of biological constraints**

The "dimensionality curse" is a strong aspect of this part of our project in terms of the amount of images that needs to be handled as input, of the potentially huge network size and the need to provide statistical (reduced) metrics of the whole network for biomedical diagnosis. All of these aspects relate to "**Big Data**" issues that require both **smart approaches from mathematics or physics and programming code efficiency**. The major biological application of this project is the analysis of the cellular porosity network evolution as a function of mineral depletion in bone in a lactating mouse model, the main goal of our HFSP grant.

Because of the highly interdisciplinary aspect of the project, **you will benefit from the support and training available in the exceptional scientific environment of Grenoble in Physics, Applied Mathematics and AI**.

Your working environment: this work will be based at the LIPHY, located on the University Grenoble Alpes campus in an exceptional mountain scenery. Our research lab offers unique interdisciplinary expertise at an international level and hosts numerous collaborators from various parts of the world in a sportive and relaxed atmosphere with state of the art technical and scientific support.

The project will be performed in close collaboration with experts in image and complex systems analysis from the LARIS (University of Angers) and other local collaborators in Grenoble.

Within the framework of this international collaboration, you will also strongly be encouraged to spend time at the different partner's labs in Canada and the US to benefit from our mutual expertise and broaden the scope of your research.