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

Master thesis offer (4–6 months) **followed by funded PhD**

Period : January to July 2022

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

Context : Human Frontiers Science Program (**HFSP**) grant award 2021-2024

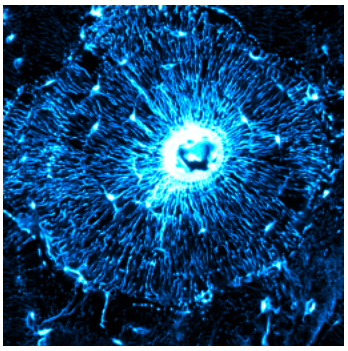
Contact : aurelien.gourrier@univ-grenoble-alpes.fr

Connectomic analysis of multiscale biological cellular networks in mineralized tissues

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

Beyond your master, you wish to pursue a PhD to tackle applied biomedical questions in an international context of scientific excellence ?

Our offer: we are currently seeking a talented Master student 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 in both cases cells are highly interconnected**, as seen on the fluorescence microscopy image on the left showing interconnected cells surrounding a blood capillary in a human femur. **The precise biological role of this network and its topology is still very poorly understood** and it is therefore tempting to apply similar ideas developed in the general framework of complex networks analysis to bones. Such approaches are expected to have a strong impact in the biomedical community.

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: *during this Master internship, 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**

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**.

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**.

This Master internship is expected to lay the ground for a PhD funded by our HFSP grant. The major biomedical 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 precise content of the PhD is opened for discussion around the following suggestions:

- **proposing strategies adapted to multiscale studies, e.g. coarse-graining, wavelets...**
- **providing dynamical analysis of network evolution as a function of biological constraints**

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.

During your PhD, you will also strongly be encouraged to spend time at the different partner's labs of the HFSP grant, in Canada and the US to benefit from our mutual expertise and broaden the scope of your research.