Title: Physics-informed modelling of osteocytes network formation

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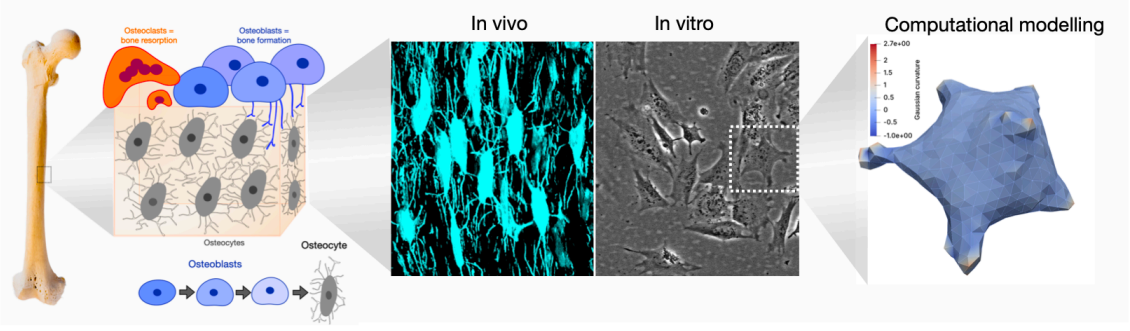
Unlike common belief, our bones are alive, filled with cells, and constantly remodelling. Osteocytes are the most abundant cells of our skeleton that live buried in the mechanically hard bone matrix and are the master regulators of bone remodelling. Osteocytes communicate with each other and with other cell types via an extensive neuron-like network within the bone. The osteocyte network is vital for mechano-transduction and osteocyte function, and changes have been associated with osteoporosis and osteoarthritis, diseases affecting millions worldwide. How osteocyte's network takes its shape remains a fundamental puzzle in biology.

This PhD project combines experimental data from model organisms' bone development with physics-based modelling to understand how extracellular material properties contribute to build and maintain osteocyte networks. Dr Erika Kague and her group will produce high-resolution imaging data of osteocyte dendrites from in vivo (zebrafish) and in vitro (mice) with varying extracellular mechanical properties. These data will be the basis for physics-based models of dendrite growth in active systems aimed at rationalising the emerging network connectivity. The theoretical framework will be developed with Dr Francesco Turci (University of Bristol), leveraging his expertise in disordered and active systems to model the morphological and dynamical organisation of dendrite extension, in collaboration with Davide Michieletto (University of Edinburgh).

By using complementary nonequilibrium physics-based approaches to experimental observations, we aim to identify principles controlling osteocytes dendritic network formation. The project bridges unique opportunity to advance our understanding of osteocytes in bone health and in diseases, providing new perspectives on bone diseases where osteocyte connectivity fails.



Physics-informed modelling of osteocytes network formation. Osteocytes are differentiated osteoblasts that are master regulators of bone remodelling, controlling bone forming cells (osteoblasts) and bone resorbing cells (osteoclasts). Osteocytes form a neutron-like network within the bone. This network is vital for osteocyte function. We will employ in vivo and in vitro experimental data and physics-based models to understand how osteocyte networks are formed and how their variations impact their function. This is a fundamentally important to understand bone in health and in diseases.