IMPRS on Multiscale Bio-Systems

Title: Network architectures in bone – structural characterization and functional interpretation

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Project description:
Living bone has the fascinating ability to adapt its structure to the mechanical loading conditions. Structural adaptation has to rely on mechanosensors within bone. It is thought that the network of osteocytes, which pervades the bone, plays a crucial role in mechanosensation. The osteocyte network is accommodated in bone by a network-like porosity, the so-called lacunocanalicular network (LCN). The fluid flow hypothesis states that load-induced fluid flow through this LCN can be sensed by osteocytes via shear stresses on their cell membranes. Over the last years, we developed a methodology that allows us to image the three-dimensional architecture of the LCN in large bone volumes, to transform the image data into a mathematical network consisting of nodes and edges, and to calculate the fluid flow through the LCN by circuit theory. With these tools at hand, we are now ready to ask fundamental questions concerning the mechanobiology of bone. (i) Different bones in our skeleton have to sustain very different loads and, therefore, differ in their mechanoresponsiveness. Can we relate such differences in the mechano-responsiveness to differences in the LCN architecture? (ii) The mechanoresponsiveness of bones decreases with age. Can we link this desensitization to architectural changes in the LCN architecture with progressing age? (iii) How are bone diseases reflected in the LCN architecture? Can an analysis of the LCN architecture serve as a new diagnostic tool of certain diseases? (iv) From the LCN architecture at different stages of bone development, can we understand how this network was formed? In this interdisciplinary project placed between bone mechanobiology, image analysis and applied network theory, you will develop evaluation methods and models of network formation, design and maintenance. During your project, you will be in contact with our research network including the Ludwig-Boltzmann-Institute of Osteology in Vienna and McGill University in Montreal.

Required background: The candidate should have a strong interest and background in computational data analysis and computer modeling. In the recent past, we made good experience with the approach that the student is doing both, imaging the network using confocal microscopy and then analyzing the data (clearly the main part of the research). The know-how gained during the PhD of analyzing large data sets will be valuable for diverse future career plans.

Paper to read before the interview:
van Tol, A.F., Weinkamer, R. et al., 2020. The mechanoresponse of bone is closely related to the osteocyte lacunocanalicular network architecture. PNAS 117, 32251-32259.
Weinkamer, R., Kollmannsberger, P. and Fratzl, P., 2019. Towards a connectomic description of the osteocyte lacunocanalicular network in bone. Current osteoporosis reports 17, 186-194.

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