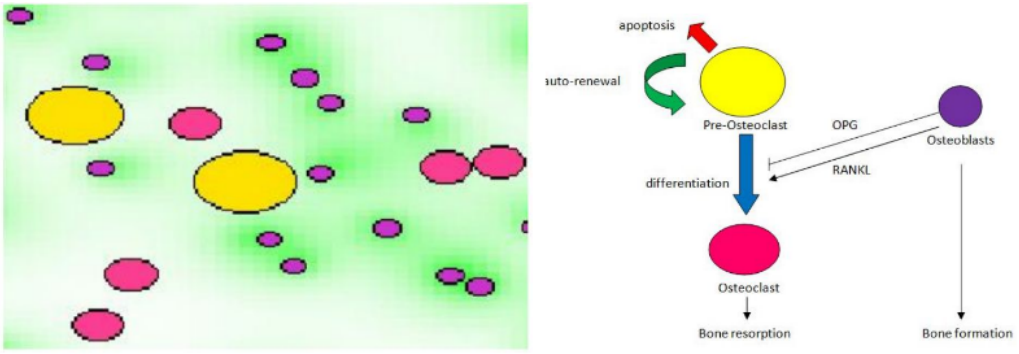
Towards a multiscale model of bone remodeling

Bone remodeling is a continuing physiological mechanism where mature bone tissue is removed and new bone collagen is formed. The normal functioning of this process depends on the balance between two types of cells: osteoclasts and osteoblasts. While the former destruct and resorb bone tissues, the latter form new bone matrix to maintain the skeletal structure. The fate of these two cells is regulated by complex signaling pathways such as the RANKL/RANK/OPG system as well as action of several hormones like vitamin D.



To better understand the dynamics of bone remodeling and its underlying mechanism, we will formulate a new multiscale model of bone remodeling. This model consists of cells represented as individual spheres that can move, divide, interact, and die by apoptosis. The fate of each cell depends on the expression of individual proteins whose concentrations is affected by extracellular signals. Partial and ordinary differential equations will be used to describe intracellular and extracellular regulation processes. The model will be used to quantify the effects of different mechanisms on the period of bone turnover under the normal and pathological conditions.

Desired skills: C++, object-oriented programming, partial differential equations, numerical methods.

References:

- Komarova, S. V., Smith, R. J., Dixon, S. J., Sims, S. M., & Wahl, L. M. (2003). Mathematical model predicts a critical role for osteoclast autocrine regulation in the control of bone remodeling. *Bone*, *33*(2), 206-215.

- Ayati, B. P., Edwards, C. M., Webb, G. F., & Wikswo, J. P. (2010). A mathematical model of bone remodeling dynamics for normal bone cell populations and myeloma bone disease. *Biology direct*, *5*(1), 28.