Equation of Osteocyte Activity in the Bone Cell Population Model

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Abstract

Mathematical models are a great way of cementing biological verbal models. Specifically, they can provide causative mechanisms linking inputs and outputs and illuminating underlying assumptions that determine a biological system's dynamics. Further, they offer a means of predicting new outcomes, as well as highlighting the most sensitive modelled components, resulting in the construction of new experimental hypotheses and reducing experimental waste. This study represents a mathematical analysis of bone cell population model. We explore this system through its homogeneous coupled ordinary nonlinear differential equations of generalized S-System type as well as through its probabilistic analogue, to investigate whether the model can capture the essential autocrine, paracrine and synergistic characteristics of bone cell communication processes, both in targeted and random remodeling processes. In-silico experimenting with a number of osteocytes up to or around a certain threshold allows us to distinguish and describe different dynamics and relations between involved cells. A constrained number of present osteocytes to a threshold describes sclerostin regulatory effects to one cycle of the bone-targeted remodelling process. The oscillating number of osteocyte around the threshold is more apt for describing random remodelling process. We use both deterministic and stochastic approaches to compare results. Additionally, we are in a good position to comment and put insights onto parameter ranges according to the constraints from the specific bone multicellular unit (BMU) activity cycle detected in the histopathological screening and 3D in-vitro experiments. Thus, we are able to correlate the biological reality that these equations represent.

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