

Christian Hellmich

VIENNA UNIVERSITY OF TECHNOLOGY

e-mail: christian.hellmich@tuwien.ac.at

Bone fibrillogenesis and mineralization: Quantitative analysis and implications for tissue elasticity

Data from bone drying, demineralization, and deorganification tests, collected over a time span of more than eighty years, evidence a myriad of different chemical compositions of different bone materials. However, careful analysis of the data, as to extract the chemical concentrations of hydroxyapatite, of water, and of organic material (mainly collagen) in the extracellular bone matrix, reveals an astonishing fact: it appears that there exists a unique bilinear relationship between organic concentration and mineral concentration, across different species, organs, and age groups, from early childhood to senility: During organ growth, the mineral concentration increases linearly with the organic concentration (which increases during fibrillogenesis), while from adulthood on, further increase of the mineral concentration is accompanied by a decrease in organic concentration. These relationships imply unique mass density-concentration laws for fibrillogenesis and mineralization, which - in combination with micromechanical models - deliver 'universal' mass density-elasticity relationships in extracellular bone matrix - valid across different species, organs, and ages. They turn out as quantitative reflections of the well-instrumented interplay of osteoblasts, osteoclasts, osteocytes, and their precursors, controlling, in a fine-tuned fashion, the chemical genesis and continuous transformation of the extracellular bone matrix. Considerations of the aforementioned rules may strongly affect the potential success of tissue engineering strategies, in particular when translating, via micromechanics, the aforementioned growth and mineralization characteristics into tissue-specific elastic properties.