# UNIVERSAL BUILDING PLANS IN BONE: MICROMECHANICS-BASED PREDICTION OF ANISOTROPIC MATERIAL BEHAVIOR

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Bone materials are characterized by an astonishing variability and diversity. Still, because of 'architectural constraints', their fundamental hierarchical organization or basic building plans remain largely unchanged during biological evolution [1]. These building plans govern the mechanical interaction of the elementary components of bone (hydroxyapatite, collagen, water; with directly measurable tissue-independent elastic properties), which are here quantified through a multiscale homogenization scheme delivering effective elastic properties of bone materials [2]: At a scale of 10nm, long cylindrical collagen molecules, attached to each other at their ends by 1.5nm long crosslinks and hosting intermolecular water inbetween, form a contiguous matrix called wet collagen. At a scale of several hundred nanometers, wet collagen and mineral crystal agglomerations interpenetrate each other, forming the mineralized fibril. At a scale of 5 microns, the solid bone matrix is represented as collagen fibril inclusions embedded in a foam of largely disordered (extrafibrillar) mineral crystals [3]. Remarkably, needle and sphere type representations of disordered minerals deliver quasi-identical mechanical behavior of such extrafibrillar porous polycrystals [4]. At a scale above the ultrastructure lacunae are embedded in extracellular bone matrix, forming the extravascular bone material. Model estimates predicted from tissue-specific composition data agree remarkably well with corresponding stiffness experiments across cortical and trabecular materials, which opens new possibilities in the exploitation of computer tomographic data for nano-to-macro mechanics of bone organs [5], especially in combination with currently investigated extensions towards damage and failure.

**References**

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