

# What is nanomechanics of bone and why is it important?

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Bone tissue is inherently hierarchical and its mechanical properties depend on both the organic and mineral components at the nanometer scale, where there are the concerns of nanomechanics of bone. The major organic component is type I collagen, which forms bundles of several hundred nanometers while itself is in the order of one nanometer. The mineral component of bone tissue consists of hydroxyapatite crystals about 1-5 nanometer thick and 25-50 nanometer long. The health of bone tissue is governed by the entombed osteocytes within the bone tissue. Osteocytes have the size of about 10 micrometers but they have hundreds of intercellular processes with the size of several hundreds nanometer.

With the advances in mechanical testing, imaging, and modeling techniques in the broad scientific field, there has been significant and novel to progress in the field of bone tissue mechanics at the nano/micro scale. Mechanical properties of individual collagen fibrils can be measured at the nano scale<sup>1</sup>. Bone tissue ultra structure can be visualized non-invasively in the hundreds of nanometer scale<sup>2</sup>. Nanoscale deformation in bone tissue *in situ* can be measured during mechanical testing<sup>3,4</sup>. Deformation between mineral and collagen can be measured directly at the nanoscale<sup>3</sup>. Bone tissue fracture mechanics can be visualized at the nanometer scale to reveal the contributions of nanoscale components to the fracture to process<sup>5</sup>. In parallel, sophisticated theoretical models have been developed to consider the hierarchical contributions of ultrastructural components including nanoscale to elastic and failure properties of bone tissue<sup>6,7</sup>. The theoretical and experimental determinations of bone tissue properties at the nanoscale

begin to converge. In the meantime, osteocytes and their associated numerous intercellular processes have been recognized as an equally important cell type as osteoblasts and osteoclasts. Bone tissue maintenance and responsiveness to mechanical loading are governed and orchestrated by osteocytes. The intercellular communication of osteocytic processes and fluid flow around them at nanoscale has been emphasized recently to be important in bone mechanics and bone biology<sup>8</sup>. Nanomechanics and nanobiology of bone tissue are on the verge of rapid development.

The question is then why is nanomechanics of bone important. Genetic mutations in either organic or mineral components at the molecular level result in metabolic bone diseases. A single point mutation in collagen gene results in osteogenesis imperfecta. Age-related fractures are determined not only by bone mass, but also bone tissue quality such as collagen and mineral properties. This session of Nanomechanics of Bone brings together a group of diverse multidisciplinary leaders in the field of materials science, applied mechanics, biomechanics, and biomedical engineering. The objectives this session would like to achieve are: (1) What is nanomechanics of bone tissue and why is it clinically important; (2) What is the current cutting-edge theories of nanomechanics; (3) How can bone tissue be experimentally studied at nanoscale and what are the needs of cutting-edge nano-equipment; and (4) How is nanomechanics relevant to bone biology and physiology.

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