SL5I_10772

XXI International Congress of Theoretical and Applied Mechanics
Warsaw, Poland, August 15–21, 2004

Nanoscale Mechanics of Biological Materials

Huajian Gao

Max Planck Institute for Metals Research, Stuttgart, Germany

In this lecture I will discuss mechanical properties associated with the nanostructures of biological materials. A simple and universal model is firstly introduced to describe the generic nanostructure of a wide variety of biological materials including bone, shell, dentin, wood, and tendon. We show that the superior mechanical properties of biological materials stem from the unique characters of their generic nanostructure in which perfection and harmony are achieved between stiff mineral nanoparticles and soft protein matrix: The mineral provides stiffness and strength for the composite structure while protein serves a multitude of support and relaxation functions. We conclude that the soft protein layer can homogenize stress distribution around the mineral and serve as a buffer to isolate damage.The nanometer size of mineral particles may have evolved to achieve maximum strength and maximum tolerance of flaws. The large aspect ratio of mineral crystals is selected to compensate the softness and weakness of protein and plays a crucial role in various mechanical properties of biological materials, such as the stiffness, stability, viscoelastic properties and interface strength. As a closely related topic, I will describe mechanics of hierarchical adhesion structures of Gecko where the nanometer size may have again been selected to achieve maximum strength while tolerating flaws in contact with a substrate. The flaw tolerance is key to robust design of structures and robustness is the key to survival.

View the extended summary