Public Abstract

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Ph.D.

Physics

Mechanical Properties of Complex Biological Systems using AFM-Based Force Spectroscopy

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An atomic force microscope (AFM) was designed and built to study the mechanical properties of small collagen fibrils and the plasma membrane of living cells. Collagen, the most abundant protein in mammals, is a major component of bone, skin and the tissues connecting bones and organs. Because of the important roles played by collagen, diseases affecting its mechanical properties are often serious, and an understanding of how disease affects collagen mechanics is crucial in disease prevention efforts. As a starting point, human collagen fibrils were produced in the laboratory and their mechanical properties measured. These results compared favorably to results of measurements on collagen obtained from disease-free mouse tails. In order to determine how disease affects collagen mechanics, collagen from diseased mouse tails was investigated in the same manner as the disease-free collagen fibrils. Significant differences between diseased and normal collagen fibrils were observed, primarily that the diseased fibrils lacked molecular bonding present in the normal fibrils. One way in which diseases affecting collagen fibrils cause serious illness is in the behavior of such fibrils while interacting with cells. To better understand cell-collagen interactions, it is first necessary to understand how cells respond to being stretching. The AFM was used to pull on cell membranes, creating thin membrane tethers between the cell and the AFM probe. A particular force is required to produce these membrane tethers, and the force varies depending on how molecules directly interact with the membrane. By directly changing these molecular interactions, different membrane tether-producing forces were measured.