Wedding of Biochemistry and Mechanics by Force

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Traditionally, chemistry and mechanics have been treated as two separate disciplines, one concentrating on the conversion of molecules from one form to another and the other focusing on the deformation of macroscopic materials under compressive or tensile stresses. However, the advent of nanotechnologies has meant that we are now able to compress or stretch individual molecules and measure their mechanical response; closing the traditional gap between the two disciplines. DNA has been shown by Bustamante and his colleagues to be stretched beyond the contour length of the standard B-form resulting in the new S-form that is stable only under a tensile stress of about 80 pN [1]. Protein molecules are also unfolded under an applied tensile force; so exposing the hitherto unknown mechanics of intramolecular segmental interactions [2,3,4,5]. By compressing single protein molecules, one can obtain Young's modulus of globular proteins under native and denaturing conditions [6]. A single synthetic polymer chain has been extended from its two ends allowing researchers to compare the experimental stretch curve with various theoretical models of polymer extension [7]. We have been applying the most sophisticated single molecule manipulation technology available to the development of surgical techniques in single living cells by inserting plasmid DNA into or extracting mRNA out of a live cell [8]. We are also pulling membrane proteins to probe their interaction with intracellular structures such as the cytoskeleton [9]. I will give an overview of the new technology being developed in our laboratory for the single molecule and single cell manipulation and its application to bio-medical fields.

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