# JILA Finds Flaw in Model Describing DNA Elasticity

September 17 2007

DNA, the biomolecule that provides the blueprint for life, has a lesser-known identity as a stretchy polymer. JILA scientists have found a flaw in the most common model for DNA elasticity, a discovery that will improve the accuracy of single-molecule research and perhaps pave the way for DNA to become an official standard for measuring picoscale forces, a notoriously difficult challenge. JILA is a joint venture of the National Institute of Standards and Technology and the University of Colorado at Boulder.

The JILA experiments, described in a new paper, reveal that a classic model for measuring the elasticity of double-stranded DNA leads to errors when the molecules are short. For instance, measurements are off by up to 18 percent for molecules 632 nanometers long, and by 10 percent for molecules about twice that length. (By contrast, the DNA in a single human cell, if linked together and stretched out, would be about 2 meters long.)

The old elasticity model assumes that polymers are infinitely long, whereas the most popular length for high precision single-molecule studies is 600 nm to 2 microns, NIST/JILA biophysicist Tom Perkins says. Accordingly, several university collaborators developed a new theory, the finite worm-like chain (FWLC) model, which improves accuracy by incorporating three previously neglected effects, including length.

The work builds on JILA expertise in measuring positions of microscopic objects. A DNA molecule (green in the animation) is linked at one end to a moveable stage and at the other end to a polystyrene bead trapped by an infrared laser. While moving the stage to extend the DNA molecule, scientists measure changes in bead position using custom electronics and a second laser. By calculating the force exerted on the bead, based in part on the intensity of the laser, and comparing it to the position of the bead in the optical trap, which acts like a spring, scientists can measure DNA elasticity.

The JILA work is part of a NIST project studying possible use of DNA as a picoforce standard, because enzymes build DNA with atomic precision. DNA already is used informally to calibrate atomic force microscopes. An official standard could, for the first time, enable picoscale measurements that are traceable to internationally accepted units. DNA elasticity could provide a force standard from 0.1 -10 pico-Newtons (pN), where 1 pN is the approximate weight of 100 E. coli bacteria cells, and roughly 6 pN is the force exerted by 1 milliwatt of light reflected off a mirror.

The JILA group collaborated with theorists from the universities of Colorado and Pennsylvania. The work was supported by the Alfred P. Sloan Foundation, a Burroughs Wellcome Fund Career Award in the Biomedical Sciences, the Butcher Foundation, a W.M. Keck Grant in the RNA Sciences, NIST, and the National Science Foundation.

Citation: Y. Seol, J. Li, P.C. Nelson, T.T. Perkins and M.D. Betterton. Elasticity of short DNA molecules: theory and experiment for contour lengths of 0.6–7 µm. *Biophysical Journal*. Published on-line in BioFAST, Aug. 31, 2007.

Source: NIST