Unraveling the DNA stretching mystery

January 20 2011, By Laura Ost

Credit: Unsplash/CC0 Public Domain

(PhysOrg.com) -- Using a new experimental test structure, biophysicists at JILA have unraveled part of a 15-year mystery in the mechanics of DNA -- just how the molecule manages to suddenly extend to almost twice its normal length. The new test structure should support research on DNA elasticity as a standard for tiny forces and help refine studies of how drugs and other substances bind to DNA.

In a new paper in the Journal of the American Chemical Society, JILA scientists disprove a leading explanation for DNA overstretching, a curious behavior in which the molecule's double helix structure (see image) suddenly extends by 70 percent when subjected to 65 picoNewtons (pN) of force. The exact steps of the process have been controversial since overstretching was discovered in 1996. Contrary to a popular theory, the new JILA work shows that DNA's backbone does not need to have a small gap, often called a nick, or sport loose ends for the dramatic extension to occur at 65 pN.

JILA is a joint institute of the National Institute of Standards and Technology (NIST) and the University of Colorado at Boulder.

"Overstretching is a really amazing phenomenon, and even after 15 years, people are still debating it," says senior author Tom Perkins, a NIST expert in the mechanics of single molecules. "DNA stretches and stretches like a rubber band and you think it's going to break, and then all of a sudden it nearly doubles in length. Something wonderfully interesting happens at this transition."

The leading theory is that overstretching introduces so much energy that the DNA melts, with a single strand peeling off from nicks in the backbone or free ends. This model assumes that nicks or ends are essential. Scientists did not test this assumption until now because there was no platform for restraining the ends without also locking the molecule's structure and rotation.

The JILA team's key advance was a clever geometry that binds a looped end of DNA to a micro-sized bead, while the other end of the DNA has both strands stapled to a surface. Lasers apply force to the bead and measure its position. The DNA has freedom to rotate but, crucially, no loose ends.

The researchers compared one piece of DNA without nicks or free ends to another piece of DNA they had nicked. They found that both molecules overstretched at essentially the same force, indicating the same mechanism is at work in both cases.

In addition to narrowing the focus of debate about overstretched DNA, Perkins says the findings and the new DNA test structure will support NIST efforts to develop an official picoNewton-scale force standard that is traceable to the International System of Units. A picoNewton is one-trillionth of a newton, the unit of force; one newton is roughly the weight of a small apple. DNA is already used informally as a calibration standard for atomic force microscopes. Further JILA studies are planned.

More information: D. H. Paik and T.T. Perkins. 2011. Overstretching DNA at 65 pN does not require peeling from free ends or nicks. *Journal of the American Chemical Society*. Published online Jan. 5, 2011.

Provided by National Institute of Standards and Technology