Researcher shows that DNA gets kinky easily at the nanoscale

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Scientists have answered a long-standing molecular stumper regarding DNA: How can parts of such a rigid molecule bend and coil without requiring large amounts of force? According to a team of researchers from the United States and the Netherlands, led by a physicist from the University of Pennsylvania, DNA is much more flexible than previously believed when examined over extremely small lengths. They used a technique called atomic force microscopy to determine the amount of energy necessary to bend DNA over nano-size lengths.

The findings, which appear in the November issue of the journal *Nature Nanotechnology*, illustrate how molecular properties often appear different when viewed at different degrees of magnification.

"DNA is not a passive molecule. It constantly needs to bend, forming loops and kinks, as other molecules interact with it," said Philip Nelson, a professor in Penn's Department of Physics and Astronomy in the School of Arts and Sciences. "But when people looked at long chunks of DNA, it always seemed to behave like a stiff elastic rod."

For example, DNA must wrap itself around proteins, forming tiny molecular structures called nucleosomes, which help regulate how genes are read. The formation of tight DNA loops also plays a key role in switching some genes off. According to Nelson, such processes were considered a minor mystery of nature, in part because researchers didn't have the tools of nanotechnology to examine molecules in such fine detail.

"Common sense and physics seemed to tell us that DNA just shouldn't spontaneously bend into such tight structures, yet it does," Nelson said. "In the conventional view of a DNA molecule, wrapping DNA into a nucleosome would be like bending a yardstick around a baseball."

To study DNA on the needed short length scales, Nelson and his colleagues used a technique called high-resolution atomic force microscopy to obtain a direct measurement of the energy it would take to bend lengths of DNA just a few nanometers long. The technique involves dragging an extremely sharp tip across the contours of the molecule in order to create a picture of its structure.

With this tool, Nelson and his colleagues measured the energies required to make various bends in DNA at lengths of five to 50 nanometers --- about a thousand times smaller than the diameter of a typical human cell.

"We found that DNA has different apparent properties when probed at short lengths than the entire molecule does when taken as a whole," Nelson said. "Its resistance to large-angle bends at this scale is much smaller than previously suspected."

Nelson is also a member of Penn's Nano--Bio Interface Center, which explores how the fields of nanotechnology, biology and medicine all intersect.

"The nanoscale just happens to also be the scale at which cell biology operates," Nelson said. "We're entering an era when we are able to use the tools of nanotechnology to answer fundamental puzzles of biology."

Source: University of Pennsylvania