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Scientists find DNA is packaged like a yoyo

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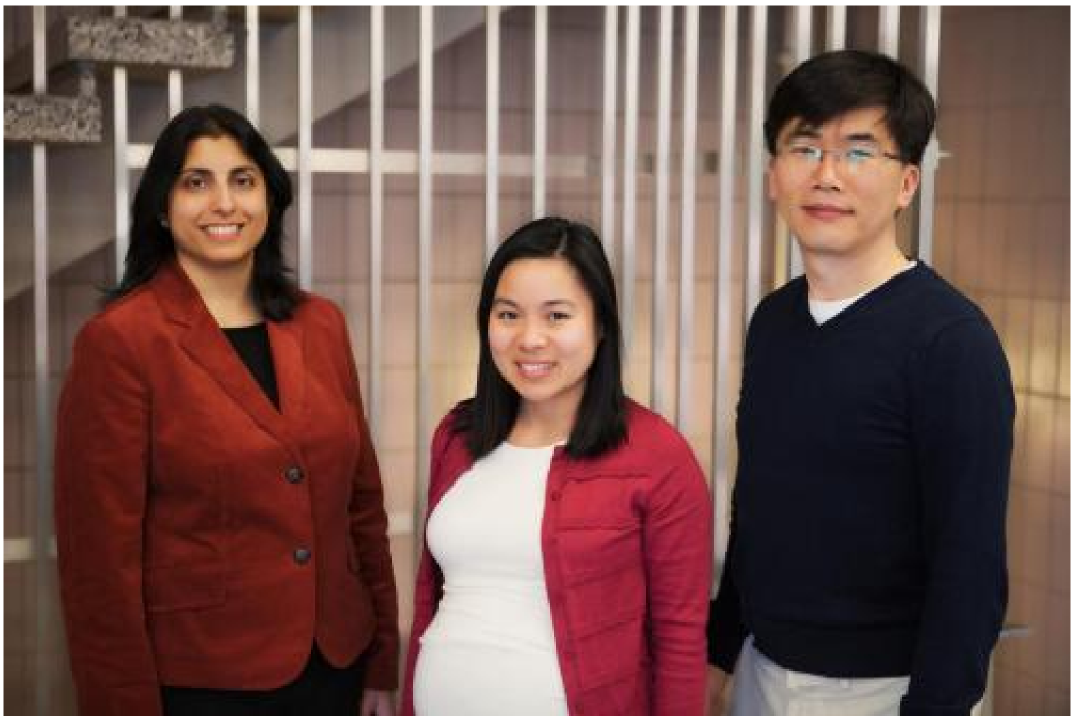

University of Illinois members Jaya Yodh, research assistant professor and CPLC Director of Education and Outreach, Thuy Ngo, graduate research assistant, and Taekjip Ha, Gutgsell Professor of Physics. Credit: Photo by Kathryn Coulter

To pack two meters of DNA into a microscopic cell, the string of genetic information must be wound extremely carefully into chromosomes. Surprisingly the DNA's sequence causes it to be coiled and uncoiled much like a yoyo, scientists reported in *Cell*.

"We discovered this interesting physics of DNA that its sequence determines the flexibility and thus the stability of the DNA package inside the cell," said Gutgsell Professor of Physics Taekjip Ha, who is a member of the Carl R. Woese Institute for Genomic Biology at the University of Illinois. "This is actually very elementary DNA physics. Many people thought we should have known this many decades ago, but there are still surprises in the physics of DNA."

The DNA is packaged into chromosomes, which resemble beaded bracelets. The string of DNA is coiled around beads, called histones, to create nucleosomes. These nucleosomes are braided together into beaded strings that are intricately woven into chromosomes.

Scientists knew the DNA could be uncoiled from the nucleosome, but it was assumed that the two ends were symmetric, meaning uncoiling the DNA would be like untying a shoe. University of Illinois researchers found that the DNA is actually very asymmetric, like the string wrapped around a yoyo. Pulling on one end of DNA will simply tighten the coil while pulling on the other will cause it to uncoil like a yoyo.

The physics of this nucleosome packaging is determined by the DNA's sequence, which makes the strand of DNA flexible enough to satisfy two conflicting principles: it has to be stable enough to compact DNA, but dynamic enough so the strand can be uncoiled and read to make proteins.

"There are many good studies that show that if you change the sequence of the gene, then it will affect other things. Different proteins may be created because they require certain sequences for binding and so on," said Ha. "But no one had really thought about sequence changes having an effect on DNA physics, which in turn cause changes in the biology."

Ha's research has shown that it is easier for the cell's protein-making machinery to read from the "weak" end of the nucleosome that uncoils more easily. They believe that genetic mutations related to diseases, like cancer, alter the stability of the nucleosome.

"This could have a major impact on how the information is read out and how different proteins are produced," Ha said. "For example, cancer-fighting proteins or cancer-causing proteins may be made differently depending on the changes in DNA flexibility and stability caused by mutations."

Next Ha plans to use next generation sequencing to determine the flexibility of an entire genome. He hopes to create the first genome-wide map of physical properties. He also wants to find out if mutations can make the DNA easier or more difficult to read.

More information: The paper, "Asymmetric Unwrapping of Nucleosomes under Tension Directed by DNA Local Flexibility," is available online dx.doi.org/10.1016/j.cell.2015.02.001

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