New Study Sheds Light On 'Dark States' In DNA

January 8 2007

Chemists at Ohio State University have probed an unusual high-energy state produced in single nucleotides -- the building blocks of DNA and RNA -- when they absorb ultraviolet (UV) light.

This is the first time scientists have been able to probe the "dark" energy state -- so called because it cannot be detected by fluorescence techniques used to study other high-energy states created in DNA by UV light.

The study suggests that DNA employs a variety of means to dissipate the energy it absorbs when bombarded by UV light.

Scientists know that UV light can cause genetic alterations that prevent DNA from replicating properly, and these mutations can lead to diseases such as cancer.

The faster a DNA molecule can dissipate UV energy, the lesser the chance that it will sustain damage -- so goes the conventional scientific wisdom. So the dark states, which are much longer lived than previously known states created by UV light, may be linked to DNA damage.

The existence of this dark energy state -- dubbed np* (pronounced "n-pi-star") -- had previously been predicted by calculations. Other experiments hinted at its existence, but this is the first time it has been shown to exist in three of the five bases of the genetic code -- cytosine, thymine and uracil.

The detection of this dark state in single bases in solution increases the chances that it may be found in the DNA double helix, said Bern Kohler, associate professor of chemistry at Ohio State and head of the research team.

The Ohio State chemists determined that, when excited by ultraviolet light, these three bases dissipate energy through the dark state anywhere from 10-50 percent of the time.

The rest of the time, energy is dissipated through a set of energy states that do fluoresce in the lab. These "bright" energy states dissipate the energy much faster, in less than one picosecond.

A picosecond is one millionth of one millionth of a second -- an inconceivably short length of time. Light travels at 186,000 miles per second, but in twenty picoseconds it would only travel just under a quarter of an inch. Still, a picosecond is not so fast compared to the speed of some chemical reactions in living cells.

In tests of single DNA bases, the dark state lasted for 10-150 picoseconds -- much longer than the bright state. The chemists reported their results in the Proceedings of the National Academy of Sciences.

"We want to know, what makes DNA resist damage by UV light?" said Kohler. "In 2000, we showed that single DNA bases can dissipate UV energy in less than one picosecond. But now we know that there are other energy states that have relatively long lifetimes."

"Now we see that there is a family of energy states in DNA responsible for energy dissipation, and this is a major correction in how we view DNA photostability."

Until now, the proposed dark energy state of DNA was a little like the dark matter in the universe – there was no direct way of probing it. The Ohio State chemists used a technique called transient absorption, which is based on the idea that molecules absorb light at specific wavelengths, and allows them to study events happening in less than a picosecond.

They found that DNA dissipates UV energy through the dark state 10-50 percent of the time, depending on which DNA base is excited, and whether a sugar molecule is attached to the base or not.

Next, Kohler's lab is investigating whether the dark state can be linked to DNA damage.

"What are the photochemical consequences of long-lived states? Are they precursors to some of the chemical photoproducts that we know cause damage? That's the Holy Grail in this field -- connecting our growing knowledge of the electronic states of DNA with the photoproducts that damage it," he said.

Kohler's coauthors include Carlos E. Crespo-Hernandez, a former postdoctoral researcher at Ohio State, and Patrick M. Hare, who just obtained his Ph.D. from the university and is about to begin a position as a postdoctoral researcher at the University of Notre Dame.

Source: Ohio State University

Citation: New Study Sheds Light On 'Dark States' In DNA (2007, January 8) retrieved 26 April 2024 from https://phys.org/news/2007-01-dark-states-dna.html