Scientists see DNA get 'sunburned' for the first time

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For the first time, scientists have observed DNA being damaged by ultraviolet (UV) light. Ohio State University chemists and their colleagues in Germany used a special technique to watch strands of DNA in the laboratory sustain damage in real time.

They observed the most common chemical reaction among a family of reactions on the DNA molecule that are linked to sunburn, and discovered that this key reaction happens with astounding speed -- in less than one picosecond, or one millionth of one millionth of a second.

Scientists are studying UV damage to understand the role it plays in sunburn and diseases such as skin cancer. This new finding, reported in the current issue of the journal *Science*, shows that the damage depends greatly on the position of the DNA at the moment the UV strikes the molecule.

UV light excites the DNA molecule by adding energy, said Bern Kohler, associate professor of chemistry at Ohio State. Some exited energy states last a long time, and others a short time. The energy often decays away harmlessly, but occasionally it triggers a chemical reaction that alters the DNA's molecular structure.

Previously, scientists believed that the longer a DNA molecule was excited by UV energy, the greater the chance that it would sustain damage. So long-lived excited states were thought to be more dangerous than short-lived ones. But this study shows that the most common UV damage is caused by a very short-lived excited state.

"The speed of this reaction has important consequences for understanding how DNA is damaged by UV light," said Kohler. "In this study, we didn't see any evidence that long-lived energy states are responsible for damage. Now it seems more likely that short-lived states cause the most common chemical damage to DNA."

That damage consists of two tiny molecular bonds that form where they shouldn't -- between two thymine bases stacked together among the billions of bases in the DNA double helix.

DNA employs some chemical reactions of its own to heal itself. But when DNA sustains too much damage, it can't replicate properly. Badly damaged cells simply die -- the effect that gives sunburn its sting. Scientists also believe that chronic damage creates mutations that lead to diseases such as skin cancer.

For this study, the chemists used a technique called transient absorption to observe the DNA damage. Transient absorption is based on the idea that molecules absorb light at specific wavelengths, and it allows researchers to study events that happen in less than a picosecond.

They took specially designed strands of DNA -- ones made solely of thymine bases, in order to boost the chance of observing a reaction between adjacent thymines -- and exposed them to UV light. Then they timed the reactions that caused the new thymine bonds to form.

Kohler stressed that he and his colleagues examined damage to isolated DNA strands, not DNA within a cell. Sunburn results from a series of chemical reactions in a living cell, and so this experiment did not allow them to see a cell sustain sunburn.

This is, however, the first time anyone has observed the initial molecular events behind damage to DNA. Kohler thinks the results might make scientists attack the problem of UV damage in a new way.

DNA in a cell is always moving, he explained. It bends and twists one way or another because it is a relatively flexible molecule. This flexibility enables the normal chemical reactions that are constantly happening in the cell. Each shape-shift can require anywhere from a few to several hundred picoseconds to complete.

That's fast, but this new study shows that UV damage happens many times faster. On the timescale that the unwanted bonds form, even a rapidly moving DNA molecule would essentially appear frozen.

That means that whether or not two thymine bases are damaged depends on the position of the DNA during the extremely brief time required for it to absorb UV light. Either two thymine bases are lined up in just the right way to bond when the UV hits, or they're not.

"This insight explains why some pairs of thymine bases get damaged more frequently than others, and it suggests that scientists can understand damage patterns to DNA by studying the factors that influence how the bases are arranged in space," Kohler said.

"In our efforts to understand photo-damage, this new result shifts our attention to the DNA structure, and the kinds of arrangements that exist at the moment DNA absorbs light."

Source: Ohio State University