Researchers discover how key enzyme repairs sun-damaged DNA

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Dongping Zhong

Researchers have long known that humans lack a key enzyme -- one possessed by most of the animal kingdom and even plants -- that reverses severe sun damage.

For the first time, researchers have witnessed how this enzyme works at the atomic level to repair sun-damaged DNA.

The discovery holds promise for future sunburn remedies and skin cancer prevention.

In the early online edition of the journal *Nature*, Ohio State University physicist and chemist Dongping Zhong and his colleagues describe how they were able to observe the enzyme, called photolyase, inject a single electron and proton into an injured strand of DNA. The two subatomic particles healed the damage in a few billionths of a second.

"It sounds simple, but those two atomic particles actually initiated a very complex series of chemical reactions," said Zhong, the Robert Smith Associate Professor of Physics, and associate professor in the departments of chemistry and biochemistry at Ohio State. "It all happened very fast, and the timing had to be just right."

Exactly how photolyases repair the damage has remained a mystery until now.

"People have been working on this for years, but now that we've seen it, I don't think anyone could have guessed exactly what was happening," Zhong said.

He and his colleagues synthesized DNA in the lab and exposed it to ultraviolet light, producing damage similar to that of sunburn, then added photolyase enzymes. Using ultrafast light pulses, they took a series of "snapshots" to reveal how the enzyme repaired the DNA at the atomic level.

Ultraviolet (UV) light damages skin by causing chemical bonds to form in the wrong places along the DNA molecules in our cells.

This study has revealed that photolyase breaks up those errant bonds in just the right spots to cause the atoms in the DNA to move back into their original positions. The bonds are then arranged in such a way that the electron and proton are automatically ejected out of the DNA helix and back into the photolyase, presumably so it could start the cycle over

again and go on to heal other sites.

All plants and most animals have photolyase to repair severe sun damage. Everything from trees to bacteria to insects enjoys this extra protection. Only mammals lack the enzyme.

Humans do possess some enzymes that can undo damage with less efficiency. But we become sunburned when our DNA is too damaged for those enzymes to repair, and our skin cells die. Scientists have linked chronic sun damage to DNA mutations that lead to diseases such as skin cancer.

Now that researchers know the mechanism by which photolyase works, they might use that information to design drugs or lotions that heal sun damage, Zhong said.

Normal sunscreen lotions convert UV light to heat, or reflect it away from our skin. A sunscreen containing photolyase could potentially heal some of the damage from UV rays that get through.

Perhaps ironically, photolyase captures light of a different wavelength -- visible light, in the form of photons -- to obtain enough energy to launch the healing electron and proton into the DNA that has been damaged by UV light.

Researchers knew that visible light played a role in the process -- hence the term "photo" in the enzyme's name -- but nobody knew exactly how, until now.

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