Base-pairing protects DNA from UV damage

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Ludwig Maximilian University of Munich researchers have discovered a further function of the base-pairing that holds the two strands of the DNA double helix together: it plays a crucial role in protecting the DNA from the ultraviolet rays of the Sun.

The iconic double helical structure of the DNA was discovered by James Watson and Francis Crick over 60 years ago. The two-stranded structure is stabilized by two main interactions – stacking of neighbouring bases on the same strand, and base pairing mediated by hydrogen bonds between bases on opposite strands. The selectivity of base-pair formation between guanine (G) and cytosine (C) and between adenine (A) and thymine (T) is essential for replication and preservation of genetic information.

Research groups led by Wolfgang Zinth (Chair of BioMolecular Optics) and Thomas Carell (Chair of Bioorganic Chemistry) at LMU have recently shown that this base-pairing mechanism serves yet another function: It helps protect the DNA from the deleterious effects of ultraviolet radiation. Their findings appear in the journal *Angewandte Chemie*.

UV radiation is known to induce photochemical reactions in the DNA, causing changes in its structure. The resulting alterations in the genetic information encoded in its base sequence can lead to cell death or cancer. In a recent study, the authors had shown that UV radiation can generate charged radicals in synthetic DNA single strands. These reactive radicals are known to damage DNA.

The researchers have now used a combination of femtosecond infrared spectroscopy – a technique which employs ultrashort pulses of infrared light (a femtosecond lasts for a millionth of a billionth of second) to probe the dynamics of excited molecular states – and bioorganic chemistry to elucidate a new function of base-pairing: it protects DNA from photodamage.

A simple dissipation mechanism

In their new study, the authors investigated natural double-stranded calf thymus DNA. After photoexcitation of this DNA with short laser pulses of UV light, the researchers discovered that the hazardous excited states, which can form in any of the bases, are deactivated by an unexpectedly simple mechanism: Each excited pair – whether it be a G-C or an A-T pair – decays into the ground state in a concerted manner. "Thus, the Watson-Crick base-pairing mechanism itself controls the dissipation of the absorbed UV energy. This contradicts the conventional wisdom, which holds that the base sequence within the same strand is responsible for the deactivation of excited states," says Wolfgang Zinth.

A second important finding of the study concerns the biological consequences of the deactivation mechanism. Watson-Crick base-pairing neutralizes the potentially dangerous states generated in DNA strands by UV light. Thus, Watson-Crick base pairing acts as a natural "sunscreen" and is of fundamental importance in enabling organisms to survive exposure to UV radiation.

More information: Bucher, D. B., Schlueter, A., Carell, T. and Zinth, W. (2014), "Watson–Crick Base Pairing Controls Excited-State Decay in Natural DNA." *Angew. Chem. Int. Ed.*. doi: 10.1002/anie.201406286

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