Researchers develop better control for DNA-based computations

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A North Carolina State University chemist has found a way to give DNA-based computing better control over logic operations. His work could lead to interfacing DNA-based computing with traditional silicon-based computing.

The idea of using DNA molecules – the material genes are made of – to perform computations is not new; scientists have been working on it for over a decade. DNA has the ability to store much more data than conventional silicon-based computers, as well as the potential to perform calculations in a biological environment – inside a live cell, for example. But while the technology holds much promise, it is still limited in terms of the ability to control when and where particular computations occur.

Dr. Alex Deiters, associate professor of chemistry at NC State, developed a method for controlling a logic gate within a DNA-based computing system. Logic gates are the means by which computers "compute," as sets of them are combined in different ways to enable the computer to ultimately perform tasks like addition or subtraction. In DNA computing, these same types of gates are created by the combinations of different strands of DNA, rather than by a series of transistors. The drawback is that DNA computation events normally take place in a test tube, where the sequence of computation events cannot be easily controlled with spatial and temporal resolution. So while DNA logic gates can and do work, no one can tell them when or where to work, making it difficult to create sequences of computational events.

In a paper published in the *Journal of the American Chemical Society*, Deiters addressed the control problem by making portions of the input strands of DNA logic gates photoactivatable, or controllable by ultraviolet (UV) light. The process is known as photocaging. Deiters successfully photocaged several different nucleotides on a DNA logic gate known as an AND gate. When UV light was applied to the gate, it was activated and completed its computational event, showing that photoactivatable logic gates offer an effective solution to the "when and where" issues of DNA-based logic gate control.

Deiters hopes that using light to control DNA logic gates will give researchers the ability not only to create more complicated, sequential DNA computations, but also to create interfaces between silicon and DNA-based computers.

"Since the DNA gates are activated by light, it should be possible to trigger a DNA computation event by converting electrical impulses from a silicon-based computer into light, allowing the interaction of electrical circuits and biological systems," Deiters says.

"Being able to control these DNA events both temporally and spatially gives us a variety of new ways to program DNA computers."

More information: "DNA Computation: A Photochemically Controlled AND Gate" Alex Prokup, James Hemphill, and Alexander Deiters, Online in the *Journal of the American Chemical Society*.

Abstract:
DNA computation is an emerging field that enables the assembly of complex circuits based on defined DNA logic gates. DNA-based logic gates have previously been operated through purely chemical means, controlling logic operations through DNA strands or other biomolecules. Although gates can operate through this manner, it limits temporal and

spatial control of DNA-based logic operations. A photochemically controlled AND gate was developed through the incorporation of caged thymidine nucleotides into a DNA-based logic gate. By using light as the logic inputs, both spatial control and temporal control were achieved. In addition, design rules for light-regulated DNA logic gates were derived. A step-response, which can be found in a controller, was demonstrated. Photochemical inputs close the gap between DNA computation and silicon-based electrical circuitry, since light waves can be directly converted into electrical output signals and vice versa. This connection is important for the further development of an interface between DNA logic gates and electronic devices, enabling the connection of biological systems with electrical circuits.

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