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Tiny self-powered DNA computer unveiled
Tuesday, 25 February 2003

A new design for an extraordinarily tiny biochemical computer made of - and fuelled by - DNA has been announced by Israeli scientists.

A team led by doctoral student Yaakov Benenson of the Weizmann Institute of Science in Rehovot has discovered that a single DNA molecule can yield all the energy needed to run a computation, according to report in today's issue of the *Proceedings of the National Academy of Science*.

The machine is so small that a tiny droplet could hold up to three trillion of these DNA computers, in total performing 66 billion operations a second, the journal reports. The Weizmann laboratory where the discovery was made is led by Professor Ehud Shapiro, who made headlines in 2001 with the publication of an earlier patented design for DNA computers.

It was the first programmable autonomous computing machine in which the input, output, software and hardware were all made of DNA molecules. It can perform a billion mathematical operations a second with 99.8% accuracy, the team said.

Most importantly, the new design incorporates a previously unknown biochemical process that generates enough heat energy to power the device, meaning in principle that a DNA computer can work without an external energy source.

Conventional electronic computers process information - as electrical impulses - through circuits etched onto silicon chips, but the technology is approaching the physical limits of miniaturisation. Technologists expect that sometime between 2010 and 2015, the long march of Moore's Law - which states that computing power doubles every 18 months or so - will come to a sudden halt.

Biochemical computing offers the promise of much greater information

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Biochemical computing offers the promise of much greater information processing and storage power in a much smaller package, by adapting the methods used in nature by the biomolecular 'machines' within a living cell. It has been estimated that a gram of dried DNA - the double helix molecule that holds the complete genetic blueprint of a living creature - can hold as much information as a trillion compact discs.

DNA computers represent information as patterns of molecules arranged along a strand of DNA, and use enzymes to perform chemical reactions that predictably change or copy those patterns. Many designs have been proposed, but all have relied for fuel on an energetic molecule called ATP (adenosine triphosphate), a molecule used by plants to convert chlorophyll into energy.

The new computer design uses naturally occurring enzymes as the 'hardware'. Each computational step requires two complementary DNA molecules - one that performs an input and another that performs a 'software' role.

These molecules spontaneously bond together, then the software molecule directs an enzyme to cut a piece of the input molecule. The enzyme then breaks two bonds in the DNA double helix to release as heat the energy stored in these bonds.


This process generates enough power to complete the computations, with a DNA molecule performing the output role.

The nascent field of DNA computing is based on a growing understanding of the molecular machinery of life, and offers fresh insights into how living systems have themselves evolved "an efficient information processing device" - the cell, the authors said.

Although the potential utility of DNA computers has been questioned by some scientists, Shapiro has said he believes it eventually will be possible to place them inside the human body to sense, identify and even correct malfunctions by making and releasing appropriate drugs.

Bob Beale - ABC Science Online

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