Early life could have relied on arsenic DNA

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26 April 2008
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A DEADLY poison, arsenic is best known for snuffing out life. But could it have played a key role in the origins of life on Earth?

Felisa Wolfe-Simon of Harvard University thinks so because the toxin behaves so similarly to phosphorus, an essential ingredient in nearly all living things. Much more arsenic would have been available in Earth's primordial oceans than phosphorus. And while microbial activity was necessary later to unlock phosphorus from rocks, arsenic could have dissolved in water from hydrothermal vents.

Phosphorus binds to four oxygen atoms to form a negatively charged phosphate ion that is used to build the backbone of DNA's double helix. Phosphate is also key in adenosine triphosphate (ATP), the "universal energy currency" that supplies energy to most life on Earth.

Wolfe-Simon and Paul Davies of Arizona State University in Tempe think arsenic could do the same jobs. Just as phosphorus forms phosphate ions, so arsenic readily forms arsenate ions. Arsenate isn't suitable for life today, because it tends to latch onto adenosine diphosphate molecules, blocking the production of ATP. However, without much phosphorus available, the first life might have evolved to make use of the next best thing, Wolfe-Simon says.

"If you put arsenic in a test tube with adenosine, you immediately get lots of adenosine monoarsenate," which is structurally similar to adenine, the "A" letter in DNA's code of A, C, G and T, says Wolfe-Simon.

If early life did use arsenate, single-celled organisms with arsenate-based DNA may still be around today wherever phosphorus is scarce.

The only stumbling block to the idea is that arsenic-based DNA tends to break down quickly. "You don't want to build your DNA out of a compound with a half-life in the order of a couple of minutes," points out Steve Benner of the Foundation For Applied Molecular Evolution in Gainesville, Florida.

However, he points out that it could be a good thing in extreme cold, where chemical reactions move very slowly. Microbes living in Antarctica or on Saturn's moon Titan might find phosphate-based DNA too sluggish to work with and have evolved to take advantage of faster-reacting arsenate instead.

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Printed on Wed Apr 23 19:00:12 BST 2008