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Heat helped hasten life's beginnings

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There has been controversy about whether life originated in a hot or cold environment, and about whether enough time has elapsed for life to have evolved to its present complexity.

But new research at the University of North Carolina at Chapel Hill investigating the effect of temperature on extremely slow chemical reactions suggests that the time required for evolution on a warm earth is shorter than critics might expect.

The findings are published in the Dec. 1, 2010, online early edition of the Proceedings of the National Academy of Sciences.

Enzymes, proteins that jump-start chemical reactions, are essential to life within cells of the human body and throughout nature. These molecules have gradually evolved to become more sophisticated and specific, said lead investigator Richard Wolfenden, PhD, Alumni Distinguished Professor of biochemistry and biophysics at UNC School of Medicine.

To appreciate how powerful modern enzymes are, and the process of how they evolved, scientists need to know how quickly reactions occur in their absence.

Wolfenden's group measured the speed of chemical reactions, estimating that some of them take more than 2 billion years without an enzyme.

In the process of measuring slow reaction rates, "it gradually dawned on us that the slowest reactions are also the most temperature-dependent," Wolfenden said.

In general, the amount of influence temperature has on reaction speeds varies drastically, the group found. In one slow reaction, for instance, raising the temperature from 25 to 100 degrees Celsius increases the rate 10 million fold. "That is a shocker," Wolfenden said. "That's what's going to surprise people most, as it did me."

That is surprising, Wolfenden said, because a textbook rule in chemistry — for more than a century —has been that the influence of temperature is modest. In particular, a doubling in reaction rate occurs when the temperature rises 10 degree Celsius, according to experiments done in 1866.

High temperatures were probably a crucial influence on reaction rates when life began forming in hot springs and submarine vents, Wolfenden said. Later, the cooling of the earth provided selective pressure for primitive enzymes to evolve and become more sophisticated, the Wolfenden's group hypothesizes.

Using two different reaction catalysts — which are not protein enzymes but that may have resembled early precursors to enzymes — the group put the hypothesis to the test. The catalyzed reactions are indeed far less sensitive to temperature, compared with reactions that are accelerated by catalysts. The results are consistent with our hypothesis, Wolfenden said.

Wolfenden's group plans to test the hypothesis using other catalysts. In the meantime, these findings are likely to influence how scientists think of the first primitive forms of life on earth, and may affect how researchers design and enhance the power of artificial catalysts, he added.

Provided by University of North Carolina School of Medicine