Scientists rebuild ancient proteins to reveal primordial Earth's temperature

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Using the genetic equivalent of an ancient thermometer, a team of scientists has determined that the Earth endured a massive cooling period between 500 million and 3.5 billion years ago.

Reporting today (Feb. 7) in the journal Nature, researchers from the University of Florida, the Foundation for Applied Molecular Evolution and the biotechnology company DNA2.0 describe how they reconstructed proteins from ancient bacteria to measure the Earth's temperature over the ages.

"By studying proteins encoded by these primordial genes, we are able to infer information about the environmental conditions of the early Earth," said Eric Gaucher, Ph.D., president of scientific research at the Foundation for Applied Molecular Evolution in Gainesville and the study's lead scientist. "Genes evolve to adapt to the environmental conditions in which an organism lives. Resurrecting these since long-extinct genes gives us the opportunity to analyze and dissect the ancient surroundings that have been recorded in the gene sequence. The genes essentially behave as dynamic fossils."

The team wanted to measure Earth's temperature billions of years ago to learn more about life on Earth during the Precambrian period. But instead of taking the traditional route — analyzing rock formations or measuring isotopes in fossils — they opted to do what they knew best: protein reconstruction.

“We’ve analyzed the temperature stability of proteins inside organisms that were around during those times,” said Omjoy Ganesh, Ph.D., a structural biologist in the UF College of Medicine’s department of biochemistry and molecular biology. “The ancient oceans were warmer. For ocean organisms living during that time to survive, the proteins within them had to be stable at high temperatures.”

After scanning multiple databases, the scientists struck gold with a protein called elongation factor, which helps bacteria string together amino acids to form other proteins. Each bacterial species has a slightly different form of the protein: Bacteria that live in warmer environments have resilient elongation factors, which can withstand high temperatures without melting. The opposite is true for bacteria that live in cold environments.

Armed with information about when bacterial species evolved, the scientists rebuilt 31 elongation factors from 16 ancient species. By comparing the heat sensitivity of the reconstructed proteins, they were able to discern how Earth’s temperature changed over the ages.

“Although the concept of ancestral gene resurrection was proposed more than 40 years ago, the development of efficient gene synthesis has only recently enabled the synthesis of ancestral genes,” said Sridhar Govindarajan, Ph.D., co-author of the paper and vice president of informatics at DNA2.0, a California-based company that constructed the genes. “Gene synthesis allows for a direct route from a calculated gene sequence to a protein that can be tested for function in the laboratory.”

Almost all bacteria are related if you go back far enough, the scientists said. Even organisms that like extreme heat are related to organisms that are very sensitive to temperature change. The key is determining when, during Earth’s history, each type of bacteria came into existence.

“Remarkably, our results are nearly identical to geologic studies that estimate the temperature trend for the ancient ocean over the same time period. The convergence of results from biology and geology show that Earth’s environment has continuously been changing since life began, and life has adapted appropriately to survive,” Gaucher said.

Source: University of Florida