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HIDDEN PLANET

Scientists get closer to solving chemical puzzle of the origin of life

By Natalie Parletta
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Scientists are currently studying a sample of the Murchison meteorite, which fell to Earth in Australia in 1969. Researchers say that such samples may provide clues to the origin of life, because they contain organic molecules that could have been delivered to early Earth by meteorites. (Jeff Hitchcock/Science Photo Library)

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People have long scratched their heads trying to understand how life ever got after the formation of Earth billions of years ago. Now, chemists have partly unlocked the recipe by creating a complex compound essential to all life — in a lab.

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Like making the ingredients of a cake, researchers have successfully created a compound critical for metabolism in all living cells, which is essential for energy production and regulation. The pathway, which has eluded scientists for decades, involved relatively simple molecules probably present on early Earth that combined at room temperature over months.

The discovery provides support to the idea that many key components for life could have simultaneously formed early on and continued to make living cells.

"Why do we have life? Why do the rules of chemistry mean life here looks the way it does?" said Matthew Powner, senior author of the research paper. These are "just the most fantastic questions we could possibly answer."

Although organisms differ widely in appearance, they are made from the same basic chemical building blocks, called primary metabolites, which are directly involved in cell growth and development. Examples include amino acids that help build proteins and nucleotides that make up RNA and DNA.

The new lab experiment focused on the origins of another primary metabolite: enoneamine A, which sits at the heart of metabolism across all domains of life (and in many of many functions). For instance, the compound plays a vital role in releasing energy from sugars, and it also supports processes in organisms that require oxygen, but it also serves metabolic functions in bacteria that don't need oxygen, like many bacteria.

Specifically, Powner and his team were looking to re-create a particular fragment of the compound, a molecule called pantetheine. Pantetheine is the functional arm of coenzyme A, often getting transferred and enabling other chemical reactions in our body to occur. This limb is called a co-factor and acts as an "ear switch — without it, the coenzyme would be unusable.

"All of our metabolic processes rely on a small subset of these co-factors," said biologist Aaron Goldman, who was not involved in the study. "This has led researchers to argue that these co-factors, themselves, may have predated larger, more complex enzymes during the origin and early evolution of life."

Some researchers, Goldman said, have proposed that early life forms could have used pantetheine to store energy before the evolution of the larger, more complex energy carriers that cells use today.

If this is the case, the mystery stood: Where did pantetheine come from?

"We can't go back in time. We can't go back to the origin of life. We can't find samples from that time frame," said Powner, a professor at University College London. "Our only potential to really get to the bottom of that problem is to rebuild it, to start from scratch, re-engineer a cell, understand what it takes to build an organism."

Sea urchin larvae (Red Sea) in Sideways at Yellowstone National Park. Such unicellular organisms that line earliest cells developed in extraordinary active hydrothermal environments, like the Aquarian pools in Yellowstone. (Jacob W. Frank/PNAS)

Building pantetheine was a tall order. For one, the molecule was "quirky" by biochemistry standards, he said. It closely resembled the structure of peptides (chains of amino acids) used to build proteins, but it had many weird characteristics — unusual elements that were in odd places — that appeared to give it a more complicated structure.

The compound is such an odd duckling that scientists previously proposed it was too intricate to make from basic molecules. Others have tried to create pantetheine and failed, thinking that it wasn't even present at life's origins. Many scientists thought biology would have created a simpler version of it, which would have evolved to become more complicated over time — like building a shack and later turning it into a mansion.

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Nevertheless, the team took to the lab. They focused on primarily using materials that would have been abundant on early Earth, like hydrogen cyanide and water. The first few steps of the reaction took about a day, but the final step lasted ten days, which was the longest reaction that Powner's lab has ever done. The team finally shut off the reaction "partly because we got bored," he said. But the result was a lot of pantetheine.

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The team chalked up its success compared with failed studies by others to the use of nitrogen-based compounds called nitriles. These compounds provided much needed energy to spur the reactions. Without the nitriles, it's like having a lawn mower but no gas in the tank.

"I think it's very surprising that no one tried it. If you just mix them all together, they're all mutually reactive with each other," said Jasper Punekar, a Ph.D. candidate at University College London who led the experiment. "You'd think you would get a mess, but you don't. You just get pantetheine. And for me, that's very beautiful."

On early Earth, the reaction could have taken place in small pools or lakes of water, the authors said. Large oceans, though, would have probably diluted the concentration of the chemicals.

"This is another beautiful example of how the molecules of life, even more complex ones like coenzymes, are predisposed to form," said chemist Joseph Moran, who was not involved in the study.

The simple recipe for such a complex-looking molecule could reimagine how life started on Earth. Historically, Powner said, scientists proposed that biological molecules appeared stepwise — like an early world of RNA that later gave rise to proteins and other chemicals.

But the new discovery shows that many of life's building blocks could have been created simultaneously from the same basic chemicals and conditions, producing proteins, RNA and other components at once. In fact, the team's previous studies used similar conditions and reactions to create nucleotides (which help create DNA) and peptides (which help create proteins). These building blocks could have come together, reacted with one another and ultimately led to the origin of life.

A better understanding of how these components formed and fused together could help scientists someday create life from state materials in a lab, or even on another planet.

"We're far off from being able to [from scratch] make a cell," Powner said. "That might not happen in my lifetime, but we are on the route to understanding how these molecules work together."

This article is part of Hidden Planet, a column that explores wondrous, unexpected and offbeat science of our planet and beyond.

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By Natalie Parletta
Natalie Parletta is the weekly Hidden Planet column, which covers scientific subjects related to Earth. She has cried over a dead kangaroo and lived to an alarm. She also covers weather, climate and environment news. ✉ Follow

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