Meteorites: Tool kits for creating life on Earth

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Meteorites hold a record of the chemicals that existed in the early Solar System and that may have been a crucial source of the organic compounds that gave rise to life on Earth. Since the 1960s, scientists have been trying to find proof that nucleobases, the building blocks of our genetic material, came to Earth on meteorites. New research, published next week in the *Proceedings of the National Academy of Sciences,* indicates that certain nucleobases do reach the Earth from extraterrestrial sources, by way of certain meteorites, and in greater diversity and quantity than previously thought.

Extensive research has shown that amino acids, which string together to form proteins, exist in space and have arrived on our planet piggybacked on a type of organic-rich meteorite called carbonaceous chondrites. But it has been difficult to similarly prove that the nucleobases found on meteorite samples are not due to contamination from sources on Earth.

The research team, which included Jim Cleaves of Carnegie's Geophysical Laboratory, used advanced spectroscopy techniques to purify and analyze samples from 11 different carbonaceous chondrites and one ureilite, a very rare type of meteorite with a different type of chemical composition. This was the first time all but two of these meteorites had been examined for nucleobases.

Two of the carbonaceous chondrites contained a diverse array of nucleobases and compounds that are structurally similar, so-called nucleobase analogs. Especially telling was the fact that three of these

nucleobase analogs are very rare in terrestrial biology. What's more, significant concentrations of these nucleobases were not found in soil and ice samples from the areas near where the meteorites were collected.

"Finding nucleobase compounds not typically found in Earth's biochemistry strongly supports an extraterrestrial origin," Cleaves said.

The team tested their conclusion with experiments to reproduce nucleobases and analogs using chemical reactions of ammonia and cyanide, which are common in space. Their lab-synthesized nucleobases were very similar to those found in the carbonaceous chondrites, although the relative abundances were different. This could be due to chemical and thermal processing that the meteorite-origin nucleobases underwent while traveling through space.

These results have far-reaching implications. The earliest forms of life on Earth may have been assembled from materials delivered to Earth by meteorites.

"This shows us that meteorites may have been molecular tool kits, which provided the essential building blocks for life on Earth," Cleaves said.

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