Did the seeds of life come from space?

During the first billion or so years of its existence, the earth was barren of life. How life sprang from this barrenness is one of the most profound questions for scientific investigation.

In 1903, the Swedish chemist Svante Arrhenius proposed that meteorites could have brought spores from other planets to the earth. This theory is now considered improbable; no spores have been found on meteorites, and it is unlikely that a spore could have survived the trip through space. Scientific attention has consequently focused on the possibility that life arose spontaneously on earth. In fact, when gases presumed to have been present in the earth's primitive atmosphere are subjected to electrical discharge or radiation, amino acids, sugars and other compounds may be produced. Some scientists believe that proteins, carbohydrates and lipids, the three major constituents of terrestrial life, could have synthesized from compounds produced in this way.

Two recent discoveries, however, have revitalized the idea that the seeds of life may have been brought to earth by meteorites. The first was the identification in 1970 of amino acids, precursors of proteins, in the Murchison meteorite (SN: 3/20/71, p. 195). Now, Irving A. Breger, Peter Zubovic and John C. Chandler of the U. S. Geological Survey and Roy S. Clarke Jr. of the U. S. National Museum of Natural History have found a precursor of a second basic life constituent in another meteorite. They report in the March 24 NATURE that the Allende meteorite, which fell on northern Mexico on Feb. 8, 1969, contains formaldehyde, a precursor of carbohydrates.

There are several ways the formaldehyde could have gotten into the meteorite. It could represent part of the initial agglomeration of the meteorite. Formaldehyde is known to exist in interstellar space and the meteorite could have absorbed the compound in its travels, or the formaldehyde could have synthesized on the meteorite from an appropriate mixture of adsorbed gases. The researchers believe it unlikely that the substance was absorbed by the meteorite during its fall through the earth's atmosphere, or that the meteorite was hot enough on landing to produce the formaldehyde from substances on the ground.

On the basis of the amounts of formaldehyde and amino acid found in the Allende and Murchison meteorites, combined with the daily influx of meteorites, the researchers estimate that meteorites could have brought 0.5×10^{14} grams of formaldehyde and 3×10^{14} grams of amino acids to earth during the time between the planet's origin (about 4.5 billion years ago) to the approximate time when life is thought to have begun. (Dorothy Oehler and J. William Schopf of the University of California at Los Angeles and Keith Kvenvolden of NASA have recently found evidence pinpointing the beginning of life on earth at 3.3 billion years ago.)

"We may now conclude that certain compounds that exist in space or may be formed on meteoritic surfaces or within meteorites can be distributed by those meteorites and, on landing on a friendly body, may well serve as the precursors of life on that body." □

Assumptions Relevant to Amounts of Formaldehyde and Amino Acids Reaching Earth Daily by Meteorite

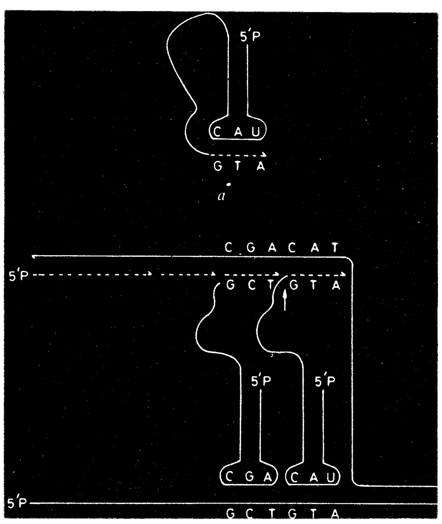
Daily influx of meteorites on earth	~ 100 metric tons
Daily fall of carbonaceous chondrites (50 percent of total)	50 metric tons
Content of formaldehyde in carbonaceous chondrites (assuming all such chondrites have the same content)	3 ppm
Content of amino acids in carbonaceous chondrites (assuming all such chondrites have the same content)	15 ppm
Time between origin of the earth and origin of life on earth (4.5×10^9 yr. to 3.5×10^9 yr.)	10^9 yr.

Breger, et al

Model for DNA evolution: Chicken-and-egg problem

If ever a hypothesis was accepted as sacred truth by biochemists during the past 15 years, it is the translation of DNA, the genetic material of the cell, into RNA and then into protein. However shadowy these cellular operations, they are nevertheless being borne out experimentally in laboratories around the world.

At least one large question remains to be answered, though. How could DNA have evolved in the first place without its modern production machinery—protein enzymes (DNA polymerases and DNA ligases)? In other words, how could eggs lay a chicken? Nicholas Brewin, a biochemist at Cambridge University, proposes an explanation. It is that the primitive DNA production gear was not protein (polypeptide) enzymes, but polynucleotide enzymes. In other words: enzymes made from the same basic genetic material as DNA itself—polynucleotides.



Nature New Biology

Adaptor (a), growing DNA (b).

Brewin has set up a model for his theory. It consists essentially of adaptor polynucleotides synthesizing DNA trinucleotides, the triplet building blocks of the DNA molecule. There are 64 adaptors, corresponding to all possible triplet nucleotide sequences that can go into a DNA molecule. Each trinucleotide is then transferred onto a growing DNA duplex, while its adaptor interacts simultaneously with the complementary nucleotide on one of the parental chains. Replication proceeds by the sequential addition of triplets on both strands of the DNA molecule, short sections of the antiparallel parental strand being replicated alternately. The synthesis of a new polynucleotide is specified by the identical parental strand as much as by the complementary strand: a 5′-3′ strand directs the synthesis of another 5′-3′ strand.

The British biochemist sees several evolutionary advantages to his model. First, polynucleotide enzymes would probably have eased separation of the two parallel, growing DNA strands that comprise the DNA molecule. They undoubtedly would have also enhanced the accuracy of nucleotide insertion into the molecule. There is no reason, Brewin speculates, why such a primitive replicating system might not have been modified in the course of evolution into modern polypeptide (protein) enzyme machinery.

The model can be tested experimentally, Brewin reports in the March 29 NATURE NEW BIOLOGY, but more experiments are needed to confirm it. □