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The Washington Post Outlook

SUNDAY, FEBRUARY 5, 1967

Puzzling Over the Dawn of Life

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Science and Man

"EXTRATERRESTRIAL LIFE" is an unusual anthology published recently by the National Academy of Sciences. A companion to a study report of the Space Science Board, "Biology and the Exploration of Mars," the anthology is a collection of papers previously scattered in the scientific literature.

It has three main themes: critical speculation on the uniqueness of life, whether as an earthly or a universal phenomenon; laboratory experiments on the formation of chemical constituents of cells under conditions supposedly like the primitive earth; and the pictures and other measurements made by Mariner IV the night of July 14, 1965, when it approached within 6500 miles of the planet Mars.

Hardly any scientific issue is more controversial. Mars, the nearest plausible target for our search for unearthly life, is always at least 40,000,000 miles away, and we simply do not know very much about it. In fact, because of their self-generated light and heat, we can tell more of the chemical details of distant stars and galaxies than we can of Mars.

Like the moon, Mars is only visible because of the light it reflects from the sun. Until Mariner IV, even the best telescopes gave us a surface definition of Mars no better than we had of the moon with unaided eyes before Galileo trained his telescope on it.

The intricate problem of investigating life needs to be sorted out into digestible fragments. Starting at the beginning involves the ultimate origin of organic molecules and the chemical compounds of carbon and hydrogen atoms—many also containing nitrogen and oxygen.

During the early development of chemical science, these hydrogen-carbon compounds so sharply distinguished life that it was held that only living organisms could produce them. Hence this branch of science is still called "organic chemistry." In 1828, however, Wohler founded modern organic chemistry by proving that urea, a simple, well-known organic molecule crystallized from urine, could be made in the laboratory by heating the inorganic salt, ammonium carbonate.

A century later, J. B. S. Haldane in Britain and A. I. Oparin in the U.S.S.R. focussed attention on the more elaborate reaction systems that may have prevailed in the atmosphere of the primitive earth.

Then, Harold C. Urey and Stanley L. Miller in this country demonstrated in the laboratory that sparking primitive gas mixture—the simplest compounds of hydrogen like CH4 (methane), NH3 (ammonia) and H2O (water) —would generate a wide variety of organic molecules, for example, an amino acid, CH3.CHNH2.CO.OH, alanine.

IN HINDSIGHT, it is no surprise that more complex molecules should have been formed. What is startling is how many of these resemble the amino acids and other constituents of present-day cells.

From amino acid molecules to cells is still a very long way, and we still face the mystery of the evolution of the organizing catalysts to assemble these building blocks into meaningful structures.

What we usually invoke here is time, measured in billions of years, with innumerable cycles of molecular reaction and disruption. We also think that inanimate substances, surfaces of clays and other minerals, can help influence the growth of interesting organic molecules, particularly when these surfaces are already coated with earlier products. This is now a realm of plausibility and speculation rather than laboratory experience.

This model of the dawn of life calls for a rich moist atmosphere—and pools, if not oceans, of water in which the organic molecules could be dissolved and react with one another. The building stones are the atoms of H, C, N and O, which are now so thoroughly captured by plants and animals that we easily forget they must have been present on earth in quite different form before life began.

Carbon plus nitrogen account for almost half the condensed matter of the cosmos, which is mainly free hydrogen. The earth's crust is dominated by silica, like a once-full test tube left with only a trace of interesting ingredients that were mainly distilled out into space by solar heat. In the beginning, however, every planet was once much richer in these life-building elements. A heavy, cold planet like Jupiter remains much closer to its original composition, and may therefore be of the most ultimate interest for these explorations.

Mariner IV's first report on Mars showed many huge craters that are relics of ancient meteorite impacts. The survival of these relics tells of a weather-free history for perhaps a half-billion years; some argue that Mars could never have had an ocean.

For the present, the lack of recent free water on Mars draws attention to the basic issues of the origin of organic molecules. It puts a greater burden on a suggestion made at various times by astronomer Fred Hoyle, by myself, and most recently by Sir Robert Robinson. This theory points to the original aggregation of cosmic gas into particles, planets and stars as the ultimate source of organic molecules. Earth or Mars would have begun with the formation of larger molecules containing H, C, N and O. The primitive beginnings of life would hang on the organization of the universe, not on the local conditions of a given planet.

For solid answers to these speculations we need to analyze extensive samples of a primitive body like the moon, and compare them with what we know of Earth and will eventually learn of Mars and the other planets.

Mariner IV and Surveyor were the first steps. NASA's budget now includes just the barest essentials for a follow-through of planetary science during the next decade.