Life: Origin and Evolution

The origin and evolution of life continues to receive considerable attention, partly because of the synthesis of biologically significant molecules (amino acids, purines, and so forth) under conditions presumed to have been prevalent on the primitive earth, and partly because of the possibility of determining the presence or absence of life elsewhere in our solar system. As a sequel to an international meeting in Moscow, in 1957, on the origin of life, a meeting was held 27–30 October 1963 in Wakulla Springs, Florida, on the origin of prebiological systems.

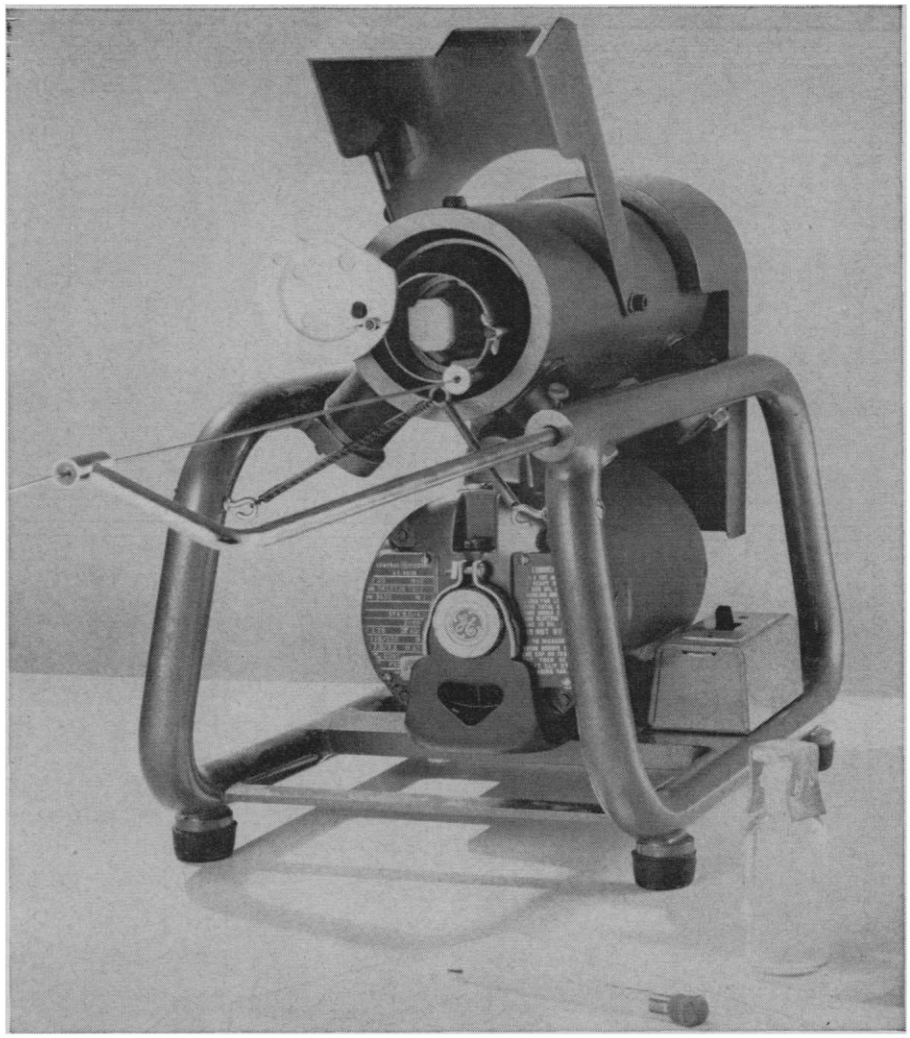
Two pioneer workers in this field, J. B. S. Haldane (Genetics and Biometry Laboratory, Orissa, India) and A. I. Oparin (A. N. Bakh Institute of Biochemistry, Moscow, U.S.S.R.), met for the first time, bringing their knowledge and insight to the participants, who covered topics from small molecules through macromolecules to precellular organization.

In the opening session, on perspectives, Haldane discussed the data needed for a blueprint of the first organism and questioned whether DNA was necessary. Could not a protein have had information-transfer capability? He and others expressed the opinion that the best way to gain insight into the origin of life was through the synthesis of a primitive cell and through study of components of modern cells. M. S. Blois (Stanford University) suggested random polymers as a matrix for chemical evolution, illustrating his comments with the fact that melanin-like material is produced by the action of ultraviolet light on solutions of tyrosine or phenylalanine. The folly of probability was discussed by P. T. Mora (National Institutes of Health) who felt that an understanding of the transition from chemical to life was impossible through modern physics and chemistry. J. D. Bernal (University of London) was absent because of illness and his paper was read by Haldane. Bernal postulated the possibility of organic synthesis in the primeval dust cloud before the earth was formed.

The climax of the first day's meeting was the evening lecture by A. I. Oparin. In a historical survey of the scientific approach to the origin of life, he outlined the growth of the idea from Darwin's work to the active experimentation of today. (Interpreting for Oparin was T. Dobzhansky, Rockefeller Institute.)

The second day was devoted entirely to small molecules. J. R. Vallentyne (Cornell University) discussed the relationship between the geological and thermal stability of amino acids. Aspartic acid, for example, is thermally labile but geologically stable. In the other amino acids, the geological and thermal stability are the same. The asymmetric hydrogenation of some carbonyl compounds was described (S. Akabori, Osaka University) and the mechanisms of the synthesis of purines and pyrimidines from nonliving starting materials were outlined (J. Oro, University of Houston).

K. Harada and S. W. Fox (Florida State University) noted that 14 of the common amino acids can be synthesized thermally by passing a mixture of methane, ammonia, and water through a heated silica tube at a temperature of 900° to 1000°C. Highly significant in this synthesis is the fact that only naturally occurring amino acids are formed. Electric discharges and ionizing radiation on simple mixtures have been known to yield amino acids, some of which are not found in nature. K. Grossenbacher and C. A. Knight (University of California, Berkeley) described the effect of electric discharges on a mixture of methane, ammonia, hydrogen, and water. In a typical experiment only 0.1 percent of the methane was left after 26 days of sparking. The formation of HCN appeared to be autocatalytic. Of great interest was the observation that some spherules, ranging from 50 to 800 Å in diameter and consisting partly of organic material, were produced. C. Sagan (Harvard University and the Smithsonian Institution) outlined the astrophysical evidence for the role of ultraviolet light in the possible synthesis of nucleoside phosphates in primitive times. It seems likely that the early reducing atmosphere was at least slightly transparent between 2400 and 2900 Å. Ultraviolet light penetrating this partial window must have been absorbed by purines and pyrimidines in the early oceans. The primordial organic synthesis of nucleic acid constituents was described by C. A. Ponnamperuma (NASA Ames Research Center). With methane, ammonia, and water, and the energy sources thought to have been available in primitive times, the purines (adenine and guanine), the sugars (ribose and deoxyribose), the nucleoside (adenosine), and the nucleotides (AMP, ADP, and ATP) can be synthesized step by step. A. Szutka



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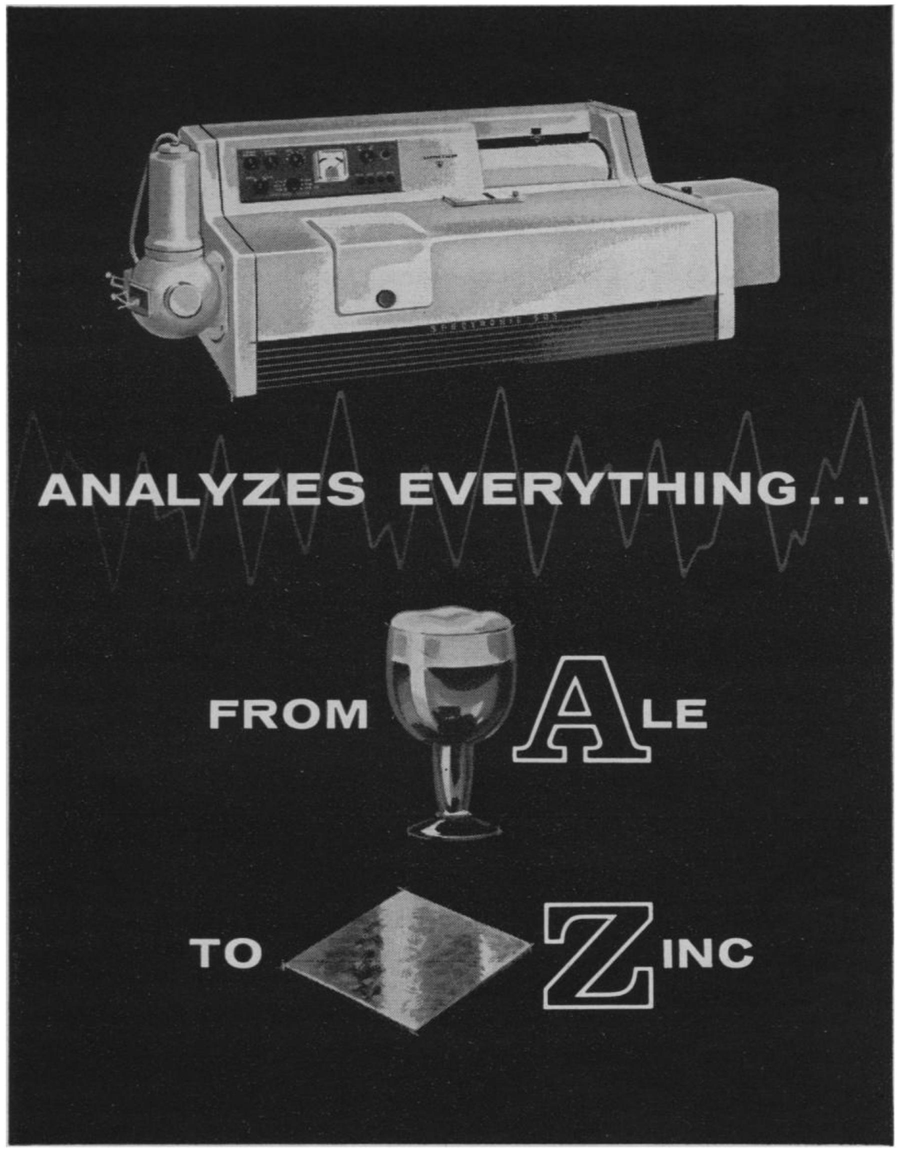
(University of Detroit) showed how porphin-like substances could have been formed by the γ-irradiation of pyrroles, thereby demonstrating that the basic structures required for photosynthesis may have been already available in the primordial "soup."

The third day's discussions centered on macromolecules. That study of the mechanism of replication may be overemphasized today as far as the origin of life is concerned was suggested by F. Lipmann (Rockefeller Institute), who feels that it may be a mistake to concentrate too much study on the nucleic acids and that the origin of the vitamins may be an important point being overlooked. G. Schramm (Max-Planck Institut für Virusforschung, Tubingen, Germany) discussed the synthesis of nucleosides and polynucleotides from metaphosphate esters. At this point Dobzhansky took great exception to the use of the term "natural selection." He felt that natural selection should be used in a Darwinian sense only and that "prebiotic" natural selection is a contradictory expression. A definition of terms was discussed, but without clear resolution. A. Schwartz (Florida State University) discussed thermal polymerization of nucleotides and amino acids in the presence of polyphosphoric acid; this substance permits decreasing the temperature for polymerization to as low as 65°C.

Oparin, who has done pioneering research on coacervate droplets and their usefulness as a precellular model, described many of the chemical reactions possible with coacervates. Harada next discussed the thermal polymerization of proteinoid from 18 naturally occurring amino acids and noted the more significant properties of this proteinoid, including the production of microspheres by boiling the proteinoid in water and allowing it to cool.

In discussing some aspects of the chemistry and morphology of microspheres, R. S. Young (NASA Ames Research Center) suggested that a membrane was necessary to provide an internal environment suitable for replication and the origin of life, and that the microsphere may be a more stable model than the coacervate droplet. Some significant experiments with microspheres, including apparent ATP-splitting activity in microspheres containing zinc, have bene conducted by Fox, whose results have indicated that such thermal syntheses may have taken place on the primitive earth in areas of volcanic activity.



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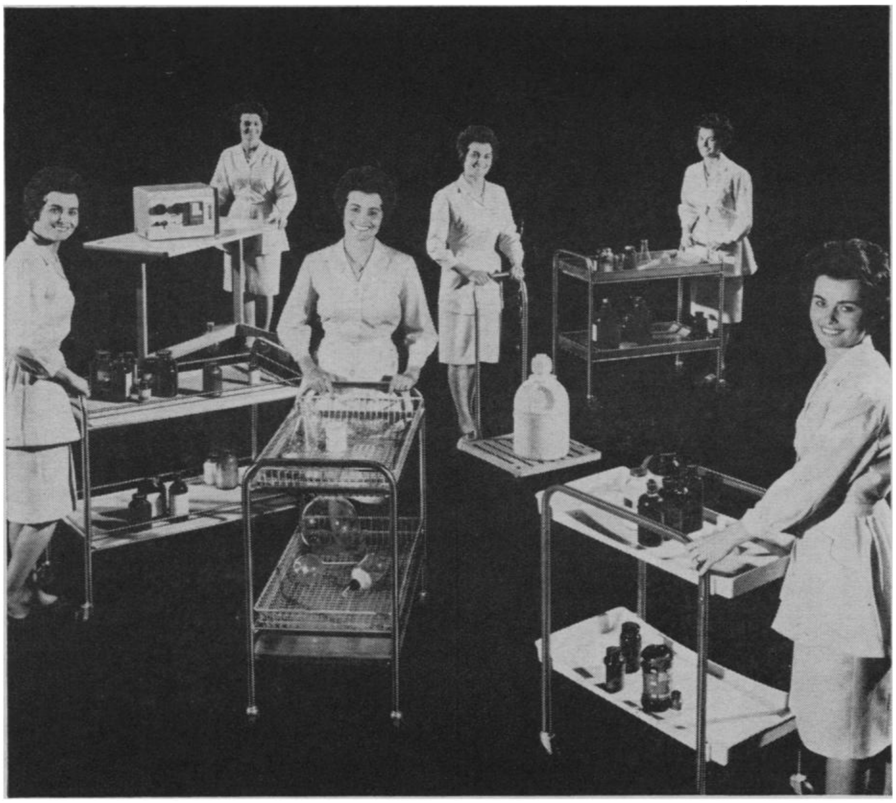

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The need for definition of terms such as "Darwinian" and "natural selection" and "chemical" and "biological evolution" was pointed up by H. H. Pattee (Stanford University) who suggested that evolution according to the Lamarck concept was possible at the molecular level and that evolution cannot occur in the primitive molecule according to the Darwinian concept.

T. H. Jukes (University of California, Berkeley) noted that understanding and interpreting the DNA code may make an important contribution to an understanding of evolution.

H. Gaffron (Florida State) was concerned with the role of light in evolution. He suggested that the early photosynthetic mechanism may have produced free oxygen. The wavelengths of light used may have been quite different from those used today.

The meeting was sponsored by the Institute for Space Biosciences of Florida State University and the National Aeronautics and Space Administration. Facilities and arrangements for the meeting were provided by S. W. Fox and his associates of Florida State University. The proceedings were opened with an official welcome from the president of Florida State University, G. Blackwell, and F. Quimby, head of the Exobiology Program of NASA. The meeting included 31 participants from the United States, England, Germany, Russia, Japan, and India. Several suggestions were made that such meetings should probably be held with greater frequency, and that this one was a most profitable experience.

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Photosynthesis

Photosynthetic mechanisms of green plants was the subject of a symposium held at Airlie House in Warrenton, Virginia, 14–18 October 1963. The major theme of the meeting was the determination of the sequence of electron transport steps in chloroplasts, especially as related to two experimentally separable light reactions. The problem was approached by the techniques of difference spectroscopy (B. Kok, K. Witt, J. Olson, W. Bonner, and B. Chance), analysis of fluorescence and delayed light emission (L. Duysens, W. Butler and N. Bishop, J.