COMMENTARY

ISSOL 89 – THE ORIGINS OF LIFE AND DEATH

The presentations at the 1989 ISSOL Meeting in Prague covered the broad sweep of prebiotic reactions, cosmochemistry and early evolution. Since the abstracts from this meeting will be published in a subsequent issue of this Journal I will not attempt to give a report on all aspects of the meeting but will just mention a few areas which were of personal interest.

Concerns regarding the validity of the hydrothermal vent model for the origins of life have been simmering since the proposal was first put forward in 1981 (Corliss *et al.*, 1981). These concerns boiled over in a paper by Miller and Bada (1988) where they claim that the biomolecules which may have been essential for the first life would not be formed but rather broken down in the high temperatures (up to 400 °C) and dilution present in the vents. These conclusions were reiterated by Stanley Miller at the Prague meeting in a paper coauthored by J. L. Bada and N. Friedmann. John Corliss, one of the originators of the hypothesis of the origin of life in vents, reviewed his proposal too (Corliss *et al.*, 1981). Corliss' presentation was more conservative than his original paper in that he omitted most of the chemical detail. He stated that life probably originated in vents but was leaving it to others to provide specific reaction pathways. He did present the "feeling" that liposomes were formed which encapsulated the essential biomolecules but he did not propose how these complex hydrophilic structures were formed from simple organic and inorganic compounds in the vent environment.

The results of one of the first attempts to perform prebiotic synthesis under the high pressures and temperatures present in hydrothermal vents was presented by Kensei Kobayashi in a project performed with Hiroshi Yanagawa. He reported the formation of amino acids by the reaction of CH_4, NH_4Cl and transition metal ions at pressures of 200 bar and 320 °C. Silicates, formed by the dissolution of the glass tube used in the reactor, resulted in the formation of amino acids as their silyl derivatives. The silicates are essential for either synthesis and/or stabilization since no amino acids are detected when glass tube were not used in the reaction chamber.

More questions are raised by this pioneering study than are answered. Unfortunately no experiments were performed using $^{13}CH_4$ and $^{15}NH_3$ so the specter of biological contamination hangs over the research. In addition, a static reactor was used instead of a flow reactor. A flow reactor would more closely simulate the dynamic conditions, with the associated pressure and temperature gradients, present in vents.

Thermodynamic analysis of the Miller and Bada data (1988) was used by Everett

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Shock in support of the possibility of prebiotic synthesis in vents. He prefixed his presentation with the plea that the audience not worry about reaction pathways and only consider his thermodynamic arguments. I attempted to do so but could not help puzzling over the reaction mechanisms as soon as I saw some of his proposals such as:

$$3CH_3COOH \rightarrow 2CH_3CH_2COOH + O_2.$$

One of the participants the audience correctly noted that favorable thermodynamics is a necessary but insufficient criterion for a reaction to proceed as written. It is unlikely that there will ever be a "final word" on the plausibility of the origins of life in a vent but certainly more data is needed so that it will be possible for all participants to carry out a better informed debate on the topic next time.

The prospect that early life was based on RNA was the stimulus for a number of the presentations in Prague. Perhaps the most novel was one by Gerald Joyce in which he reported on a research project for the laboratory study of the evolution of RNA. He is investigating the amplification, mutation and selection of a piece of catalytic RNA (ribozyme) as his simplified model of a primitive 'RNA world'. Molecular biological techniques are used for amplification and mutation while selection is based on the ability of the RNA to catalyze the transesterification reaction characteristic of the ribozyme from the protozoan *Tetrahymena*. Preliminary results suggest it will be possible to perform this evolutionary study but some additional experiments will have to be carried out before Joyce can don the white mantle of the 'God' of his 'RNA world' and set the wheels of evolution in motion.

Joyce's study takes on further significance in the light of the report that an RNA has been engineered which joins oligonucleotide substrates which are hydrogen bonded to a template which is not covalently bonded to a ribozyme (Doudna and Szostak, 1989). These workers have devised coupling conditions which are general for any base pair preceding the juncture of the two RNA oligomers and are not restricted to a terminal CU_{OH}. Thus it appears likely that it will be possible to study evolution in RNA worlds that are much more complex than the one proposed by Joyce.

Since it is well known that death (and taxes) is coupled to life it is inevitable that the prospects of the extinction of early life be an important part of deliberations on the origins of life. The proposed extinction of many forms of life, including the dinosaurs, by a comet or meteorite raised the question of the extinction of primitive life around 4.5–4 billion years ago at the time of intense bombardment of the Earth's surface. This argument was formulated quantitatively by Maher and Stevenson (1988) where they estimated the impact frequency on the Moon during this time period and assuming a higher impacts frequency on the Earth after correction for the greater gravitational attraction of the Earth relative to the Moon. Guy Foglemann presented a variation on this approach where he and Verne Oberbeck calculated that the time interval between impacts that were large enough to sterilize the Earth was about 2.5×10^6 years. This calculation suggests that the origin of life was extremely rapid ($<2.5 \times 10^6$ yr) on the geological time scale and took place many times. This conclusion was questioned by several meeting participants who are also working on this question. There is no agreement on the size of the impact sufficient for extinction of life nor is it certain that life in protected environments such as underground caves or in hydrothermal vents would be extinguished by a catastrophic event. At present it is clear that the late bombardment of the early Earth limits the time period for the origins of life but the extent of the limitation is not clear. Research in this area has the potential to provide significant time constraints for the origin of life on Earth and I am looking forward to more detailed data on this topic at the 1992 ISSOL meeting in Barcelona, Spain. A session in which the potential for the catastrophic extinction of taxes is discussed would also be welcome.

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