Dialogue on the onset and early evolution of life

MICHAEL J. RUSSELL[1] AND EVERETT L SHOCK[2]

[1] Scottish Universities Environmental Research Centre, Rankine Avenue, East Kilbride, Glasgow G75 0QF, Scotland; Michaelr@chem.gla.ac.uk

[2] School of Earth & Space Exploration and Department of Chemistry & Biochemistry, Arizona State Unviersity, Tempe, AZ, 85287, USA; eshock@asu.edu

Convection currents in various guises not only pumped materials and chemical energy to emergent and burgeoning life, but also were to convey the early prokaryotes to further nutrients and chemical and photochemical energies. Yet the chemical vortex we call life could only deal with a portion of the energies and materials on offer, and then only incrementally. Geochemists try to figure out what these were and thereby the likely nature of the earliest metabolic operating systems, whereas evolutionary microbial physiologists tend to seek what now works most cheaply via ATP currency in the central metabolic pathways and cycles. As connections are sought between these somewhat mismatched paradigms (the convective output and the expedients of metabolism) uncertainties are many, as is the potential for misunderstanding. Focussing on the uncertainties while attempting to curtail contingencies we debate:- the temperature limitations on the onset of life and, eventually, photosynthesis; to what extent the CO_2 concentration of the early atmosphere controlled the temperature of the hydrosphere and thereby the windows of opportunity for life to emerge; the significance of a high partial pressure of CO_2 in its fixation, reduction and in carboxylations; how H_2 might have been activated; the roles, if any, of $HCOO^-$, COS and CO; the pros and cons of an alkaline hydrothermal environment; the pH of the Hadean ocean; how minerals and mineral sulfide and oxide clusters may have been co-opted to act as host, hatchery, catalyst and also as sources for the active centres of the precursors to the metalloenzymes; how pyrophosphate was first generated; how the first conjugated stable cyclic and heterocyclic organic molecules were synthesized; and how the evolution and differentiation of the precursors to the prokaryotes can be seen as stages in the negotiation of a series of kinetic barriers.

Whatever the provisional outcome of this *open* debate, we undertake it in the knowledge that — in Doctorow's phrase — "the world composed and recomposed itself constantly in an endless process of dissatisfaction".