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The First Bacterial Habitats: What was Normal, What was Extreme?

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While we all instinctively know what life is, the definition of an extremophile is subjective. Consideration of the environment from which life arose may help objectify our definition. Life, as a dissipative structure, emerged coupled to the focus of an existing far-from-equilibrium open system, viz., the seepage site of a submarine hydrothermal convection cell away from a spreading centre (Russell & Hall 1997). We could say that conditions critical for the onset of metabolism and the origin of a genetic code defined a normal environment. While the commencement of metabolism, driven by a potential of half a volt (redox partners H_2/H^+), and Fe^{2+}/FeIII), appears favoured by temperatures of a moderate electrolyte of ~100 ºC, the ease with which the interactions of small molecules (via H bonding and van der Waals' forces) are affected by thermal factors, and the fragility of RNA, argues for a lower temperature for the first replicators, perhaps as low as 35 ºC (Forterre 1998). That a peptide nucleic acid (PNA) can survive at higher temperatures has been invoked to support a thermophilic origin of a fully coded life. But PNA is disqualified on the basis of its lack of catalytic and self-splicing activities, and its tendency to bind irreversibly to amino acids. Instead, a co-evolutionary hypothesis in which RNA (perhaps attached to mackinawite) codes for, and forms, the peptide bond is gaining experimental support (Mellersh 1993; Mellersh & Wilkinson 2000).

Although the first phototrophs emerged in what was then a hostile environment, they became commonplace, thanks to environmental change and the propensity of many Bacteria to develop efficient sunscreens (Cockell 1998). Likewise the *superoxide dismutase* (involving $2H^+$), evolved by aerobic Bacteria, has contributed to the 'normalisation' of these organisms. Also the development of a sodiummotive force (in place of the protonmotive force) has allowed some bacteria to colonize highly alkaline saline environments.

Thus mesophiles were the 'norm', and microbes living at springs above 70 ºC, or in very saline waters and in polar lakes and deserts (Wynn-Williams et al., 1999), are evolved *bona fide* extremophiles.

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