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Life Prior to the Terrestrial Rock Record

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The stable carbon isotope compositions of graphitic inclusions in apatite crystals from southwestern Greenland are indicative of a biological source (Mojzsis et al., 1996). Assuming that alternative explanations for this 13ºC depletion (e.g. metamorphism, contamination) can be entirely discounted, this would indicate that life has existed on Earth for as far back in time as the rock record extends (approx. 3850Ma, Nutman et al., 1997). Thus, the challenge is to attempt to reconstruct the course of events during the first 600Ma of Earth's history that preceded the rock record, a time when life either originated on Earth or was introduced from elsewhere.

In lieu of a rock record, alternative strategies are required to assess the evolution of Earth's crust, atmosphere and hydrosphere, and the frequency and significance of impact events during these early stages of formation. If it is assumed that life originated on Earth, then the severity of impact events during the earliest Archean severely limits the window of opportunity for such an occurrence (Chyba and Sagan, 1992). Ironically, whilst the higher frequency and severity of impacts may have been deleterious for life's origin and survival, the same impacts may have provided the earliest inventory of organic compounds essential for life's origin. The importance of this extraterrestrial inventory of organic compounds cannot be underestimated. This is because laboratory simulations of organic synthesis under early Earth conditions have yet to result in an appropriate inventory of life's building blocks with the requisite stereochemistry for construction of the biopolymers ubiquitous to all living systems.

Carbonaceous meteorites have provided the only direct information concerning the organic compounds present in our solar system at the time of its formation. The Murchison meteorite, a relatively recent, observed fall, is least likely to have been contaminated by modern, terrestrial biota. Engel and Nagy (1982) reported that amino acids in the Murchison meteorite exhibit an excess of the L-enantiomer that is typical of all living systems on Earth. More recently, Engel and Macko (1997) confirmed that these Murchison amino acids were extraterrestrial, based on their moderate to extreme enrichments in ^{15}N and ^{13}C relative to terrestrial organic matter. Bailey et al. (1998) have presented compelling evidence for circular polarisation in star formation regions that may explain the L-amino acid enantiomer excess observed in the Murchison meteorite.

Unless a plausible, terrestrial, abiotic mechanism for homochirality is eventually discovered, it appears that the most likely source for this organic matter on the early Earth was via impacts.

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