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IMPACT, RNA-PROTEIN WORLD, AND THE ENDOPREBIOTIC ORIGIN OF LIFE

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The numerous impact craters on the ancient surfaces of the Moon, Mars, and Mercury suggest the idea that impacts may have sparked the emergence of life on early Earth during the tail end of the Late Heavy Bombardment Period (~4 billion years ago). Both comets and asteroids played two distinct roles in the prebiotic origin of life. Comets delivered water and key ingredients of life from outer space, which were then accumulated, concentrated, and polymerized in hydrothermal crater basins on Earth created by the asteroids. Large impact crater basins (~500 km diameter) offer a number of possibilities as crucibles for endoprebiotic origin of life including: impact-generated hydrothermal vent systems; prolonged convective circulation of heated water; sequestered sedimentary basins for concentration of biomolecules; and nanopores and pockets in mineral substrates for polymerization of biomolecules such as simple RNA and protiens. Archean Greenstone belts in Greenland, Australia, and South Africa probably represent the relics of these primordial craters, where the early life was synthesized and preserved.

Life probably arose in a sequence of four stages in hierarchical fashion: cosmic, geological, chemical, and biological. In vent communities RNA and protein molecules emerged simultaneously and were encapsulated. The dual origin of 'RNA/protein world' is more parsimonious than the widely embraced 'RNA world' from the constraints of hydrothermal vent environments and the phylogeny of ribosomes. In this scenario, membranes came first to encapsulate simple RNA and protein molecules from mineral surfaces, where they began to perform two critical functions within protocells, replication and metabolism respectively. Once the membranes encapsulated these simple RNA and protein molecules, they began to interact and initiate serial endoprebiosis, leading to hierarchical emergence of cell components including plasma membrane, ribosome, retrovirus, and finally DNA with the development of the genetic code. Replication is the key breakthrough in the emergence of life. The hot subsurface environment of the crater basin, the oldest ecosystem, was suitable for the emergence of thermophilic life. RNA viruses and prions may represent molecular relics of the prebiotic world that predated the appearance of first cells.

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