Opening avenues in astrobiology, a testimony

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Abstract

In a first avenue, I handled "serious" chemistry. The silk made by the silk worm was known to adopt a beta-sheet water-insoluble textile form and an unstable water-soluble form present in the worm's gland before spinning. No chemical procedure was known to produce synthetic models long enough to adopt the desired conformations. After several tries, I finally succeeded in making an artificial protein mimicking the properties of the natural protein. The water-soluble form of silk could be studied and deciphered, leading to a new protein conformation adopting a crankshaft-type geometry.
Impressed by the Miller experiment, I tried then to understand how simple peptides could have emerged and accumulated in the primitive oceans. The reducing fluids of submarine hydrothermal systems associated with their metallic sulphurs may have been an important source of amino acids. During an IFREMER campaign in 2001, I collected samples of the hydrogen-rich fluids at the Rainbow deep-sea site. Amino acids were detected of the L-isomeric form, that is, as relics of living species and not chemically produced, as I had hoped.

The delivery to Earth of extraterrestrial amino acids always puzzled me. To estimate whether amino acids in micrometeorites could have survived a trip in space, I devised an experiment to expose amino acids to space conditions in Earth orbit on board the unmanned Russian satellites FOTON, the MIR station and the ISS. The amino acids were exposed both in the free state and associated with clay, basalt powder and meteorite powder. It is the latter, which, at constant thickness, provided the best protection, when the thickness of the minerals was at least 4-5 microns.

The most effective activated amino acid derivatives for the formation of oligopeptides in aqueous solution was shown to be the N-carboxyanhydrides (Leuchs anhydrides). I successfully used N,N'-carbonyldiimidazole to selectively polymerize protein amino acids at the expense of the non protein ones. During my sabbatical year in Leslie Orgel laboratory and in later work, I demonstrated that homochiral alternating polypeptides with hydrophilic and hydrophobic amino acids adopt beta-sheet structures, thermostable and resistant to racemization. Short basic alternating peptides accelerate the hydrolysis of oligoribonucleotides.

The discovery of a second genesis of life on another celestial body would demonstrate the ubiquity of life and thus the relative simplicity of its emergence. In 1996, ESA Manned Spaceflight and Microgravity Directorate asked me to convene an Exobiology Science Team to design an integrated suite of instruments dedicated to the search for life on Mars. The basic recommendations of the Science Team served as guidelines for the ESA ExoMars mission scheduled for 2016 and 2020.

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Because Mars had a relatively warmer and wetter past climate, it hosts sedimentary rocks. Such consolidated sedimentary rocks ought therefore to be found among the Martian meteorites. However, no such sedimentary material has been found in any SNC meteorite. To study the physical and chemical modifications to sedimentary rocks during atmospheric entry from space, I initiated the STONE experiments, flown by ESA. STONE was a series of six experiments to test the survivability of terrestrial sedimentary rocks, analogues of Martian sediments, embedded in the heat shields of FOTON capsules during entry into Earth's atmosphere. At the same time, the panspermia hypothesis was tested with live endolithic cyanobacteria protected by 1-2cm of rock thickness. A dolomite, a volcanic sandstone, and a basalt control sample partly survived entry into the atmosphere. The endolithic microorganisms did not survive. It was concluded that atmospheric transit acts as a strong biogeographical filter to the interplanetary transfer of photosynthetic microorganisms. However, microfossils in the volcanic sandstone did survive.

In 1999, Gerda Horneck, Beda Hofmann, the late David Wynn-Williams and myself considered that there would be real interest for Europe to create a European Astrobiology Network to help European researchers developing astrobiology programs share their knowledge, to foster their cooperation, to attract young scientists to this quickly evolving interactive field of research, and to explain astrobiology to the public at large. Twenty years later, it's my great pleasure to address my best anniversary wishes to EANA.