



Introduction to Origins of Biological Homochirality

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Introduction

The chemistry of terrestrial life is based on a spatial asymmetry: namely, on certain molecules, whose three dimensional geometrical structure or conformation is not identical to that of their mirror image or spatial reflections though a mirror. The parity **P**, or space inversion, is a fundamental discrete spatial symmetry transformation of fundamental physics, and is broken at the molecular level. Such molecules therefore possess chirality or handedness. Homochirality is ubiquitous in biological chemistry from its very start. Amino acids, the building blocks of proteins, and the sugar backbones present in DNA and RNA are chiral molecules. The way in which chirality in chemistry, or molecular handedness, may have emerged in a primitive terrestrial environment and how it can be triggered, amplified, and transferred, are deeply challenging problems rooted in fundamental scientific concepts with exciting promises for the technological advancement of science and society. Chirality constitutes a unifying feature of the living world and is a prime driving force for molecular selection and genetic evolution in biology. Many questions arise along the way: what are the reasons for molecular systems to break their mirror symmetry and under what conditions? What physico-chemical mechanisms are required so that a tiny excess of one enantiomer leads to chiral amplification at the macroscopic level? What are the origins of homochirality here on Earth? Progress in resolving these fascinating origin of life problems can only make great strides from the collaboration between researchers coming from diverse backgrounds: theory, experiment, non-equilibrium thermodynamics, crystallography, catalysis, nucleation, chemical engineering, liquid crystals, surface science, spectroscopy, organic synthesis, and quantum chemistry, just to name a few. The purpose of this Special Section of OLEB is to bring together a selection of current cutting-edge chirality research papers by leading experts in this field.

Huber and Trapp have developed an efficient simulation software tool to predict reactions occurring on a molecular level based on a stochastic algorithm. With this they investigate in detail four different reaction scenarios. Absolute asymmetric synthesis without the intervention of any chiral factor was achieved in the Soai reaction in the 1990s. A comprehensive authoritative review of this unique reaction is provided by Soai, Kawasaki and Matsumoto. Fernández, Cuccia, Viedma and Cintas have teamed up to review the (sweet) problem of

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how sugars became chiral. These authors revisit the past and current understanding of sugar chirality in the context of prebiotic chemistry, with careful attention paid to recent developments and insights. Next, Gleiser reviews three potential mechanisms for the emergence of biological homochirality on the primitive earth: namely, (i) whether it is a stochastic process driven by fluctuations, or (ii) driven by circularly polarized light, or perhaps (iii) driven by parity violation in the weak interactions. Each mechanism leads to different observational consequences. The collection is completed by Buhse and Micheau, who have delved into the intriguing problem of temporary chiral symmetry breaking that can take place in closed systems, here using Frank-like schemes and addressing their relevance for prebiotic chemistry.

We are grateful to our colleagues who have gracefully contributed to this special collection of papers, and we hope the reader may find inspiration from the approaches taken in these scientific articles.

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