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## Molecular Cooperation: A Self-less Origin of Life

N. Lehman<sup>1</sup><sup>1</sup>Department of Chemistry, Portland State University

\* nils@pdx.edu

**Introduction:** Molecular cooperation is the obligate dependence of multiple information-bearing molecules on the propagation of the system as a whole. In an RNA world, multiple types of such cooperation would have been possible [1], including simple reaction pathways with more than one informational reactant, polymer strands that interact to form a catalytic whole, cross-catalysis and cyclical-catalysis, a formal autocatalytic set, and perhaps even a hypercycle. I will discuss these various types of molecular cooperation and explore how they differ from “simple” chemistry that may have many reactants but no cooperative component.

**Reproduction, replication, and recombination:** Living systems are characterized by the propagation and proliferation of informational units as a function of time. Szathmáry [2] introduced a distinction between replicators and reproducers. Here, I will expand on this difference, tie them into prebiotic chemistry, and emphasize that cooperation must have played a key role in the origins of life, rather than being a later evolutionary invention. *Reproduction* is the ability of one molecule to catalyze the production of other, similar molecules. *Replication* is a sub-set of reproduction whereby a template is used to augment the creation of a second molecule from the first, one monomer at a time. *Recombination* is the swapping of large blocks of genetic information, rather than a series of unit-by-unit replication events. We have shown that RNA-dependent RNA recombination can lead to reproduction [3], and that under certain circumstances this type of reproduction can happen cooperatively [4]. Now I will demonstrate that recombination can outperform replication under a variety of common conditions, and conclude that it was far more probable that in life’s origin, reproduction occurred via recombination-like chemistry and that replication chemistry was a later biotic invention. The “self” as we know it today, was made possible only after an emergence of a molecular collective. There is clearly increased need to apply the principles of evolution, particularly competition, cooperativity, complexity, and ecology to molecular systems when considering the mechanisms of abiogenesis on the Earth.

**References:** [1] Higgs PG and Lehman N (2015) *Nature Reviews Genetics* 16:7–17. [2] Szathmáry E (2005) *Phil. Trans. R. Soc. B* 361:1761–1776. [3] Hayden EJ and Lehman N (2006) *Chem. Biol.* 13:909–918. [4] Vaidya N et al. (2012) *Nature* 491:72–77.