BP 30: Symposium SYOL: Origin of Life (with CPP and DY)

Time: Friday 9:30–11:30 Location: H 0105

Invited Talk BP 30.1 Fri 9:30 H 0105

From sequence to function: Random polymerization and modular evolution of RNA — •Susanna C. Manrubia — Centro de Astrobiología (INTA-CSIC), Madrid, Spain

A main unsolved problem in the RNA World scenario for the origin of life is how a template-dependent RNA polymerase ribozyme emerged from short RNA oligomers obtained by random polymerization on mineral surfaces. A number of computational studies have shown that the structural repertoire yielded by that process is dominated by topologically simple structures, notably hairpin-like ones [1]. A fraction of these could display RNA ligase activity and catalyze the assembly of larger, eventually functional RNA molecules retaining their previous modular structure: molecular complexity increases but template replication is absent [2]. This allows us to build up a stepwise model of ligation-based, modular evolution that could pave the way to the emergence of a ribozyme with RNA replicase activity, step at which information-driven Darwinian evolution would be triggered.

[1] Stich, M., Briones, C. and Manrubia, S. C. (2008) On the structural repertoire of pools of short, random RNA sequences. Journal of Theoretical Biology 252, 750

[2] Briones, C., Stich, M. and Manrubia, S. C. (2009) The dawn of the RNA world: Towards functional complexity through ligation of random RNA oligomers. RNA 15, 743

Invited Talk BP 30.2 Fri 10:00 H 0105

Spontaneous autocatalysis and periodic switching in a prebiotic broth — •Eva Wollrab[1], Sabrina Scherer[1], Karsten Kruse[2], and Albrecht Ott[1] — [1]Biologische Experimentalphysik, Universität des Saarlandes, Saarbrücken — [2]Theoretische Biologische Physik, Universität des Saarlandes, Saarbrücken

The pioneering experiments of Stanley Miller and Harold Urey have suggested that a large number of today's biomolecules spontaneously emerged under prebiotic conditions. How these organic molecules self-organized to produce the earliest forms of life is poorly understood. Here we perform Miller-Urey-type experiments and monitor the temporal development of the organic mixture using real-time mass-spectrometry. We observe the continuous emergence of a large number of substances during hours, followed by several orders of magnitude faster, autocatalytic growth of polymeric species. In the following these species appear and vanish periodically, while the amplitude of the oscillation increases. Due to the high complexity of the considered chemical dynamics, it will be difficult to determine the precise molecular pathways in the system. However, we will discuss possible, more general mechanisms that lead to the observed behavior. Our results show that upon weak energetic driving, a randomly generated, complex chemical system can spontaneously generate order.

Invited Talk BP 30.3 Fri 10:30 H 0105

Thermal solutions for molecular evolution — •Dieter Braun — Systems Biophysics, Physics Department, Center for Nanoscience, LMU Munich, Germany

Disequilibrium conditions are central for understanding the origin of life. Taking energetic chemicals at high concentrations to synthesize more complex molecules will not be enough to understand early molecular evolution.

Thermal gradients drive two processes. Laminar thermal convection leads to highly regular temperature oscillations that allow the melting and protein-based replication of DNA. In the same setting, molecules move along the thermal gradient (Soret effect), leading with thermal convection to strong accumulation of biomolecules. More complex molecules are exponentially better retained.

Our experiments implement both replication and accumulation in a micrometer-sized chamber. The setting offers an elegant implementation of a Darwinian process of replication and selection that is solely driven by a thermal gradient.

Early replication however has to be implemented without proteins. We demonstrate that a pool of Transfer RNA yields a protein-free route to replication and translation. In addition, Obermayer and Gerland showed that replication-like behavior is already found by selective degradation of single over double stranded RNA. If combined with a length selective thermophoretic trap, complex dynamics are expected. As a first indication, we found the enhanced polymerization of nucleotides in a thermophoretic trap.

Invited Talk BP 30.4 Fri 11:00 H 0105

Systems chemistry: Self-replication and chiral symmetry breaking — •Guenter von Kiedrowski — Chair for Bioorganic Chemistry, Ruhr-University, Bochum, Germany

Self-replication is one of the major principles without life could not exist. Whether the origin of self-replication is identical to the origin of the hypothetical RNA world or whether it existed at an earlier stage of evolution is an open question that has stimulated chemists to search for systems capable of making copies of itselves via autocatalytic reactions. As self-replication means autocatalysis plus information transfer, the reaction products must necessarily be able to store more structural information than their precursors. Templating as a means to transfer structural information has been exploited since the first successful example of a chemical self-replicating system almost two decades ago. Today we have a broad variety of such systems employing oligonucleotides, peptides, and small organic molecules as templates and autocatalytic, cross-catalytic, collectively autocatalytic and non-autonomous (stepwise) schemes of self-replication. Chirality and the spontaneous emergence of optical activity, viz. chiral symmetry breaking may be seen either as the key prerequisite to allow for self-replication of proto-biomolecular structures, or, as a systemic result of self-replication when starting from prochiral precursors. For example, while PNA as well as a recently described small organic replicator are achiral entities, the introduction of variant prochiral building blocks are expected to yield chiral replicators.