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Non-equilibria for the Emergence of Life: towards the Dew RNA world

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Understanding the emergence of life means to recreate a most simple physico-chemical system that is capable of open ended Darwinian evolution. We will discuss a cascade of experiments that imply a fundamentally simplified RNA world that starts from the solid state.

We revisited polymerization and templated ligation of RNA from nucleotides with 2',3' cyclic phosphates. They oligomerized under alkaline conditions at pH 9-10 without catalysts or added salts, reaching 10mers in a day, both in the 'dry' state or in the wet-dry cycling at a heated air-water interface [1]. At high temperatures, the oligomers were dominated by G, but cold and dry conditions, achieved in the planet simulator of McMaster University, yielded random sequences of GC or GCAU. The yield for oligonucleotides which contain still a functional 2'3'-phosphate end peaks between 4°C and 25°C.

Under similar conditions, phosphorylation from Trimetaphosphate and templated ligation was observed under such "dry" conditions. We envisage therefore a one pot reaction from nucleosides to the replication of oligomers. The separation of strands would be provided by the condensation of salt-free dew droplets which also dissolve new feeding nucleosides from the solid state, triggering another cycle of phosphorylation, polymerization and templated ligation in the "dry" state.

We could show that air-water interfaces drive more sophisticated Ribozymes. We shown that CO_2-water interfaces can drive the replication towards sequence lengths of up to 1300mers, overcoming the tyranny of the shortest by the length selective accumulation under evaporation-based capillary flow. The long strands separate under the pH and salt cycling provided by the Hadean atmosphere of CO_2. While the replication was still implemented by a polymerase to enhance kinetics, preliminary results show a similar strand separation for Ribozymes under elevated Mg^{2+} concentrations.

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[2] **Nature Physics** doi.org/10.1038/s41567-022-01516-z (2022)