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An Origin of Life in Cycling Hot Spring Pools: Emerging Evidence from Chemistry, Geology and Computational Studies

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Introduction: Evidence consistent with an origin of life in a hot spring setting has been accumulating over the past decade. Laboratory and field studies demonstrated that RNA-like polymers and peptides can be synthesized nonenzymatically from their monomers by cycles of hydration and dehydration [1]. Cycling conditions simulate fluctuating fresh water hot spring pools in hydrothermal fields associated with volcanic land masses. Recent investigations of the 3.48Ga Dresser Formation in Western Australia discovered geyserite bedded with well preserved stromatolites [2], suggesting that some of the earliest evidence for life indicates thriving microbial populations in fresh water hot springs on land rather than salty marine conditions. Two independent computational studies used thermodynamic and kinetic analysis to confirm the feasibility that phosphodiester bonds can form spontaneously, using the free energy made available by evaporation that concentrates monomers into thin films on mineral surfaces [3]. Polymers accumulate in a kinetic trap because the rate of ester or peptide bond formation is significantly faster than the rate of hydrolysis. Additional laboratory observations show that such polymers are encapsulated in lipid vesicles during the cycles, forming protocells that can be subjected to combinatorial selection. These results (figure 1) demonstrate the value of interdisciplinary approaches that link chemistry, geology and computational modeling in advancing our understanding of the origin of life as it may have occurred in a cycling hot spring setting on land [4].

References:

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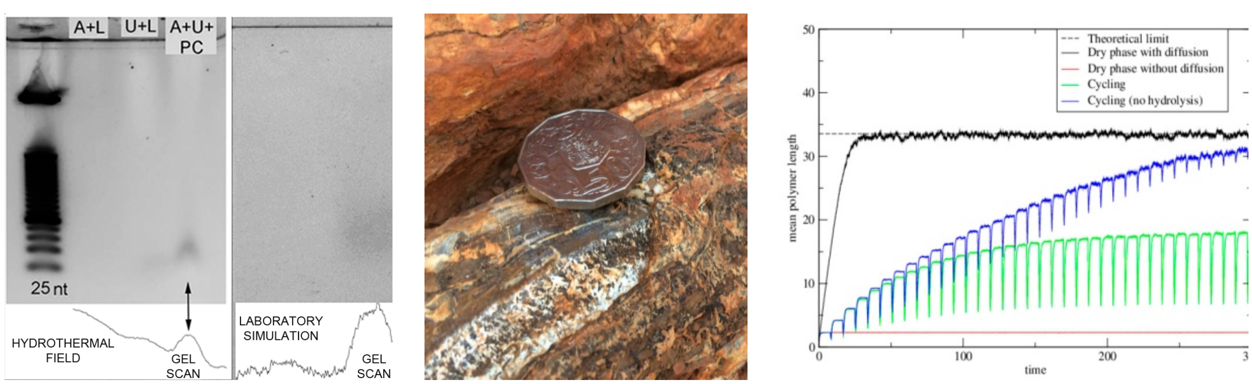

Figure 1 – Left, RNA-like polymers synthesized in a fumarole vent at Bumpass Hell, California and reproduced in the lab through hydration-dehydration cycles in the presence of POPC as an organizing matrix [1]; Center, branching stromatolite (white band) preserved with geyserite in the 3.48Ga Dresser Formation in Western Australia [2] and; Right, computational modeling of kinetic trap where polymer length grows over time through wet-dry cycling with hydrolysis and influx of monomers [3].