SYNTHESIS AND CHARACTERIZATION OF INFORMATIONAL MOLECULES FORMED UNDER PREBIOTIC CONDITIONS

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All processes in extant biology are possible and facilitated by information encoded in polymers. Therefore, the origin of informational molecules had to be a crucial step in the origin of life on Earth. An important molecule in this context is RNA and the RNA World has been hypothesized as a crucial step in the transition from chemistry to biology. However, the RNA molecule is comprised of intra-molecular bonds, which are prone to hydrolysis, especially under the harsh conditions that are thought to have been prevalent on the early Earth [1]. Furthermore, the formation of nucleotides with extant bases, and their subsequent polymerization, have both been problematic, to say the least. Certain environmental niches, such as volcanic geothermal pools, allow the formation of RNA-like polymers, under dehydrating-rehydrating (DH-RH) conditions, by potentially forming kinetic traps [2]. However, the low pH and high temperature conditions that are required for such polymerization to occur also result in the cleavage of the N-glycosidic bond, thereby producing polymers with abasic sites [3]. In the first part of the present study, we set out to characterize the effect of prolonged cycling, under DH-RH conditions, on the stability of resultant molecules and also looked at how they might affect the product distribution. Our observations indicate lower fitness for modern nucleobases under prebiotically relevant conditions. These results are also supported by older experiments wherein formation of nucleosides with extant bases was shown to be difficult.

Alternate bases, on the other hand, have resulted in nucleosides in higher yields, suggesting a viable and prebiotically relevant solution to the longstanding "nucleoside problem" [4]. Towards this extent, we also recently demonstrated the synthesis of a pre-RNA World nucleotide using ribose 5'-monophosphate (rMP) and barbituric acid (BA) as the base analog, under dry-heating conditions [5]. This result was simultaneously also demonstrated by the Hud group thus strengthening the more recently posited pre-RNA World hypothesis [6]. Furthermore, polymerization of the resultant monomer, i.e. the BA-nucleotide, was also observed when we carried out DH-RH cycles at low pH and high temperature. The resulting RNA-like oligomers were shown to have intact bases unlike the reactions that were carried out using canonical nucleotides. Additionally,, incorporation of BA onto pre-formed sugar-phosphate backbones was also observed when pre-formed rMP oligomers were subjected to heating with BA. Aforementioned studies provide important preliminary evidence that alternate bases could have indeed gotten incorporated into early polymers that may have predated the molecules of an RNA-World. Importantly, these results suggest that BA could have been a putative precursor of modern nucleobases,.Moreover, it also highlights the possibility that the prebiotic soup, which would have contained several types of heterocycles, might have facilitated simultaneous sampling of other potential pre-RNA World heterocycles.

We discuss the selective advantage that such primitive informational polymers could have had under pertinent selection pressures. Importantly, these kinds of processes have implications for shaping the prebiotic landscape that allowed for the emergence of primitive informational polymers of the pre-RNA World(s), prior to the emergence of a putative RNA World.

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