227 Views of RNA: Is RNA Unique in Its Chemical Isomer Space? H. James Cleaves II[1,2,3,4*], Markus Meringer[5] & Jay Goodwin[6]1. Earth-Life Science Institute (ELSI), Tokyo Institute of Technology, 2-12-1-IE-1, Ookayama, Meguro-ku, Tokyo, 152-8550, Japan (henderson.cleaves@gmail.com); 2. Institute for Advanced Study, 1 Einstein Drive, Princeton, NJ 08540; 3. Blue Marble Space Institute of Science, 2800 Woodley Rd. NW #544, Washington, DC 20008; 4. Center for Chemical Evolution, Georgia Institute of Technology, Atlanta, GA 30332; 5. German Aerospace Center (DLR), Earth Observation Center (EOC), Münchner Straße 20, 82234 Oberpfaffenhofen-Wessling, Germany; 6. Department of Chemistry, Emory University, Atlanta, GA 30322.

Introduction: Ribonucleic Acid (RNA) is one of the two nucleic acids used by extant biochemistry, and plays a central role as the intermediary carrier of genetic information in transcription and translation. If RNA was involved in the origin of life, it should have a facile prebiotic synthesis. A wide variety of such syntheses have been explored [1-4]. However, to date no one-pot reaction has been shown capable of yielding RNA monomers from likely prebiotically-abundant starting materials, though this does not rule out the possibility that simpler, more easily prebiotically-accessible nucleic acids may have preceded RNA [5,6]. Given structural constraints, such as the ability to form complementary base-pairs and a linear covalent polymer, a variety of structural isomers of RNA could potentially function as genetic platforms. Using structure generation software [7], all of the potential structural isomers of the ribosides ($BC_5H_9O_4$, where B is nucleobase)) (Figure 1), as well as a set of simpler minimal analogues derived from them, that can potentially serve as monomeric building blocks of nucleic acid-like molecules were enumerated [8]. Molecules were selected based on their likely stability under biochemically relevant conditions (*e.g.* moderate pH and temperature), and the presence of at least two functional groups allowing the monomers to be incorporated into linear polymers. The resulting structures were then evaluated using molecular descriptors typically applied in quantitative structure–property relationship (QSPR) studies and predicted physico-chemical properties. Several databases were queried to see if any of the computed isomers had been synthesized previously. Very few of the molecules that emerged from this structure set have been previously described [8]. We conclude that ribonucleosides may have competed with a multitude of alternative structures whose potential proto-biochemical roles and abiotic syntheses remain to be explored.

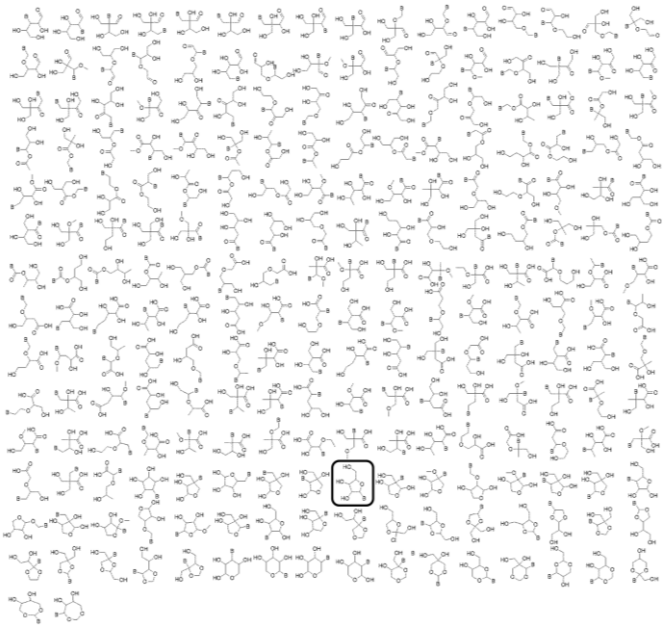

Figure 1. The enumerated set of riboside isomers. Structures are ordered according to the location of the double bond equivalent, beginning with aldehydes, then ketones, esters, BC(=O)C linkages, BC(=O)O linkages, carboxylic acids and finally rings. The structure corresponding to the natural ribosides is highlighted by a black cartouche.

References:

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