Solvent-Specific Constraints on Chemical Alphabets. Siddhartha Jena[1] and Anson Kahng[2], [1]Princeton University Department of Molecular Biology, sjena@princeton.edu, [2]Carnegie Mellon Department of Computer Science, akahng@cs.cmu.edu.

Given the long-standing interest in the possibility of life on other planets, one of the natural questions that remains is what the genetic information of such an exoplanet would look like. For inspiration, we examine our own DNA. Szathmary observed that each letter in the DNA alphabet can be described by the number of hydrogen bond donor and acceptor sites on it, which allow for specificity of coding [1]. However, these hydrogen bonds are competing against hydration forces; in the dsDNA state, they are protected from solvent hydration by hydrophobic base stacking and other intermolecular effects [2]. Without this, the base pairs would rapidly separate and hydrate. We can generalize this model to a non-Earth setting to understand the relationship between solvation effects and information transfer in chemical languages. Assuming these chemical languages on other planets are built linearly out of a static alphabet and carry accessible information, we can see that the necessity for unique, distinguishable letters is equivalent to a necessity for distinguishable intermolecular forces. However, not all solvents will result in the same types of interactions as the hydration forces present on earth. The limitations placed on extraterrestrial chemical languages, therefore, are a function of the chemical properties of the solvents present on the planet. In this paper, we investigate, for a given solvent effect, the energetic limitations on the alphabet and therefore on the complexity, probable error rate, and information bandwidth of a chemical language [3]. We also propose a solvent-mediated evolutionary pressure for the development of coding distance in our hypothetical chemical language. Understanding the chemical and physical limits placed on coding efficiency, and therefore on information capacity of a life-sustaining world, will allow us to predict probable limits on the complexity of life that may exist on habitable planets.

References:

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