DETECTING LIFE UNIVERSALLY IN OCEAN WORLDS, ICY MOONS, AND ENCELADUS PLUMES.
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Introduction: Bodies of water in our solar system offer places where alien life might be discovered in a form sufficiently similar to known terran life that we will be able to recognize it as biology. In deciding what to look for, we are guided by a model that assumes that Darwinism supported by a linear biopolymer is the only way that organic matter can self-organize to give properties that we value in a biosphere. If these assumptions are accepted, we can ask: What features must that biopolymer have to allow replication, with errors, where those errors are themselves replicable.

This talk will present experimental data for two of these features, both based on a requirement for Darwinism that the physical properties of a Darwinian biopolymer must not change dramatically as the structure of the biopolymer changes to reflect changing information. In water, this is possible only if the biopolymer has a repeating backbone charge (that is, it is a *polyelectrolyte*).[1] In terran DNA and RNA, that repeating charge is negative, and is carried by the linking backbone phosphate groups. However, alternative genetic systems are chemically conceivable where the backbone has a different anionic group, or even a cationic group. In DNA and RNA, the repeating backbone charge so dominates the physical properties of the biopolymer any replacement of the nucleobase to change the genetic information of the molecule creates only a small perturbation of those properties.

The second feature is an "aperiodic crystal" structure first suggested by Schrödinger,[2] despite his not knowing the structure of terran nucleic acids. In terran DNA and RNA, the Watson-Crick A:T and G:C pairs have similar sizes (due to the size complementarity of the pairing concept, big purines pairing with small pyrimidines). This allows the double helix of DNA to be crystal-like in structure, with the formation of the double helix benefitting from the reliability of a phase transition. Just as the process crystallization of an organic species allows the crystal to exclude most impurities, the formation of the aperiodic crystal allows a physical process to exclude replication errors. The Schrödinger criterion requires the building blocks to all have the same chirality (*homochirality*), be few in number, and have interchangeable packing.

Polymers having these two features are expected to arise rarely, if ever, without Darwinism. Further, even in the presence of Darwinism, they will be sparse, just as they are in a sample of life on Earth.

However, their two features allows them to be concentrated, detected, and analyzed from samples of ocean worlds. For example, a solid support containing regularly spaced positive charges will adsorb a biopolymer with repeating negative charges preferentially over the adsorption of simple anions such as chloride, sulfate, or phosphate (**Fig. 1**). Further, surfaces able to collect polyelectrolyte biopolymers that can support Darwinism are easy to build and likely robust to space travel. Conceptually, they can be as simple as a silica waveguide with charges imprinted on its surface. Once concentrated, the biopolymer can be recovered and analyzed for Schrödinger-type structural regularity.

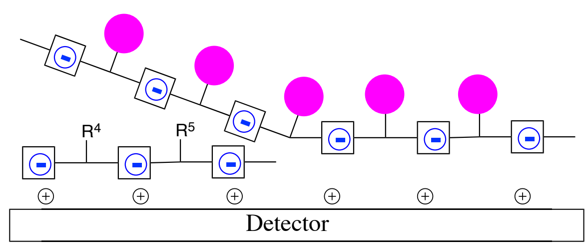

Fig. 1. Detector with repeating positive charges concentrate polyanionic Darwinian biopolymers from an alien ocean. Capture detected with high sensitivity by displacement of a fluorescent short polyanionic biopolymer. To capture a polycationic alien genetic biopolymer, an anionic surface is used.

What sensitivity must such devices have? On Earth, the oceans contain ca, 10^9-10^{10} genetic molecules per liter, perhaps 10^4-10^5 building blocks in length, ca. 10^{13}-10^{15} anions (or, in more exotic life, cations).[3] If electrochemical detection is used, the device becomes a universal biological detector able to detect Darwinian biopolymers in alien oceans at bioloads perhaps one million times lower than in an ocean on Earth. The ability to concentrate universal Darwinian biopolymers allows the sensitivity to be limited only by the volume of sample that can be collected.

References:

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