

DETECTING EXTANT LIFE ON MARS. AN INSTRUMENT DESIGN THAT AVOIDS GUESSWORK. S. A. Benner. Foundation for Applied Molecular Evolution, 13709 Progress Blvd., Alachua, FL 32615 USA

Introduction. Darwinian evolution is believed to be the only way matter can self-organize to give properties valued in life. Synthetic biology has taught us that to support Darwinism in water, an informational biopolymer must have two structural features [1][2]:

- (i) The exchangeable informational building blocks must all have the same size/shape. They must all fit in an "aperiodic crystal" structure.
- (ii) The biopolymer must have a repeating backbone charge. The charge may be positive or negative; in terran DNA and RNA, it is negative, and is carried by the linking phosphates,

Polyelectrolytes are easy to capture from dilute solution. All that is necessary is to pass water across a surface or through a filter that presents a high density of the opposite charge. The polyvalency of coulombic interactions allows polyelectrolyte binding to compete with binding of salts. Thus, an effective architecture to detect extant life universally in water seeks to process as much liquid water as possible across such surfaces or filters (Figure 1).

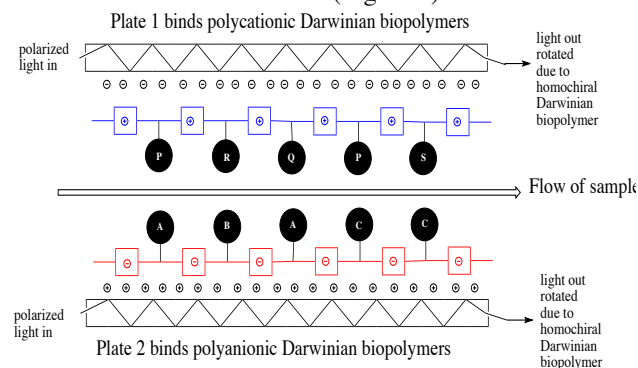


Figure 1. Capture of genetic polyelectrolytes.

Building block homochirality is enforced by the Schrödinger criterion. Heterochiral building blocks cannot fit an aperiodic crystal. This allows us, by optical inspection of adsorbed polyelectrolytes, to learn if they fit the Schrödinger criterion. Joining many building blocks of the same chirality into a polymer generates superchirality. In DNA, this is the right-handed double helix; the chirality is "greater" than the sum of the individual building blocks. Superchirality ensures that an oligomer rotates light more than the rotation from separated building blocks.

We do not want to guess where to find extant life. Much of Mars exploration now seeks to identify locales most likely to hold extant life. However, the polar ice caps provide the largest reservoir of accessible water on Mars. Further, they sample the entire Martian regolith via dust storms. This generates a life detection instrument (Figure 2) whose sensitivity is

limited only by the amount of ice it can melt, itself limited only by the amount of energy it can deliver.

The instrument efficiently exploits available resources. The ice itself contains abrasive dust. Thus, passing the melt through a cyclonic centrifuge (a Sharpless centrifuge is common in biological labs) simultaneously disrupts any Martian cells while removing the minerals, which may themselves be chiral; if the minerals are not removed, downstream chirality measurements will be ambiguous.

At any point, samples may be withdrawn to inspect for cell structures, mineral compositions, or other features of the regolith that have been collected from the global surface. Further, following pressurization, liquid flow is driven by pressure gradient, delivering a waste effluent into an evaporation pan after the polyelectrolytes have been removed. The evaporates contain all of the soluble materials in the ice, which would include metabolites of interest to those seeking amino acids, metabolic intermediates, or other biosignatures.

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References: [1] Benner, S. A., Hutter, D. (2002) Phosphates, DNA, and the search for nonterrestrial life: A second generation model for genetic molecules. *Bioorg. Chem.* **30**, 62-80. [2] Benner, S. A. (2017) Detecting Darwinism from molecules in the Enceladus plumes, Jupiter's moons, and other planetary water lagoons. *Astrobiol.* **17**, 840-851.

