

RUBISCO STARS AND THE RIDDLE OF LIFE J. Davis¹ and D. Hofmans², ¹Massachusetts Institute of Technology Department of Biology, MIT Building 68 Room 233, Cambridge MA 02139 ²University of Amsterdam, Faculty of Humanities, Department of Art, Religion, and Cultural Sciences and The Arts & Genomics Centre, P.O. Box 9502, 2300 RA, Leiden, The Netherlands, joedavis@mit.edu, dhofmans@gmail.com



Arecibo Radar at night (November 7, 2009) Photo: Ashley Clark

Introduction: Here we report transmission of a coded signal from the Arecibo Observatory to commemorate the 35-year anniversary of the Drake message for extraterrestrial intelligence (ETI). On November 7, 2009, a signal was transmitted to intercept three stars likely to have planets (GJ 83.1; SO 025300.5+165258; G5B). Virtually any non-random signal would have sufficed, but for philosophical purposes we chose to transmit the DNA sequence of the gene for the large subunit of a protein, ribulose 1, 5 bisphosphate carboxylase oxygenase (RuBisCo), the most abundant protein on Earth. The RuBisCo sequence was unambiguously coded together with a secondary message, “I am the Riddle of Life Know Yourself.” The sequence was encoded as a text and voice message by a method that will be described.

Discussion: The RuBisCo gene sequence is significant knowledge of molecular genetics that did not exist in 1974. RuBisCo uses energy supplied by photosynthesis to convert inorganic carbon dioxide in the air into organic compounds, creating high-energy hydrocarbon bonds that make the existence of humans possible. It communicates the central importance of the sun in sustaining life and our understanding of the crucial role of CO₂ in biogeochemical systems.

The second part of the message communicates information that would almost certainly have no significance for ETI but that has special resonance for human

beings. Although there is intrinsic interest in attempting to communicate with extraterrestrial intelligence, or to search for signals from such entities, there are other reasons to carry on the search that are closer to home. “Know Yourself and You Will Know All the Secrets of the Universe...” is inscribed at the entrance to the temple of Apollo at Delphi. Understanding secrets of the universe that include the notion of ETI is a problem that only partly pertains to astronomy.

Ultimately, by sending messages to extraterrestrial intelligence, human beings are even more importantly engaged in a search for themselves. If message-senders are to reveal themselves to anyone else, they must first reveal themselves to themselves. This has not only been a central dilemma in the search for extraterrestrial intelligence. It has also been an essential ingredient in the body of art, poetry and literature, history, psychology and an important problem in classical philosophy.

The loneliness implied by the search for ETI is heightened by the seeming futility of attempting to communicate with any intelligence other than our own. Yet, far from being a reason to refrain from creating and sending such messages, serious efforts to contact extraterrestrials will necessarily raise the vital questions: Is this what we know? Is this who we are? thus, revealing the need to continue the search.

Another important sub context of the November 7 RuBisCo message refers to earlier projects undertaken by one of the authors (J. Davis) in which the usefulness of biological media has been investigated both in terms of message content and as alternative models for signal carriers in active searches for ETI [1-3].

Genomic information contains much of what is known as well as what is unknown about life on Earth. Whether or not such information derives specifically from the genome of *Homo sapiens*, it implies human knowledge about the basic operations of life as well as a level of technological sophistication needed to resolve it. The genomes of living organisms may be co-opted to conserve extra-biological data with unprecedented information density. A single gram of DNA can contain at least as much information as a trillion CDs [4]. A gram of DNA contains 10²¹ DNA bases or at least 10⁸ tera-bytes of data [5]. Hence, a few grams of DNA have the potential to store all of the data stored in the world.

Furthermore, biological media answer three basic engineering problems associated with active searches for extraterrestrial intelligence (SETI). 1) Hundreds of

billions of copies of a message can be cheaply and conveniently produced for hundreds of billions of target stars. 2) Biological carriers, especially sporulating bacteria, can withstand extremes of radiation, temperature and vacuum that characterize space environments. 3) Dormant bacterial spores can remain biologically viable for indefinite periods of time.

Summary: The *RuBisCo Stars* transmission mapped a mathematical base-4 numerical sequence corresponding to the 1434-mer RuBisCo gene into an audio file comprised of 1-, 2-, 3- and 4-syllable sets separated by “spaces”. For example, the DNA sequence, “CTGA” is coded for with the words “I_am_the_riddle-of-life_know-yourself.” Voice synthesizing software was used to convert the coded text into an audio file. No digital communications were possible at Arecibo Radar on the night of November 7, 2009 because equipment needed to precisely encode a binary message was temporarily out of order. The authors and their collaborators decided to use an iPhone to output the RuBisCo-coded audio signal that was interfaced with Arecibo Radar.

The words, “I am the Riddle of Life Know Yourself” recall the ancient message for *Homo sapiens* that has already stood the test of time. It speaks poignantly to the paradox of SETI noted by Alexander Zaitsev and others [6]. Humanity defines itself through the search for similar intelligences, but the search is for civilizations who actively transmit practical interstellar signals. Some of the lessons humans have learned seem to be exquisitely tragic ones since self-indictments of censorship and xenophobia must be included in what has been discovered about *Homo sapiens* thus far in the messages from Earth.

Concluding Remarks: In 35 years since the Drake transmission from Arecibo, radar antennae all over the world have more or less routinely searched the sky for unambiguous signals from advanced extraterrestrial civilizations. The [SETI@Home](#) project, organized by UC Berkeley has allowed millions of lay enthusiasts to participate in SETI sky surveys by donating processing time on home computers. Continuing SETI efforts help to drive a broad spectrum of research, provide jobs for astronomers and others and foster the growth of new technologies and new intellectual approaches to problems associated with SETI. Yet, over these same 35 years, few serious messages have been transmitted to ETI. The arts and sciences of SETI remain mired in political and moral debates and research is tied to entrepreneurship and private funding. Meanwhile, various amateur and commercially motivated transmissions have taken place, but such transmissions have been insufficiently powerful and arbitrarily or naively

composed by groups and individuals who seem to have little contact with the formal, scientific community.

The *RuBisCo Stars* effort differs from both amateur and purely scientific SETI because its “principal investigators” are scholars in the arts and humanities. They found compelling concentricity with the interests of astronomy and astrobiology and could not have successfully undertaken the *RuBisCo Stars* project at all without tacit approval of many scientists and engineers. Like SETI research, contributions of the arts and humanities are also routinely underestimated and underfunded. Yet, the authors recognize that *RuBisCo Stars* may serve as a footprint for practical interdisciplinary collaboration.

The *Rubisco Stars* transmission has provoked a resurgence of interest in historical details surrounding the 1974 transmission and individual roles that figured in the composition of that message and its transmission from Arecibo. As a result, the *Rubisco Stars* episode has inspired people to re-evaluate their positions and enhance their communications. Based on that, we can assume that at least on one planet, the message is being heard loud and clear.

References: [1] Davis, J., Boyd, D., Weiczorek, M., O'Reilly, H., (2003) *Art and Genetics in Nature: Encyclopedia of the Human Genome* Nature Publishing Group, Macmillan, London, UK 188-195 [2] Reichle, I., (2009) *Art in the Age of Technoscience: Genetic Engineering, Robotics and Artificial Life In Contemporary Art*, Springer, New York/Vienna 97-119 [3] Davis, J., (1996) *Art Journal* 55(1), 70-74 [4] Bharadwaj, L. M., Bhondekar, A. P., Shulka, A. K., Bhalla, V. and Bajpai, R. P., (2002) *DNA-based high density memory devices and biomolecular electronics at CSIO, Biomedical Applications of Micro- and Nanoengineering Workshop, SPIE*, Melbourne, Australia [5] Gehani, A., LaBean, T., and Reif, J., (2000) *DNA-based Cryptography* in editors: Winfree, E., and Gifford, D. K. (eds.) *DIMACS DNA-based computers V*, American Mathematical Society, Providence, RI [6] Zaitsev, A., (2006) *Bull. Spec. Astrophys. Obs.*, 60