Astrobiology Is the New Modern Framework Encompassing SETI . . . and So Much Else

DAVID MORRISON

The Search for Extraterrestrial Intelligence (SETI) is a scientific effort that has attracted wide popular interest over the past half century. We all ask "Are we alone?" and SETI programs provide a potential way to answer this question. Intellectually, SETI—and efforts to assess the likelihood of its success—are embedded within a broader framework of astrobiology, which is the study of the living universe. Astrobiology, and its predecessor discipline exobiology, address the origin, evolution, distribution, and future of life in the universe. Primarily, scientists use our knowledge of the history of life on our own planet to investigate the habitability of other worlds and to develop strategies to search for biosignatures of life beyond Earth.

Today astrobiology has developed into an international multidisciplinary field, bringing together biologists, chemists, astronomers, geologists, and planetary scientists to seek common ground. There are two major professional journals in astrobiology, international meetings, several nascent professional societies, a NASA Astrobiology Institute (where I work), and an explosion of college courses and books on this topic. It is within this broader context that we should examine SETI programs and their scientific underpinnings.

Studies of life on our planet continue to broaden our understanding of the robustness of life, and its ability to survive and even thrive in seemingly extreme environments, ranging from boiling hot springs to Arctic sea-ice to the cooling water of nuclear reactors. But while life may be widespread, detecting it on other worlds is challenging. Within our solar system, we may need to return samples to Earth for detailed study that might reveal unambiguous signatures of past or present life. For planets around other stars, astronomical techniques are all we have. The problem here is to understand what global biomarkers (such as oxygen in an atmosphere) can be relied upon, and how we can develop the new instruments to make the required measurements. SETI presents us with an alternative approach to biomarkers. While the occurrence of a technological civilization is probably rare even on living worlds, the detection of a radio or optical signal from such a civilization would provide unambiguous evidence of life.

Peter Schenkel's article "SETI Requires a Skeptical Reappraisal" mostly lacks the modern astrobiology perspective. His target is high expectations of the success of SETI based largely on philosophical positions that go back to Giordano Bruno. In fact, much of his article seems to be aimed at refuting his own past optimistic positions, making his reappraisal a personal statement of reduced expectations. Probably the truth about current ideas on SETI lies between these optimistic and pessimistic extremes.

One area in which I believe Schenkel is too negative is the matter of the prevalence of exoplanets—planets circling other stars. It has been common in evaluations of the Drake equation to set this number at between 10 percent and 100 percent, based until recently on little hard information, since no exoplanetary

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systems had been discovered. All this has changed in the past decade, with more than 150 exoplanets known today. Initial results were confusing and perhaps disheartening for SETI supporters, since the systems being discovered were dominated by giant planets very close to their suns. These "hot Jupiters" are

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incompatible with the presence of Earth-like planets. But these strange (to us) configurations are actually found in only about 10 percent of solar type stars. Recent improvements in detection technology are now revealing systems with giant planets in jovian-like orbits, which leave open the possibility of terrestrial planets like our own. Today these Earth-like planets are undetectable, but within three years the NASA Kepler observatory should be able to find analogues of Earth. Thus the new results, while inconclusive on the prevalence of Earths, are actually encouraging. Earth-like planets may be common in the universe, and we should soon know!

The "rare Earth" hypothesis is also used by Schenkel as an argument against the common presence of inhabited planets. He correctly lists several unusual features of Earth that seem to have been favorable to the evolution of advanced life. The exact duplication of such a situation in another planetary system is indeed rare. But are these elements of our past history really required? I do not think we know enough about the origin and evolution of life to define the range of conditions that are conducive to life and intelligence. Earth is rare, but it does not necessarily follow that inhabited planets are rare.

His note that it required "more than 96 percent" (I think he meant 99 percent) of the age of Earth for higher intelligence to evolve illustrates an interesting logical error. We always look at the past from our present perspective. I read Schenkel's article only today, which represents less than one trillionth of the age of the Earth, but that really does not say anything about the probability of this article having been written and sent to me by the editor of SI. Besides, there are probably many Earth-like planets with up to twice the age of our solar system.

Is SETI likely to succeed in our lifetimes? I do not know. I hope so, of course, but I cannot assign a probability to such near-term success. I think the situation demands skepticism but not pessimism. I think that Schenkel would agree with this perspective.

There are two well-known SETI-related conclusions of which we can be confident, however. If we succeed, any civilization we detect will almost surely be far in advance of our own, and the message itself may be indecipherable. We should not, therefore, look to SETI for easy solutions to our current challenges on Earth. The second conclusion is that, while we may not succeed if we search, we are assured of failure if we do not search.

The New Approach to SETI Is from the Bottom Up, Rather Than the Top Down

DAVID DARLING

As far as the prevalence of life and intelligence throughout the galaxy goes, the simple fact is we still have no idea. All our estimations and projections continue to be based on a single datum—namely, the life we find around us here on Earth. There are those, such as Peter Ward and Donald Brownlee, who personally see evidence that complex life may be quite rare, even if unicellular life comes about fairly routinely. There are others who see it differently. To give a specific example, routine cosmic catastrophes will, it is claimed, destroy the chances of complex life emerging except in the most unusual cases. Yet, one such catastrophe, at the end of the Cretaceous, was the very reason that high-level intelligence developed on Earth! All of our current hypotheses about the likelihood of extraterrestrial life and intelligence are nothing more than opinions based on inference and one data point. What we must do is continue to look for hard evidence, both locally (within the solar system) and across interstellar distances. Neither optimism nor pessimism is helpful when based on ignorance.

Set against the fact that SETI has not so far received a positive signal are a number of encouraging developments in astronomy and astrobiology. These include the detection, since the mid-1990s, of more than 150 extrasolar planets, and increasing signs from within the solar system that the conditions deemed necessary for the development of life as we know it (water, organics, and a suitable energy source) may arise on multiple worlds around a single star. Astrobiology is in the ascendancy. Mars, Europa, and Titan head a short list of locales in our neighborhood where scientists would not be at all surprised to find extant microbic life. We are detecting increasingly complex molecules in interstellar space and evidence that life might be able to survive trips between worlds aboard meteorites. As I explain in my book *Life Everywhere* (Basic Books, 2001), terrestrial life, from the outset—not just over the past few hundred million years—has shown a propensity to become increasingly complex and display the rudiments of intelligent behavior.

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