Program of Dialogue on Science, Ethics, & Religion

Summary

Life Elsewhere? Astrobiology, Science, and Society

By Catherine Baker

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The search for extraterrestrial life is quixotic — or at least less immediately purposeful than the quest for a cure for cancer. Nonetheless, it falls squarely within the human purpose for science: to explore nature so that we can understand ourselves better.

The means by which scientists search for life elsewhere, and the meaning of this enterprise, was the theme of a March 27 lecture sponsored by the Dialogue on Science, Ethics, and Religion (DoSER), a program of the American Association for the Advancement of Science (AAAS). The featured speaker was Dr. Bruce Jakosky, an astrobiologist involved in the Mars Global Surveyor mission as an Interdisciplinary Scientist for Surface-Atmosphere Interactions. Dr. Jakosky also heads the University of Colorado effort in Astrobiology, as part of the larger NASA Astrobiology Institute initiative.

"We only have one example of life in the universe, and that is life on Earth," said Dr. Jakosky. "We have to start with what we know." By studying Earth, scientists have determined what a planet must have in order to support life: liquid (not necessarily water, but most probably); building-block elements (such as hydrogen, oxygen, nitrogen, and especially carbon); and an energy source (such as "sunlight" for photosynthesis or hydrothermal and chemical processes). "Pretty much any planet that meets those requirements will be able to support life," he added.

The fact that life on Earth exists under a multitude of conditions — inside hot springs, deep beneath the ocean, in the desert, in the arctic cold, and elsewhere — speaks to its adaptability. "More than anything else, that's one of the keys to suggest that life could be widespread," said the astrobiologist.

Armed with this information, scientists look at other locations in the universe to see if they have conditions amenable to life. An obvious candidate is Mars, Earth's nearest planetary neighbor. Photographic evidence shows that the Martian surface has been carved with tributary systems. Their similarity to the markings left by river systems on Earth lead geologists to believe that they were created by water rather than by some other kind of liquid such as molten rock. Mars also appears to have volcanoes, which would provide an energy source.

"Mars appears to meet all of the requirements we would place on a planet in order to support the origin of life or the existence of life," said Dr. Jakosky. "The question then becomes not can Mars sustain life but is there life there?"

The planet Earth itself provides potential evidence pertaining to this question in the form of meteorites, many of which have been discovered in Antarctica. Scientists confirmed that these meteorites are from Mars because gases within the rock are essentially identical to the Martian atmosphere.

Unfortunately, evidence of life in the rocks is ambiguous. "We're only going to find out by actually going to Mars, finding places where we think life could have existed, picking up rocks that we think will have that memory, and bringing them back to Earth for study," Dr. Jakosky said.

A second strong candidate for supporting life in our solar system is Europa, a satellite of Jupiter about the size of Earth's moon. The surface of Europa, composed of almost pure water ice, is cross-hatched with rifts that appear to have been tectonically formed, "suggesting there might have been or might still be a liquid ocean underneath the surface."

Outside of this solar system some 100 planets have been discovered. All of them are as large as, or larger than, Jupiter because the means to see smaller planets is not yet available. Scientists believe that some of these Jupiter-like planets may have Earth-like neighbors orbiting close to their sun. "If there are, there's the possibility that they might be able to support life."

Dr. Jakosky noted that the search for life elsewhere cannot be accomplished using the conventional scientific method of creating an experiment to test a hypothesis. Instead it calls for "historical science" and the construction of "historical narratives."

An example of historical science in astrobiology is the effort to understand the conditions on Earth at the time of the origin of life, in order to predict the kinds of conditions that could support life elsewhere. This can be pursued by examining fossils and the geological record.

Of course missions to Mars are hypothesis-driven, for example, a mission would collect atmospheric data in order to support or refute a hypothesis about Martian climate. But at the same time these ventures are exploration-driven: "We go there and we don't know what we're going to find."

Exploration for its own sake is invaluable, Dr. Jakosky asserted. "Every time we have sent a spacecraft to Mars, we have discovered that we're seeing a completely different planet." Two examples of recent unexpected discoveries include evidence of vast gullies and evidence that Mars has a liquid core.

He added, "It's an interesting contradiction that NASA and Congress require us to propose spacecraft missions that are going to address hypotheses, yet what they really value, what everybody really values, is the discovery."

Most questions in astrobiology don't have practical applications. Furthermore, the pace of astrobiological discovery is so fast that any important findings are quickly superceded. Findings merely open the door to more questions. For these reasons astrobiologists cannot pursue this line of work for the glory. So why do they do it? "The conclusion I draw is that we're not doing it for the specific knowledge; we're doing it for the act of exploring," said Dr. Jakosky.

"In essence I see exploring the world around us as no different from exploring the arts or exploring the humanities." Through this scientific pursuit "we are learning about who we are as a species, as a society; in essence, we're learning about what it means to be human."

Finding life elsewhere would be a “truly profound discovery,” he continued, “even a discovery of the most insignificant single-celled microbe.” It would be as profound as Copernicus’ proposal that the Earth was not the center of the universe or the discovery of Darwin that humans were not the center of all biology. “The discovery of life elsewhere would in some sense be the last thread of evidence to tell us that life is nothing special but just a particularly interesting example of planetary chemistry.”

The urge to explore is always in tension with the need to be practical and to justify research, especially in this era of tight budgets. Dr. Jakosky urged scientists to recognize their responsibility to engage the public in a dialogue about both the nature and the value of science, astrobiology in particular. “We have to do these things while continuing to do high quality science,” he concluded.

Commentary on the astrobiologist’s remarks was provided by Jim Miller, senior program associate in the DoSER program at AAAS who holds Ph.D. in theology with a focus on science and theology. Dr. Miller expanded on the theme of exploration, which he suggested has roots in pre-human life. Even single-celled organisms rove in their environment in search of nutrients, he noted. In that sense, exploration is for economic benefit. Early humans also explored for survival but in the act of exploration they found themselves in new situations that required creative adaptation.

“Beyond this there is this feature we find in many species, but is particularly well-honed in human beings,” said Dr. Miller. That feature is curiosity. Musing on the similarity between the words *wandering* and *wondering*, he noted, “This kind of curiosity is rooted in searching for the means of subsistence, but built upon that is this general wondering about what one encounters.”

Dr. Miller also offered a unified conception of experimental science and exploratory science. He suggested the term “extraordinary science,” first proposed by the science historian and philosopher Thomas Kuhn. Extraordinary science is ordinary experimental science that seeks understanding in contexts where the prevailing theory seems inadequate. In this light, the search for the origins and extent of life in the universe starts with the ordinary collection and testing of evidence on Earth but becomes extraordinary as the search moves off this planet.

Dr. Miller expanded upon Dr. Jakosky's reference to historical science by suggesting that research in every scientific discipline can be considered historical. "You have in most scientific accounts a way of exploring how a variety of causal relationships bear upon a particular phenomenon at a particular moment." The main difference is that the timeline of different sorts of "nested causes" may be on much shorter scales, he added.

Dr. Miller then broached the topic of the potential effect on religion of the search for life elsewhere. He asserted that this culture tends to think of science and religion as (in a phrase coined by Stephen Jay Gould) *non-overlapping magisteria:* matter, facts, and reason are completely distinct from spirit, values, and faith. Yet there has been emerging over the last several decades an alternative view in which these two spheres interact. According to this newer view, "these terms cannot be understood in isolation from one another at least not in their fullness; they need to be understood in terms of their relationships."

Dr. Miller described a circularity in which science produces a description of nature which then shapes and alters religious thinking; at the same time, religion bears a sensibility about the ultimate meaning of things which affects what is valued in science and how the science is conducted.

Because of this relationship, the scientific discovery of life elsewhere cannot help but touch religion. Dr. Miller described three ways in which this could happen. First, he echoed Dr. Jakosky's remarks that the discovery of extraterrestrial life would be another "decentering" revolution, at least for the Abrahamic religions (Judaism, Christianity and Islam) in which the material world is quite important and whose sacred texts are implicitly geocentric.

Second, if life is discovered elsewhere, it would add to the sense that life emerges from natural processes, undercutting the predominant religious conception of a supernatural impetus to life.

Third, religions may have an important role in overcoming the “reductionism” that necessarily occurs when complex phenomena are broken into component parts for scientific study. “The challenge is to put them [the parts] together to understand the whole,” Dr. Miller said this task may be assisted by a synergistic sensibility that is encouraged by some religious traditions.