Summary, "Searching for a Second Genesis of Life in our Solar System"
22 September 2005
DoSER Public Lecture
AAAS Auditorium
1200 New York Avenue, NW
Washington, DC

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Has life originated anywhere else in the universe besides on Earth? Scientists have sought to answer that question by transmitting radio signals into space and listening for signals back from space, in hopes of communicating with extraterrestrials. So far this has been without success. They have tried to create new forms of life in the laboratory, also so far without success. A third route is to go out in search of life elsewhere — in the near-term, on Mars or on Jupiter's moon, Europa. Such an approach could answer the question about a second genesis, a second origin of life independent of the Earth, within the next five to six years, if NASA funds such exploration and the exploration proves fruitful.

So said Christopher P. McKay at a September 22, 2005 lecture sponsored by the Dialogue on Science, Ethics, and Religion (DOSER), a program of the American Association for the Advancement of Science (AAAS). Dr. McKay is a planetary scientist with the Space Science Division of the National Aeronautics and Space Administration (NASA)-Ames Research Center. He has been actively involved in planning for future Mars missions including human settlements.

According to Dr. McKay, the search for other life in the solar system will test the Copernican principle, which stipulates that nothing is special about the human location in the universe. Any discovery of another example of life would probably enrich biology (which he called "probably the most practical and useful of all the sciences"), since all life on Earth essentially represents just one example, sharing as it does the same biochemistry and the same genetic structure.

Dr. McKay described the search technique as "operational" in that it involves determining what life as we know it needs to operate and then seeking locations in the solar system where such needs could be met. There are only a few criteria for life on Earth and "key in the list is liquid water, the defining ecological property for life. It's the one thing that no life forms can grow or reproduce without." Another essential criterion is an atmosphere with carbon and nitrogen. The NASA scientist acknowledged that there may be other sets of conditions that support life, but they are unknown; the search for Earthlike conditions is limited but practical.

Mars is the near-term target for several reasons. First, there are more spacecraft on or circling Mars than any other planet (These are NASA's two Mars-orbiting

spacecraft, the Surveyor and the Odyssey; its twin terrestrial robotic explorers, the Rovers; and the fist non-U.S. mission to succeed on Mars, the European Space Agency's Mars Express). Secondly, Mars appears to have conditions conducive to life, including evidence of past liquid water and a former atmosphere with the essential elements. Third, it has the potential to preserve evidence of the life it once had.

Venus also may have once had liquid water and an atmosphere containing carbon and nitrogen, but because of its violent geologic activity and superheated sulfuric atmosphere "it's hard to imagine where evidence of its early life might still be preserved," Dr. McKay pointed out. "Mars by contrast has been placed in cold vacuum storage." After Mars, Europa is the next plausible target.

From previous spacecraft missions to Mars, scientists know that there is water on the planet now, preserved as ice. The channels evident on the surface appear to have been created by water. Furthermore, the Rovers have provided analysis of the soil that shows salt deposits consistent with water. Though the planet has probably never been warm by Earth standards, "the point is that it had liquid water, and water is what matters for life, not temperature."

Mars is too small to have retained the atmosphere it once had. "It's one tenth the mass of the earth," explained McKay. "As a result of that, there's no plate tectonics, no recycling of the carbonates, no completion of the long term geochemical carbon cycle, less gravity." One implication is that if Mars had been the size of the Earth it would still be habitable today. Conversely, if Earth were the size of Mars it would not be habitable today. "Size matters," he said.

The NASA scientist emphasized that compelling evidence for "a second genesis" may not come from fossils that might be discovered on Mars, because those fossils could represent life that originated on Earth. There are many extant samples of Martian rock that traveled through space and landed on Earth as meteorites. Scientists have demonstrated that the temperature inside such rock during space transit would not be high enough to kill organisms that might be dormant inside. Thus it is theoretically possible that Martian microbes traveling on space rock populated Earth, or vice versa — that they stem from the same genesis.

Dr. McKay thus described the search as a "crime scene investigation. We want to find evidence of life, but fossils won't work; we need corpses." The best location for such corpses, according to McKay, is in the permafrost on Mars. "And that's the place where we can design a mission right now to do the job." NASA is considering just such a proposal submitted by Dr. McKay and colleagues.

Evidence from Earth helps point to the Martian polar regions as the most promising places to look. Cores drawn from the Siberian permafrost that are 3.5

million years old have been found to contain bacteria. In Antarctica, there may be ice that is 8 million years old. On Mars, the southern polar region may contain ice-rich permafrost 3 to 4 billion years old.

In all likelihood any microbes found in deep-buried ice would no longer be alive, due both to thermal decay and exposure to millions of years of accumulated radiation. However, the preserved samples could be quite revealing scientifically. "Dead is fine," Dr. McKay said.

If organic material is recovered from Mars, the question then arises, how do we know it was once alive? It will not display the most obvious property of life, which is activity. If it shares a common ancestor with Earthly life, various tests can be conducted such as amplifying the DNA or analyzing for the presence of ATP, a molecule that provides energy to cells. "But that's the case that's not interesting," asserted the NASA scientist. "We need to develop a more general way to search for life."

Dr. McKay suggested a technique based on the Lego principle. "This is based on the rather mundane observation that biology is built up of a small number of components," he explained. For Earthly life, those components include such things as the proteins, the nucleic acids, and the polysaccharides. All organisms on Earth are built from these same units, used "over and over again like a LEGO kit." Life that is the result of a separate genesis from Earthly life probably will also be constructed from a set of units, but perhaps a different set, just as there are more than one kind of children's construction toys — Lincoln Logs, for example, in addition to LEGOS.

Dr. McKay noted the ethical concern that exploration of Mars might contaminate it before its own potential for life has been determined. "It would be bad if we had to admit that in our first step out into the universe we came across alien life form and we killed it," he said. On the surface of the planet, contamination is not a problem, because the absence of an atmosphere makes ultraviolet light deadly. Thus, it is not essential to sterilize equipment or people if they stay on the surface, since any introduced organisms would die or survive only in dormant form in protected areas. In addition, contaminated pieces or surface areas could be removed. On the other hand, anything that penetrated the surface would have to be completely sterilized to avoid contamination. Dr. McKay termed it "biologically reversible exploration" and noted that it was a more cost-effective way of doing space research than trying to achieve absolute sterility.

Why is it important to avoid contamination and — by extension — to consider the possibility of reviving indigenous Martian life by modifying the current environment there? "One approach is to say [there are] fundamental ethical principles related to the value of life and the diversity of life," Dr. McKay explained. "But even if you have no ethics, even if you take a purely utilitarian point of view, studying a second genesis and a second biosphere might be much

more valuable than not." And one could argue that "restoring life to a dead biosphere is a worthy goal for a space-faring people," he added.

Following Dr. McKay's remarks, Rabbi Nancy Fuchs-Kreimer, Ph.D., described the various theological questions that stem from the search for a second genesis. Dr. Fuchs-Kreimer is Associate Professor of Religious Studies and Director of the Religious Studies Program and Reconstructionist Rabbinical College outside Philadelphia.

On the subject of extraterrestrial life as on all subjects, she said, "Jewish thinking often goes toward the practical, toward practice here and now." She gave two examples of questions that Jewish thinkers have raised. Since Jewish holidays are defined by astronomical cycles, how would a Jew living on Mars know when the Sabbath is or when to bless the new moon? And how many are needed for a prayer group (traditionally ten men) if Martians have two heads? (The answer depends on whether each head operates independently). Dr. Fuchs-Kreimer emphasized that while these questions seem silly, "they are a way to get at bigger philosophical ideas."

Christians also have their theological questions, she noted. For example, C. S. Lewis wondered whether, if life on Mars is found to exist in a separate descent from Adam and Eve, would such beings be without sin? Would they be covered by the redemption of Jesus or need a separate redeemer? In such instances, would a Christian be obligated to evangelize them?

The rabbi said that in her opinion — and in the opinion of the few other Jewish scholars whose opinions on such matters she had been able to find — the Jewish faith would not be fundamentally challenged by the discovery of life elsewhere in the universe. "Jewish religion is not dependent on having a cosmology separate from the science of the day," she said, adding that throughout Jewish history, interpretations of the faith have drawn upon the science of the time. Furthermore, Judaism traditionally has not adopted a literal reading of scripture. "Are there worlds beyond ours, life beyond ours, a second genesis? The Jewish answer to the scientist is: if you say so!

"Our God is big enough to encompass it all. God can create more worlds; God is not diminished by learning more about what God wrought. The primary Jewish theological position is that God is in charge of it all. Whatever you find, God will grow as big as we need God to be for the information you bring us."

Dr. Fuchs-Kreimer noted that the Jewish prayer book and the Midrash (classical rabbinic biblical interpretation) both make references to God creating many worlds before Earth. Therefore, the idea of multiple worlds is not outside Jewish thought. Instead, "the real crux of the matter for Jewish theology is the place of human beings in it all." In Jewish thought, humans are central: "Man is the *telos*, the purpose for everything." And so the question of life beyond this world really

moves to the question of “is the whole universe actually centered around this species we call human beings? Is this species lifted up from nature in some special way?”

Such a question does not emerge simply from considering the possibility of alien life, she pointed out. “It also comes up as we learn more about animals and the qualitative rather than quantitative distinction between humans and the animal world.”

This line of inquiry also leads to a reexamination of the traditional Jewish concept of Jews as God’s chosen people. Noting that she herself comes from the Reconstructionist tradition that has rejected this notion, Dr. Fuchs-Kreimer said that there is a connection between the concept of a chosen people (found in many cultures) and the concept of a chosen species. “As we grow in our understanding of life in the universe, we become more humble, we Jews, about our place in the human family,” she said. “I’m not sure that we lose that much.”

In a lively question and answer session, Dr. McKay was asked to define life. The scientist answered that one possible response is to say that life is a system that undergoes Darwinian evolution: reproduction, selection, and mutation leading to further reproduction. “I think that’s probably the best definition… It may be that in the end even after we’ve found many variations of life, we still don’t have a simple closed form definition for it, in the same way we don’t have a simple closed form definition for fire.”

Another questioner wanted to know if it is possible that life could originate more than once in a location; for example, does life continue to originate on Earth? Dr. McKay responded that such a phenomenon is possible, and offered two explanations for why we have not yet discovered new successions of life if they have in fact occurred. It could be that existing life dominates all the resources so that subsequent life cannot get a foothold: “that life itself becomes inconsistent with further life.” Or it could be that life continues to originate but we have not developed the means to recognize it. “We’ve come up with sophisticated means for detecting ourselves, but if one in a million bacteria is alien and represents a second genesis, that would be very difficult to detect.” Such a question emphasizes the problem of having only one example of life from which to draw inferences, he added.

Also in answer to questions, Dr. McKay speculated on the various findings that could emerge from the search for life. If the same form of life is discovered on Earth and Mars, it could be that the genesis is somewhere else completely different. This would point toward a “galactic ecology, maybe even from star to star. You can move a long way in 100 million years.”

Anther possibility is that we will discover one set of building blocks used in all life, a “global optimum” that results wherever life is able to evolve. “This question won’t be answered theoretically, it will be answered empirically.”

Yet another possibility is that a search for life on Mars turns up nothing. “If we go to Mars and find that it is dead as a doornail, maybe the Copernican principle isn’t right, maybe there is something cosmically special about life on earth. It would give us pause, to think that maybe this is the only spark of life and we are the only carriers.

“I would find it interesting if we find that Mars had all the requirements for life and yet it didn’t originate there. It would say to me that we don’t understand something about life.”