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Reconsidering the Theological and Ethical Implications of Extraterrestrial Life

Richard O. Randolph, Margaret S. Race, and Christopher P. McKay

Introduction

As we stand on the threshold of a new millennium, we also find ourselves at the brink of a new and exciting era in space exploration. In fact, this new era has already begun, with the successful landing and exploration of Mars by the Pathfinder mission in July 1997. Pathfinder represents an important scientific accomplishment for NASA because it demonstrated the agency's ability to successfully explore space at a relatively modest price. At the same time, Pathfinder revealed once again the genuine interest and fascination that people all over planet Earth have for space exploration.[1]

The Pathfinder mission is just one of several recent events—both scientific and cultural—that reveal this deep and almost unquenchable curiosity about space—and the possibility that there is life "out there." In August 1996, the public was captivated with NASA's announcement that a meteorite from Mars may contain evidence of early microscopic life. Shortly after the NASA announcement, media coverage of the discovery—and public discourse concerning the discovery—turned to an examination of the theological implications of evidence for extraterrestrial, albeit unintelligent, life.[2] To a lesser extent, public reaction to the Hale-Bopp comet in the Spring of 1996 is also suggestive of many persons' deep passion to know more about space.

If anything, cultural events reveal this passion in greater relief. Popular culture, at least in the West, is permeated with claims of UFO sightings, visits from extraterrestrials, and "alien abductions." At the same time that NASA was triumphantly landing Pathfinder on Mars, thousands of people were converging on Roswell, New Mexico to commemorate the fiftieth anniversary of the "Roswell incident," where the U. S. Government is alleged to have covered up the crash of an alien spaceship. Popular culture is also replete with books, television shows, and movies that explore the possibility of contact with extraterrestrial life. In addition to the popularity of television shows such as *The X-Files*, the significance of this cultural phenomena was demonstrated in the Summer of 1997 with the long-anticipated release of the movie, *Contact*, based upon a science fiction novel by Carl Sagan. Despite mediocre reviews, *Contact* played to large audiences.[3]

Margaret Race is the Principal Investigator of a research grant on Planetary Protection at NASA Ames Research Center, and has published numerous essays concerning the issues surrounding both forward and back contamination in space exploration. She received her Ph.D. in Zoology from the University of California at Berkeley, where she has also been a frequent guest lecturer.

Chris McKay is a Research Scientist at the NASA Ames Research Center. He received his Ph.D. from the University of Colorado in Astro-Geophysics. Research projects have taken Dr. McKay to a wide diversity of ecosystems on planet Earth, including the antarctic and arctic regions, as well as the Gobi Desert of Mongolia, the Negev Desert, and the Atacoma Desert in Chile. He has to his credit a long list of publications, including "Does Mars Have Rights? An Approach to the Environmental Ethics of Planetary Engineering," in Moral Expertise *(Routledge, 1990), edited by Don MacNiven.*

Richard Randolph is Editor of the CTNS Bulletin *and Program Director at the Center for Theology and the Natural Sciences in Berkeley.*

Much of the passionate interest in space exploration and the possibility of extraterrestrial life comes because of their connection with a question that is foundational for human experience: Are we alone in the universe? This question has profound theological implications—especially for the three monotheistic traditions of the world. Understandably, discussion of this fundamental question often centers around discussions of encountering intelligent extraterrestrials.[4] While it is possible that some day we may encounter intelligent extraterrestrial life, the more likely scenario in our lifetimes is that our first encounter will be with non-intelligent life-forms.

The recent Pathfinder mission to Mars was only the first in an ambitious series of NASA missions planned for exploration of Mars, Earth's nearest planetary neighbor where extraterrestrial life is a real possibility. In March 1998, the next step in this exploration takes place, when the Mars Global Surveyor—which is already in orbit around Mars—begins photographing and mapping the Martian surface. NASA plans to continue its exploration with additional landers and orbiters taking off for Mars every 26 months, when the paths of Mars and Earth bring them in closer proximity. By the year 2005, NASA hopes to launch a mission that will return martian samples to Earth. And, as early as 2011, astronauts could be rocketing from Earth for the first human landing on the Red Planet. In the distant future, there may be even more grandiose plans, including the possibility of engineering an atmosphere on Mars that could support biological life.

Are we alone in the universe?

These ambitious exploration plans have implications that go beyond the theological concerns usually touched upon in discussions about extraterrestrial intelligent life. In particular they raise important, additional ethical questions regarding cross-contamination of the planets and future long-term decisions about planetary engineering on a large scale. In this essay, we want to look more closely at these issues by discussing the search for extraterrestrial life through continued exploration of Mars. Our hope is that by providing scientific and technical details in several key areas, we will highlight important ethical and theological concerns associated with the search for primitive extraterrestrial life, thus stimulating consideration and discussion of some previously overlooked topics. In light of our advancing capabilities to explore far beyond Earth, it is prudent to consider not only the way we undertake exploration but also the implications of maintaining repeated future contacts or planning deliberate, invasive activities on extraterrestrial bodies where life may be discovered.

Two Methods in The Search for Extraterrestrial Life

The current search for extraterrestrial life actually encompasses two distinct endeavors—the search within our galaxy for *extraterrestrial intelligence* (SETI) and the search within our solar system for evidence of the origin and evolution of primitive, *non-intelligent life* (exobiology). These two efforts differ in several important ways. Not only are there significant differences in the scientific expectations about the nature of life between SETI and exobiological exploration, there are major differences in the type of incoming data anticipated and in the technological methods of exploration.

Most people are probably familiar with the SETI approach to searching for intelligent extraterrestrial life. This research is centered around the use of radio telescopes to listen for signals coming from distant locations in our galaxy. If and when signals are received and verified, they would be interpreted as evidence of technologically advanced beings elsewhere in the Universe. In practical terms, this search method relies on the construction and operation of radio telescopes and the interpretation of incoming signals, rather than on spacecraft, missions, or direct contact with the extraterrestrial life under study. Because searches conducted by SETI are entirely through indirect, non-intrusive methods, there are no environmental impacts or planetary cross-contamination concerns involved, either on Earth or in space.

By contrast, exobiological research—the search for evidence of non-intelligent extraterrestrial life—is based on more direct methods of exploration. NASA's current exploration strategy for our solar system seeks to answer questions about the origin and evolution of life via an ongoing series of one-way robotic missions to nearby planets and celestial bodies. These missions will be followed in the not too distant future by round-trip missions that return extraterrestrial materials to Earth. Rather than just listening to radio signals, researchers are able to collect data and measurements, perform experiments, and even gather samples from extraterrestrial locations via remotely operated scientific equipment on board orbiting or landing spacecraft. Depending on the mission and its objectives, scientists can accumulate direct and indirect data on the presence or absence of life, either living or fossilized. They can also gather site-specific chemical and environmental information that allows for comparisons with analogous environments on Earth—or with conditions considered essential for living systems in general. By their very nature, these exploration missions are intrusive, raising questions about environmental impacts and planetary cross-contamination both on Earth and on those celestial bodies visited.

Science and Mars Exploration

Our interests in searching for primitive extraterrestrial life on Mars are the natural outgrowth of what we already know about the Red Planet. On the surface of Mars there are large river valleys and drainage networks. Although dry at the present time, these features are direct evidence that at one time Mars had liquid water on its surface.[5] The majority of these fluvial features occur in areas of Mars that have a high density of impact craters. The high crater density indicates that these surfaces—and hence the period of water flow—date back to the final stages in the formation of the planets, about 3.8 Gyr (billion years) ago.

The biological importance of the timing of water on Mars becomes clear when we compare the early Mars to the early Earth.[6] On Earth, there is convincing evidence for life-forms, including photosynthetic ones, present at 3.5 Gyr ago and there is good chemical evidence—in the form of carbon isotopes—for photosynthetic life present at 3.9 Gyr ago. Thus, on the geological time-scale, life appeared rapidly on the early Earth.

The observation that Mars and Earth were similar in that both had liquid water at a time when life first appeared on Earth naturally opens the question of life on early Mars. Although science does not yet have a consensus theory, all hypotheses put forward for the origin of life on Earth would imply that if Mars did have an Earth-like environment early in its history, then life should have arisen on Mars as well.[7]

Unfortunately, the conditions at the surface of Mars became such that liquid water was no longer stable and hence life could not persist. Any life that currently persists on Mars must do so in subsurface refugia. Although the Viking Missions to Mars in 1976 did search for active life-forms on the surface, the current scientific focus is a search for microscopic fossils.

As important as finding fossils on Mars would be, it is not enough in the search for martian life. Fossils will tell us that there was life on Mars, but they cannot address the essential question: Was there a second genesis on Mars, or was life there the same as life here on Earth? The possibility that life on Mars could be identical to life on Earth arises from two fairly recent developments in science. First, we know that all known life-forms on the earth today are biochemically similar and phylogenetically related. In other words, all life on Earth has DNA and relationships between different organisms can be demonstrated by comparing their genes using sophisticated laboratory tests. Second, we now know that large amounts of geological material can be exchanged between the planets in the forms of meteorites and asteroids. For example, there are twelve rocky meteorites that are known to have been ejected from Mars and landed on Earth long ago.[8] It is also possible that rocks could have traveled from Earth to Mars. Furthermore, during the end of the formation of the planets, 3.8 Gyr ago, the rate of impact was orders of magnitude higher than at present. Thus, at the very time that Mars had liquid water on its surface, and Earth had the first evidence for life, the two planets were exchanging considerable material, and probably life as well. Earth and Mars were not—and are not now—biologically isolated with respect to microorganisms, any more than the continents of the present Earth are isolated with respect to microorganisms. Thus, it is entirely possible that fossils on Mars may merely represent evidence of a life-form common to both Earth and Mars. To determine if martian life was biochemically distinct from life on Earth will require access to the biochemical components of a martian organism—dead or alive. Such biochemical material may be found alive in subsurface habitats or, more likely, frozen and dead in permafrost of the southern polar regions. Just as fossils and evidence of life can be found in rock samples on Earth, so too will we search for them on Mars.

Was there a second genesis on Mars, or was life there the same as life on Earth?

Both the scientific and ethical implications of finding life on Mars are much more vast if that life-form represents a second and independent genesis of life. A comparison of the biochemistry and genetics of another life-form to the biochemistry and genetics of life on Earth could allow us to begin developing a broader theory of life. The existence of a second life-form would also strongly support the suggestion that life is commonplace throughout the galaxy if Earth-like planets are present. From an ethical point of view, the need to preserve a life-form, however lowly, must be more compelling if that life form represents a unique life-form with an evolutionary history and origin distinct from all other manifestations of life.

Contamination Controls During Exploration of Mars

Since the early years of the space program, there has been concern about planetary protection; that is, the prevention of harmful cross-contamination between planets and other solar system bodies during space exploration. The Outer Space Treaty of 1967, requires that exploration of celestial bodies and studies of outer space must be done "so as to avoid their harmful contamination and also adverse changes in the environment of the Earth resulting from introduction of extraterrestrial matter."[9] In practical terms, the concerns are twofold: the avoidance of *forward contamination*, the introduction onto a planetary body of terrestrial microbes carried on outbound spacecraft or equipment; and *back contamination*, the introduction onto Earth of contamination or life-forms carried on a returning spacecraft or in returned soils or samples.

The risk is not zero, any samples returned from Mars by spacecraft must be . . . treated as though potentially hazardous until proven otherwise.

As applied to exploration of Mars, all one-way spacecraft that will orbit or land on the planet are intensively prepared prior to launch to prevent forward contamination. Depending on the mission, a variety of elaborate procedures are used such as cleanroom assembly of the spacecraft, sterilization of landing spacecraft, special planning for orbital lifetimes to avoid premature impact on the planet, and heat treatment or special packaging of scientific instruments to further reduce the bioload or number of microbes on the outbound spacecraft. Current forward contamination policies and controls are based on the prevailing scientific view that the probability of terrestrial organisms surviving and growing in the harsh martian environment is extremely low, as is the probability of martian life occurring in the surface layers of the planet. Thus, terrestrial contamination is not considered a significant hazard to the martian environment, but rather a potential problem for scientific experiments.[10] The main concern is that if terrestrial contaminants or microbes are inadvertently deposited by an arriving spacecraft, they could lead to false positives or incorrect information in subsequent life-detection experiments. From one perspective, current forward contamination controls may serve to protect the on-board science payload and in doing so, they indirectly protect the local martian environment because of the strict cleanliness standards applied.

Not surprisingly, concerns about contamination for a round-trip Mars sample return mission in 2005 are more complicated. Current back contamination policies are based on the prevailing scientific view that the potential is extremely low for large-scale ecological or pathogenic effects on Earth from any replicating martian organisms that might be contained in the sample. However, because the risk is not zero, any samples returned from Mars by spacecraft must be strictly contained and treated as though potentially hazardous until proven otherwise.[11] As with the return of lunar samples during the Apollo program, both forward and back contamination control measures will be imposed on the mission. In addition to requiring extensive cleaning as well as contamination avoidance on the outbound spacecraft, designs for the return portion of the mission will require a fail-safe, durable container that can be remotely sealed, cleanly separated from Mars, monitored en route, and opened in an appropriate research facility on Earth. No samples may be released from quarantine or containment until they are certified as non-hazardous using a rigorous battery of life detection and biohazard tests. Although the likelihood of releasing and spreading a contained living organism may be low, special equipment, personnel, handling, and accident avoidance are warranted to minimize exposure and possible harmful effects, should a life-form be discovered. The rationale behind these elaborate back contamination measures is similar to the need for environmental, health, and safety measures on Earth when transporting or handling infectious agents or importing non-native organisms to new areas.

Because of these contamination concerns, it is appropriate that decisions about Mars sample return and handling on Earth consider the ethically acceptable levels of risk posed by the importation and handling of potential extraterrestrial organisms on Earth. It is likewise appropriate to consider *who* will be involved in making decisions about these risks and how the scientific uncertainty will be handled during deliberations and planning. Although unique because of their extraterrestrial nature, the concerns and questions about Mars sample return are actually quite similar to those encountered during the 1970s and 1980s by ethicists debating the implications of genetic engineering. Should scientific exploration proceed in the face of potentially novel life-forms and scientific uncertainty? Are current handling procedures adequate to safeguard Earth and its inhabitants? Would a mistake be irreversible? Are government officials broadly focused in their framing of the benefits and costs of an experiment with potentially global repercussions? Fortunately, there will be ample opportunity to debate the anticipated risks of Mars sample return along with the practical and ethical implications. Information about mission plans, risk analyses, and decisions on sample handling will be made available to the public through the environmental impact statement and other required government reviews. It will be important that ethicists are among those who are involved in the deliberations of such a momentous proposal. The prospect of discovering life elsewhere and transporting it to our home planet deserves thorough analysis and consideration.

If and when extraterrestrial life is discovered and verified on Mars, there are some additional ethical concerns that go beyond those discussed above. Obviously, it would be necessary to review back contamination controls to ensure their adequacy in protecting Earth and its inhabitants from harmful effects. However, forward contamination concerns would take on added significance in ways not previously considered. If the newly discovered life-form is unique to Mars or dramatically dissimilar from life as we know it, it would be prudent to reconsider whether future exploration can be done in a way that doesn't interfere with the continued existence or evolution of martian life. It might also be necessary to reconsider whether the subsequent handling on Earth of extraterrestrial organisms is even warranted. Finally, looking ahead to the distant future with the potential for large-scale human colonies and activities on Mars, it would be appropriate to consider the ethical implications of deliberate actions that would contaminate and possibly change forever the environment on our nearest planetary neighbor. These latter concerns are especially relevant in light of the long-term prospects for future planetary engineering described below.

Resuscitating Mars

If Mars did once have liquid water, a thicker atmosphere, and possibly a biosphere, it is interesting to consider if Mars might once again be made habitable. Of all the planets in the solar systems beyond Earth, Mars is the only one that can be made habitable using current or near-term technologies.[12] Indeed, the fundamental challenge in making Mars habitable is to warm it up from its present mean temperature of -60ºC to temperatures warm enough to drive out the carbon dioxide frozen into the polar caps and absorbed into the soil. Aided by the carbon dioxide greenhouse effect, the temperatures will then rise high enough that water can exist as a liquid on the surface of Mars once more. Warming planets is a technology that humans have mastered and, in fact, are exercising, unwisely, on the earth. The warming is accomplished by the release into the atmosphere of so-called super greenhouse gases such as freon. These gases are often thousands of times more effective than carbon dioxide at holding in the earth's thermal energy. Calculations indicate that if a judicious combination of these gases were produced in the martian atmosphere at levels of 1 part per million (ppm), then sufficient warming would result for Mars to be habitable for plants and microorganisms. While the atmosphere would not be breathable for most animals and humans due to the virtual absence of oxygen, the red planet would have become the green planet and a second home for life.

We note here that most studies of terraforming Mars—as the above process is called—do assume that there is no life on Mars at present or that any life present is merely a collection of bacteria originally derived from Earth. If there is a unique life on Mars, then the alteration of the environment to enhance the survival of that life-form could be the focus of terraforming. Clearly replacing that martian life-form, however lowly, with life from Earth represents a new extreme in biological interference.

Ethical Implications of Terraforming Mars

If it is possible to alter Mars and restore it to a habitable state with a planetary-scale biosphere, should we do so? It is interesting to pursue this as a question in environmental ethics but this runs into trouble immediately. The entire field of environmental ethics has been developed with Earth as the subject. On Earth, nature and life are—for all intents and purposes—equivalent. Thus a reverence for nature "free from the taint of our arrogance" is the same as a reverence for life as a phenomenon of intrinsic value. This is not so on Mars where nature is merely a collection of lifeless—although magnificent in their own right—rocks and dirt. Thus, we face on Mars a new choice: between nature and life; between Mars as a lifeless world and Mars with life.

To assist in making such a choice it is useful to try to determine normative axioms of environmental ethics. In other words, it is helpful to define the philosophical basis for human choices with respect to the environment.[13] The axioms we describe are not meant to represent the perspectives of any individual or group. Indeed many writers in environmental ethics express views that are some combination of these axioms we present. The purpose of this analysis is not to categorize points of view regarding the environment but to decompose such views into parts that are logically separable. The three basic approaches to environmental ethics that we define are:

1. **Preservation**, the belief that human action in nature should be minimized
2. **Stewardship**, the principle that humans must use nature wisely for their own benefit
3. **Intrinsic Worth**, the supposition that there exists a class of objects that have intrinsic worth regardless of their utility or relationship to humans

We can consider the implications of each of these approaches to the ethics of terraforming Mars. From the perspective of *Preservation,* there is an imperative to leave Mars unaltered; to neither enhance its environment for the indigenous biology, if any, nor to introduce life from Earth. By contrast, *Stewardship* would imply that the broad scientific and economic advantages from having a second planetary-scale biosphere would justify planetary alteration. The most difficult case to consider is that of *Intrinsic Worth.* If the class of objects that is deemed to have intrinsic worth is all of life and life only, then this position could lead to an argument for introducing life on Mars. If, however, the class of objects deemed to have intrinsic worth is taken as all natural objects—living as well as non-living—then this point of view would lead to conclusions similar to those arrived at with the *Preservation* approach.

Of course, as noted above, most environmental ethicists express views that contain some combination of these perspectives. As we have implied, one could take the "intrinsic worth" view that the natural attributes of Mars, that is, the rocks and dirt, have value in and of themselves. This view, when combined with the "preservation" perspective, would lead to the position that terraforming Mars is unethical. Conversely, one could take an alternative "intrinsic worth" view that restricts worth to biological life alone. Such a view, when combined with the "stewardship" perspective, would lead to the counter-position that terraforming Mars is ethical. Indeed, terraforming Mars could be obligatory, if it would promote the flourishing of some—as yet undiscovered—life-form indigenous to Mars. One could imagine additional combinations of these three normative axioms, as well.

There are also theological bases within the Christian tradition . . . that can be applied to Mars.

There are also theological bases within the Christian tradition for human action in the environment that can be applied to Mars. The argument, that humans are separate from nature, and that humans are endowed by God with special purpose and dominion, has been criticized as a contributing cause of environmental disrespect.[14] Human separateness from nature would suggest that to spread life from Earth to Mars is of trivial importance since the true purpose of human existence lies outside of the natural world. An alternative view within Christian tradition is the notion of co-creators. Matthew Fox traces back to Hildegard of Bingen (1098-1179) notions that "Humankind alone is called to assist God. Humankind is called to co-create. . . . God created humankind so that humans might cultivate the earthly and thereby create the heavenly. . . . [H]umans have the vocation of creation."[15]

Among contemporary Christian thinkers, Phil Hefner has also developed the co-creator theme quite extensively. Hefner prefers the term, "created co-creators," because it acknowledges that the human-divine partnership is not one of equals. By identifying humans as *created*, Hefner notes that within conventional Christian views, humans are finite and contingent, while God is infinite. Yet, despite their finite contingency, humans are still called to be partners in creation with God.[16] In a discussion of modern science, Dufner and Russell also see a role for continued creation in nature. They state that the "theme of *creatio continua* reflects the continued creative participation of God through the openness of creation."[17] If creation is interpreted not as a process that was completed in ancient times but as an ongoing activity in which humans can serve a constructive and beneficent role, then the spreading and encouraging of life—the quintessence of creation—could be viewed positively.

While deliberate alteration of the environment of Mars may be decades away, it might still prove useful to begin the ethical and theological discussion today. These issues will require careful reflection and, even more valuably, it may help us see our own environmental issues more clearly from this distant perspective.

Conclusion

We stand on the brink of an exciting era in space exploration. The alluring promise of exploration is reflected in our cultural fascination with the possibility of discovering extraterrestrial life. The prospect of finding intelligent extraterrestrial life somewhere in the universe inevitably raises questions which go to the very core of human existence: Are we alone in the universe? If we are not alone, what are the implications for our self-understanding as humans? What are the religious and theological implications for the world's religions, particularly the three Western, monotheistic traditions which posit a Creator-God?[18]

The prospect of discovering non-intelligent life somewhere in our solar system is also exciting. Unfortunately, in our rush to consider the implications of intelligent extraterrestrial life, we risk overlooking important ethical and theological questions associated with exploration for primitive or non-intelligent life forms. This kind of exploration, conducted closer to our home planet, raises some important questions concerning responsible human exploration of space. In this essay, we have examined two of the most pressing issues in this regard. The first issue concerns back contamination of Earth. How do we determine an ethically acceptable level of risk when returning samples to Earth from Mars and other places within our solar system?

The second issue concerns the obligations which we owe to planets and other extraterrestrial bodies.[19] Specifically, should we pursue terraforming, or planetary engineering, in which we attempt to create an atmosphere more hospitable to biological life as we know it? This issue has two dimensions. The first concerns our ethical obligations to non-intelligent extraterrestrial life, if and when we discover it through space exploration. There is currently no NASA policy, or international protocol, for the proper handling of non-intelligent extraterrestrial life. We believe that such a policy should be developed now, before these discoveries are made. Such a policy would be informed by an ethical analysis concerning our obligations as space explorers.[20] The second dimension to this issue concerns what obligations, if any, we owe to an extraterrestrial setting where there are no biological life-forms. In other words, if there is no biological life on Mars, do we still have a moral obligation to refrain from significantly altering the martian environment? The core issue here is the question of ethical obligations owed to the non-biological entities, such as rocks and dirt, that comprise, perhaps exclusively, the martian "ecosystem."

What is ethically responsible space exploration?

Although the issues described in this essay are very diverse, they do share a common ethical denominator. As we embark upon a new and exciting era, what is ethically responsible space exploration? While it remains to be seen, we suspect that the prevailing anthropocentric, or even geocentric, ethical perspectives will be inadequate for the questions outlined in this essay, as well as others sure to be raised by continued space exploration. We believe that a *cosmocentric* ethic will be required.

Our intent in this essay was not to develop such a cosmocentric ethic *per se*. Rather, we have attempted to frame some of the relevant issues, in the hope of provoking careful reflection and discussion in the future.

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[1] In the United States, this widespread interest in the Pathfinder mission was reflected by extensive media coverage. See, for example, Sharon Begley, "Greetings from Mars," *Newsweek*, 14 July 1997 (23-29); Leon Jaroff, "Rock Festival on Mars," *Time,* 21 July 1997 (54-56); William J. Cook, "A Drive on the Red Planet," *U.S. News and World Report,* 7 July 1997 (65-69); and William J. Cook, "An Accessible Planet," *U.S. News and World Report,* 21 July 1997 (47-48).

[2] For an insightful examination of the theological implications raised by the NASA discovery, as well as a thoughtful analysis of the public response to these theological implications, see Christopher J. Corbally, S.J., "Religious Implications from the Possibility of Ancient Martian Life," a paper presented at the Annual Meeting of the American Association for the Advancement of Science, in Seattle, Washington, February 13-18, 1997. (This paper is also available on the internet at "www.aaas.org/spp/dspp/dbsr/resource/corbally.html".)

[3] Of course, part of the commercial success of *Contact* could be attributed to the fact that it was wisely released just after NASA's successful Pathfinder mission. A second movie released earlier in the summer of 1997 was the spoof, *Men in Black*. Illustrative of the poor reviews that *Contact* received are: Anthony Lane, "Spaced Out," *The New Yorker,* July 21, 1997 (81-82); David Ansen, "Do You Hear What I Hear?" *Newsweek,* 21 July 1997 (68); and Richard Schickel, "Mission: Predictable," *Time,* 21 July 1997 (69).

[4] For a careful and thoughtful examination of religious speculation concerning extraterrestrial life, see Ted Peters, "Exo-Theology: Speculations on Extra-Terrestrial Life," *CTNS Bulletin* 14, no. 3 (summer 1994): 1-9.

[5] There is direct evidence for large features on Mars that are due to the flow of a low viscosity liquid. See M. H. Carr, *The Surface of Mars* (New Haven: Yale University Press, 1981). Although other liquids have been suggested there is broad agreement that liquid water was the agent of erosion.

[6] C. P. McKay, "The Search for Life on Mars," *Origins of Life and Evolution for the Biosphere* 17 (1997), 263-289.

[7] W. L. Davis and C. P. McKay, "Origins of Life: A Comparison of Theories and Application to Mars," *Origins Life Evolutionary Biosphere* 26 (1996), 61-73.

[8] The twelve meteorites are known to come from a common parent body because of the characteristic ratios of the oxygen isotopes in the silicates. Gas bubbles in one of the meteorites contains gases identical to those measured on Mars by Viking, indicating that this meteorite and—by inference—all twelve come from Mars.

[9] United Nations Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies. U.N. Doc. A/RES/2222(XXI); TIAS No. 6347, New York, USA. January 1967.

[10] Space Studies Board (SSB), National Research Council. "Biological Contamination of Mars: Issues and Recommendations" (Washington, DC: National Academy Press, 1992).

[11] Space Studies Board (SSB), National Research Council. "Mars Sample Return: Issues and Recommendations" (Washington, DC: National Academy Press, 1997).

[12] Serious studies of planetary engineering on Mars have appeared in the leading technical journals. See C. P. McKay, O. B. Toon, and J. F. Kasting, "Making Mars Habitable," *Nature* 352 (1991), 489-496.

[13] Our approach parallels that of C. P. McKay, "Does Mars Have Rights? An Approach to the Environmental Ethics of Planetary Engineering," in *Moral Expertise,* ed. D. MacNiven,

(New York: Routledge, 1990), 184-197. One difference is that what McKay refers to as anti-humanism we refer to as "Preservation." This broadens the idea to include approaches that restrict human-induced change but do so not from an antipathy to human action. For example, Eugene C. Hargrove in *Foundations of Environmental Ethics* (Denton, Texas: Environmental Ethics Books, 1996) presents an argument that Nature can be compared to a work of art. In this way, "existence is not simply an arbitrary ingredient in states of affairs in the world but is rather a positive value in its own right." This notion that what is, is what ought to be—long rejected in applications to political and social thought—has strong current in environmentalism and finds a voice in Alexander Pope's verse:

All nature is but art, unknown to thee;
All chance, direction, which thou canst not see;
All discord, harmony not understood;
All partial evil, universal good:
And, spite of pride, in erring reason's spite,
One truth is clear, Whatever IS is RIGHT.

Even in this positive expression, the implication that human changes are somehow inferior to the natural order is present.

[14] Lynn White's essay, "The Historical Roots of Our Ecological Crisis," *Science* 155 (1967), 1203-1207, is the best known example of this argument.

[15] Matthew Fox, "Creation-centered Spirituality from Hildegard of Bingen to Julian of Norwich, 300 Years of an Ecological Spirituality in the West," in *Cry of the Environment: Rebuilding the Christian Creation Tradition,* ed. P. N. Joranson and K. Butigan, (Santa Fe, New Mexico: Bear and Co., 1984), 98.

[16] Philip Hefner, *The Human Factor: Evolution, Culture, and Religion* (Minneapolis, MN: Fortress Press, 1993), see especially pp. 255-277.

[17] A. J. Dufner and Robert. J. Russell, "Foundations in Physics for Revising the Creation Tradition," in *Cry of the Environment: Rebuilding the Christian Creation Tradition*, 173.

[18] For a careful and insightful examination of Christian and Jewish theological speculation concerning intelligent extraterrestrial life, see the essay by Ted Peters, *op. cit.*

[19] In addition to Mars, there are other possible scenarios for discovery of life in our solar system. The two most likely locations would be the Jovian moon, Europa, and/or one of the asteroids in the sun's asteroid belt.

[20] We intend to address this question more fully in a subsequent essay.