

Microbiologists' Perceptions of Planetary Protection

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February, 2001

Introduction

As society enters the 21st century, NASA and its international partners are planning to conduct numerous new and exciting missions within the solar system. Many of these missions are motivated by scientific questions in Astrobiology that focus on the origin and evolution of life in the universe. These explorations will involve the search for evidence of life beyond Earth and the return of geological and atmospheric samples to Earth for analysis. In a society that places ever-increasing importance on the role of public involvement in science and technology policy, questions about the possible risks of biological contamination from sample return missions will be examined and debated in the media. These perceptions will, over time, form an important input to the development of risk management policies and strategies concerning sample return missions. Studies on risk perception that we conduct today form a baseline of information against which we can observe changes in public risk attitudes.

A significant barrier to the development of effective risk management results, in part, from the difficulties lay people have understanding the complexities of science and technical risk assessment. These difficulties are potentially magnified in the case of interplanetary biological protection, where scientific understanding of extraterrestrial organisms is particularly low (or nonexistent), the potential consequences of exposure to (or contamination by) such organisms (if they exist) is virtually unknown, and the mechanisms for managing the risks of such exposure are either novel or complex.

Previous research has shown that many of the problems faced by risk-management organizations are the result of differing perceptions of risk (and risk management) between the general public and scientific experts. Indeed, a consistent finding in risk perception research is the

heavy reliance that lay people place upon scientific disagreements as indicative of the degree to which they should be concerned about a risk issue. In essence, if experts don't know enough to agree, then there must be a problem worthy of attention.

As plans for sample return missions progress and requirements for planetary protection are analyzed and debated, members of various scientific disciplines, including microbiologists, will be called upon for judgments concerning the potential hazardousness of these endeavors, as they were during the Apollo Program when lunar samples were returned to Earth. Some of these judgments will be made in the context of technical and scientific meetings or the environmental impact statement process; others will be made in response to media probes of experts' views about the risks to society of space research activities.

Microbiology is a scientific discipline that offers a unique perspective on planetary protection because extraterrestrial life in our solar system, should it exist, is most likely microbial in nature, and methods of quarantining, handling, analysis, and curation of samples returned from Mars (or other celestial bodies) will be based on those of microbiological science. Likewise, microbiology will continue to inform space planners about approaches for planetary protection. The development of an effective planetary protection policy will require microbiologist input to achieve the goals of the Outer Space Treaty of 1967, by which exploration must be done in a way that avoids harmful cross-contamination between planets and other bodies during exploration. This study focuses on microbiologists' perceptions, views, attitudes, and beliefs concerning planetary exploration and planetary protection, including the risks associated with sample return and the adequacy of risk management approaches which seek to safeguard the environment, health, and safety of Earth.

METHODOLOGY

Data for the study came from a survey on planetary exploration and protection administered to a sample of microbiologists attending the 98th General Meeting of the American Society of Microbiologists held in Atlanta, Georgia, from May 17-21, 1998. A special five-session colloquium titled "Prospecting for Extraterrestrial Microorganisms and the Origin of Life: An Exercise in Astrobiology" offered an opportunity to inform microbiologists interested in such issues and to obtain study respondents. The study and its purpose were announced during the colloquium, and attendees were invited to participate by completing a copy of the survey available at the back of the room and returning it to a conveniently located collection box. Surveys were made available on the day of the colloquium, as well as the following day.

The survey was four pages in length and was designed to be self-administering. A short introduction outlined the purpose of the study, and provided a brief overview on planetary protection. The content of the survey was developed to assess a number of concepts relating to planetary protection, including beliefs about life elsewhere in the solar system, perception of sample return risks, and perceived adequacy of risk management. All of the survey items required only categorical responses (e.g., strongly agree, agree, disagree, strongly disagree). In addition, respondents were asked to provide general biographical information about themselves (e.g., gender, age, professional orientation). The survey was a refinement of earlier surveys used to study lay audiences (see suggested readings).

RESULTS

Sample Characteristics

A total of 201 completed surveys were returned. Respondents were near-equally divided by gender (58.7% males and 41.3% females), with an average age of 41.7 years (s.d. = 12.5

years). Most respondents held a Ph.D. degree (65.7%), with smaller percentages holding the MA/MS degree (12.4%), or the BA/BS degree (16.4%). In terms of organizational affiliation, 66.2% came from academic institutions, 10.9% from private industry, and 16.9% from government. The remaining respondents came from other institutions such as HMOs, hospitals, and clinics. Respondents were also asked to indicate their primary divisional affiliation within the ASM. Most of the respondents (58.2%) came from the General and Applied Microbiology divisions of ASM (e.g., general microbiology, environmental, and general applied microbiology). Smaller numbers came from Diagnostic Microbiology and Epidemiology (10.4%), Pathogenesis and Host Response Mechanisms (12.9%), and Molecular Microbiology, Physiology, and Virology (16.4%). The majority of the respondents (68.2%) indicated that they had attended meeting sessions on exobiology and sample return.

Beliefs About Life Elsewhere

Though the existence of life elsewhere in the solar system is still scientifically inconclusive, research has long been underway to discover where conditions might exist for life other than on Earth. Respondents were asked their opinion concerning the possibility of life on other planets in our solar system, as well as the possibility of life on Mars. In general, respondents were optimistic about the existence of life on other planets in our solar system. Over half (58.2%) of the respondents agreed that life might exist in such a broad expanse; about one-third indicated “don’t know” (31.3%). When the domain of reference was restricted to Mars, however, agreement tended to drop: only 40.3% agreed that it is highly probably life exists on Mars. Again, approximately a third (32.3%) indicated “don’t know.”

Perception of Risk

General Risk Perception. To place perception of space exploration and sample return risks in a broad risk-perception context, respondents were asked to rate the hazardousness of 28

Insert Figure 1 About Here

activities and technologies. These included space-related risks (e.g., sample return, satellite debris, asteroids), general risks of a biological origin (e.g., bloodborne parasites, STDs, bacteria in food), and other risks to which society is exposed (e.g., nuclear power plants, radon, global warming). Judgments were made with regard to “the risks for your country as a whole” on a four-category risk scale: almost none, slight, moderate, high risk. A “don’t know” alternative was provided. Figure 1 shows the percentage of respondents giving a “moderate” or “high” risk rating for each of the 28 hazard items.

Highest among the hazard ratings for biological risks were antibiotic resistance, viruses, and AIDS. Suntanning was also rated highly, along with ozone layer depletion. Perhaps most striking about the results shown in Figure 1 is the relatively low position that all of the space-related risks occupied, including biological and/or ecological risks of Mars samples. As a category of risks, these drew relatively little concern when presented in the context of a larger societal risk picture. This does not mean, however, that biological risks of space activities are perceived as unimportant or insignificant; only that when viewed from the perspective of a number of hazards to which society is exposed, space-related risks do not loom large. Most of the other hazards shown in Figure 1 have been demonstrated to result in death, injury, or illness. For space-related hazards, however, few (if any) members of society at large have been shown to have suffered physical loss.

Perception of Sample Return Risks. Specific items were included in the survey pertaining to the threat posed by possible life on Mars, and the ability of microbiology to predict such risks. These responses are shown in Figure 2.

Insert Figure 2 About Here

There was a great deal of uncertainty about whether life on Mars could pose a biological threat to Earth, with almost half of the respondents (42.8%) indicating “don’t know.” More respondents tended to disagree (34.4%) that Mars life (if it exists) poses no threat to life on Earth than to agree (22.9%). Thus, respondents were generally cautious about the ecological hazardousness of possible Mars life, perhaps in part because the question itself was posed as “no threat.”

In terms of our ability to predict with reasonable certainty how life elsewhere would impact our environment, a large majority disagreed (71.2%) that current scientific understanding of microbiology is sufficient to make such predictions. Only 10.4% gave a “don’t know” response.

Overall, respondents were quite cautious about putative Martian life posing “no threat” to Earth’s environment, and cautious as well about samples returned from other planets posing no significant risk to Earth. These views are generally consistent with the strongly-expressed attitude that the current state of microbial science is insufficient to make reasonably certain predictions about how extraterrestrial biota might impact the terrestrial environment.

Perception of Risk Management

Risk Assessment Strategies. All risk management approaches involve methods of risk characterization and assessment. These methods are intended to provide a basis for evaluating and

Insert Figure 3 About Here

classifying risks for the purpose of undertaking appropriate protective or mitigative measures. Perhaps the simplest of risk characterization approaches involves a judgment of hazardousness. Respondents were asked to indicate whether samples of materials from Mars should be considered as hazardous, and whether experiments done on Mars will be sufficient to determine whether it is safe to bring materials back to Earth. Figure 3 summarizes these responses.

Respondents were generally in strong agreement that materials returned to Earth from Mars should be considered hazardous until proven otherwise. Only 1.5% of respondents indicated “don’t know,” suggesting a very low level of uncertainty. However, respondents were not particularly confident in the potential for experiments done on the Martian surface to sufficiently determine the safety of Mars samples; over half (58.2%) disagreed that such experiments would be adequate. However, a fairly large portion (21.9%) indicated that they “don’t know.” These results tend to suggest that respondents prefer a cautious approach to risk assessment, and generally prefer not to rely on *in situ* methods of risk characterization.

Adequacy of Bioprotection. Sample return missions as currently planned will result in extraterrestrial materials being returned to Earth for analysis. Such missions would involve strict quarantine of these materials until they can be proven to pose no hazard to Earth’s environment. Respondents were asked to indicate the “degree of adequacy” of current methods of quarantining and bioprotection to accomplish the goals of sample characterization, life detection, and biohazard testing. Responses were made on a four-category scale: none, slight, moderate, high. Figure 4 summarizes these responses graphically, showing the percentage of respondents giving either a “moderate” or “high” rating. A “don’t know” response category was provided.

Insert Figure 4 About Here

Across all three quarantining objectives there appeared to be a high degree of consistency, with approximately half of respondents in all three cases indicating that current methods are either moderately or highly adequate. However, about a third of respondents indicated “don’t know,” suggesting a reasonably high level of uncertainty about this issue. Nonetheless, respondents were generally optimistic that current approaches to biological risk management through quarantining and containment methods are satisfactory.

DISCUSSION

Space exploration to study the origins of life is a challenging endeavor, complicated by the interdisciplinary nature of the scientific questions at issue. In the face of our recently expanded understanding about extremophile microbes and primitive life on Earth, it is not surprising that questions persist about the possible nature of life elsewhere and the potential hazards such life may pose to Earth and its biota. Judgments about the adequacy of measures taken to ensure the protection of Earth’s biosphere during various phases of sample return missions will, at least in the early decades of such missions, largely be a matter of expert scientific opinion and decision making under uncertainty. The results of the present study reveal that, for the most part, scientific opinions coming from the microbiology community are likely to be conservative and cautionary regarding the current ability of microbial science to make confident predictions about how life elsewhere is likely to interact with the terrestrial environment. Likewise, microbiologists appear, at least from the present respondent sample, to regard life elsewhere (should it be discovered) as hazardous until proven otherwise. These results are consistent with the recommendations of two studies by the National Research Council and match the sentiment of lay respondents in earlier studies (see suggested readings).

However, some open questions remain regarding such views and opinions. For the most part, knowledge and awareness of planetary exploration is relatively new. We have at present no evidence that life exists on other planets or bodies in our solar system, thus the cautious views expressed by respondents in the present study reflect the professional responsibility that most members of scientific groups would express when faced with a paucity of real data. Deeper questions concern how such views would be modified in light of some, but limited data, suggesting the possibility, but not the confirmation, that life on Mars is similar to microbial life on Earth. As more data are generated from successive missions, we can anticipate a shifting landscape of scientific information and perhaps revised views about the very nature of life itself. These questions become more scientifically demanding when they interact with questions concerning technical measures for planetary protection that vary in cost and feasibility.

As society moves forward with its space exploration efforts, new data will emerge to inform and enrich the scientific views presented in this paper. We speculate that the coming decades will see an increasingly vigorous scientific debate within the microbiological community concerning planetary exploration and planetary protection. That debate will be scrutinized closely by a vigilant public eager to know about life elsewhere, but concerned that exploration is done in a responsible manner.

Acknowledgment

This research was supported in part by the National Aeronautics and Space Administration and SETI under NASA Grant #NAG 2-986 (Subcontract #986-9701) to Decision Science Research Institute. The authors would like to thank the members of the American Society of Microbiology who participated in the study.

Suggested Readings

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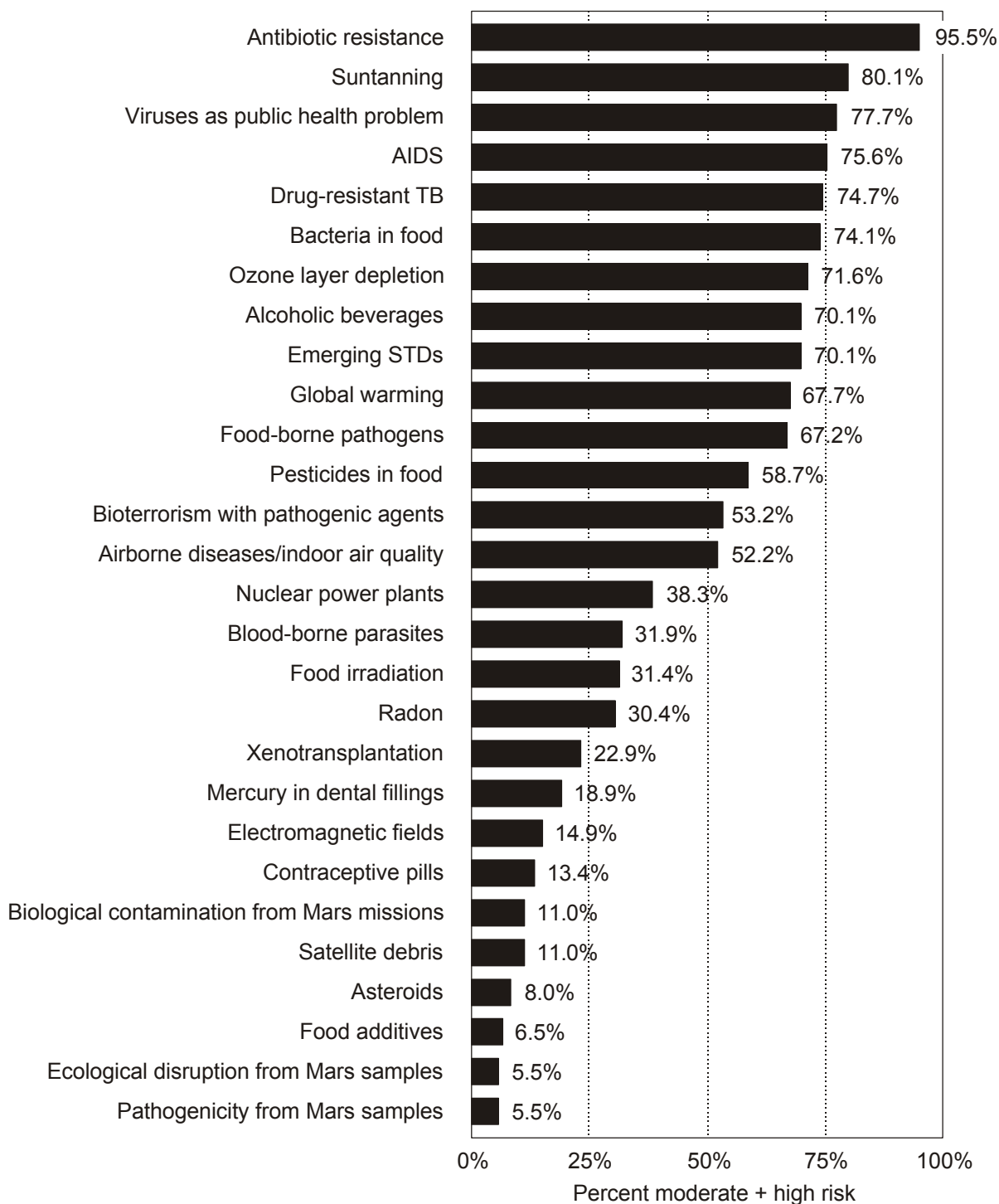


Figure 1. Perceived risks and hazards.

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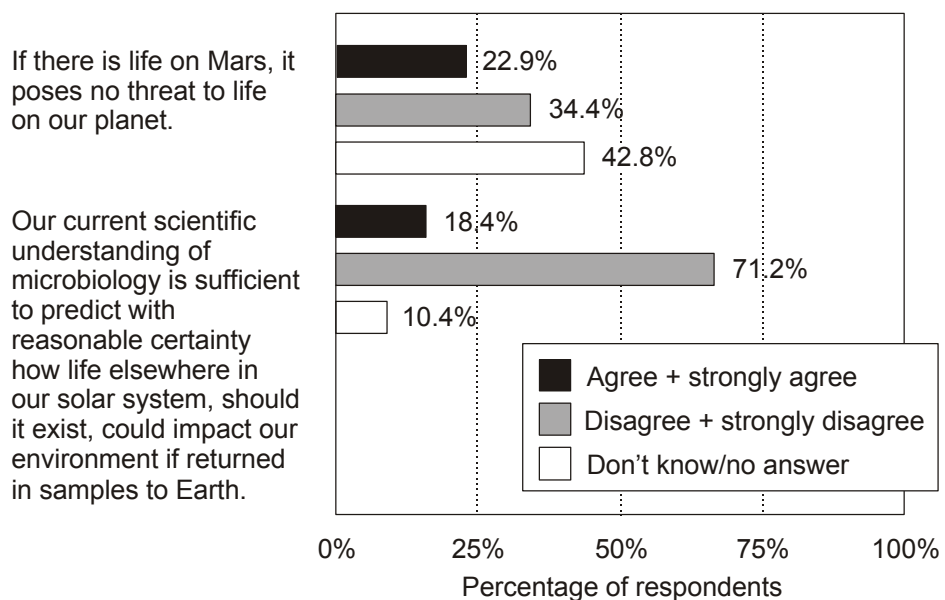


Figure 2. Perception of sample return risks.

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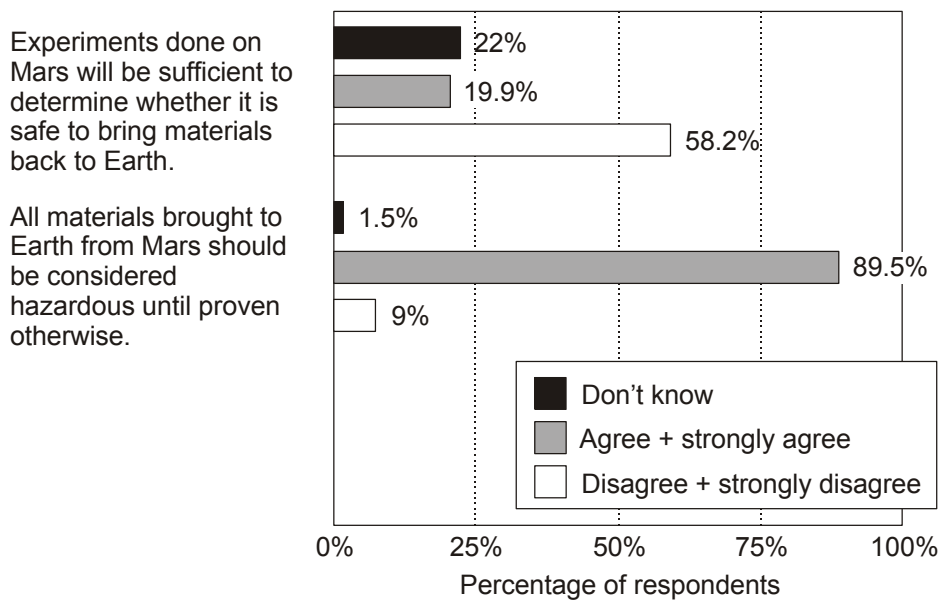


Figure 3. Perception of hazard testing.

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With regard to samples of materials returned to Earth from other planets, in your view how adequate are current methods of quarantining and bioprotection for:

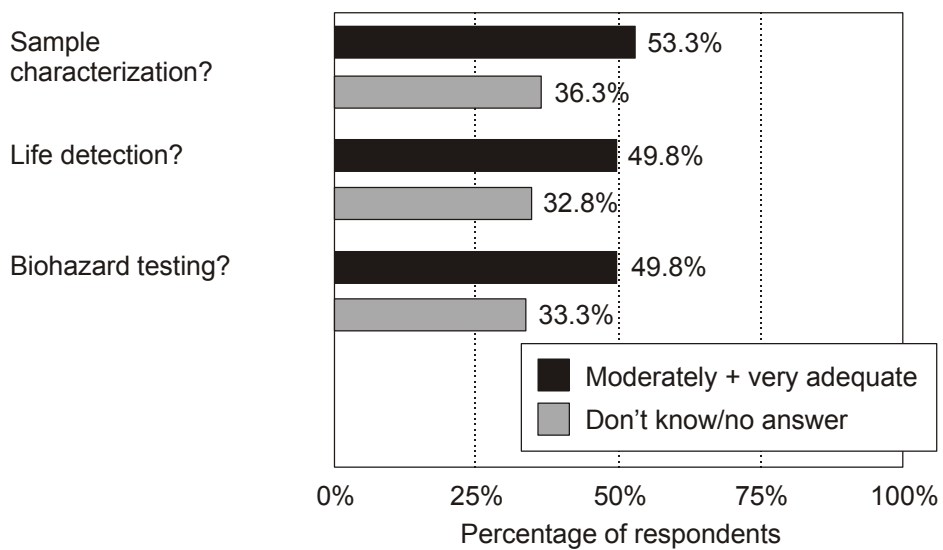


Figure 4. Perception of bioprotection.

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