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Communicating about the discovery of extraterrestrial life: Different searches, different issues☆

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Abstract

Current searches for evidence of extraterrestrial (ET) life are accomplished in a number of distinctly different ways. The various searches can be viewed in three general categories: (1) 'SETI' searches for messages from extraterrestrial civilizations, (2) exploration for extrasolar or habitable planets, and (3) searches and research within the solar system (e.g., planetary missions, meteorites, cosmochemistry). Each search-type occurs in different locations, uses different scientific instruments and methods, and seeks different types of evidence and data. Moreover, the meaning and implications of a 'discovery' in each of the categories are different, as are the policy, legal and societal ramifications. In considering how to manage future communications about the discovery of extraterrestrial life, it will be important to understand these distinctions, anticipate relevant concerns and issues, and be prepared to explain them clearly to the public.

1. Introduction

Finding credible evidence for the existence of extraterrestrial (ET) life would be significant news for both the scientific community and the public at large. Managing the communication of such a dramatic discovery would be an unprecedented challenge for scientists, government agencies, and the mass media. The 1997 announcements about presumed fossil life in the martian meteorite ALH84001 provided a dress-rehearsal of sorts for the kinds of frenetic questioning and excitement that are likely to accompany verifiable evidence for 'ET' life. With astrobiological exploration and research proceeding on so many fronts worldwide, it is wise to consider well in advance how communication about extraterrestrial life will be handled. Along with information about the discovery itself, it will be necessary to convey the implications of discovery from multiple perspectives—scientific and otherwise—and to clearly distinguish the type of ET life that may be involved. The need for communicating this complexity is obvious if one analyzes the impressive range of scientific efforts currently involved in the search for ET life.

Astrobiological searches for ET life encompass a broad spectrum of scientific research efforts [1]. In general, this multidisciplinary field seeks *evidence* of life (not necessarily life itself), searching *everywhere* we can explore, using *diverse scientific methods*. At present, the research and exploration can be viewed in three general categories: (1) 'SETI' searches for messages from intelligent ET civilizations, (2) exploration for extrasolar and/or habitable planets, and (3) 'exobiology' research and missions within the solar system.

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Table 1
Differences in approach for major search types

Search type	Where	Methods used	Type of evidence
SETI	Galaxy	Radiotelescope	Electromagnetic signals
Extrasolar planets	Galaxy	Telescopes; interferometer	Transits; 'wobble'; atmospheric 'signatures' with special interest in biologically related chemistry
Exobiology			
Missions (*in situ*)	Solar system (SS)	Spacecraft missions; instruments	Physical/chemical, geological, biological (alive, dead, pieces)
Meteorites	Earth	Lab instruments; experiments	Physical/chemical, geological, fossil, structural evidence
Origin of life experiments	Earth	Lab instruments & experiments (e.g., impact simulations)	Physical/chemical; molecular; replicated 'process'; synthetic replicating life forms
Cosmochemistry	Earth and SS	Collected materials, simulated samples & remote data	

Table 2
Scientific nature and understanding of possible discoveries

Search type	Nature of 'discovery'	Scientific meaning of ET life
SETI	Intelligent life; Sentient Beings?;	Advanced civilization 'Aliens'; unknown biology; may be 'old' (current status/existence unknown)?
EXTRASOLAR PLANETS	Planetary locations; possibly earth-like; atmospheres (possibly biogenic?) Evidence of metabolism?	Alien solar system Habitable sites? Biogenic atmosphere? May be 'old'? (current status unknown);
EXOBIOLOGY		Exobiology Searches with possibilities of cross contamination; Able to study life type directly and in real time
In situ	Microbial? (simple/complex?) alive; dead; pieces?	Can determine if related to Earth life. Multiple or 2nd Origin? Panspermia?
Meteorites	Fossil; biogenic; biomarkers (Could find living microbe?)	Possible past life; (or possibly extant?) Can determine if related to Earth life?
Origin of life research	Artificial ET life forms?	
Cosmochemistry	Man-made simulation of process?	Replicating systems? Repeated emergence of life? Life as a cosmic imperative?

Each looks in different locations, using different scientific instruments and methods, and gathers different types of evidence and data (Table 1). Not only are there significant differences in search methods and locations, it is important to recognize that the nature of presumed ET life and the scientific meaning of a discovery are likewise quite distinct (Table 2).

All these distinctions must be borne in mind when preparing for public communication because of their relevance to broad societal implications of future discoveries in the short and long terms. In preparation for managing the communication of a discovery, it is instructive to systematically compare and contrast the features of the different searches and examine them in the context of both science and types of societal ramifications. When ET life and searches are viewed from this broad perspective, it is possible to untangle the implications of different searches, reveal the relevant issues in legal, policy, practical, ethical/theological realms, and anticipate the potential impacts on humankind at present and in the decades to come.

2. Distant searches for ETI and extrasolar planets

For millennia, humans have wondered whether our species and home planet are unique. With modern advances in astronomical understanding and technology, searches are underway to scan the far reaches of space in an organized fashion for evidence of other life. In particular, searches for extraterrestrial intelligence (ETI) and extrasolar planets are each conducted using telescopes that scan locations light years away and outside the solar system. Both involve the collection of data in the form of 'signals' conveying indirect or remote information relevant to ET life. In the case of SETI, the focus is on electromagnetic signals or messages; whereas in searches for extrasolar planets, it is on measurements of wobbles, transits or interferometer data identifying the presence, size and characteristics of other planets as well as their location within their solar system. In both types of searches, if positive data are detected, information may be quite 'old' depending on the astronomical distances involved. Because the data are collected remotely and with no direct interactions with the target bodies, there are no special procedures or regulatory controls imposed upon the searches during exploration. In fact, there are no specific treaties or laws directly relevant to either exploration effort, except perhaps those that involve the construction of telescopes or facilities in particular locations on Earth.

The nature of and evidence for ET life differs markedly between these two systematic search efforts. By definition, if ETI signals are discovered, they will be presumed to emanate from an intelligent and advanced civilization, capable of deliberately devising technologies that can send detectable signals beyond their home location. Even if we detect and verify a signal, we will be unable to know details about the nature of the life form or its biochemistry and physiology, or whether it even persists at present. Likewise, while positive indications for a 'habitable' extrasolar planet could convey exciting information about earth-like planets with possible biogenic atmospheres potentially conducive to life as we know it, we are unlikely to know much about the persistence or type of organisms or the biochemical processes behind observed phenomena. For both SETI and extrasolar planet exploration, even if additional studies and searches are undertaken to learn more about a particular discovery, they are unlikely to yield a full understanding about the newly discovered life forms or result in direct experience or interaction with them.

3. Exobiological searches within the solar system

In contrast, exobiological searches encompass a diversity of search types and activities that are comparatively nearby—either Earth-based or conducted within the solar system—all of which gather real-time information relevant to life and celestial locations. For the sake of this discussion, the range of search types fall roughly into three distinct types: (1) space exploration, missions and associated research, (2) studies of meteorites and materials delivered to Earth by natural influx, and (3) experiments and laboratory studies related to cosmochemistry and the origin of life. In exobiology, while some of the data are collected remotely as signals of various sorts (Images, remote sensing, spectral analyses, etc.), considerable data are gathered in direct fashion through experiments, sample collection, roving, digging, drilling, lab experimentation, etc., thus involving situations with potentially direct impacts or interactions. The various types of exobiological searches for ET life gather evidence in the form of physical/chemical, geological, biological, structural, and molecular data, not unlike routine scientific studies on Earth.

Because of the range of research types, there are likewise a variety of possible discovery scenarios that may be envisaged within exobiology. For example, a robotic rover or lander that transmits the information to Earth could find evidence for microbial ET life on Mars; so too could future astronauts on the martian surface who might come in direct contact with ET life. Alternatively, it could be discovered on Earth, in a containment laboratory where returned samples are examined, or inside meteorites or other collected extraterrestrial materials. In the extreme, the chemical evolutionary process leading to ET life formation might be duplicated artificially in the lab through various experiments with mixes of interplanetary organic molecules in environmental conditions simulating the early Earth. Researchers are also seeking to create life or self-replicating molecules in the laboratory. Thus the nature of 'exobiological' searches, with varied discovery scenarios and research types, raises questions about possible cross contamination and scientific risks that are not found in either SETI or extrasolar planet searches.

Even during the process of exploration prior to the discovery of ET life, there are regulatory and practical implications for exobiology in the form of planetary protection controls for missions or environmental, health and safety (EHS) regulations on Earth. Spacecraft and missions to locations in the solar system are governed by policies outlined in The Outer Space Treaty of 1967 [2] which stipulates that exploration must be done in a manner that avoids harmful cross contamination in the form of either forward contamination of the target body by hitchhiker terrestrial microbes, or back contamination of Earth by extraterrestrial materials or samples upon return [3]. In addition to the specific directives and controls imposed by particular launching agencies or countries in accordance with the OST and the international Committee on Space Research (COSPAR), there are a complex array of routine environmental, health and safety laws and regulations that may also apply to the research and activities conducted in Earth-based labs [4].

Exobiology builds upon a vast array of direct knowledge about living systems, their metabolism and biological signatures, combined with extensive information about celestial bodies and processes in the solar system. It is possible even now to speculate about the biochemical nature of putative ET life, to consider its likely adaptation to potential habitats, and to identify promising places for search and collection. Based on our current knowledge of life on Earth and conditions in the solar system, we can surmise that ET life is likely to be microbial and found in places with conditions amenable for liquid water to exist, either persistently, transiently or in the recent past. If microbial ET life is found *in situ* by robotic spacecraft or astronauts visiting new locations, more than its existence can be verified in real time. Through direct studies, it will be possible to determine whether it shares DNA and Earth-like biochemistry, and whether and how it may be related to the current three-domain view of life on Earth. Moreover, if it has a distinct biochemistry unrelated to life as we know it, we will have direct opportunity to study the life in detail, either on Earth or in its native location to characterize it more fully.

Earth based studies of meteorites also contribute direct information relevant to the nature of ET life. Already debates about alleged fossil life in the meteorite ALH84001 have spurred extensive research on extremophiles, nanobacteria, and comparative topics relevant to ET life. If perchance an extant or dormant life form were discovered in a meteorite, it would be possible to conduct direct studies of its nature and biochemistry, comparing it with important features of life on Earth. Likewise, laboratory research on cosmochemistry offers insight into the nature of early life by seeking to re-create the conditions and molecular mix of precursor molecules that may have lead to life as we know it. If for example, a Miller–Urey type of experiment or a laboratory impact simulation show evidence for initiation of a replicating process based on organic life forms, it would allow direct comparison with present day living systems and address questions about whether life is a cosmic imperative. Such a finding would transform our views of the universe, suggesting the potential for life to arise repeatedly whenever and wherever initial conditions are suitable [5]. Whether exobiological evidence for ET life is gathered on Earth or elsewhere in the solar system, a discovery could quickly generate far more direct data and understanding of the nature of life than other search types. Neither ETI nor extrasolar searches could conceivably yield the opportunity for such comprehensive analysis of an ET discovery. As importantly, an exobiological discovery of ET life would also prompt discussion of broad societal implications that are immediately more complicated than those associated with search types outside the solar system.

4. The full implications of discovery

Discovery and verification of the existence of ET life will be extraordinarily profound scientifically, but mere scientific knowledge about the existence of ET life *per se* is not what determines its meaning and implications for humankind. To understand the full impact of a possible ET discovery, we must extend beyond the scientific discovery itself and consider the nature of the presumed life as well as the potential for human actions or plans to cause impacts on it or from it. For comparison, it was not the scientific knowledge about inheritable traits or the discovery of DNA's structure that had meaning or implications for humankind, but rather the subsequent uses and applications of the information through deliberate actions such as selective crop and livestock breeding, eugenics, genetic engineering and biotechnology. When and if we learn that we are not alone in the universe, we should be prepared similarly to communicate about the full implications.

As shown in Table 3, the societal, policy, legal, ethical, theological implications of a 'discovery' are distinctly different for the various search types. For the most part, our current consideration of the impacts focuses primarily on near term actions taken by governments and launching agencies. In the longer term, it will be necessary to consider implications more broadly, including such perspectives as the individual, private sector and even the extraterrestrial life types themselves. As mentioned earlier, already there are considerable differences in policies and oversight for the three major search types during the exploratory period;

Table 3
Representative societal and longer term implications of discovery types

Search types	SETI	Extrasolar	Missions	Meteorites	Origin/cosmochem
Policy	SETI Principles (No enforcement)	None needed?	No current COSPAR or NASA policies; may need cosmocentric policies and laws?	None needed? If extant life found in meteorite, may need EHS regulations?	No current policies; May raise EHS and regulatory issues similar to cloning or genetic engineering
Philosophical, theological, ethical	Existence of sentient beings raises questions on creation, dogma & man's place in divine plans	No immediate issues	Ethical issues are: 'rights' of ET and responsibilities are: ET environments; interfere with evolutionary trajectories; shift in ethics and policies to cosmocentric focus?	Minor or no near term issues?	Multiple creations? Man's place in universe; deliberate tinkering with natural order; 'playing' God?
Individual	None	None	Lab worker safety; contamination issues; astronauts as human subjects	Lab worker safety and containment	Lab worker safety? Responsible exploration?
Government actions	How should consultation be handled? Who should respond?	None	EHS, PP, ethical & decision-making issues are: future missions/actions; accidents? Impact of mixing ecologies?	Proper containment and security	EHS, PP, ethical & decision-making issues are: future missions & actions; accidents?
Societal issues & private sector	None? (Psychological?)	None	Terraforming? Colonization, commercialization, tourism, extraction, patent rights? Etc.	Minor or no issues?	Issues of scale up and creation or use of 'new life'? Regulatory controls or moratorium? EHS & PP concerns

extrapolating to the post-discovery phase, the issues get even more complicated.

When it comes to anticipating the discovery of ET life, the SETI community is alone in having conducted serious international discussions of how to respond *if* and *when* a signal from ETI is detected. A set of "SETI Principles" were developed over a period of years and approved by the SETI Committee of the International Academy of Astronautics (IAA) in 1989. The Declaration of Principles is not legally binding and has no enforcement provisions, but it has been endorsed by numerous major organizations [6]. Rather than presuming anything about ET life itself, the SETI Principles focus instead on the human response anticipated in the face of a discovery scenario, providing step-by-step operational guidelines for verifying the signal, sharing information openly, and consulting broadly and internationally prior to making contact in the form of a return message. Already researchers have identified a number of anticipated implementation problems likely to arise upon discovery, despite the existence of the SETI Principles. These include problems with the level and type of organizational readiness [7], the limited discovery scenarios considered [8], and a lack of preparations for mass media communications [9,10].

Despite the shortcoming of the SETI Principles, they represent the only organized attempt to codify guidelines and policies about what to do upon discovery. For extrasolar planet searches, while there are no current or anticipated policies related to the discovery of ET biogenic atmospheres or locations, it is likely that none are needed in large part because the nature and distance of possible discoveries all but preclude significant practical concerns, except perhaps the sharing of scientific information. The same cannot be said of other search types. Despite the extensiveness of organized and individual research efforts comprising exobiological research, there are currently no policies or recommendations applicable to the discovery of non-intelligent life, whether on Earth or other solar system bodies. Put simply, there is no clear guidance on what to do if and when non-intelligent ET life is found, despite the fact that a discovery could occur at any time and will undoubtedly prompt immediate need for response from multiple levels—scientifically, governmentally and societally. Science and technology are clearly ahead of policies in a number of areas [e.g. environmental, health and safety policies (EHS), as well as planetary protection (PP)], resulting in potentially serious gaps in knowing what will or should be done upon discovery. This uncertainty must be included in the overall communication planning.

5. Managing the communications

We already know that communicating about an ET discovery is likely to be complicated by public attitudes, misperceptions, Hollywood style science fiction, ethical/theological considerations, and national interests. The communication process is likely to be frenetic, with input from scientific and space community interests as well as an array of international institutions [11]. This means that planning for communication about a discovery must consider how to deal with potential conflicts, gaps, misunderstandings and debates from the start, whether they center around scientific topics or otherwise. Prominent among the anticipated concerns are likely to be varied questions of theological and ethical implications [11], risks to Earth's biota and environment, and concerns over the long term advisability and implications of continued exploration and interaction. To the extent the humans are directly involved in a discovery (e.g., handling or collecting samples, analyzing alien life in labs etc.), serious questions arise about laboratory worker and/or astronaut safety [12,13]. Additional concerns include the rights of ET life and responsibilities toward it [14,18], extraterrestrial property rights and environmental ethics [15,16], and future actions by either governments or the private sector with the potential for large scale or global impacts (e.g., colonization, commercialization, extractive industries, tourism, terraforming, etc.) [17,18]. In addition, since all policies, laws, and ethics on Earth are based upon life as we know it, some have even suggested the need for a comprehensive overhaul from a cosmocentric perspective if ET life is discovered [16,19].

We know there will be tremendous excitement upon discovery of ET life—and a great opportunity to educate the public about the science and technology behind the discovery. However, communication must go well beyond basic science, and specifically address the use of scientific information in risk analysis and decision-making, as well as the longer-term societal implications that draw meaning from equally important non-scientific disciplines. As shown in Table 4, all search types will involve communication about the science and technology behind a discovery, but additional categories of scientific and non-scientific information may be needed to differing degrees for a comprehensive understanding of the discovery. Consequently, there will be a need to prepare in advance for handling the diverse perspectives anticipated.

As preparation for managing the discovery communication, it may be advisable to plan targeted pre-discovery communication efforts aimed specifically at the scientific and space communities in addition to the public. Astrobiology is a diverse, multidisciplinary field in which professionals are likely to focus on a single discipline or search type, and perhaps not recognize the diversity of issues, concerns, and implications behind the various searches. Communications preparations should ideally involve the education of professional audiences in order to engage them in systematic analysis and public discussion about all aspects of the search and discovery scenarios.

Looking ahead, the management of communications for a discovery may also depend on which type of ET life is found first. It is not totally clear whether the discovery of one particular type of ET life would enhance or adversely impact other search efforts underway or planned. For example, if ET life were discovered by a rover on Mars or in a containment glove-box on Earth, what might be the impact on plans for future sample return or human missions? What controls and policies would apply? Could a verified SETI signal somehow affect ongoing exobiological research? Who among scientific, theological or governmental institutions should be involved in making decisions for humankind about the advisability of further contact or interactions with ET life and how would we know whether planned actions could be mitigated or reversed if necessary?

Citizens worldwide deserve to be informed and educated about the facts and implications of the first ET discovery and their meaning in relation to societal concerns and subsequent actions. Overall, communication, outreach and education regarding the discovery of ET life must be planned with a multidisciplinary and long-term view—integrating the scientific, technological, societal aspects in information—that will be conveyed to the public, whether via mass media coverage or through educational outreach. The topic of extraterrestrial life is one of keen interest to diverse publics worldwide. The implications of discovery and possible future actions by space faring nations compel us to think about the meaning of life, the evolutionary trajectory of humankind, and the future of life on our home planet. How we respond in the short or long term to the discovery of ET life has significant repercussions for ourselves and future generations on planet Earth, as well as for the

Table 4
Categorical view of information type and issues by search type

Search type	Science as Facts	Risks/ decision Info	Societal meaning/actions
SETI	Presumed existence of intelligent, sentient beings; technological civilization BUT no likely details on form or function of ET life	Send a return message? Psychological impact?	We are not alone. Societal interactions unlikely unless significant advances in technology. Raises questions about 2nd Genesis and theological implications etc.
Extrasolar planets and habitable planets	Existence of planetary locations; taxonomy of solar systems and planet types; information on atmospheric composition/processes; possible metabolism?	None	There may be other habitable locations—with or without life. Unlikely to prompt pressing societal actions or concerns
Exobiology			
In situ missions (orbiters, rovers, sample return, humans)	Physical, chemical, biological evidence for microbial ET life; characterize and understand habitat, biochemistry, features, relationships etc. Might extend taxonomy of life in the universe;	Mission related issues (e.g., sample return to Earth; biocontainment; astronaut interactions; mixing ecologies; impacts on martian ecology and evolution from human actions, etc.)	ET life exists now; need determine if/how related to Earth life. Multiple or 2nd Genesis? New concerns include cross contamination, mixing of ecologies; ethical 'rights' of ET life? Obligations towards ET life and environments? Need for cosmocentric policies & ethics? Possible direct impacts on planned space activities?
Meteorites	Evidence for possible microbial life? (simple/complex?) Alive; dead; pieces? Fossil? biogenic; biomarkers;	None, unless living microbe detected	ET life existed in recent past; may have broader implications if live ET forms are detected (see above)
Origin of life; cosmochemistry	Able to mimic/synthesize life and replicate process of its emergence/formation; model of precursor conditions & initial chemistry for life; comparative understanding of terrestrial, interstellar and interplanetary life; life may be a cosmic imperative	Like genetic engineering? Laboratory & environmental controls over man-made life? Limits or moratorium on creation or applications? Altering 'natural order'? Concerns about cross contamination, safety etc.	Life may be widespread and simple to emerge. Theological, ethical and legal implications of man-made life and artificial replicating systems. Possible impacts on R & D similar to genetic engineering.

ET life itself. How we communicate about it is equally important. As we plan to communicate about scientific efforts and successes in the search for life, but it must be done in the context of responsible exploration for all.

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