Astro 2020 APC White Paper

White Paper Title: Preparing for the Discovery of Life Beyond Earth

White Paper Description

This paper addresses an urgent issue in the state of the profession. Extraterrestrial life may be detected within years or decades, and for the sake of involved scientists and the broader community, substantial and ongoing support is vital for collaborative interdisciplinary research (science, social science, humanities) on the social impacts of searches and discovery, and for related education.

Thematic areas: extraterrestrial life, biosignatures, technosignatures, social consequences of science, planetary systems, astrobiology, exobiology, search for life beyond the Solar System

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Please note: this list of 118 cosigners was compiled *in a single calendar day* starting July 9. It would likely be much more extensive had the circulation period been longer. It includes: multiple NASA researchers, members of the International Academy of Astronautics SETI Permanent Committee, the SETI Institute, Breakthrough Listen, SSoCIA, and NASA Astrobiology programs; representatives of many disciplines, from astronomy, astrophysics and astrobiology to anthropology to history to theology; many working astronomers; Chairs, professors, and researchers from multiple American universities and international institutions.

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Preparing for the Discovery of Life Beyond Earth

Abstract

The remarkable discoveries in astrobiology in the last few decades, including extremophile life on Earth, the existence of oceans on worlds such as Europa and Enceladus, and thousands of planets beyond our solar system, as well as ongoing programs searching for extraterrestrial intelligence, all raise an urgent question: what is the impact on humanity of discovering life beyond Earth? The humanistic implications of astrobiology fall under the broad heading of astrobiology and society, a suite of issues raised already in NASA's first Astrobiology Roadmap (NASA 1998), elaborated in subsequent versions (NASA 2003; Des Marais et al. 2008), still present in its current Astrobiology Strategy document (Hays 2015), and recognized as well in other international documents that guide research in astrobiology (Horneck et al. 2006). In the same way that social, ethical and legal aspects are being studied for frontier areas of science and technology such as the Human Genome Project, nanotechnology, and artificial intelligence, the impact of the discovery of life beyond Earth deserves serious and systematic attention. Indeed, the World Economic Forum has declared the discovery of life beyond Earth one of five X factors – emerging concerns for planet Earth of possible future importance but with unknown consequences (World Economic Forum, 2013). This research must be a combined effort encompassing the sciences, social sciences and humanities, and should become an integrated part of the astrobiological endeavor.

This paper suggests that the National Academies should create a federal funding structure – e.g. a NASA collaboration with NSF (SBE) and/or the National Endowment for the Humanities – to foster sustained collaboration between scientists, social scientists, and the humanities addressing ongoing, emerging, and future societal issues resulting from intentional searches or serendipitous discoveries of extraterrestrial life. This is a substantial research program that incorporates history, the nature of discovery, and analogy among other approaches. For example, the very nature of scientific discovery as a process provides insights into how the discovery of life beyond Earth and its consequences will play out (Dick, 2018). Moreover, the societal impact will very much depend on the discovery scenario, ranging from microbes to intelligence and via biosignatures, technosignatures, or fossils. We need therefore to consider the nature of discovery and parse under what circumstances the discoveries may take place. The general question "What is the societal impact of discovering extraterrestrial life?" makes no sense unless we are talking about a specific discovery scenario and understand the nature of scientific discovery.

The determinants of public response and societal impact are cross-cutting and will involve multiple characteristics of the detection, including factors such as certainty, potential threat or benefit, proximity, scientific source, nature of the announcement, media response, and so on.

While we cannot make firm predictions, history, analogy and other social science approaches can provide guidelines. As the World Economic Forum concluded, "looking forward and identifying emerging issues will help us to anticipate future challenges and adopt a more proactive approach rather than being caught by surprise and forced into a fully reactive mode." (World Economic Forum, 2013). We need to develop policies to have the best chance of having a positive impact on society when and if alien life is discovered under a variety of scenarios.[1]

1.0 Introduction

Astrobiology science is ramping up dramatically in its methods and reach. Missions within the solar system may yield a detection of life within the decade (extinct, extant, similar to Earth life, dramatically different, or indeterminate). Observations of extrasolar planets may soon yield atmospheric observations which indicate life – though these may be ambiguous and require decades to confirm (Catling et al 2018, and AbSciCon 2019 sessions).

Simultaneously, the search for technosignatures is also expanding in intensity and range of methods, fueled primarily by private sponsorship (Wright 2019a; Margot et al 2019; NASA Technosignatures Workshop Participants 2018). In addition, NASA's quasi-freeze on support for this area is beginning to thaw (Wright 2019b). Under these circumstances it is our responsibility to society to understand the potential consequences of this work. As outlined below, work in this area has been sporadic and largely unfunded.

Former NASA Chief Historian and NASA/Library of Congress Blumberg Chair in Astrobiology Steven J. Dick has argued at length that a roadmap and subsequent research on these issues are essential (Dick, 2018). The questions here are legion, and potentially Earth-shaking. Who should take the lead in preparing for discovery? What do we do if life is actually discovered, microbial or intelligent, near or far? Should national governments be in charge, international political and scientific institutions, scientists and social scientists, ethicists and theologians, or some mix thereof? How do we prevent contamination of potential microbes on Mars, Europa, Enceladus or other habitable sites in the solar system, and (more perhaps more urgently from most Earthlings' point of view) how do we protect our planet from back contamination in the event of the discovery of microbial life? If a message is received as a result of a successful Search for Extraterrestrial Intelligence (SETI) program, should we answer? If so who speaks for Earth? Should we initiate messages as part of a Messaging Extraterrestrial Intelligence (METI) program? If so what should we say, and who, if anyone, should control what is said? These questions are only the leading edge of the many decisions that will have to be made once alien life is actually discovered. And, as we have emphasized above, each scenario will have its own unique problems and solutions.

[1] For a rapid review at the NASA Technosignatures Workshop 2018, see K Denning's lightning presentation at the 00.34 mark here: https://www.hou.usra.edu/meetings/technosignatures2018/presentation/?video=morningdiscussion3.mp4

2.0 Recent history

During the interval between the Viking missions and the present day, the primary means by which extraterrestrial life could have been definitively detected has been SETI, the search for technosignatures. Since the early 1990s, that observational work has largely been sustained through privately sponsored research programs (Wright 2019a, Margot et al 2019). When NASA previously funded that work, it also supported some interdisciplinary studies which examined the potential impacts of a detection and suggested policy and best practices (Billingham et al., 1999). When the NASA High Resolution Microwave Survey (HRMS) project was cancelled (Dick and Strick, 2004; Garber, 1999), that interdisciplinarity was also cut adrift, and despite sporadic backing there is at present no centralized effort to study the impact of the detection of life beyond Earth on society.

2.1 NASA's Early Support for Interdisciplinary Work on Societal Impacts

John Billingham, an early Chief of the Exobiology Division at NASA Ames in the mid-1970s, was both an architect of the NASA SETI program and a strong proponent of interdisciplinary work exploring cultural aspects of the search for extraterrestrial life. He frequently emphasized scientists' and agencies' responsibilities to the global community. From the time that SETI planning began – including the 1970s workshops at Ames on the evolution of intelligence and civilization, and on extrasolar planet detection – societal aspects were also considered. Following their $140 000 NASA grant in 1974 for their "Proposal for an Interstellar Communication Feasibility Study", Billingham's SETI Program Office within Exobiology at Ames was established in 1976, where a small group of astronomers and technology experts was joined by Ames sociologist Mary Connors, who was tasked with studying the societal aspects of SETI (Billingham 2011: 70-71).

In one of his final retrospective papers, Billingham noted that he and his group were mindful of the "profound consequences for humankind" (2011:78) of the work they had started, which is why the International Academy of Astronautics SETI Committee eventually produced some guidelines for SETI scientists. He also noted that by 1990, "it had been obvious to us for 20 years that there were many questions dealing with the implications of SETI for society that had not been addressed", which is why he and social psychologist Roger Heyns (the former Chancellor of UC Berkeley) convened three NASA-sponsored workshops in 1991-92 with specialists in "history, theology, anthropology, psychology, sociology, international law, relations and policy, political science, the media, and education." (Billingham 2011: 79). The resulting report (Billingham et al 1999) recommended extensive further studies. But there has been no systematic follow-up due to lack of funding since the NASA SETI program was terminated.

The SETI Institute rose from those ashes with Billingham as co-founder, and there his legacy continued. For years, CEO Tom Pierson and Institute astronomers (e.g. Drake, Tarter, Shostak)

occasionally included social scientists in technosignatures conversations through workshops, often convened by psychologist Douglas Vakoch. Broad conversations at the SETI Institute have continued at present under astrobiologist Nathalie Cabrol (e.g. the interdisciplinary Decoding Alien Intelligence workshop, 2018), but in recent years there has been no dedicated, funded social science research.

3.0 Current Status

Wright (2019a, 2019b) , Margot et al 2019, and the NASA Technosignatures Report (2018) note that despite a recent resurgence in philanthropically funded searches, the technosignatures science community has been decimated by the lack of federal funding, and that there has been minimal student training or formal curricular development. (One promising exception is Breakthrough Listen, which has had about 60 undergraduates come through its program as interns). The lack of federal funding applies even more to the interdisciplinary aspects of SETI. The generation of researchers who were involved in the original NASA-sponsored interdisciplinary discussions (mid 1970s - 1992) about the societal implications of the search for extraterrestrial life, did keep the discussion alive in other venues (IAA SETI Committee, SETI Institute, and their own disciplinary conferences), but have now mostly retired or passed away. As they drop out of the conversations, their work is too often forgotten, not least because it was published in books, workshop reports, or journals not readily available in digital form that current astrobiologists and technosignatures scientists frequent. Given the lack of support for the work, few of their students continued in academia to address these issues. The new generation of SETI and astrobiology researchers may have only occasional exposure to these long-established broad themes and conversations, and their training tends towards the technical, and does not necessarily include the interdisciplinary history of the profession or the societal implications of the work they do. And so, when they confront a societal issue related to their work, these astronomers may not know where, or how, or with whom, to begin.

In the absence of a university center or strong and stable network to build upon and extend the interdisciplinary work already done, the sporadic NASA Astrobiology-sponsored initiatives are insufficient. Most often, workshops or edited volumes are enough only for scholars to begin mapping the research that needs to be done, with no opportunity for follow-through. Academic researchers who work on these topics typically do so in relative isolation at their home institutions, with occasional shared meetings and collaborations, and may only work on astrobiology/technosignatures intermittently. Or they may do excellent doctoral work and then struggle to find permanent academic employment. The Blumberg Chair in Astrobiology, co-sponsored by NASA Astrobiology and the Library of Congress, rotates each year. Incumbents in that Chair may focus on any aspect of astrobiology and society, not necessarily with an astronomy focus.

Privately funded research programs do not necessarily have this commitment, either; as noted, the SETI Institute does not consistently have a research focus on the societal impacts of its astronomy, and no longer has a resident social scientist active in research. Meanwhile,

Breakthrough Listen does not specifically sponsor research related to post-detection concerns or societal implications of its astronomy, and is instead heavily focusing on technology and software development and observation, with occasional broader interdisciplinary conversations such as the Making Contact workshop in 2018[2] . Breakthrough Listen's advisory board includes only one trained social scientist, John Gertz, who, though active in producing policy papers calling for greater interdisciplinarity and regulation (e.g. 2017), is not a university-based PhD active in a research ecosystem.

The primary international SETI group, the International Academy of Astronautics' SETI Permanent Committee, occasionally holds relevant workshops and policy discussions, but these are infrequent and have limited participation. (The Post-Detection Working Group was temporarily cancelled and has yet to be effectively reconstituted.) The annual International Astronautical Congress SETI sessions are also insufficient as they are not designed for extensive discussion and conference registration cost can be a significant factor for attendance. Further, the IAC SETI Committee is neither a research organization, nor significantly populated by social scientists or humanists able to undertake this research. By far, most members are astronomers and engineers, although in the early days of the Committee, a higher proportion of members from other fields were involved.

Individual social scientists and humanists have worked in this area. See, for example, works in Oman-Reagan's edited Primer, Harrison 2011 and 2007, Michaud 2007, Vakoch 2013, Race et al 2012, Traphagan 2015, Capova et al 2018, Denning and Race 2010, Denning 2011, Elliott and Baxter 2012, Dick 2015 and Dick 2018 for comparatively recent examples. But despite noteworthy efforts to consolidate a community by a few individuals (e.g. Vakoch, Capova et al / European Astrobiology Institute, the emerging Social and Conceptual Issues in Astrobiology group (SSoCIA), some Blumberg Chairs, and the short-lived Astrobiology & Society Focus Group of the NAI), there is no funded, centralized program.

Scientists on occasion do make their own efforts to address the social implications of future detections (e.g. Rio Scale and Rio Scale 2.0), but these are sporadic, infrequent, and unfunded, and do not always involve social scientific expertise. Interdisciplinary collaborations will be much more effective, (Dick, ed. 2015, Dick 2018, Denning *et al* forthcoming 2019, Capova et al 2018, Dominik and Zarnecki, eds. 2011).

Within the last decade, NASA-funded work on the societal implications of the detection of extraterrestrial life, has been primarily limited to the 2014 Blumberg Chair projects of Steven J. Dick (Dick ed 2015 and Dick 2018), a 3-year multidisciplinary project focused upon Mars and microbial life (Bertka, ed, 2000), and a group project at the Center for Theological Inquiry at Princeton with limited scope. The Astrobiology & Society Focus Group was short-lived and its

[2] The 2018 in-person and virtual workshop Making Contact, hosted by Breakthrough Listen and organized/moderated by doctoral students in anthropology Claire Isabel Webb (MIT) and Michael Oman-Reagan (Memorial University of Newfoundland), brought together an interdisciplinary community of scholars who emphasized the need for critical interdisciplinary work regarding social impacts of detection, as well as other related topics.

host, the NASA Astrobiology Institute, will soon be history. This is remarkably little support for research about something which has been recognized as an existential risk (World Economic Forum, 2013), and for which extensive research was recommended as long ago as the Brookings report (U. S. Congress, 1961).

Wright (2019b) and others have recommended that the Astro2020 Decadal should address the lack of federal support for technosignature searches by recommending that NASA and the NSF support research, training, and curricular development in this field. Whether or not this comes to pass, as a matter of responsibility to the public NASA and the NSF should fund research on the implications, policy, and best practices relating to the implications for society of a successful search for extraterrestrial life. A sustainable research community needs to be built, urgently.

4.0 Rationale for Government Support

4.1 Responsibility to the public

- Astrobiology science is significantly publicly funded, and there is now no clear way that interdisciplinary work on societal implications will be routinely and consistently funded in a way that can sustain a long-term research program.
- The various telescopes used in technosignatures searches were, to a very significant extent, funded by taxpayers.
- The US-government-driven-and-supported rise of public-private partnerships in space research and exploration increases the government's responsibility to consider the downstream consequences of such arrangements, in the event of life detection.
- It is a generally well-recognized principle that when scientific investigation instigates significant ethical and social questions, government agencies supporting the science and technology should also support work on those important questions.
- As Dominik and Zarnecki (2011) put it: "While scientists are obliged to assess benefits and risks that relate to their research, the political responsibility for decisions arising following the detection of extra-terrestrial life cannot and should not rest with them."

4.2 Scientific progress brings new issues with it

- Existing work on the societal implications of a detection of extraterrestrial life needs to be updated. The 'classic' SETI scenarios (an information-rich transmission or a beacon) addressed by early social science in this field are now subsumed within myriad possibilities, which have not been sufficiently explored in terms of their potential social impacts. For example, the detection of candidate biosignatures in an exoplanet atmosphere, or possible engineering around a distant star, would spark myriad public questions that astronomers would not necessarily be able to answer. New modes of astronomical detection of extraterrestrial life could involve announcements of ambiguous or inconclusive results, and very lengthy delays (years or decades) between initial indications and confirmation, which could be especially problematic during our

time of shaky scientific authority in the public sphere, rapidly shifting mass communication patterns, etc.

- This work is not just done and solved once, and therefore funding needs to be ongoing, and multiple perspectives and expertises should be involved. For example, simply having a couple of social scientist advisers to NASA will not be sufficient, as the area is steadily expanding in complexity and fundamental research needs to be done, for such advisors to draw upon in their recommendations.

- Exoplanet studies have instigated a host of new issues. When astronomers speak and write of exoplanets to their junior students and to the public, and when government agencies use powerful imagery to represent exoplanets, their audiences develop impressions about the accessibility and relevance of these worlds (e.g. the frequently held erroneous assumption that "habitable" could mean habitable for humans), and they deserve informed discussions about the implications of this work.

4.3 Responsibility to scientists, students, and citizen scientists

- Scientists themselves want this work to be done. Scientists involved in life-detection work (astrobiology or technosignatures or exoplanets) or planning for such research, have myriad questions about their own responsibilities, best practices, public communication, and the potential social impacts of their work.

- It is increasingly possible that a government-funded scientist will 'trip over' an indication of life in the course of research primarily focused on other topics.

- It is increasingly possible that an indication of extraterrestrial life will be 'tripped over' by a citizen scientist or student in a government-supported program. There should be guidelines in place for them and for their scientist supervisors.

- The *negative* consequences for individual scientists, teams, students, or citizen scientists, of either premature claims of extraterrestrial life, or announcements of actual scientific successes, can be significant. Female and minority scientists are particularly vulnerable to vicious attacks on social media, with significant negative consequences to their careers, lives, and families. A system and best practices should thus be created which will shield individuals from the potential negative consequences of doing their science, if they should happen to detect extraterrestrial life. This is ever more important in the eras of unreliable news, social media privacy invasion, and in the context of potential astronomical life detections which may be significant enough to report, but not firmly conclusive (and realistically, this would encompass the majority of detections currently possible).

4.4 No one else will commit to it like a federal science organization can

- Perhaps the review committee is thinking: "shouldn't a social sciences/humanities agency fund this as part of existing competitions?". However, federal funding generally available to social scientists and humanists involves competition against research proposed about other worthy and urgent causes (e.g. child poverty, social inequalities, environmental adaptation, refugees) and success is never guaranteed. Social science grant adjudicators will usually be unfamiliar with astrobiology / exobiology / technosignatures and may not appreciate the rapid progression in these fields and the urgency of the work proposed. This work should therefore be funded in conjunction with the science which is bringing the issues to the fore – just as it was in the earliest days of the NASA-sponsored search for extraterrestrial life. Note that the costs of this research would be *trivial* in comparison to the costs of the astronomy.
- This social science/humanist/policy work can only be done in close collaboration with scientists, which is likely best arranged by the same government agencies which fund the science.

Finally, this is a subject of international importance, and so international collaboration is warranted, and the US is well-poised to be a leader in this regard.

5.0 Recommendations

We echo the NASA Technosignatures Workshop report (2018:52) , which suggested NASA partnerships with federal programs to foster *sustained* interdisciplinary work on existing and potential impacts of the search for life in the universe. Candidate agencies include the NSF Directorate for Social and Behavioral and Economic Sciences, particularly some programs within the SBE Office of Multidisciplinary Activities. (See Denning and Race 2010 for prior suggestions to the SBE 2020 review).

Other options include academic institutions with strong social sciences and humanities representation as well as NASA/NSF-funded science work in astrobiology, astronomy, and exobiology.

These following areas in particular warrant support: roadmapping; actual research to follow the roadmapping; interdisciplinary education; open archive/repository for this interdisciplinary work; conference attendance fund; adding to existing astrobiology coordination structures; amplifying existing interdisciplinary programs like the Blumberg Chair.

5.1 Support for roadmapping

As noted, Dick 2018 explains at length the need for a roadmap for societal impact issues.

Some present-day roadmapping is underway (e.g. Capova et al 2018, forthcoming IAC paper by Denning et al 2019) by interested interdisciplinary researchers in astronomy, astrobiology, social sciences, humanities, and law, but there is a dire need for long-term institutional structure, support so roadmapping exercises such as these can be carried out more fully as a first step, and so that the essential recommended research can then actually be done.

5.2 Provision for actual research to follow that roadmapping

The research questions are too many to be enumerated here, but include fundamental social research geared to: understanding current global concerns about potential or definite detections of extraterrestrial life; recommending best practices for dissemination of scientific results (negative, ambiguous, positive), including representation of exoplanets and hypothetical life; ethical complexities in governmental vs. privately-sponsored life detection initiatives; potentials for commodification of discoveries; and mapping social implications of emerging potential detection scenarios (e.g. extant vs extinct life, biological vs postbiological intelligence, a living planet with no details whatsoever about its inhabitants).

5. 3 Support for interdisciplinary education

Long-established relevant work in the social sciences and humanities drops off scientists' horizons very quickly unless a constant interchange and presence is maintained, and/or interdisciplinary education is emphasized. Most education in astrobiology, exobiology, and technosignatures is focused upon the science, so scientists emerging into the myriad fields now involved in life detection do not necessarily gain exposure to the established work in the social sciences and humanities. Curricular development could easily offset this difficulty. In parallel, dedicated funding to support graduate students and postdoctoral students in the social sciences and humanities in learning to work with scientists, would yield valuable results.

5.4 Centralized archive/repository for this work to be created and maintained

As noted, one barrier to effective interdisciplinarity is simply limited easy access to prior and current work. However, repositories, archives, primers, and guides require considerable labour for collation and long-term maintenance. This is easily funded, however.

5.5 Support for social scientists and humanists to attend relevant science conferences. Social scientists and humanists with a great deal to contribute cannot regularly attend astronomy, astrobiology, or space exploration meetings unless they have a substantial grant for this purpose, which is unlikely. So there is insufficient overlap between these communities, which could be easily corrected with a small, consistent budgetary investment in a grant program to support conference attendance.

5.6 Adjuncts to the new emerging Astrobiology funding/research coordination structures.

The reconfiguration of NASA Astrobiology into Research Coordination Networks and Interdisciplinary Consortia for Astrobiology Research poses some new options for including social sciences and humanities in the work, but only if these are admissible budget lines and only if teams are encouraged to include these other disciplines and researchers in their projects.

5.7 Amplification of existing efforts

As the Technosignatures Report stated with regard to the Blumberg Chair: "This program, co-sponsored by NASA and the Library of Congress, fosters "research at the intersection of the science of astrobiology and its humanistic and societal implications," which can overlap into technosignatures. Chair-holders occupy the position for one year or less, however, and the research and events produced do not necessarily filter deeply into the science community. There may be ways to amplify the extent and impact of this program for both biosignatures and technosignatures." Dedicated funding is one way to accomplish this amplification, in the same way, for example, that the Human Genome Project used a small percentage of its funding for Ethical, Legal and Social Impacts.

5.8 Cost estimates

Exact cost structures, schedules, and plans would be determined by the method of funding (e.g. based primarily at a single institution vs attached to existing networked programs).
A total outlay on the order of $1-2 million per year for 10 years could allow for detailed research road-mapping, critical research, the rebuilding of a research community with the necessary expertise in the social sciences and humanities, and constructive/useful exchanges between scientists and social scientists/humanists.

Finally: If these recommendations are followed, the results would be a scientific community and society much better prepared for the detection of extraterrestrial life, and the reduction of potential negative consequences for all concerned.

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