U.S. House of Representatives
Committee on Science, Space, and Technology

HEARING CHARTER

Astrobiology: The Search for Biosignatures in our Solar System and Beyond

Wednesday, December 4, 2013
10:00 a.m. – 12:00 p.m.
2318 Rayburn House Office Building

Purpose

The purpose of this hearing is to examine astrobiology research and the search for biosignatures in our Solar System and beyond. The hearing will include a general assessment of the multi- and interdisciplinary nature of astrobiology research, including the role astrobiology plays in formulating NASA space missions. It will also examine the techniques and capabilities necessary to determine the potential for the existence of biosignatures within our Solar System. With the discovery of potential Earth-like planets outside of our Solar System, the hearing will also investigate what methods are being used to determine if any of these planets may harbor life. The hearing will explore existing and planned astrobiology research strategies and roadmaps.

WITNESSES:

- **Dr. Mary Voytek**, Senior Scientist for Astrobiology in the Science Mission Directorate at NASA headquarters

- **Dr. Sara Seager**, Professor of Physics and of Planetary Science at M.I.T. and 2013 recipient of a MacArthur Foundation "Genius Grant" for her work in exoplanet research

- **Dr. Steven J. Dick**, Baruch S. Blumberg Chair of Astrobiology, John W. Kluge Center, Library of Congress

Background:

The United States pioneered the field of astrobiology, and currently leads the world in astrobiology research. Astrobiology is multi-disciplinary and inter-disciplinary and attracts physicists, organic chemists, biologists, geologists and astronomers, among others from around the world to the United States to conduct their research. While conducting research, individual scientists must verse themselves in a variety of scientific disciplines, while also collaborating with colleagues across scientific fields. Astrobiologists study microbial life in underwater lakes beneath Antarctica, living organisms that can thrive in extreme temperatures at the edge of volcanic fissures on the bottom of the ocean and bacteria that live in deserts in order to better understand the varied conditions in which life might exist in the diverse environments on planetary bodies in our Solar System and beyond.

In their 2008 *Assessment of the NASA Astrobiology Institute*, the National Academies of Science collected several definitions of astrobiology from scientists. They found that it "is variously defined as the study of the origin, evolution, distribution, and future of life in the universe; the study of life as a planetary phenomenon; the study of the living universe; or the origin and co-evolution of life and habitable environments."[1]

Our Solar System

Astrobiology has been a part of space missions almost from the beginning of the space program. Current and future proposed space science missions within our Solar System incorporate astrobiology research, including the Mars rovers and orbiters, Cassini's fly-by examination of Saturn's moon Enceladus and proposed robotic missions to the Jupiter moons of Europa and Titan, in addition to many other missions.

Beyond Our Solar System

Astrobiologists and astrophysicists work together to discover and categorize exoplanets beyond our Solar System. The first definitive exoplanet discovery occurred in 1992.[2] On September 29, 2010, the Keck Observatory announced that it had identified the first Earth-sized planet orbiting a star in a "habitable zone," an area where a planet's distance from its sun increases the possibility it could have surface temperatures that could support the existence of liquid water.[3] On April 18, 2013, NASA's Kepler mission released details of its discovery of two new planetary systems that include three super-Earth sized planets in the "habitable zone."[4] On November 4, NASA announced that a review of Kepler's data from the past three years showed that there are over 3,500 potential exoplanets in our galaxy, 647 of them located in the "habitable zone."[5] The data also led scientists to estimate that there could be 140 billion planets in the Milky Way galaxy. One of these planets is 12 light years away.[6]

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[1] National Research Council of the National Academies. *Assessment of the NASA Astrobiology Institute.* 2008. http://www.nap.edu/catalog/12071.html

[2] http://tech.mit.edu/V114/N22/psr.22w.html

[3] http://www.keckobservatory.org/recent/type/news//keck_observatory_discovers_the_first_goldilocks_exoplanet/

[4] http://www.nasa.gov/mission_pages/kepler/news/kepler-62-kepler-69.html

[5] http://www.scientificamerican.com/article.cfm?id=kepler-telescope-earth-sized-planets

[6] Ibid

NASA's Astrobiology Program

In the 1960, NASA established a formal astrobiology program. Currently, NASA's astrobiology program resides in the Planetary Science Division of the Science Mission Directorate, and includes four divisions:[7]

- *NASA Astrobiology Institute (NAI)* - In 1998, the NAI was established to coordinate and organize the various astrobiology research activities NASA funds. Scientific teams competed for NASA funding, and the 11 teams that were selected formed the first NAI through cooperative agreements between NASA and the teams' institutions. This structure remains today.
- *Exobiology and Evolutionary Biology (EXO)* – Supports research on the following topics: identification of habitable planets; how complex organic molecules travel between planetary bodies; and the study of potential planetary conditions suitable for organic life.
- *Astrobiology, Science and Technology Instrument Development (ASTID)* – Supports instrument development for use in astrobiology research on space flight missions and Earth-based experiments; contributes concepts to planetary exploration missions and small science payloads.
- *Astrobiology Science and Technology for Exploring Planets (ASTEP)* – Contributes to the development of technology that will foster the search for life in planetary bodies within and without the Solar System, including the design of *in situ* laboratories and sample analysis and return techniques.

Astrobiology Roadmap

In the past decade, NASA has published two Astrobiology Roadmaps, approximately five years apart. The last roadmap was published in 2008, and the next roadmap is expected to be published in 2014. The purpose of the roadmap is to outline definitions, goals, accomplishments and public outreach and education objectives in the field of astrobiology.

Each roadmap focuses on three essential questions:

- How does life begin in the universe?
- Does life exist elsewhere in the universe?
- What is the future of life on Earth and beyond?

[7] http://astrobiology.nasa.gov/

The 2008 roadmap includes seven science goals for the astrobiology community:[8]

- Understand the nature and distribution of habitable environments in the universe. Determine the potential for habitable planets beyond the Solar System, and characterize those that are observable.
- Determine any past or present habitable environments, prebiotic chemistry, and signs of life elsewhere in our Solar System. Determine the history of any environments having liquid water, chemical ingredients, and energy sources that might have sustained living systems. Explore crustal materials and planetary atmospheres for any evidence of past and/or present life.
- Understand how life emerges from cosmic and planetary precursors. Perform observational, experimental, and theoretical investigations to understand the general physical and chemical principles underlying the origins of life.
- Understand how life on Earth and its planetary environment have co-evolved through geological time. Investigate the evolving relationships between Earth and its biota by integrating evidence from the geosciences and biosciences that shows how life evolved, responded to environmental change, and modified environmental conditions on a planetary scale.
- Understand the evolutionary mechanisms and environmental limits of life. Determine the molecular, genetic, and biochemical mechanisms that control and limit evolution, metabolic diversity, and acclimatization of life.
- Understand the principles that will shape the future of life, both on Earth and beyond. Elucidate the drivers and effects of microbial ecosystem change as a basis for forecasting future changes on time scales ranging from decades to millions of years, and explore the potential for microbial life to survive and evolve in environments beyond Earth, especially regarding aspects relevant to US Space Policy.
- Determine how to recognize signatures of life on other worlds and on early Earth. Identify biosignatures that can reveal and characterize past or present life in ancient samples from Earth, extraterrestrial samples measured in situ or returned to Earth, and remotely measured planetary atmospheres and surfaces. Identify biosignatures of distant technologies.

The 2014 roadmap is expected to assess how well the astrobiology program has accomplished these goals, how the field has grown and evolved and what its focus should be in the coming years.

[8] https://astrobiologyfuture.org/resources/7