I. Bridging Living and Non-living Matter: Oral Link with Poster

Conveners:

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The goal of this symposium will be to review the current state of the art in research on the emergence of biological complexity and evolutionary processes that led to the formation of the first living systems. This goal will be accomplished by bringing together as symposium speakers an interdisciplinary group of leading experimentalists and theorists representing planetary science, physical and organic chemistry, biochemistry, and molecular and cellular biology whose research contributed to the field in recent years.

The subject of the symposium is directly related to one of the main goals of astrobiology - to create a field of "Universal Biology" by studying origins of cellularity and protobiological systems not only on Earth but also elsewhere in the universe, with particular focus on the origins and early coordination of key cellular processes such as metabolism, energy transduction and information transfer between consecutive generations. This subject is highly topical considering recent and anticipated progress in building and integrating components for models of protocells and artificial cells, and the development of novel theories and laboratory models of protobiological self-organization.

The symposium will be organized as a series of talks and posters that will cover topics ranging from chemical and environmental constraints on the emergence of life to minimal cells. It will serve not only as a forum for exchanging ideas and forging stronger collaborations between practitioners in the field, but also as a comprehensive learning opportunity for students and young researchers.

II. **“Astrobiology on the Moon" Oral with Posters**

Conveners:

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Lunar exploration provides a high potential to foster the objectives of astrobiology. Lunar geoscience studies help to understand the origin and evolution of Earth like planets. The Moon played a key role in early Earth evolution. Lunar or cislunar telescopes on the Moon can detect and characterize if life exists elsewhere in the universe. The Moon will be used for emplacing life science experiments, human outposts, bases and biospheres that will play a key role in the future of life beyond Earth. The symposium comes at a special time when US lunar exploration architecture has been presented, and when international agencies are defining their lunar and planetary exploration program. It will help to foster interdisciplinary communication between astrobiologists, geoscientists, microbiologists and space scientists.

Topics include: The Moon as keystone to study planetary evolution and astrobiology; Summary results and goals from ongoing lunar robotic missions; Precursor missions and moon-based laboratory for astrobiology and life sciences; Human bases, Living off the land and sustained; Searching on the Moon for samples from early Earth and life

There are many reasons why the time is right to highlight the moon as an astrobiological topic. First, astrobiology focuses on the habitability of planets, and arguments have been made, mostly in public rather than scientific fora, that a large moon such as ours has a profound influence on habitability. If this is true, it has implications both for the future habitability of the earth as our moon continues to recede, and for the search for habitable planets elsewhere. Second, in light of President Bush’s Moon/Mars initiative, lunar exploration has once again become a priority for NASA. This symposium is particularly timely as it will be begin the discussion of how lunar science can aid the advancement of astrobiology, for example, as the source of information for impact history on the early Earth. As plans advance for lunar missions, the time is now to include astrobiology in the considerations.

III, **Triggers of Mass-extinctions in the Earth's history. Terrestrial vs. Extraterrestrial. Applications for planetary habitability: Oral Link with Posters**

Convener: Alexander A. Pavlov, pavlov@lasp.colorado.edu

This symposium solicits papers that present new experimental data, modeling results and observational constraints on the possible triggers of Mass-extinctions throughout Earth's history. Triggers of Mass-extinctions are very important in our understanding of the evolution of life on Earth and will put useful constraints on the habitability of Earth-like planets elsewhere. Emphasis will be placed on theoretical and observational studies that provide constraints on the "necessary" magnitude of a specific trigger, the probability for a specific trigger to occur and on the susceptibility of the biosphere to such triggers during different periods of the Earth history.

Fundamental problems to be discussed include:
1) "Terrestrial" triggers – critical outgassing of the toxic gases (H_2S etc.), extreme warming events and CO_2-poisoning, continental distribution, extreme cooling events (including Snowball).
2) "Extraterrestrial" triggers – impacts, cosmic ionizing radiation, variations in interstellar and interplanetary dust.
3) Biological constraints on triggers of mass-extinctions – tolerance of biota (microorganisms and advanced life) to UV, temperature fluctuations, toxic gases, ionizing radiation.
4) Planetary habitability – e.g. which planetary systems are more susceptible to impacts or irradiation hazard?

This is a truly interdisciplinary symposium which will bring together planetary scientists, biologists, astronomers and geologists and would generate a lot of interest for general public.

IV. Interdisciplinary Research in Cold Mars-Analogue Environments: Oral and Poster Link

Conveners:
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Mars analog sites feature a combination of geological and environmental conditions that make them reasonable terrestrial analogues for direct Martian studies. As such, studies at these sites are important both for interpreting existing Mars data and for developing field instrumentation, protocols and interpretive strategies for future Martian exploration. This symposium will address methods and results from interdisciplinary cold-climate Mars analogue studies. Participants are invited to contribute in topics such as characterization of organic, biological, geochemical, and mineralogical materials to decipher potential biosignatures, discussing microbial adaptations to cold-climate habitats on Earth (and by extension on Mars), exploring the effects of weathering, biological overprinting and contamination of geobiological records, testing for life in Mars-analogue environments, addressing the challenges of *in situ* cold-climate life-detection investigations, and presenting creative avenues in engaging the public in Mars-analogue studies.

V. How do “extremophiles” impact our perception of the habitability of Earth and extraterrestrial environments? Oral and Poster Link

Convenors:

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In recent years, studies of life at extreme environments have pushed our understanding of the habitable range of conditions on Earth. Some of the notable findings include prolific microbial communities in acidic mine drainage, intact organisms in both extremely low and extremely high temperature natural systems, and microbial life in deep subsurface environments where both nutrients and energy sources may be in short supply. Likewise, laboratory studies have pushed the boundaries of microbial activity and survival, with new insights on temperature and pressure limits and cell metabolism as prime examples. The proposed session will highlight work that places studies of the limits to life into a global and/or planetary context. Cross-disciplinary communication in studies at the limits to life will benefit the Astrobiology community by 1.) Improving the environmental relevance of biological studies, and 2.) Integrating the most current understanding of microbial physiology and activity into the search for extraterrestrial life.

Some of the interdisciplinary topics that we would like to highlight include:

1.) Integrated discussion of the physical, chemical, and temporal parameters that serve to define microbial ecosystems
2.) Assessment of potential habitats for past or current extraterrestrial life: Are extreme environments useful analogues?
3.) The use of “extremophilic” ecosystems to test life-detection criteria and instrumentation
4.) Improved understanding of the role of “extreme environments” in the evolution and proliferation of life on Earth
5.) Evaluating the contributions of extreme ecosystems to global biogeochemical cycles

Modern extreme environments:

-Deep subsurface work
-Mid-ocean ridges and ridge flanks
-Ultramafic-hosted sites
-Terrestrial hot springs
-Artic sea ice/ permafrost environments
-Acidic mine drainage/Rio Tinto
-Dry desert environments

Extraterrestrial and early Earth environments (present-day analogues and planetary settings)

-Mars, Titan, Europa, Venus,Other extraterrestrial systems? Early Earth

VI. Astrobiological Achievements of the NASA Astrobiology Institute: Oral Link with Posters (Thursday)

Conveners: Executive Council of the NASA Astrobiology Institute via Bruce Runnegar, NASA Astrobiology Institute, Ames Research Center, Moffett Field, CA 94035; Bruce.Runnegar@nasa.gov

Proposal: The NASA Astrobiology Institute (NAI) was founded in 1998 as a new way to do science (a distributed institute) and to help found the new field of astrobiology. Seven years later, the Institute has 16 teams distributed across the nation from Hawaii to Massachusetts. The proposed one-day session will highlight astrobiological achievements of the NAI, as a microcosm of the progress of astrobiology as a whole.

Session plan: A half-day parallel session with a set of invited speakers selected by the PIs (Executive Council members) of the 16 NAI teams. Not all NAI teams will be represented in the program. This will be a carefully selected set of highlights

VII. Sulfur on Earth and Mars: Microbiology, Mineralogy, Isotope Geochemistry, Photochemistry, Role in Mars Exploration, Environmental Impact. Oral and Poster Link

Conveners: Lee Kump, Dept. of Geosciences, Pennsylvania State University, 535 Deike Bldg., University Park, PA 16802; lkump@psu.edu; Bruce Runnegar, NASA Astrobiology Institute, Ames Research Center, Moffett Field, CA 94035; Bruce.Runnegar@nasa.gov

Sulfur is a key element for environmental reconstruction and a powerful source of novel biosignatures. The proposed session would deal with the following issues:

Atmospheric oxidation. On Earth, the atmospheric roles of sulfur and oxygen appear to have reversed at the time of the Great Oxidation Event (GOE) when the atmospheric biosphere first emerge. Prior to the GOE, volcanic sulfur passing through the atmosphere was partitioned by photochemical reactions into two reservoirs, each exhibiting anomalous "mass-independent" isotope effects as measured by the ratios of $^{33}S/^{32}S$ versus $^{34}S/^{32}S$. These changes are recorded in sulfur minerals and are being used by some to understand the nature and timing of the Great Oxidation Event, but others have different interpretations so this session will also provide an opportunity to explore the controversy.

Novel chemistry. Experimental O and S gas-phase chemistry of the mass-independent fractionation processes along with theoretical work is a hot field. A chemical understanding of these processes will be of great importance to interpretations of environmental conditions on the early Earth and Mars.

Novel microbiology. Deeper understanding of the many ways microorganisms have and are using S compounds as a redox source of energy is being informed by studies of microbial reactions; by isotopic effects associated with these reactions; by whole-genome analyses of the organisms and their S metabolizing pathways; and by biomarker studies which enable these pathways to be identified in sedimentary environments.

Novel histories. The recently realized ability to extract trace sulfate from most sedimentary carbonates provides temporal access to the marine S cycle throughout Earth history. It is now possible to measure the isotopic composition of both the reduced and the oxidized reservoirs in all sorts of astrobiologically significant sites.

Sulfur on Mars. Mars may be the red planet because of the iron in the regolith, but it is also S-rich (relative to Earth) from core to surface. The abundance of S, and sulfate minerals, in surficial deposits has been recently. Understanding the origin and significance of S, as well as the potential role of sulfates as environmental indicators and repositories of potential biosignatures, will greatly inform future missions to Mars.

Sulfidic oceans and mass extinctions. Sulfur seems to have exchanged places with oxygen or Fe as a dissolved components of deep ocean waters throughout Earth history. Basically, Fe and S are incompatible components because iron sulfide is insoluble and oxygen and sulfide are incompatible because of source/sink effects. Thus, the alternation in time of these three components provides a way of explaining many poorly understood features of the geological and paleobiological records, including local and planetary-scale mass extinctions.

VIII. Extraterrestrial pre-biotic chemistry: Synthesis in the Solar System and beyond: Oral with Poster Link

Convener: Conel Alexander,
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It has been suggested that organic matter in primitive meteorites and interplanetary dust particles (IDPs) are largely interstellar in origin, and that they could have played a role in the origin of life on Earth. If organic matter from meteorites/IDPs did influence the development of life and it formed in the interstellar medium (ISM), the ubiquity of this material in the Galaxy has obvious consequences for the origin of life outside the Solar System. The purpose of this symposium would be to bring together meteoriticists, astronomers, and experimental and theoretical astrochemists to compare and contrast the organic matter in various extraterrestrial objects (meteorites, IDPs, comets) and environments (protoplanetary disks, ISM) with experiments and models, and explore what role, if any, exogenous organic matter could play in the origin of life.

IX. Exploring Planets Around Other Stars

Conveners:
L. Jeremy Richardson, NASA Goddard
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What are the prospects over the next two decades for detecting habitable worlds and planetary systems like the one we inhabit? How are current space missions contributing to this goal?

Since the first detection of a hot Jupiter around a solar-like star 10 years ago, much progress has been made in the field of extrasolar planet detection and characterization. Over 160 planets are now known to orbit other stars, and nine of these pass in front of their parent stars as seen from Earth, which allows us for the first time to learn about extrasolar planet sizes and atmospheric compositions. This symposium will provide an overview of the current state of knowledge of extrasolar planets and a discussion of future prospects for detecting Earth-like planets around nearby stars.

We anticipate talks summarizing the various detection methods that have been successful so far, as well as techniques that are now being refined for the next generation of planet-finding missions. We will discuss what we know and hope to learn soon about planetary statistics (how common are Solar Systems like ours?), atmospheric characterization of giant planets and terrestrial planets (including signs of habitability to life as we know it), origins of planetary systems and implications for habiitability, signatures that planets are currently forming within circumstellar disks, and the future proposed missions for planet detection and characterization. All talks and discussion will stress the direct connection between extrasolar planets and astrobiology.

X. Engaging Public Perceptions of Evolution: Challenges and Opportunities for Scientists and Science Educators: Oral

Conveners:
Connie Bertka, Director, Program of Dialogue on Science Ethics and Religion
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Life on Earth has existed in its present form since the beginning of time? According to a recent 2005 Pew Forum on Religion and Public Life Survey, forty-two percent of the American public thinks the answer is “yes.” Even more sobering is the fact that this percentage has remained nearly unchanged for decades. The most recent challenge to public understanding of science in general, and evolution in particular, is “intelligent design.” ID has the potential to appeal to an even broader public audience, as evidenced by the success of the Kansas State Board of Education in changing the definition of science such that explanations beyond nature may be discussed in the science classroom. If the scientific community at large wasn’t paying attention before, we are now.

Science educators working with high school students, college students, and the public at large, have had to confront this issue. This symposium will bring together a panel of educators, both formal and informal, who have dealt specifically with the teaching evolution controversy to provide an opportunity to both brief the astrobiology community on the present status of significant events, and to encourage a broader discussion of challenges and opportunities.

X. **Follow the Energy: Oral with Poster Link**

Conveners:

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Life universally requires energy to build and maintain organization and complexity in a universe that is constantly moving towards maximum entropy. This need for energy represents a constraint on habitability, origins of life chemistry, and the activities of extant organisms, including possible biosignature formation. Thermodynamics, which describe the cycling of energy in chemical systems, offers the potential to express these constraints in quantitative terms.

We propose a session that broadly considers the relationship between environment, energy, and life. While biology-centric, such a session would encompass topics from a range of disciplines, and be couched largely in a language (thermodynamics) that represents a common cross-disciplinary thread. Possible topics include:

- Defining and quantifying the biological requirement for energy
- Understanding energetic constraints on origins of life chemistry, and defining the possibilities for early energy-transducing systems in biology
- Understanding how energy is deposited and released during planet formation and evolution
- Identifying and quantifying possible energy sources for life, with specific emphasis on subsurface environments (e.g., water-rock chemistry, Europan ice chemistry, “vent glow photosynthesis”)
- Understanding what sorts of energy can be put to use in biology
- Understanding how energy availability and cycling shape the properties and activities of biological systems
- Understanding whether biologically-mediated energy cycling generates diagnostic biosignatures (e.g., redox biosignatures)

XII. Where Have All the Cowgirls Gone? Success Strategies for Women (and Men!) in Astrobiology: Thursday Workshop

Conveners: Julie A. Huber, Marine Biological Laboratory7 MBL Street, Woods Hole, MA 02543Office: 508-548-3705, x6616; Fax: 508-457-4727; jhuber@mbl.edu
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Because of its interdisciplinary nature and integrative questions, Astrobiology brings together a diverse group of scientists from different backgrounds and approaches. However, despite an inclusive and very relationship-oriented approach to science, when it comes to the representation of women, the field of Astrobiology looks rather similar to its more traditional "parent" disciplines. For example, recent data indicates that despite the fact that women receive close to 50% of doctorates in biology, only 15% make it to the full professor level (Handelsman 2005). A similar lack of senior female scientists is easily visible at Astrobiology conferences (both the NAI General Meeting and the Astrobiology Science Conference). In the five conferences held since 2001, on average women represent less than 7% of invited speakers. It is an interesting contrast that the audiences at these conferences, including the authors on submitted abstracts, are well-represented by women, especially at the graduate and early career levels.

What is the problem and how do we solve it? In this symposium, we take a solution-oriented look at changing this situation through developing individual skills and confidence. We do not assert that real change in the community can come from the "top down" approach of enforcing official or unofficial rules about the numbers of invited female speakers. Rather, our philosophy for this workshop is that women can individually promote the growth of their own careers by learning and practicing the same strategies that work for all successful researchers, men and women alike.

With role-playing, skits, and small-group breakouts, this workshop will be a fun and informative opportunity to learn about the subtle, if classic, mistakes that women sometimes make in presenting their research and connecting with colleagues. Furthermore, we will demonstrate how to replace these mistakes with more effective strategies for presenting oneself in a clear, engaging and confident manner. We will also address the dire need for an active spirit of mentorship in our community, and we will demonstrate strategies that mentors can use to help all of their early career underlings, male and female, push their own limits and, thereby, the limits of science itself.

Men and women are invited to participate in the activities of this workshop; all may benefit from exploring this topic. Much literature exists on how to encourage women to succeed in science for traditional disciplines, and we will bring together these recommendations and discuss how they can apply to Astrobiology. Our community prides itself on the unique pathways and discoveries of its members; it is now time to look at our community and determine how we can better represent, encourage, and support the future of the field.

XIII. **Assessing the need for a lander on Europa: Oral Link with Poster**

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The top exploration priority for the outer planets is a mission to Europa [1]. Much of the science motivating such a mission can, and will, be accomplished utilizing instruments on board an orbiting spacecraft. However, the science goals (as detailed in the Europa Geophysical Explorer, the Jupiter Icy Moons Orbiter, and the Europa Orbiter science definition team reports [2]) also specifically refer to the NASA Decadal Survey goal of identifying and mapping 'surface compositional materials with emphasis on compounds of astrobiological interest'. One critical outstanding issue facing the community right now is whether or not such a goal can be sufficiently satisfied without a lander on the surface of Europa.

The 2006 Astrobiology Science Conference could serve as the perfect forum for attempting to bring some resolution to this issue. Many of the top astrobiology science and engineering minds will be present and a symposium or workshop resulting in a short report from the astrobiology community could be an important contribution to mission related work. Specifically, I expect this report to be a useful guideline for optimizing the astrobiology science return on a Europa mission given the constraints of both time and money.

The proposed format would involve an oral session with an associated poster session. Key presentations by members of the Outer Planets Assessment Group (OPAG) would be given. The symposium will begin with an introductory talk designed to bring astrobiologists up to speed with current issues, then it would jump into specific concerns and problems.

1. Outer Planets Assessment Group, http://www.lpi.usra.edu/opag/meetings.html
2. See documents available at: http://www.lpi.usra.edu/opag/resources.html

XIV. The environmental impact of life: redox changes from the microscale to composition of the atmosphere and ocean: Oral Link to Posters

Conveners:
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Olivier Rouxel, Woods Hole Oceanographic Institution
Boswell Wing, McGill University

Redox conditions on a hierarchy of scales are controlled by, and influence, the presence of life. Locally, redox conditions associated with biological activity might be faithfully recorded by mineralogical or geochemical indicators and can serve as potential biosignatures. On a global scale, the redox evolution of Earth's atmosphere and ocean from an essentially anoxic condition to the present oxygen-rich state are undoubtedly rooted in biological activity. This redox transition has been the focus of recent astrobiological research, and its tempo been refined through development and application of new analytical tools. As a whole, however, comprehensive techniques for the study of Precambrian environmental redox conditions are in their nascent stages. In particular, lessons learned from modern environments as well as short periods of anoxia and euxinia in the Phanerozoic can guide in studies of the redox state of Precambrian surface environments.

This symposium will bridge a gap between specialists using various tools to constrain the redox state of the modern, Phanerozoic, and Precambrian ocean and atmosphere. Field, laboratory, and theoretical studies that examine elemental, isotopic, and/or mineralogical redox indicators are welcome. We look forward to submissions that attempt to bridge the scale gap between biological control over microscale redox conditions and the global effects of life on composition of the atmosphere and ocean. Studies that examine how non-biological processes can control redox state at various scales are particularly encouraged to help define the conditions under which local and global redox indicators might be taken as robust biosignatures.

XV. Habitability on Mars: Surface vs. Subsurface: Oral Link to Poster

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Mars clearly has abundant evidence on the global scale for water having been on the surface at some point in the past. Additionally, the MER rovers have provided intriguing evidence for surface and very near surface water at the outcrop scale. Thus, valley networks, possible, oceans, and ancient lakes/playas are the big players at most meetings. This session will start with what is known about Martian surface water and find out if those water-related features are/were habitable or if we need to delve a bit deeper.

Recently, the Mars Odyssey GRS discovered large concentrations of hydrogen within 1 meter of the surface which may be ground ice. Additionally, surface water may be lost not only to the atmosphere but also by seepage into the ground. Thus, there may be significant quantities of ice and/or water within the martian upper crust. Protection from radiation and from large climatic changes make the subsurface a potentially viable habitat. The subsurface is not only a *possible* place but potentially the *best* place to find both current and past habitable environments on Mars.

This session will be organized as a type of debate between "Pro Surface" and "Pro Subsurface". We will hear from speakers as to why either is the best place to search for life or even why a combination of the two is the best. The interdisciplinarity of this session lies in the fact that astrobiologists and geologists must work together to assess the habitability of the martian subsurface. Additionally, those who develop instrumentation to search for biosignatures will be able to provide input on how surface and subsurface missions are different.

Potential Topics:

- Time scales of surface water: Was surface water ever present on the surface long enough to support or initiate life?
- The question of flux: According to the Goldilocks Hypothesis, life needs sustained thermodynamic disequilibrium and a constant supply of cations and anions – where can we find this on Mars?
- The best places for habitable environments in the subsurface in the past
- Currently habitable places in the subsurface
- Evolution of subsurface habitable environments through time: How have they changed? Have they moved?
- Besides the obvious differences in platforms (rovers/landers vs. drills, etc.) what are the major differences in two missions, one which focuses on the search for surface biosignatures and one which focuses on the search for subsurface biosignatures?
- Ascertaining past habitat: If one drills and finds some type of biosignature, how does one determine whether that life developed on the surface (and is now found further down the stratigraphic column) or in the subsurface?

XVII. Elements of Life (Metallomics): Oral with Poster Link

Conveners: Ariel Anbar (ASU) anbar@asu.edu; Jim Elser (ASU); David Emerson (ATCC)

Astrobiologists are well acquainted with the use of Fe and some other inorganic elements as electron donors and acceptors in microbial respiration. As a result, a great deal of attention has been given to biological cycling of Fe, Mn and other such elements. However, the importance of these and other elements extends beyond microbial respiration because all known living systems require a highly non-random selection of chemical elements as basic building blocks of cellular and extracellular structures. These include not only the macroelements C, H, O, N, P and S but also a variety of micronutrient elements, mostly transition metals, which are active components of metalloenzymes and other molecular structures. These elements comprise the "metallome". Examples include Mg, Fe, Mn, Cu, Ni, Zn, and Mo, which are required co-factors for cell growth in many microorganisms. The biochemical reactions in which these elements are involved are critical to the biogeochemical cycles of C, N and S.

The extended biological stoichiometry of life and the use of inorganic elements in respiration are still poorly understood. The implications are increasingly clear to biochemists and biogeochemists working in modern systems, but have yet to be fully assimilated by the astrobiology community. Astrobiological consequences are profound. At the most fundamental level, elemental abundances need to be considered when defining what is a "habitable environment"; if the terrestrial experience is any guide, liquid water, carbon and energy are clearly necessary but insufficient conditions for life. Equally important, the course of evolution- especially the origin and evolution of key biochemical pathways- must be shaped by elemental availability. Recognition that life requires a unique assemblage of elements also suggests novel biosignatures; life may leave its fingerprints in the relative abundances of bioessential elements in ancient sediments.

The proposed session would bring together chemists, biochemists, ecologists, microbiologists and geoscientists working in these areas with the goal of stimulating new research avenues in astrobiology.

XVIII. **Titan as a Prebiotic Chemical System**

Conveners:
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Titan, a natural satellite of Saturn, has intrigued many people since its discovery in 1655 by Dutch scientist Christiaan Huygens and with an atmosphere discovered by Gerard Kuiper in 1943. Nitrogen dominates the atmosphere, while methane is the second most abundant gas but there is only ~10 ppm oxygen, as CO. Titan's upper atmosphere is bathed in ultraviolet photons from the Sun and particle radiation although the 95 K surface is very well shielded. Consequently, methane in the stratosphere is broken apart by the UV and makes C2 and higher hydrocarbons while methane condenses out in the ~70K troposphere. Titan is the second largest moon in the solar system (after Jupiter's Ganymede) and one of 3 moons with bulk densities of 1.8 g/cm3, and radii ~ 2500 km (Ganymede, Callisto, and Titan) and one of 6 moons with roughly the same mass of silicates (Moon, Io, Europa, Ganymede, Callisto, Titan). Is life a natural outcome of the formation and early evolution of planets? If the origin of life came in a series of steps of increasing self-organization and chemical specificity then we may see the progression from primordial chemical diversity to prebiotic chemical selection to self-organizing chemical systems on Titan's surface. Cassini/Huygens has given us some new tantalizing data, but there is still much to learn.

The scope of this symposium is the past, present and future of Titan. This symposium will examine Titan as a **system** with the goal of trying to better understand the chemistry and potential for a prebiotic world. There are many questions to address. How did Titan form? What was the origin of its atmosphere? What is the source of methane and the timing of its outgassing to the surface? How much methane is present today in the surface-atmosphere system of Titan? How thick are the deposits of organic materials, where are they in the Titan crust, and what is the extent of their further chemistry beyond stratospheric photochemistry toward complex organics of prebiotic interest? How has organic chemistry evolved over time on the surface of Titan, and is the evolution progressive or cyclic? Was Titan's surface much warmer in the past and what will conditions be like when the Sun becomes a red giant? What are the next appropriate steps in the exploration of Titan in terms of mission design and instrument techniques?

XIX. **Radio Astronomy: New Instruments And Their Importance For Astrobiology: Needs Opinions**

Convener: Jill Tarter
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Astrobiologists have recently become more and more familiar with what optical and infrared observations of starforming regions, the interstellar medium, solar system objects, and extrasolar planets can tell them. As a group we are somewhat less knowledgeable about the potential for new insights from the realm of radio telescopes. There are a number of new groundbased instruments under construction or planned for the future in this wavelength regime. Many of them have already included areas of great interest to astrobiology in their 'science cases'. This session would allow scientists from the telescope community to discuss the capabilities of these instruments to study the formation of planets in protoplanetary disks, the creation, modification, and delivery of organic biomolecules, the pristine relics of our own solar system, and even searches for extraterrestrial technologies. There are still opportunities for astrobiologists to impact design decisions for some of these instruments to improve their future relevance to astrobiology, and additional opportunities to form partnerships with scientists more familiar with the existing instrumentation to conduct near-term, novel explorations of fundamental importance to questions pertaining to the origin and evolution of life here and elsewhere.