A.1.2 Research in Exobiology

1. Scope of Program

The goal of NASA's Exobiology Program is to understand the origin, evolution, and distribution of life in the universe. Research is centered around the origin of life and is focused on achieving this goal by tracing the pathways taken by the biogenic elements, leading from the origin of the universe through the major epochs in the evolution of living systems and their precursors. These epochs (and the approximate percentage of funding historically allocated to each) are: the cosmic evolution of the biogenic compounds (15%); prebiotic evolution (35%); the early evolution of life (35%); and the evolution of advanced life (15%). The areas of research emphasis in this program are as follows:

- *Cosmic Evolution of the Biogenic Compounds*

The principal goal of research in the area of the cosmic evolution of the biogenic compounds is to determine the history of the biogenic elements (C, H, N, O, P, S) from their birth in stars to their incorporation into planetary bodies. Emphasis is placed on studies that constrain or extend concepts of possible chemical evolution relevant to the origin, evolution, and distribution of life.

- *Pre Biotic Evolution*

Research in the area of prebiotic evolution seeks to understand the pathways and processes leading from the origin of a planet to the origin of life. The strategy is to investigate the planetary and molecular processes that set the physical and chemical conditions within which living systems arose. Four major objectives are to: i) determine constraints on prebiotic evolution imposed by the physical and chemical histories of planets; ii) develop models of active boundary regions in which chemical evolution could have occurred; iii) determine what chemical systems could have served as precursors of metabolic and replicating systems both on Earth and elsewhere; and iv) determine in what forms prebiotic organic matter has been preserved in planetary materials.

- *Early Evolution of Life*

The goal of research into the early evolution of life is to determine the nature of the most primitive organisms, the environment in which they evolved, and the way in which they influenced that environment. As an approach to understanding life in the universe, the opportunity is taken to investigate two natural repositories of evolutionary history available on Earth, in particular, the molecular record in living organisms and the

geological record in rocks. These paired records are used to: i) determine when and in what setting life first appeared; ii) determine the characteristics of the first successful living organisms; iii) understand the phylogeny and physiology of microorganisms thought to be analogs of primitive environments; iv) determine the original nature of biotic energy transduction, membrane function, and information processing through study of extant microbes; and iv) elucidate the physical, chemical, and biotic forces operating on microbial evolution.

• *Evolution of Advanced Life*

The research associated with the study of the evolution of advanced life seeks to determine the extrinsic factors influencing the development of advanced life and its potential distribution. This research includes an evaluation of the influence of extraterrestrial and planetary processes on the appearance and evolution of multicellular life, conducted by: i) tracing the effects of major changes in the Earth's environment on the evolution of complex life, especially during mass extinction events, and ii) determining the effects of global events and of events originating in space on the production of environmental changes that affected the evolution of multicellular life. Also, studies will be considered that seek approaches to investigations furthering our understanding of the distribution of life elsewhere in the universe. Note that an Evolutionary Biology NRA is planned that will focus on the process of evolution and the future of life on Earth and in space.

• *Planetary Protection Research*

There are numerous areas of research in exobiology that also have implications with respect to preventing the contamination of extraterrestrial environments by terrestrial organisms carried by spacecraft, and for understanding the potential survival of extraterrestrial organisms that may be returned to Earth. Research is required in order to allow NASA to understand the potential for contamination and to set standards in these areas for spacecraft preparation and operating procedures and for returned-sample analysis. Many of these research requirements derive directly from recent National Research Council reports on planetary protection requirements for solar system exploration missions (see National Academy Press at <http://www.nap.edu/>).

Therefore, this ROSS-99 NRA is also soliciting exobiology research pertinent to planetary protection goals in the following areas:

The widest possible spectrum of Earth microbes, the use of modern molecular analytical methods to detect and classify organisms on spacecraft surfaces during assembly and launch processing, as well as the development of new methods for the same purposes; Procedures for detection, preliminary characterization, and containment of organisms (living, dead, or fossil) in returned samples;

Procedures for sample sterilization which largely preserve sample information; and
The limits of life, including the potential for organisms to originate and thrive on bodies such as Europa, Ganymede, Callisto, Phobos, Deimos, P-type asteroids, D-type asteroids, C-type asteroids, undifferentiated metamorphosed asteroids, differentiated asteroids, and/or comets.

• *Instrumentation*

Included in the scope of the Exobiology Program is the development of advanced instrument concepts and technologies that may enable exobiology research in space exploration. The severe constraints of weight and volume on payloads and the unique nature of some potential exobiological investigations necessitates novel concepts for flight instrumentation to maximize the scientific return of future missions. Note: Beyond advanced instrument concepts, the Planetary Instrument Definition and Development Program supports the development of exobiology instruments through the breadboard stage (see Program Element A.3.5 in this NRA).

2. Programmatic Information

Proposals are sought for new projects within the scope of the Exobiology Program. Proposals submitted in response to this NRA should be for work that is not currently supported by the Exobiology Program, as well as tasks that are currently funded in the Exobiology Program but whose periods of performance are expiring in 1999 or in the first half of 2000. Periods of performance from one to five years (typically three years) may be proposed, as appropriate to the nature of the contemplated research. Proposers are reminded that programmatic balance (see historical percentages above) may limit the opportunities for funding in some areas. Also note that NASA procurement regulations require that any task accepted for a period of performance longer than three years requires the submission of a complete proposal for review at the end of the first three yeas.

The Exobiology Program usually competes one-third of the program every year and so anticipates that approximately $3M will be available to support research proposed in response to this NRA.

Funds are available under the Planetary Major Equipment Program (Program Element A.3.6 in this NRA) to provide for upgrading of analytical instruments required by investigations sponsored by the Exobiology Program. New, major analytical instrumentation that is necessary for the conduct of proposed research, or that would substantially improve its quality, should be identified and requested in a special section of each proposal, to be titled "Major Equipment Request." Details of specific guidelines, restrictions, and exclusions are provided in the Planetary Major Equipment Program section of this NRA.

Progress reports for funding the second or subsequent years of research, for previously approved multiple year awards, will be considered separately and should be sent directly to the Exobiology Program Scientist at least 90 days before their funding anniversary date.

NOTE: Appendix C contains critical information necessary for the preparation and submission of proposals submitted in response to this NRA. In particular, Section C.5.3 contains detailed standards concerning the format, page limits, and contents of a proposal. The submission of a proposal not in compliance with these standards may complicate and/or hinder its efficient and complete evaluation. Therefore, deficiencies in format and/or omission of key information may result in a proposal being found unacceptable for evaluation, or if evaluated, being adversely affected during the evaluation process.

A Notice of Intent is requested for this program element. The schedules for submission of the Notice of Intent and proposal are given in Table 1 of the cover letter of this NRA. The World wide Web site for submitting both the NOI and the *Cover Page/Proposal Summary* (see Appendix C.5) is <http://cass.jsc.nasa.gov/panel/>; proposers without access to the Web or who experience difficulty in using this site may contact the Lunar Planetary Instutute by E-mail at <exorp@lpi.jsc.nasa.gov> or by phone at (281) 486-2137 for assistance. Hard copies of the proposals are to be delivered to:

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