Update from NASA Astrobiology Program

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CAPS, Washington, DC
March 27, 2019

Exobiology – ROSES 18

Moved from Step 1/Step 2 to NOI/Step 2

- Will continue this in ROSES-19

Moved call from October to May due date

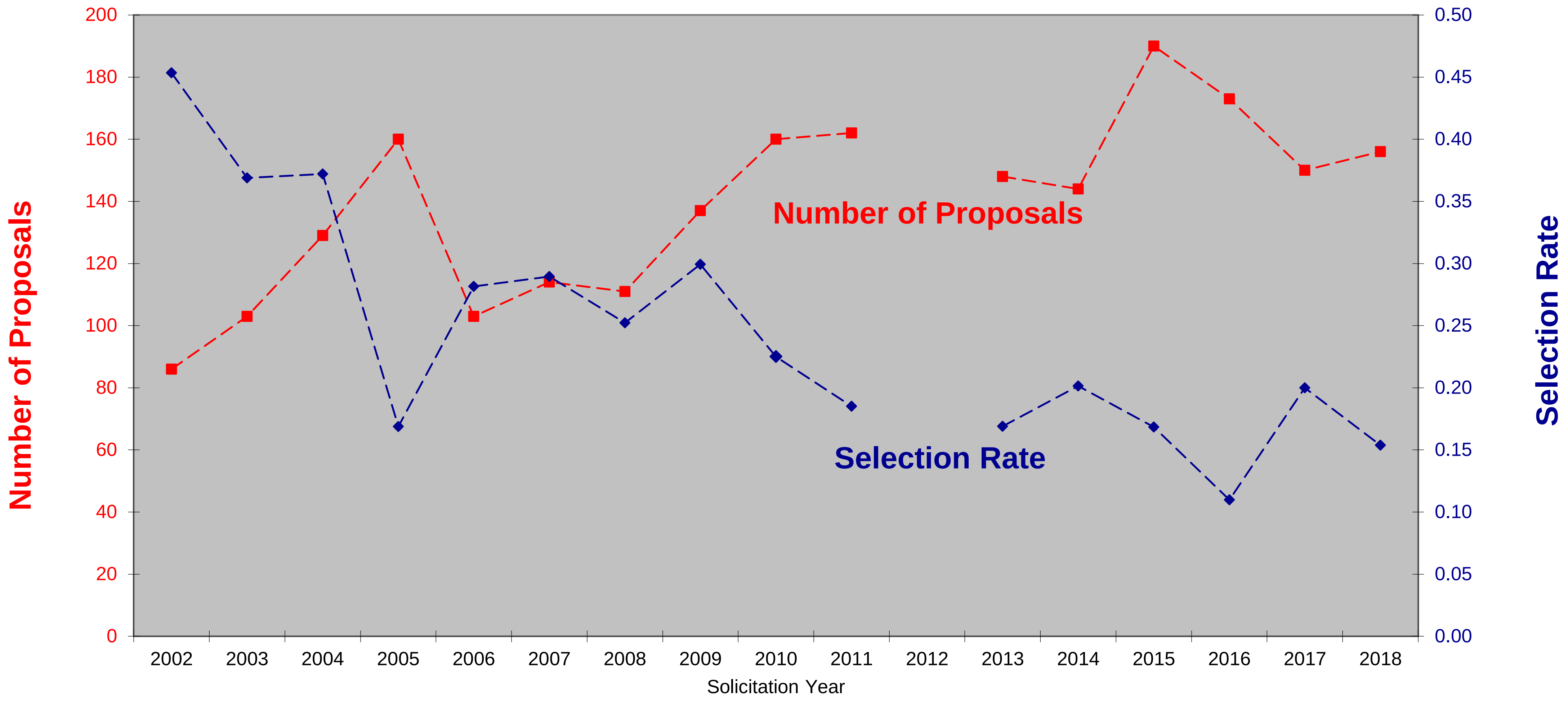
- ROSES-19 full proposal due date is 6/13

156 Proposals submitted

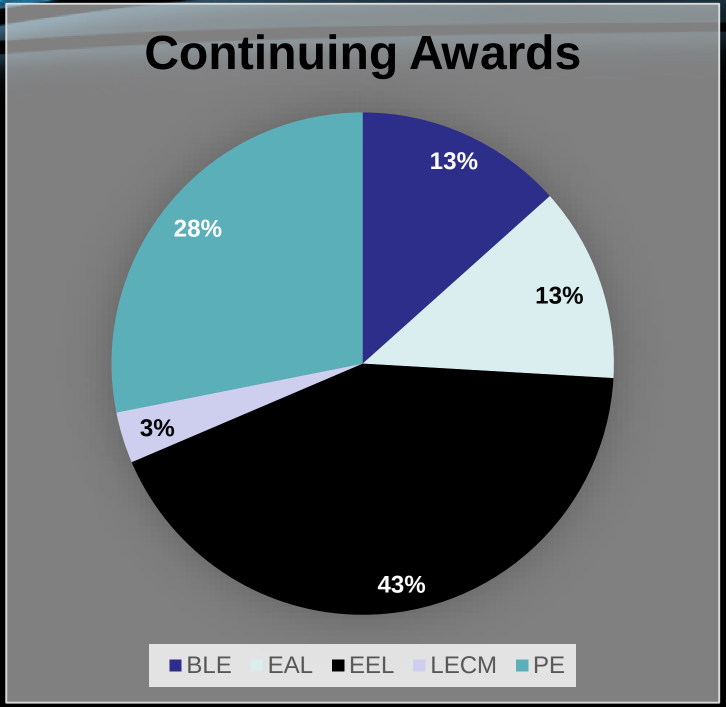
- 24 proposals were selected for funding
- 21 fully selected
- 1 partially funded
- 1 conditionally funded (1-year proof-of-concept)
- 1 funded through general R&A funds

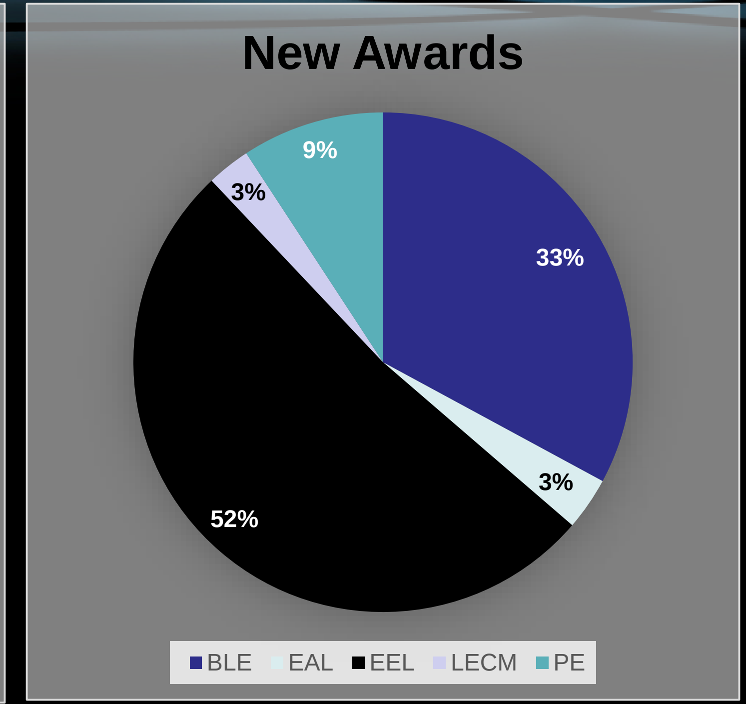
Selection rate is 15.3%

History of Exobiology NRAs



Distribution of Funded Tasks





Percentages based on award amounts. Abbreviations are: BLE Biosignatures and Life Elsewhere; EAL Evolution of Advanced Life; EEL Early Evolution of Life and the Biosphere; LECM Large scale environmental change and Macro-evolution; PE Prebiotic Evolution.

Program currently funds 8 NESSF awards, NESSF will be replaced by Future Investigators in NASA Earth and Space Science and Technology (FINESST), and 1 Early Career Fellow who has received start-up funding (note: no ECF program in ROSES-17 or -18)

<u>Habitable Worlds</u> – ROSES 17/18

<u>ROSES-18</u>

Step 1 due 11/15/18

Step 2 originally due 1/17/19, moved to 3/29/19 due to shutdown

- ROSES-19 NOI due 11/15/19, full proposals due 1/17/20

<u>ROSES-17</u>

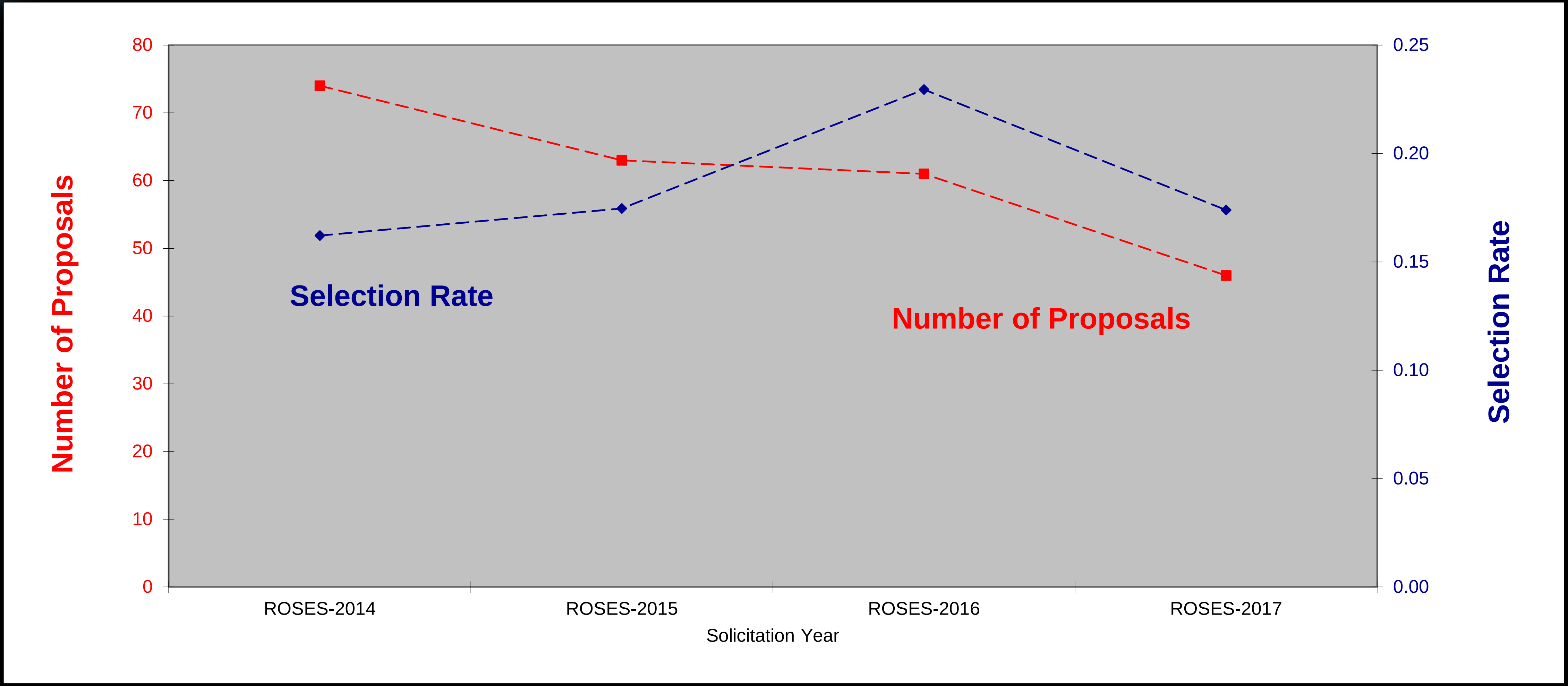
46 Proposals submitted

- 8 proposals were selected for funding
- 7 fully selected
- 1 partially funded
- 1 funded by HPD

Selection rate is **17.4%**

<u>Currently</u>: 21 Active grants, 3 active NESSF awards. NESSF will be replaced by Future Investigators in NASA Earth and Space Science and Technology (FINESST)

History of Habitable Worlds NRAs



Planetary Science and Technology through Analog Research (PSTAR) – ROSES 17/18

ROSES-18

PSTAR was not solicited due to lack of funding

ROSES-17

61 Step-1 Proposals submitted (11 discouraged)

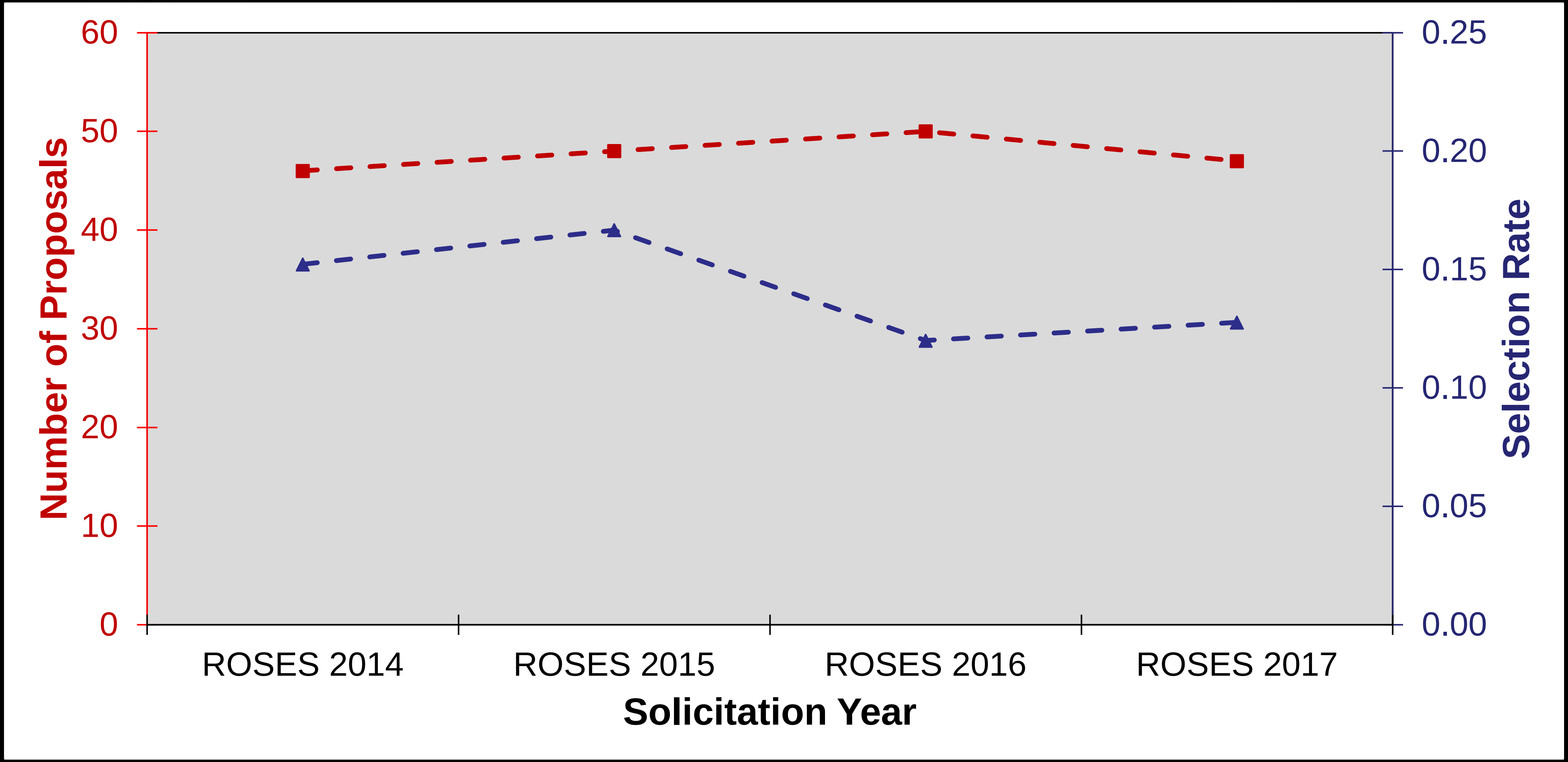
47 Step-2 Proposals submitted

- 6 proposals were selected for funding
- 4 related to Mars exploration
- 2 related to Icy/Ocean Worlds exploration
- 1 selectable for the Mars Exploration Program

Selection rate is **12.8%**

Currently: 17 Active grants, 1 active NESSF awards. NESSF will be replaced by Future Investigators in NASA Earth and Space Science and Technology (FINESST)

History of PSTAR NRAs



Planetary Protection Research – ROSES 17

ROSES-17 selections made in September 2018

Starting on bi-annual trend with May due date

- ROSES-18 NOI due 4/12/19, full proposals due 5/10/19
- ROSES-19 will not be solicited; ROSES-20 due May 2020

ROSES-17

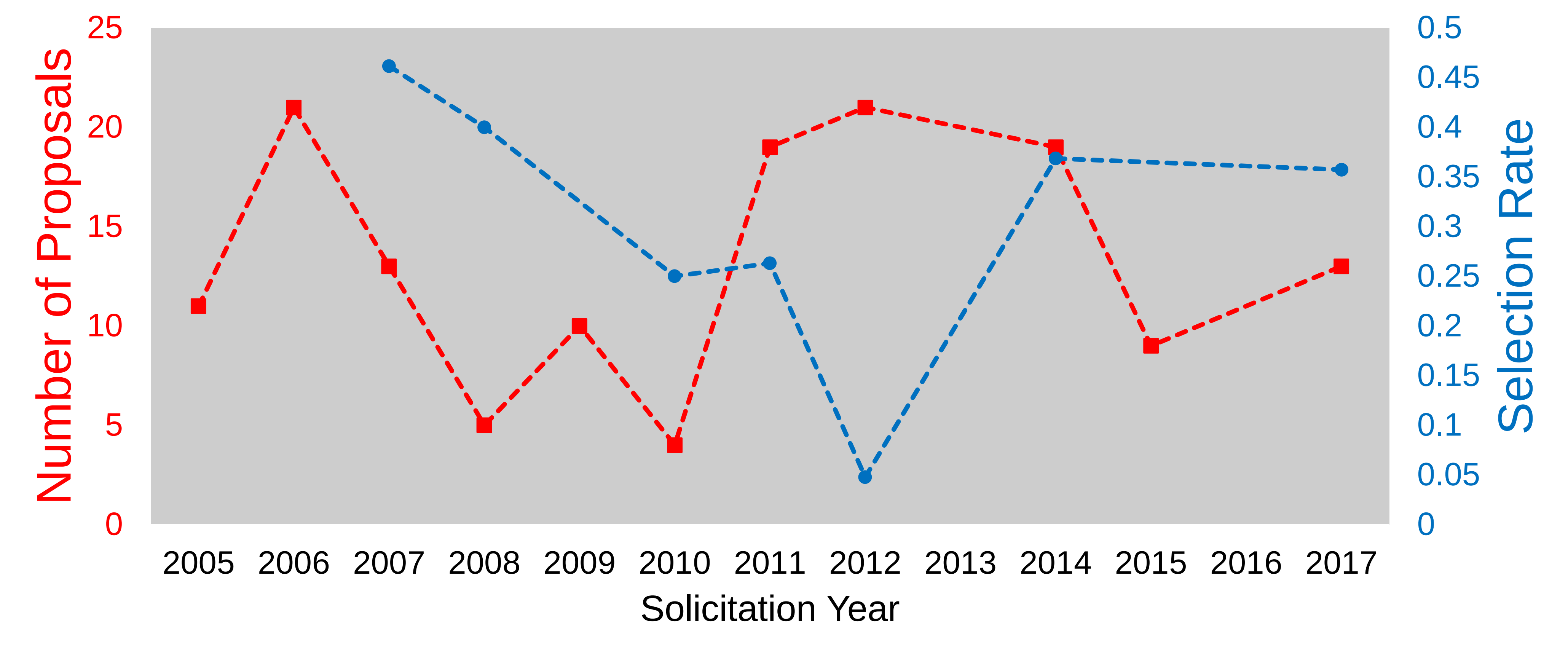
14 Proposals submitted

- 5 proposals were selected for funding
- 2 fully selected
- 3 partially funded (1 funded by PDART)

Selection rate is **35.7%**

Currently: PPR funds 1 NESSF awards. NESSF will be replaced by Future Investigators in NASA Earth and Space Science and Technology (FINESST)

History of PPR NRAs



Astrobiology Research Coordination Networks

NExSS
Nexus for Exoplanet System Science

N-FoLD
Network for Life Detection

From Early Cells to Multicellularity

PCE_3
Prebiotic Chemistry and Early Earth Environments

NOW
Network for Ocean Worlds

Astrobiology Research Coordination Networks

NExSS

From Early Cells
to
Multicellularity

NfoLD
Network FOr Life Detection

Prebiotic Chemistry and Early Earth Environments
PCE_3

NOW
Network for
Ocean Worlds

Astrobiology Research Coordination Networks

Co-Leads:
Natalie Batalha
Dawn Gelino
Anthony Del Genio
Vikki Meadows

NExSS

Steering Committee: V. Airapetian, D. Apai, S. Desch, J. Fortney, J. Graham, W. Henning, H. Jang-Condell, A. Jensen, W. Moore, N. Turner, J. Wright, D. Brain, S. Andrews, T. Brandt, D. Charbonneau, J. Christiansen, R. Dasgupta, R. Dawson, J. Davenport, C. Dong, N. Haghighipour, S. Kane, R. Kotulla, G. Rieker, T. Robinson, H. Schlichtin, S.-H. Shim, A. Shields, K. Stassun, A. Weinberger, C. Reinhardt, A. Mandell

PIs invited from SMD Programs: NAI ADAP, XRP, Habitable Worlds

2015: 18 invited, 94% accept; 2017: 2 invited, 50%; 2018: 29 invited, 72%

Astrobiology Research Coordination Networks

NExSS

Goal: to investigate the diversity of exoplanets and to learn how their history, geology, and climate interact to create the conditions for life

Objectives:

- To further our joint strategic objective to explore exoplanets as potential habitable and inhabited worlds outside our solar system.
- To leverage existing programs in SMD to advance the field of Exoplanet Research, specifically research in comparative planetology, biosignature and habitat detection, and planet characterization.
- Establish a mechanism to break down the barriers between, divisions, disciplines and stove piped research activities.

Astrobiology Research Coordination Networks

NExSS

Measures of Success:

- Investigators carry out and propose interdisciplinary research through new collaborations
- Produces a plan for utilization of current space telescopes
- Spawns ideas for new and exciting missions
- Identifies new targeted technologies needed not yet reported elsewhere
- Influences Decadal Surveys for both Planetary Science and Astronomy and Astrophysics
- Enhances international engagement

Astrobiology Research Coordination Networks

Co-Leads:
Tori Hoehler
Sarah Johnson
Britney Schmidt

Steering Committee: R. Arevalo, K. Benison, K. Bergmann, D. Blake, G. Chin, G. Cooper, F. Corsetti, C. Foreman, W. Hug, K. Junge, F. Kenig, G. Love, R. Mathies, B. Orcutt, A. Pavlov, A. Pontefract, K. Rogers, E. Shock, R.T. Short, P. Sobron, D. Stillman, A. Stockton, R. Summons, W. Swingley, S. Yu

Invited 26 PIs from 5 PSD R&A programs, 92% acceptance rate.

Astrobiology Research Coordination Networks

NFoLD
Network For Life Detection

Goal:

To investigate life detection research, including biosignature creation and preservation, as well as related technology development

Objectives:

- Advance Life Detection Strategy and Capability: Facilitate research and technology development for detecting evidence of life beyond Earth.
- Catalyze Collaboration: Identify research and technology objectives that may be best or only achieved through interdisciplinary collaborations.
- Support NASA Programs and Missions: Improve the integration of life detection science and technology into all stages of planetary and astrophysical missions.
- Foster Community Development: Increase scientific and demographic diversity in the life detection community.

Astrobiology Research Coordination Networks

<u>Measures of Success:</u>

- Advance Life Detection Strategy and Capability: Enhance capabilities for detecting evidence of life beyond Earth.
- Catalyze Collaboration: Create an environment and develop activities that promote and enable new collaborations.
- Support NASA Programs and Missions: Facilitate integration of life detection science and technology into mission development, from Decadal Survey and program planning to mission science definition, implementation, and interpretation.
- Foster Community Development: Enhance engagement with international members of the life detection community and facilitate the involvement of students and early career researchers in all aspects of NfoLD activities.

Astrobiology Research Coordination Networks

Co-Leads:
Karyn Rogers
Loren Williams
Ramanarayanan Krishnamurthy
Tim Lyons

Steering Committee: V. Airapetian, A. Badran, S. Benner, D. Bong, D. Burke, A. Burton, I. Chen, G. Cody, G. Cooper, R. Dasgupta, J. Elsila, P. Falkowski, G. Flynn, R. Garrod, M. Hirschmann, C. Keating, R. Black, R. Lupu, J. Lyons, U. Muller, M. Pasek, S. Sandford, R. Smith, G. Villanueva, D. Woon

Invited 33 PIs from Exobiology and Emerging Worlds programs, 76% acceptance rate.

Astrobiology Research Coordination Networks

Goal:

Investigate the delivery, synthesis, and fate of small molecules under the conditions of the Early Earth, and the subsequent formation of proto-biological molecules and pathways that lead to systems harboring the potential for life.

Objectives:

- Integrate the early Earth and prebiotic chemistry communities and break down disciplinary barriers that stymy the pursuit of plausible prebiotic chemistry pathways.
- Develop robust and fully-parameterized models of early Earth environments that can be explored both experimentally and theoretically for their potential to host prebiotic chemical pathways.
- Promote novel and innovative experimental and theoretical approaches to exploring the abiotic → prebiotic → biotic transition.
- Identify planetary conditions that can or cannot give rise to life's chemistry and thus inform the exploration for life throughout the universe.
- Characterize geochemical and geophysical constraints of early Earth environments that can be applied to test, verify, validate, and guide existing and future experimental and theoretical prebiotic chemistries.

Astrobiology Research Coordination Networks

Measures of Success:

- New collaborative teams across the early Earth and prebiotic chemistry disciplines propose and conduct interdisciplinary research that transforms origins research.
- Ideological and dogmatic barriers that have previously divided the origins of life and prebiotic chemistry communities are overcome by improved community communication and collaboration.
- Novel research avenues arise independently of traditional ideas and lead to innovative approaches for exploring prebiotic chemistry under plausible planetary conditions.
- The growing body of knowledge of early Earth conditions relevant for prebiotic chemistry experimental design is made accessible through a virtual portal that interfaces experimentalists with known early Earth constraints.
- The trajectory for early Earth research is extended to better inform prebiotic chemistry research, specifically the temporal evolution of global parameters, controls on co-varying parameters, and the manifestation of global conditions in specific early Earth environments and the resulting local conditions.
- Early Earth models are expanded and refined to include the early history of complex organic molecules on Earth.
- Constraints from prebiotic chemistry research are included in the criteria for exploration and detection of habitable worlds.

Astrobiology Research Coordination Networks

Co-Leads:
Chris German
Alison Murray
Alyssa Rhoden
ESD Co-Lead to be announced

NOW
Network for Ocean Worlds

Steering Committee: TBD

Identified 55 potential PIs from 6 PSD R&A programs, and 10 potential PIs from 3 ESD R&A programs.

Astrobiology Research Coordination Networks

NOW
Network for Ocean Worlds

Goal:

Advancing comparative studies to characterize Earth and other ocean worlds across their interiors, oceans, and cryospheres, investigate their habitability, search for biosignatures, and understand life in relevant ocean world analogues and beyond.

Objectives:

- Enhance communication within NASA's ocean worlds community (PSD and ESD) to identify and stimulate novel, collaborative directions of inquiry.
- Pursue activities that both reveal and help to address critical knowledge gaps in ocean worlds research.
- Stimulate and facilitate new ocean worlds collaborations to undertake high-impact interdisciplinary research with applications to current and ongoing missions.
- Cultivate and augment the training of a new generation of interdisciplinary ocean worlds researchers.

Astrobiology Research Coordination Networks

Measures of Success:

- New collaborations traceable to NOW activities
  - Submission of novel, collaborative research proposals to NASA
  - Publication of results of ocean worlds research and technology
  - Funding of ocean worlds research via other federal and private agencies
  - Establishment of international cooperative agreements for ocean worlds study
- Influence of NOW-disseminated information
  - Inputs to relevant bodies (NAS, OPAG, CAPs, Decadal Surveys)
  - Incorporation into future NASA mission prioritization and design
  - Regular publication of white papers in, e.g., Nature, Science, EOS.
- Expansion of the ocean worlds community (Grow-NOW)
  - Mentoring of NPP Fellows and students across NOW research teams
  - Entraining interdisciplinary scientists and engineers new to ocean worlds research
  - Cultivating new partnerships in technology development, including industry engagement

NOW Network for Ocean Worlds

C.XX INTERDISCIPLINARY CONSORTIA FOR ASTROBIOLOGY RESEARCH (ICAR)

- Proposals should describe an interdisciplinary approach to a single, compelling question in astrobiology, and may address a single Science Strategy goal or several Science Strategy goals.
- A Step-1 proposal is required and the Step-1 proposal is binding.
- Team size and resources requested should be appropriate to the scale of the proposed research.
- There is no ideal size of an ICAR Team, but the scope of the research and the resources requested should exceed those typically considered in a Research Opportunities in Space and Earth Sciences (ROSES) program element (e.g., Astrobiology: Exobiology, Astrobiology: Habitable Worlds).
- Award sizes are expected to fall within $600- $1,000 K per year for five years.
- Proposals to this program element that are awarded funding will become members of the newly established Astrobiology Program Research Coordination Networks that are relevant to their selected research.

C.XX Interdisciplinary Consortia for Astrobiology Research (ICAR)

The areas of research emphasis and the RCNs covered in this solicitation are as follows:

1. The Nexus for Exoplanet System Science (NExSS) investigates the diversity of exoplanets and to learn how their history, geology, and climate interact to create the conditions for life
2. Prebiotic Chemistry and Early Earth Environments (PCE3) investigates the delivery, synthesis, and fate of small molecules under the conditions of the Early Earth, and the subsequent formation of proto-biological molecules and pathways that lead to systems harboring the potential for life
3. From Early Cells to Multicellularity (FECM) investigates the earliest biological processes and the evolution of life on Earth into more complex organisms.

C.XX Interdisciplinary Consortia for Astrobiology Research (ICAR)

Tentative Schedule

ROSES Announcement	July 15, 2019
Step -1 Proposals Due	Sept 16, 2019
Step -2 Proposals Due	Dec 19, 2019

ASTROBIOLOGY at NASA
LIFE IN THE UNIVERSE

Sociedad Mexicana de Astrobiología (SOMA)

International Partner Series 02/04

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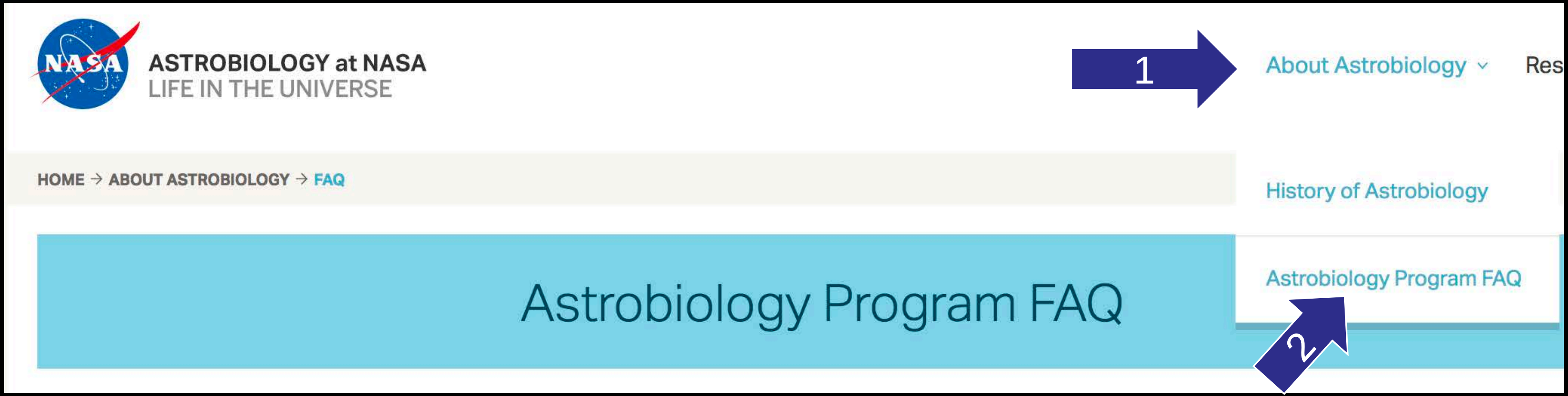
NASA Astrobiology Program - FAQs



This document contains answers to Frequently Asked Questions about the Astrobiology Program organized by topical areas:

- NASA Astrobiology Program (goals, 2015 Strategy, history, contact)
- Funding Astrobiology Research (ICAR, Workshops, Early Career, topic-specific programs)
- Coordinating Astrobiology Research (RCNs: what, who, how)

The NASA Astrobiology Postdoctoral Program

- In 2000, the NASA Astrobiology Institute began participating in the NASA Postdoctoral Program, allowing the NAI principal investigators to identify members of their teams who could serve as advisors.

- In 2010, the eligible advisors were expanded to include principal investigators selected for grants from the Astrobiology Program.

- Since 2000, 118 Ph.D. scientists and engineers have been supported to conduct astrobiology research within the astrobiology program

2018 Astrobiology NPP Selections

Mario Rivas
Advisor: George Fox, Rutgers University of Houston (RCN - Prebiotic Chemistry: Center for the Origin of Live (COOL))
Topic: *"On the early evolution of the translational apparatus, a structural insight"*

James Eguchi
Advisor: Tim Lyons, U California, Riverside (NAI, Alternative Earths)
Topic: *"Evolution of atmospheric O2 and CO2 driven by planetary tectonics"*

Hadi Fares
Advisor: Christine Keating, Pennsylvania State University, (Exobiology; Prebiotic Evolution)
Topic: *"Impact of the Wet/Dry Cycle on Protocells"*

Amanda Garcia
Advisor: Betul Kacar, University of Arizona (NAI Georgia Tech/University of Montana, Missoula team – RELIVING THE PAST)
Topic: *"The deep history of nitrogenases: Connecting the geochemical record of nitrogen fixation to isotopic signatures"*

Adrienne Hoarfrost
Advisor: Yana Bromberg, Rutgers University of Arizona (NAI, Evolution of Nanomachines Geospheres and Microbial Ancestors (ENIGMA))
Topic: *"Linking Life and Earth with Deep Transfer Learning"*

NPP Fellows at AbSciCon 2017

Will be meeting again at AbSciCon 2019

The Lewis & Clark Fund for Exploration and Field Research in Astrobiology

2006 - 2019

Partnership between American Philosophical Society and NAI

Provides small grants (up to $5K) to graduate students, postdocs, and early career scientists for astrobiology field research around the world

The Lewis & Clark Fund for Exploration and Field Research in Astrobiology

In 2018, the Astrobiology Program partnered with the American Philosophical Society to provide travel grants for 10 graduate students and postdoctoral scholars to conduct field research in astrobiology.

Heda Agic, University of California, Santa Barbara
"Investigating Habitats of Early Eukaryotes, Shanxi Province, Northern China"

Alberto Candela Garza, Carnegie Mellon University
"Automated Detection of Biosignatures in the Atacama Desert, Chile"

Jasmeet Dhaliwal. Pennsylvania State University
"A Fieldwork and Geochemical Study of Holuhraun Volcano, Iceland, as an Analog for Hydrothermal Vents and Martian Volcanism"

Benjamin Johnson, University of Colorado, Boulder
"Paleoarchaen Seawater Temperature, Nutrient Levels, and Depth: Reconstruction From Altered Oceanic Crust in the Pilabara Craton, Northwestern Australia"

Bridget Lee, University of California, Riverside
"*Banded Iron Formations, Minas Garais, Brazil, as Key to the Rise of Atmospheric Oxygen"*

The Lewis & Clark Fund for Exploration and Field Research in Astrobiology (continued)

Maeva Millan, Georgetown University
"The Preservation of Organic Molecules in New Zealand Hydrothermal Environments as Mars Analogs"

Claire Nichols, Massachusetts Institute of Technology
"Determining the Earliest History of Earth's Ancient Magnetic Field, Greenland and Its Implications for the Origins of Life"

Yuem Park, University of California, Berkeley
"Dramatic Global Change During the Era of Animal Evolution: A New Archive of Neoproterozoic Snowball Earth Glaciation From the Tambien Group of Ethiopia"

Lauren Seyler, Woods Hole Oceanographic Institution
"From the Frying Pan to the Fire: How Microbes Survive Rapidly Changing Conditions in Flat Cone Spring, Sentinel Meadows, Yellowstone National Park"

Jonathan Zaloumis, Arizona State University
"Biosignature Preservation and Detection in Mars-Analog Sulfate Deposits From the Atacama Desert, Chile"

Diversity and Inclusion in Astrobiology

The **Astrobiology Faculty Diversity (AFD) Program**, formerly the **Minority Institution Research Support (MIRS) Program** has coordinated research sabbaticals, with researchers funded by the NASA Astrobiology Program, for 31 faculty members from Minority Serving Institutions (MSIs). Results have included increased publication of scientific papers, increased numbers of astrobiology graduate students from faculty laboratories, the employment of a student at GSFC and sustained collaboration.
https://astrobiology.nasa.gov/funding/nasa-astrobiology-faculty-diversity-program-former/

The **Minority Institution Astrobiology Collaborative (MIAC)** met in person the day prior to AbSciCon 2017. http://phl.upr.edu/projects/miac

A **survey** intended to measure the demographics od the astrobiology astrobiology community has been approved for distribution by the NASA Ames Research Center Human Research Institutional Review Board, and is will be distributed at AbSciCon 2019.

The Astrobiology Graduate Conference

The **Astrobiology Graduate Conference (AbGradCon)** is an annual meeting organized exclusively by and for graduate students and postdocs. The 14th AbGradCon was successfully held with roughly 100 participants in June 2018, at the Georgia Institute of Technology, in Atlanta, Georgia.

AbGradCon 2019 will be hosted in Utah in late July.

AbGradCon 2020 is scheduled to be held in Tokyo, Japan, and will mark the fourth AbGradCon held outside of the continental US, encouraging greater interaction and collaboration amongst international astrobiologists. Support has been provided by the NASA Astrobiology Program, through the NAI, however the organizers have been increasingly successful in soliciting non-NASA support from foundations and scientific societies, who provide funding for international participants.

International Summer School in Astrobiology

Since 2002, the **International Summer School in Astrobiology** has been a joint program organized by the NAI and the Centro de Astrobiologia for 36 US and international students. The week includes eight lectures a field trip to a location of astrobiological significance, and group projects which are presented at the end of the week.

Ask an Astrobiologist: NASA's Live Virtual Talk Show

Ask an Astrobiologist is an hour-long virtual talk show where renowned scientists are interviewed live via videoconference.

Topics discussed include:

- Scientific interests
- Career path
- Mentorship
- Current scientific studies
- Future of astrobiology

The last 30 minutes of the show consists of live audience questions from Twitter, Facebook and SAGANet (the social network for astrobiology).

After completing 20 episodes, Ask An Astrobiologist has over 11,250 views, 387 likes, and 87 comments.

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New Video Series: Astrobiology in the Field

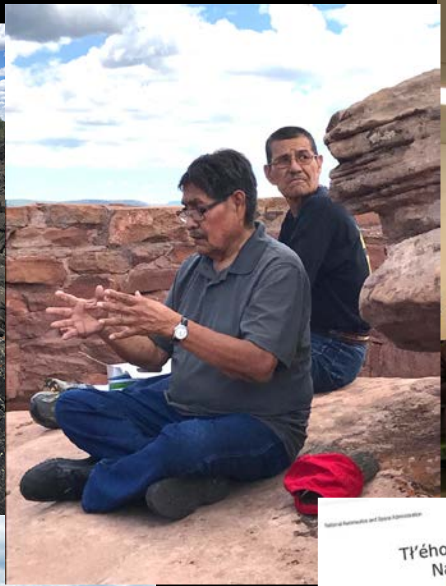
Astrobiology in the Field is a new video series that highlights NASA Astrobiology-funded field work around the world.

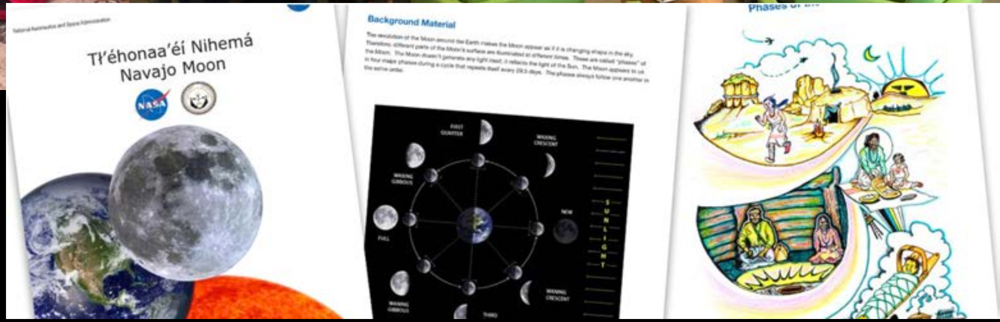
The first episode takes place in Iceland, highlighting the PSTAR-funded FELDSPAR team, led by Dr. Amanda Stockton (GaTech).

The series aims to create a more holistic image of what a scientist can be, including highlighting teams that are early career, diverse, and female-led.

This series is planned to be yearly, and each episode will be ~20 minutes long.

NASA and the Navajo Nation Partnership





Begun in 2005, the NASA and the Navajo Nation Partnership just celebrated 14 years in January, 2019 by hosting two workshops for K-12 educators from across the Navajo Nation. These were the most recent in a series of ongoing, annual Winter workshops.

The partnership also produces Summer Camps for Diné youth, held annually each July, and has produced two educator guides.

Presentations and hands-on activities in both programs bring together scientific and Cultural knowledge into a "dual-learning environment" wherein connections between these two ways of knowing are explored.

A recent space.com article covered the partnership:

https://www.space.com/nasa-partnership-with-navajo-nation.html

Astrobiology Learning Progressions – NGSS Connections

In order to maintain support for educators and scientists as they continue to engage learners with astrobiology content, the NASA Astrobiology Program is creating a new resource.

The Next Generation Science Standards (NGSS) introduce a framework for teaching and learning that outlines progressions of learning from K-12 based on individual scientific disciplines. In general, learning progressions represent a progressive increase in the sophistication of a person's understanding, and detail how a concept should be taught at each grade band.

NGSS' discipline-based progressions guide what students in each grand band can reasonably be expected to understand and/or learn. This is guiding the synthesis of custom, interdisciplinary progressions for core concepts in astrobiology which are underpinned by discipline-based concepts in Earth, space, life, and physical sciences. Interdisciplinary progressions like this don't exist in NGSS or other teaching standards sets.

In order to facilitate authentic, long-term learning of these interdisciplinary concepts, scientists and educators need to know the general level of foundational knowledge of their learners in each of the individual disciplines so they can best build upon it. The Astrobiology Learning Progressions can be used as a tool to "tune" presentations and lessons specifically toward a learner's cognitive ability and foundational knowledge. They will also be used as an organizing tool for lesson plans, learning media, and other educational materials in astrobiology.

CLQ 1: How does understanding the origin and evolution of the Universe inform our understanding of the origin of life?

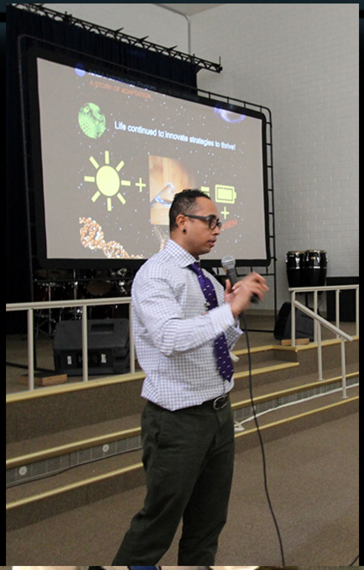
Concepts relevant to the content of this Core Learning Question that learners in each grade band are being taught, and can reasonably be expected to understand and/or learn. NGSS references are in parentheses:

Grades K-2	Grades 3-5	Grades 6-8	Grades 9-12
Earth, Space, Stars (ESS1.A); Sun (ESS1.A) (PS3.B); Moon (ESS1.A); air (ESS3.A)	Solar System, 8 planets, identifying states of matter, gravity (PS2.B)	Atomic Theory (PS1.A); Elements and the Periodic Table (PS1.A); Motion of the objects in the Solar System (ESS1.A); Comets and Meteorites, Kuiper Belt, Gravity (ESS1.B); Solar System Formation (ESS1.B)	Fusion (PS1.C) (ESS1.A); Stellar Evolution, Supernova, and Nucleosynthesis (ESS1.A); Big Bang Theory(ESS1.A); Describing stellar population/metallicity theory, Nebula/Giant Molecular Cloud, Accretion, Circumstellar/Protoplanetary disc, volatiles, inner and outer solar system conditions, Kuiper Belt, Planet migration

Sub-question 1.1: Star and Planetary System Formation…creating the physical context for the emergence of life

Grades K-2	Grades 3-5	Grades 6-8	Grades 9-12
You are from Earth. Earth is a planet in our Solar System, which consists of 8 planets with a Sun in the center. How did all of those things get here? The Earth has been around for a long time. But a long, long time ago, no stars or planets or life existed yet. At that time, there were only huge clouds out in space. Over time, the stuff in those clouds was pushed and pulled together, and started swirling and spinning round and round like a CD spins in a CD player. (outdated analogy?) Eventually, most of the material pulled into the center and became the Sun. Everything else started crashing into each other and sticking together and formed into the planets, including Earth.	Learning about where we came from involves learning how did the Sun, Earth, and the whole Solar System formed. Before the Solar System formed, there was a huge cloud of gas out in space that contained little bits of solid matter--small rocky particles like tiny stones and miniscule ice cubes. A great source of energy nearby triggered all this material to begin swirling and swirling like a whirlpool (need the right analagy!), and condense down into the shape of a spinning frisbee. Most of the gaseous and solid matter was pulled into the center and became the Sun. The rest of the matter was still swirling around it, and the small rocky and icy pieces began colliding and sticking to each other. As they stuck together, they got bigger and bigger and eventually formed into the planets, moons, asteroids, and comets in our Solar System. All these things continue to orbit around the Sun today, and so do we, riding on Earth!	Life emerged from the Earth. Earth is life's home…it's the physical environment in which life first came into being. In order to understand how life formed, we need to understand how the Earth formed. The Earth formed through the same process that created our whole Solar System. The Sun, the Earth, the 7 other planets, and all the moons, comets, and asteroids in our Solar System were all "born" together and "grew up" together. It all started with a huge cloud of gas and dust and tiny rocky particles out in space. Space can be a very dynamic place, and scientists think the explosion of a nearby star (called a supernova) provided the energy needed to start all that material spinning and swirling into a disk, like a CD or record on a record player. Most of the material wound up in the center of the disk, and eventually became the Sun. The rest of the particles began colliding and sticking, producing many tiny pieces of rock. Those small pieces then collided with each other, forming larger and larger ones, which collided with each other to form even larger ones. These were young planets, and eventually, over a long time and through many, many collisions, 8 planets were formed - Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune, each orbiting the Sun in the center. All the planets and the Sun formed together, from the same material, at the same time.	As the physical context for life, it is important to learn about Earth's origins so we can understand life's origins. Although life may exist in situations other than that of a planet orbiting a star, it makes sense to explore the phenomenon of planetary system formation as a context for the emergence and evolution of life. The story of the formation of our Solar System begins in a region of space of diffuse gas and "dust" called a giant molecular cloud. The majority of the material within the cloud consisted of Hydrogen and Helium produced at the time of the Big Bang, with small amounts of heavier elements such as Carbon and Oxygen which were made via nucleosynthesis in prior generations of stars (see 1.1 above). The material in the cloud was not uniformly distributed - there were regions of higher density and regions of lower density. Evidence from meteorites suggests that the energy produced (shockwave) by a nearby exploding star (supernova) passed through a higher denisty region in the cloud (called the pre-solar nebula - pre = before; solar = star or Sun), and caused it to begin to collapse, or flatten, and ultimately, begin spinning like a CD. This is called a circumstellar (circum = around; stellar = star) or protoplanetary (proto = first or before) disk. Almost all of the material in the disk collected in the center, giving rise to the young Sun. The particles in the spinning disk began colliding with each other. The energy of collision caused them to stick together, forming larger and larger fragments. The larger a fragment became, the more mass it had and therefore the more gravitational pull it exerted. Which in turn drew more and more material to it, and the larger it became, and so on. This process is called accretion, and resulted in the production of many planetesimals (smaller than the size of the planets today), and evenutally, the planets themselves. Material in the disk that easily disintegrates in the presence of heat (volatiles) such as water and gases could not survive the conditions of the inner Solar System, as the young Sun in the center was extremely hot and produced a strong stellar wind. So the volatile material accumulated in the outer Solar System, giving rise eventually to the gas giant planets (Jupiter and Saturn), the "ice giants" (Uranus and Neptune), and the icy comets beyond in the Kuiper belt. Heavier elements such as Iron and Nickel could withstand the conditions near the young Sun, and gave rise to the rocky planets (Mercury, Venus, Earth, and Mars). The outer planets may be in different locations today vs. where they initially formed in the disk--this is described as a planet migrating. As the planets evolved, they influenced one another's ultimate distance from the Sun and orbital shape.

Astrobiology for the Incarcerated – All Learners Matter



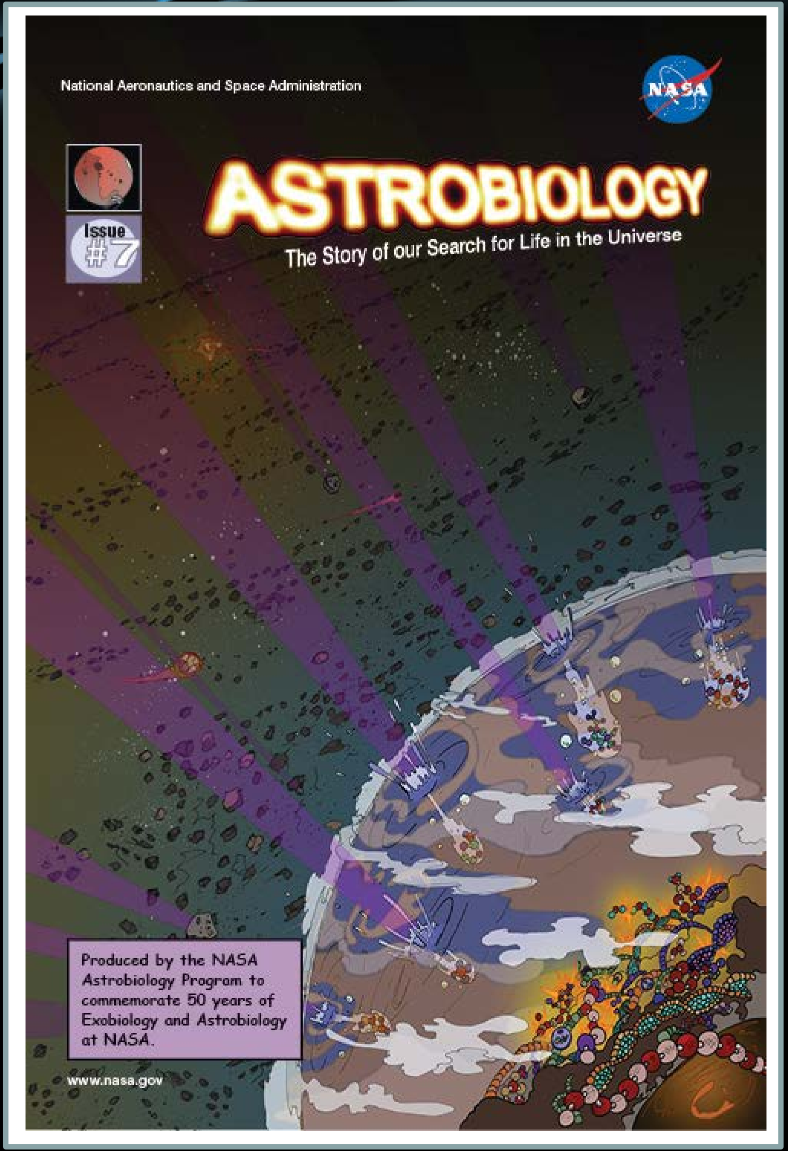
Astrobiology for the Incarcerated is a collaboration between the Sustainability in Prisons Project, the Initiative to Bring Science Programs to the Incarcerated, and the NASA Astrobiology Program.

Based on the philosophy that there are no "throw away" kids (or learners of any age), this collaboration leverages pre-existing programs that bring lectures to incarcerated adults and hands-on activities to incarcerated youth.

From December, 2017 – April, 2018, astrobiology lectures were co-presented by two members of the astrobiology community to >1400 men and women in 17 prisons and 1 jail in 4 states (UT, WA, OH, FL). Hands-on programs were delivered to >300 youth in 8 Juvenile Justice System facilities.

Extensive evaluation studies were completed via pre/post surveys in accordance with strict IRB protocols. Data show statistically significant increases in astrobiology content knowledge and attitudes including value of science and science identity. These gains were independent of race, gender, facility type, or religious inclination.

Follow up activities are being planned to expand the content and type of programming offered to reflect all of SMD and its resources.



Astrobiology

The Story of our Search for Life in the Universe

- Issue 1: Astrobiology's Beginnings
- Issue 2: Missions to Mars (3 Editions)
- Issue 3: Missions to the Inner Solar System (2 Editions)
- Issue 4: Missions to the Outer Solar System
- Issue 5: Analogs on Earth
- Issue 6: Exoplanets
- **Issue 7: Prebiotic Chemistry and the Origins of Life**

AbSciCon 2019

Astrobiology Science Conference

- Held every two years
- 2019 edition in Bellevue, Washington
- [900 Number of expected attendees]
- [860 Number of submitted abstracts]

Questions?