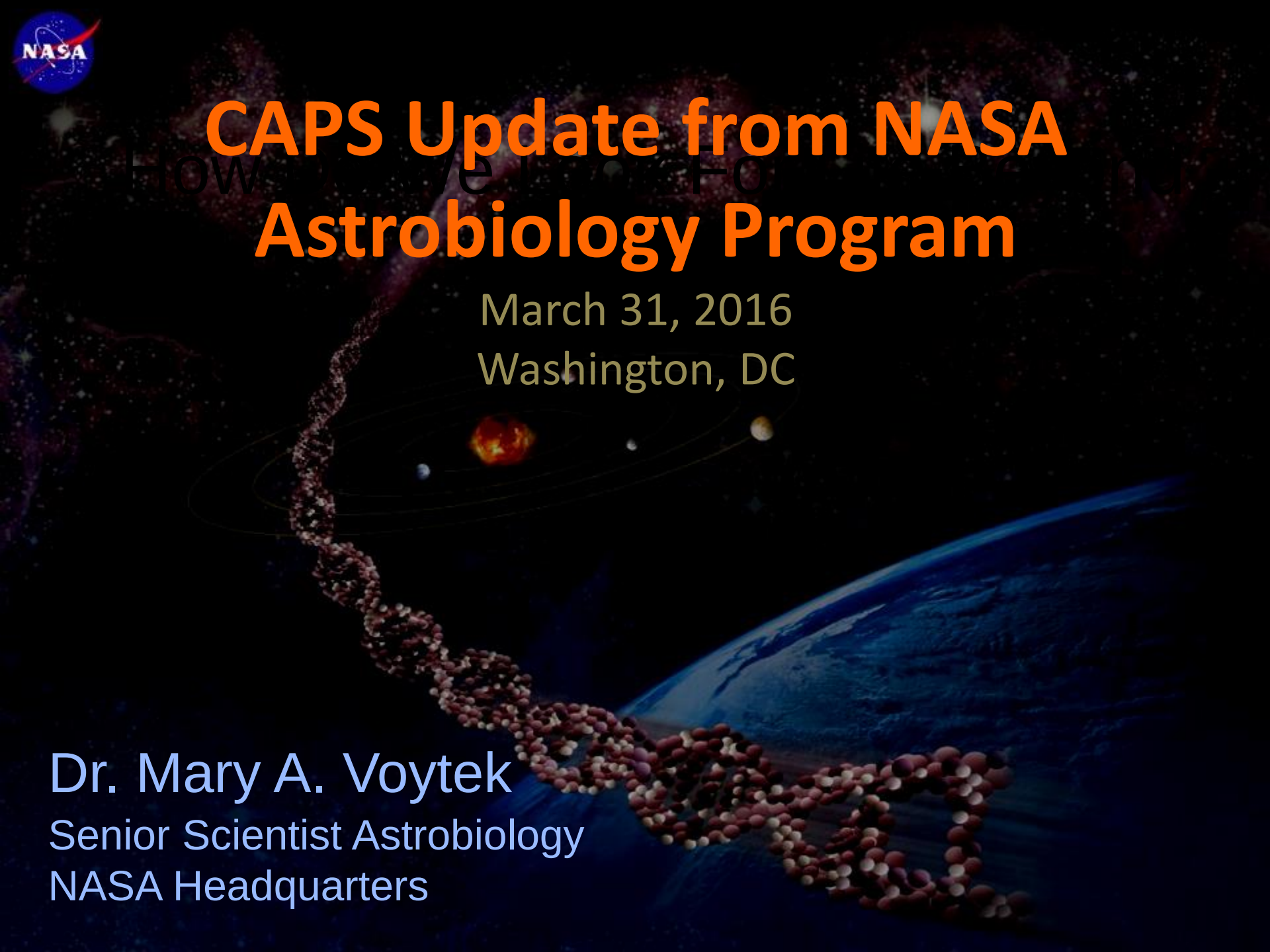
# CAPS Update from NASA Astrobiology Program

March 31, 2016
Washington, DC



Dr. Mary A. Voytek
Senior Scientist Astrobiology
NASA Headquarters

# NASA Science Mission Directorate

# The Astrobiology Science Strategy


- Broad participation in creation:
  - 33 Lead Authors
  - 77 Contributors
  - 744 members of *astrobiologyfuture.org*
  - 12 reviewers who made invaluable contributions.
- Goal was to create an "inspirational and aspirational" document.
- A PDF version is available on the Web. (Limited Printed Copies)
  - Will be "wiki-fied" to make it a living document.

# Astrobiology Program Funding Priorities

- Identified by Gaps in Investment Portfolio
- Identified through Topical Workshops
  - National Academies
  - NASA
- Science Needs in Support of Ongoing and Future Missions
  - MSL
  - OSIRIS-Rex
  - ExoMars
  - MARS 2020
  - Europa
- Partnerships with Other Agencies
  - NSF- Center for Chemical Evolution
  - NSF- Ideas Lab
- National Science Priorities
  - Microbiome Initiative
  - Ocean Worlds

# Notional Astrobiology Funding 2016

| Program | Funding level |
|---|---|
| Exobiology and Evolutionary Biology | $17M |
| Emerging Worlds | $2M |
| Habitable Worlds | $7.5M |
| Planetary Science and Technology through Analogue Research (PSTAR) | $13M |
| NAI | $20M ($1.3M) |
| NASA Astrobiology Postdoc Program | $1.5M |
| NASA Earth and Space Science Fellowships | $700k |
| NSF CCE | $2M |
| NSF Ideas Lab (OOL) | $?(FY17) |
| Astrobiology Workshops | $750K |
| Astrobiology Technology (PSD, STMD) | $3-20M |

# How Did the Ideas Lab Originate?

Summer 2007, EPSRC contacts NSF in response to NSB report

Begin dialog to share best practices

NSF first IL in 2009 on Synthetic Biology, has held 6 IL since then.

# What is the Concept?

Inputs: Grand Challenge Topic, Creative People, Money

↓

Creative Environment: "Ideas Lab"

↓

Outputs: Potentially Transformative, Novel, Adventurous, Innovative, Interdisciplinary Ideas "Wow Factor"

# Who is Involved?

Mentors

- focus on the topic

Facilitators

- focus on the process

Participants

# Participant Selection Process

Open call for participants

- 2-page application
  - Expertise, experience
  - Teamwork, communication, “outside the box”

Selection panel

- Panel of “Mentors”
- Advised by organizational psychologist


Interact

Clarify

Ideate

Develop

Implement

Five day residential sandpit

2 months

Submit full proposals

Real time peer review

Select project ideas

# NSF-NASA Joint Ideas Lab

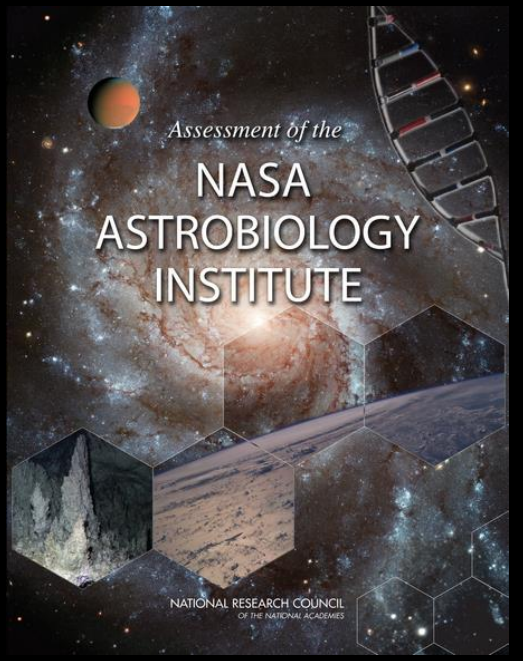
Working Title: “The Origin of Translation”

Timeline

- Call by June 2016
- Participant Selections  Sept 2016
- In Person “Ideas Lab”  Late 2016/Early 2017
- Final Proposals Due Spring 2017

# NAI Review

**Both Science and Support Activities will be reviewed in 2016-2017:**




Last Assessment of the NASA Astrobiology Institute

National Research Council Committee on the Review of the NASA Astrobiology (2007)

As part of the reorganization of the R&A and instrument development programs, the Planetary Science Division is embarking on a reevaluation of its science support activities.


# The Nexus for Exoplanet System Science

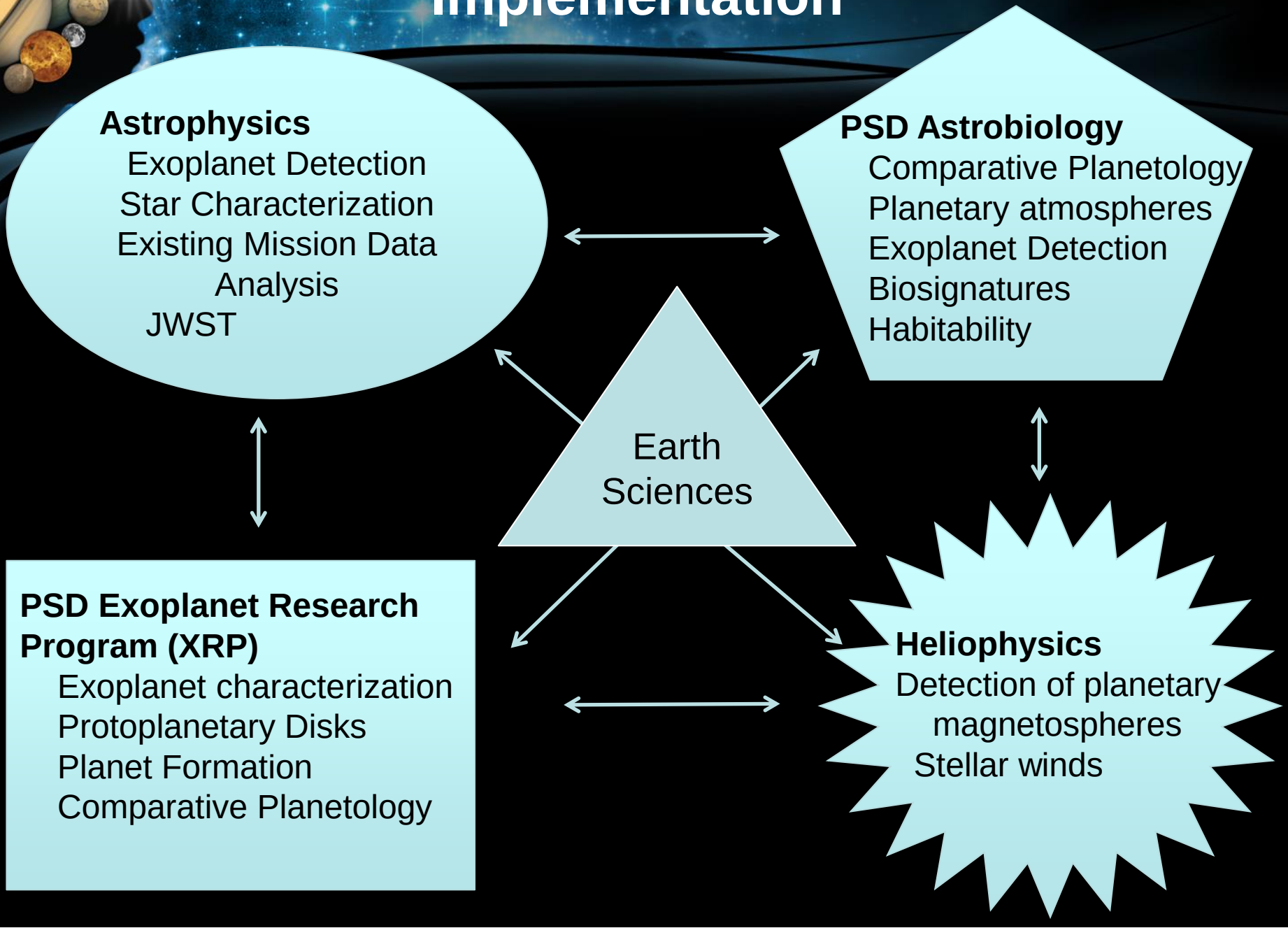
## Research Coordination Network

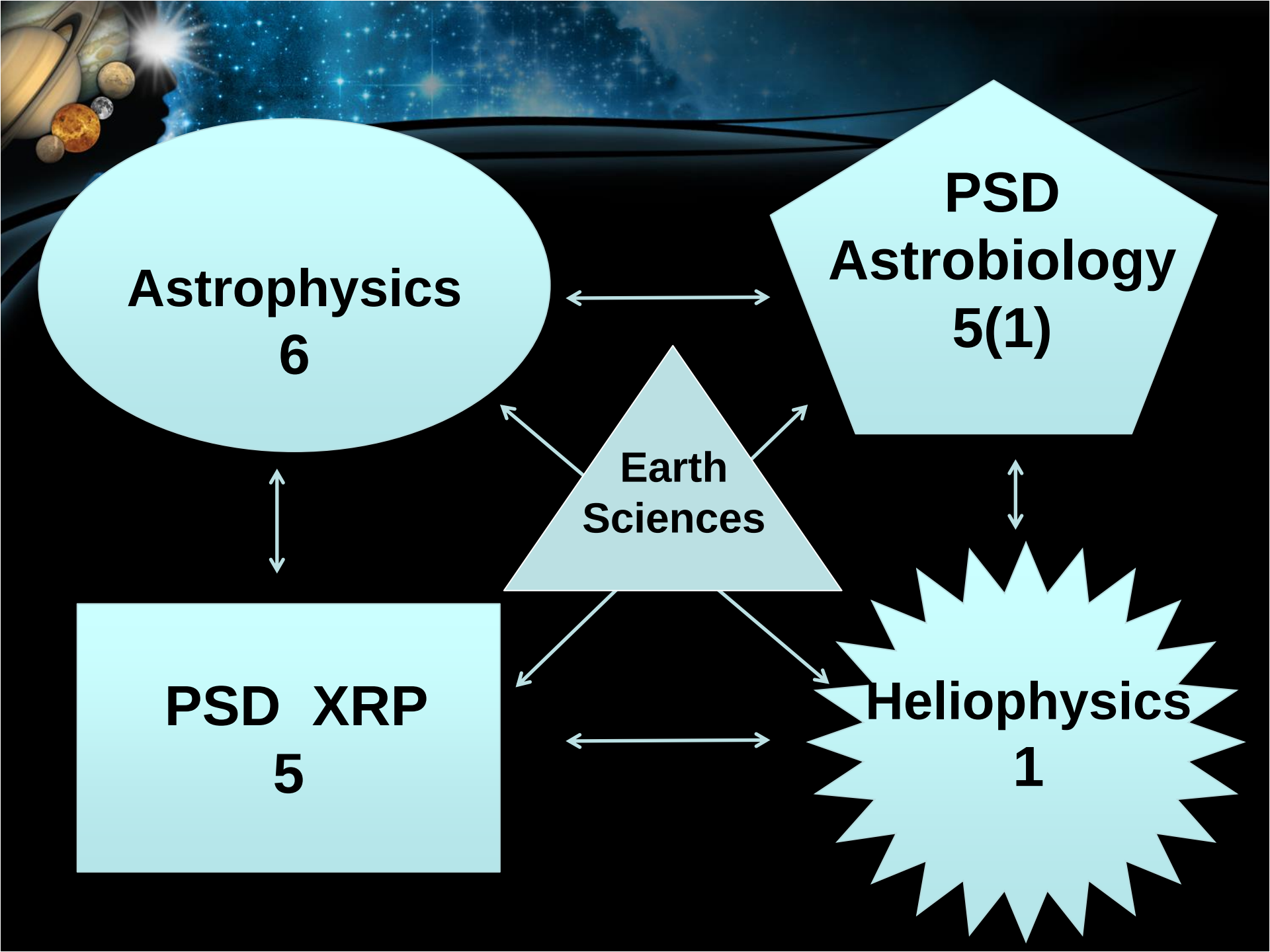
**https://nexss.info**

Cross Divisional SMD initiative

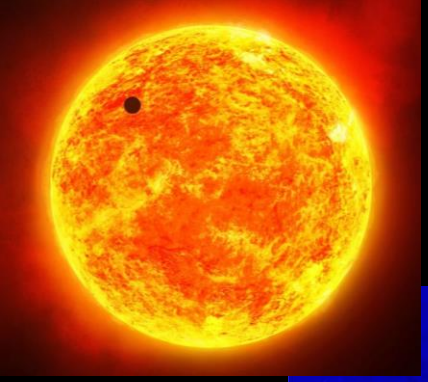
HQ reps:
Mary Voytek (PSD)
Martin Still (ASD)
Jeff Newmark (HSD)
TBD (ESD)

# Implementation

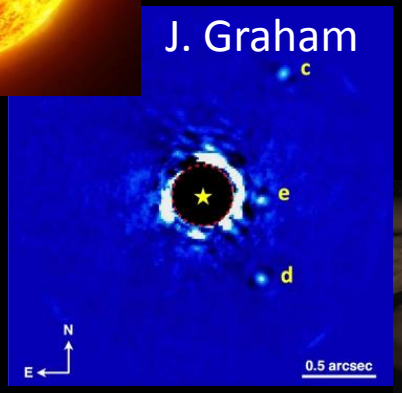



Astrophysics
6
PSD
Astrobiology
5(1)
Earth
Sciences
PSD XRP
5
Heliophysics
1

# The NExSS Teams

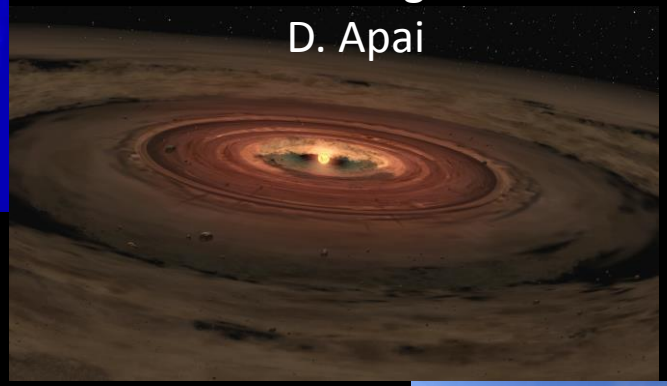


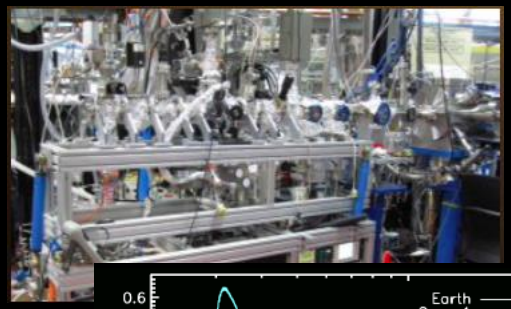
D. Fischer
E. Ford
J. Wright
D. Deming
A. Jensen
J. Graham



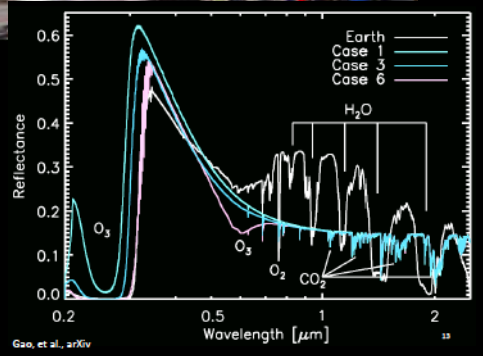

Co-leads:
Natalie Batalha
Dawn Gelino
Tony Del Genio

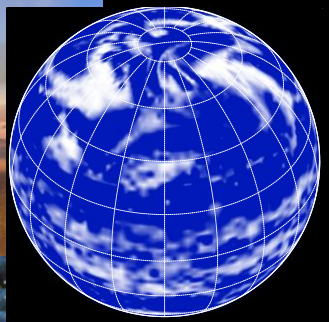
N. Turner
H. Jang-Condell
D. Apai





H. Imanaka
J. Fortney



B. Moore
V. Airapetian

W. Henning
S. Desch
V. Meadows
T. Del Genio

# Getting Started

Kickoff Meeting April 2015

- Charge to the Teams from Jim Green and Paul Hertz
- Facilitated working groups

Monthly webinars since June 2015

- Getting to know you and your science

Monthly PI telecons

- Brainstorming on workshop, communication and education activities in support of the NExSS goals

# NExSS white paper: Laboratory Work for Understanding Exoplanet Atmospheres (led by J. Fortney, >30)

- Needs for future measurements
  - Pressure-induced line broadening parameters (self- , foreign)
  - Optical properties of particles, haze formation
  - Reaction rate constants
  - Photoabsorption cross-sections at high T
  - Lab spectroscopy of continuum absorption
  - Oxygen absorption by early magma ocean

- Draft released for community comment
- Relevant to APDA ROSES NRA highlighting timeliness of Laboratory Astrophysics research in support of JWST

# Workshops:

Upstairs Downstairs: Consequences of Internal Planet Evolution for the Habitability and Detectability of Life on Extrasolar Planets

- Tempe, AZ, Feb. 17-19 (led by PSD)
- Joint NExSS-NAI-NSF effort, in-person + virtual participation (Workshop Without Walls) + winter school for students/postdocs

Biosignatures workshop (led by PSD, APD), July 2016

- Joint NExSS-NAI-ExEP effort
- Partnering with tentatively approved ExoPAG SAG-13 in support of JWST, WFIRST, HabEx/LUVOIR studies

Exoplanetary Space Weather, Climate and Habitability Workshop, Fall 2016

Identifying which stars the are best place to search for habitable planets and life

# E.4 HABITABLE WORLDS

NASA's Habitable Worlds Program includes elements of the Astrobiology Program, the Mars Exploration Program, the Outer Planets Program (all in the Planetary Science Division) and Exoplanet research in the Astrophysics Division. A common goal of these programs is to identify the characteristics and the distribution of potentially habitable environments in the Solar System and beyond.

11/18/2016
(Step-1)

01/20/2017
(Step-2)

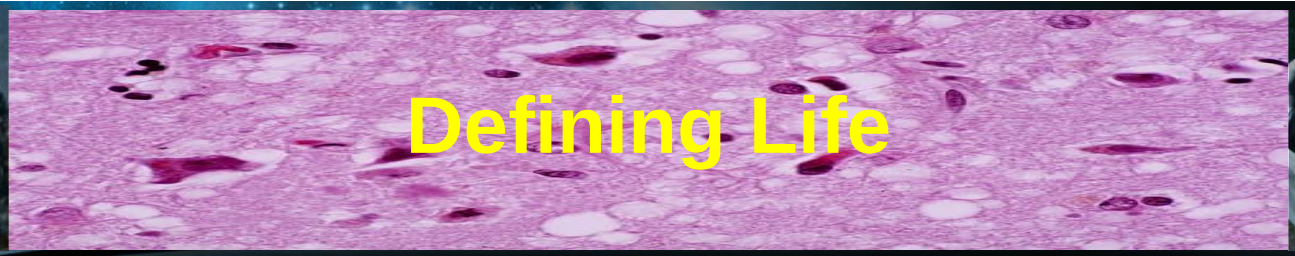
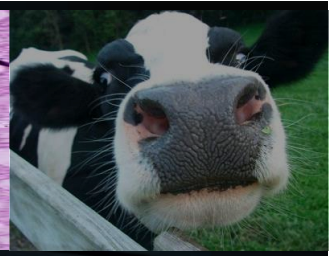
# The NASA Astrobiology Debates

*…future leaders of America engaging astrobiology*

**Resolved: An overriding ethical obligation to protect and preserve extraterrestrial microbial life and ecosystems should be incorporated into international law.**

100 graduate and undergraduate students have participated as debaters, judges and hosts, including 76 debaters from 23 different U.S. universities, the Japanese National Team and Ecole de Guerre.

NASA Astrobiology Debates will engage over 2000 university and secondary education students during the 2015-16 school year. Remaining events include an online tournament for college & HS students and an “in-person” championship for DC middle schoolers on May 21, 2016.

# Defining Life

Life is chemistry with a history (and memory).

NASA: Life is a self-sustaining chemical system capable of Darwinian evolution.

Definition → General theory of living systems

E.g. Terran life: Uses water as a solvent; Is built from cells, exploits a metabolism that focuses on the C=O carbonyl group; Is a thermodynamically dissipative structure exploiting chemical energy gradients; and Exploits a two-biopolymer architecture that uses nucleic acids to perform most genetic functions and proteins to perform most catalytic functions.

How to detect Life?

# LIFE DETECTION LADDER

| Ladder Rung | Feature | Measurement | Instrument | Likelihood | Specific to Earth Life vs. Generic Life | Ambiguity of Feature | Ambiguity of Interpretation | False Positive | False Negative |
|---|---|---|---|---|---|---|---|---|---|
| **Life (metabolism, growth, reproduction)** | | | | | | | | | |
| Darwinian Evolution | | | | | | | | | |
| Growth and Reproduction | | | | | | | | | |
| Metabolism | | | | | | | | | |
| **Suspicious biomaterials [not necessarily biogenic]** | | | | | | | | | |
| Functional Molecules | | | | | | | | | |
| Potential Building Blocks | | | | | | | | | |
| General indicators | | | | | | | | | |
| **Habitability** | | | | | | | | | |
| Environmental conditions | | | | | | | | | |

| Ladder Rung | Feature | Measurement | Instrument | Likelihood | Specific to Earth Life vs. Potential for Generic Life | Ambiguity of Feature | Ambiguity of Interpretation (how likely produced abotically?) |
|---|---|---|---|---|---|---|---|
| **Life (metabolism, growth, reproduction)** | - | - | - | - | - | - | |
| Darwinian Evolution | changes in heritable traits in response to selective pressures | not possible | | no | ~ | ~ | |
| Growth and Reproduction | concurrent life stages or identifiable reproductive form [growth and reproduction] | cell(like?) structures in multiple stages | microscope | low | Earth | What is a cell? What morphological differences exist? | low |
| Metabolism | isotopes | isotopes indicative of active metabolism | irMS | low/med | Earth (can you abstract?) | source, sink, context | low |
| | co-located reluctant and oxidant (e.g. oxygen and methane) [Inferred Persistence] | chemical concentrations of substrates and products involved in redox reactions | spectroscopy | med/high | Generic | mixed reactions, large inventory of chemistries | low-med |

| Ladder Rung | Feature | Likelihood | Specific to Earth Life vs. Generic Life | Ambiguity of Feature | Ambiguity of Interpretation |
|---|---|---|---|---|---|
| **Suspicious biomaterials** | | | | | |
| Functional Molecules | DNA | | | | |
| | RNA | | | | |
| | Lipids | | | | |
| | Structural Preference | | | | |
| Potential Building Blocks | complex organics | med | Generic | | medium |
| | amino acids (e.g. glycine) | high | Generic | | medium |
| | lipids (fatty acids, esters, carboxylic acids) | med/high | Generic | abiotic pathways to products | med-high |
| General indicators | distribution of metals [e.g. vanadium in oil reserves] | med | Generic | knowledge of background | medium |
| | patterns of complexity (organics) | high | Generic | documentation of differences between abiotic and biotic limited | medium |
| | chirality | high | Generic | How much of an excess is necessary? | high |

| Ladder Rung | Feature | Measurement | Instrument | Likelihood | Specific to Earth Life vs. Generic Life | Ambiguity of Feature | Ambiguity of Interpretation |
|---|---|---|---|---|---|---|---|
| **Suspicious biomaterials [not necessarily biogenic]** | | | | | | | |
| General indicators | distribution of metals [e.g. vanadium in oil reserves] | deviation from background bulk concentrations (Preferences) | XRF | med | Generic | knowledge of background | medium |
| | patterns of complexity (organics) | deviation from random organic complexity distribution | LCMS | high | Generic | documentation of differences between abiotic and biotic limited | medium |
| | chirality | material produced by extraterrestrial life | LC-MS/MS | high | Generic | How much of an excess is necessary? | high |

# LIFE DETECTION Workshops

**Agnostic Biosignatures (early Summer 2016)**

Lee Cronin and Jen Eigenbrode

**Extant Life on Ocean Worlds Workshop (late Summer 2016)**

Stephanie Getty & GSFC

**Workshop on Advanced Technologies for Life Detection on Icy Planets/Icy Terrain (early Fall 2016)**

Denise Podolski, Ron Turner, STMD


Questions???