NASA Astrobiology Program Update

David Grinspoon
Senior Scientist for Astrobiology Strategy

Lindsay Hays
Program Scientist for Astrobiology

PAC Meeting
November 13, 2023

New AB program leadership

Senior Scientist for Astrobiology Strategy (David Grinspoon):

"Up and out"

Expand the astrobiology program within NASA and beyond.

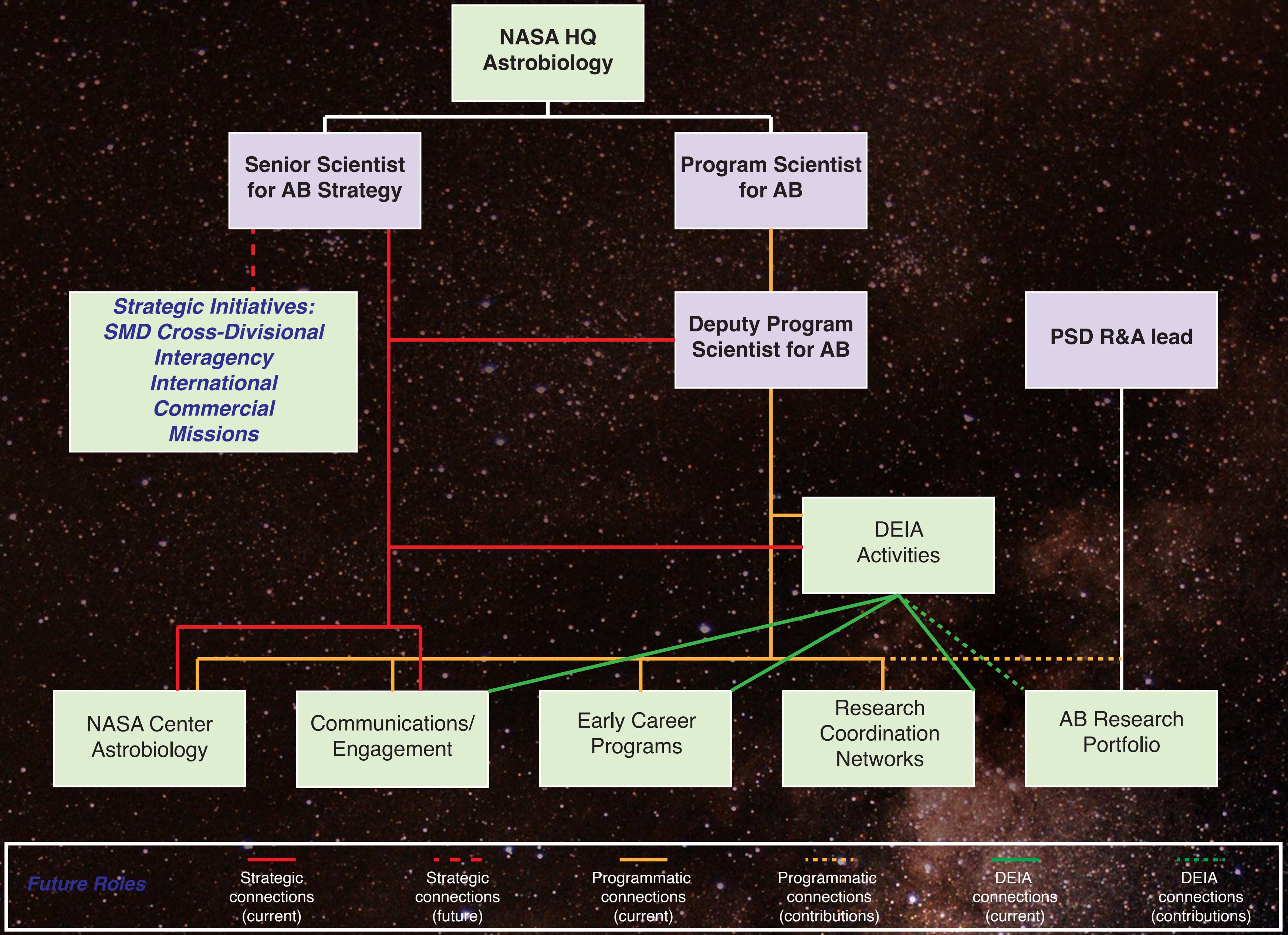
Program Scientist for Astrobiology (Lindsay Hays)

"Down and in"

Manage existing research programs.

Deputy Program Scientist for Astrobiology (Becky McCauley Rench)

New NASA Astrobiology Org Chart



Astrobiology Research Programs

- C.5 Exobiology (PO: Lindsay Hays)
  - Aim is to understand the origin, evolution, distribution, and future of life in the Universe. Research is centered on the origin and early evolution of life, the potential of life to adapt to different environments, and the implications for life elsewhere.
- C.14 Planetary Science and Technology Through Analog Research (PSTAR) (PO: Becky McCauley Rench)
  - This program solicits proposals for investigations focused on exploring the relevant environments on Earth in order to develop a sound technical and scientific basis to conduct astrobiological research on other Solar System bodies.
- C.20 Interdisciplinary Consortia for Astrobiology Research (ICAR) (PO: Lindsay Hays)
  - Proposals that describe a multi-million dollar, five-year project with an interdisciplinary approach to a single, compelling question in astrobiology. For projects larger than the scope of the individual research programs, but within the scope of the Research Coordination Networks.
- F.4 Habitable Worlds (HW) (PO: Becky McCauley Rench)
  - Aim is to use knowledge of the history of the Earth and the life upon it as a guide for determining the processes and conditions that create and maintain habitable environments and to search for ancient and contemporary habitable environments and explore the possibility of extant life beyond the Earth.

Research Coordination Networks

The Nexus for Exoplanet System Science

nexss.info

To investigate the diversity of exoplanets and to learn how their history, geology, and climate interact to create the conditions for life, dedicated to the study of planetary habitability.

From Early Cells to Multicellularity

lifercn.org

To understand how life and the Earth coevolved, focused on key innovations in the transition from early cells to multicellularity.

The Network for Life Detection

nfold.org

To advance life detection strategy and capability and catalyze interdisciplinary collaborations for research and technology objectives.

The Network for Ocean Worlds

oceanworlds.space

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

Prebiotic Chemistry and Early Earth Environments

prebioticchem.org

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.

Assessment of NASA's
Nexus for Exoplanet System Science Initiative

Assessment Team Members and Affiliations

Mark Marley (co-Chair)
University of Arizona

Nicolle Zellner (co-Chair)
Albion College and NASA HQ

Bradley Burcar, NASA Goddard Space Flight Center

Ofer Cohen, University of Massachusetts Lowell

Colin Goldblatt, University of Victoria

Tiffany Kataria, Jet Propulsion Laboratory

Quinn Konopacky, University of California, San Diego

Kathleen Mandt, Johns Hopkins Applied Physics Laboratory and NASA Goddard Space Flight Center (starting April 24, 2023)

Larry J. Paxton, Johns Hopkins University Applied Physics Laboratory

Margaret Tolbert, University of Colorado, Boulder

Nicholeen Viall, NASA Goddard Space Flight Center

Ex Officio Members
Lindsay Hays (NASA Headquarters)
Eric Mamajek (Jet Propulstion Laboratory)

NExSS Assessment

- Assessment undertaken early 2023, cross-divisional review panel
- Intended to:
  - assess the overall success of NExSS with regards to the progress on its stated goals
  - gather lessons learned from the first six years of operation of NExSS
  - collect information regarding the challenges NExSS has faced
- Findings:
  - Positives:
    - NEXSS has demonstrably catalyzed interdisciplinary, community interactions in ways that have benefited the community, including observing campaigns, modeling, input to decadals
    - NExSS is of high value for early career researchers involved in the NESS program
  - Areas for improvement:
    - NASA Division representation
    - Leadership structure and selection process
    - Financial and logistical support to the Co-Leads
    - Mission statement clarity and goal prioritization
- Report and NASA response released soon

2023 Astrobiology Mission Ideation Factory

Search for Life at Mars

- NASA Goddard Space Flight Center, August 21-25
- Contracted with KnowInnovation
- 32 participants, U.S and international, first year graduate student to early career faculty, as many institutions, cross-disciplinary
- 6 mission ideas presented at end of week by teams off 3-7 individuals
- 7 mentors from variety of backgrounds
- Planning follow-up activity (Phase 2) to work on mock data from mission ideas and how they could be used to detect life

UPCOMING: Biosignature IDEAS Lab

Inputs: Grand Challenge Topic, Creative People, Money

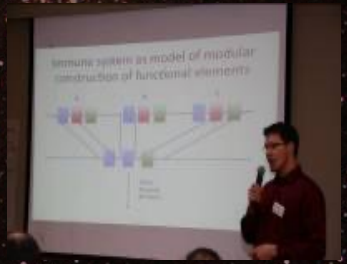
Creative Environment: “Ideas Lab”

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

UPCOMING: Biosignature IDEAS Lab

Who is involved?

- Mentors
  focus on the topic
- Facilitators
  focus on the process
- Participants



Interact

Clarify

Ideate

Develop

Implement

Real time peer review

2 months

Submit full proposals

Three-day residential sandpit

Three virtual meeting days

Select project ideas

ASTROBIOLOGY at NASA
LIFE IN THE UNIVERSE

BIOSIGNATURES IDEAS LAB

VIRTUAL & IN-PERSON: REGISTER TODAY!

NASA's Astrobiology Program invites scientists at US Institutions to apply to the Biosignatures IDEAS lab, a hybrid workshop to develop new and innovative grant proposals through real-time peer review. The workshop will include several virtual pre-meetings, three days of in-person sessions and three full-day virtual sessions. We expect to fund a few of the proposals developed by this process through the Exobiology program.

For more information, and to apply for this workshop, please visit the link below:

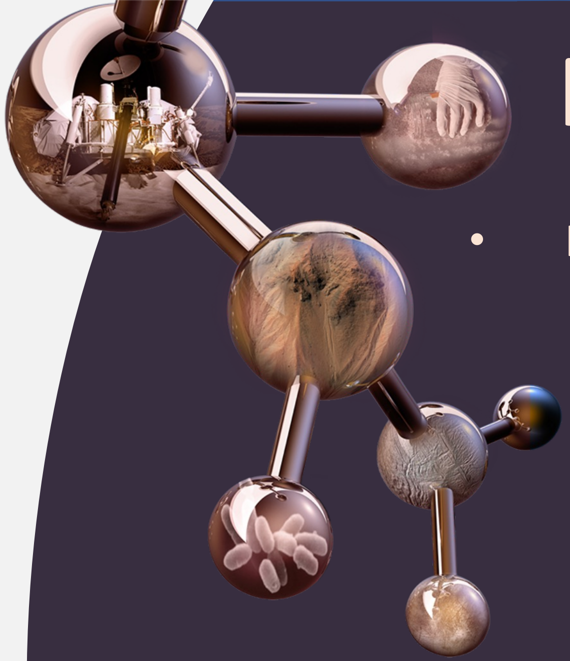
BIOSIGNATURES IDEAS LAB

Application Deadline: November 16th, 2023

Ideas Lab In-Person Sessions
Denver, Colorado (Tentative)
Day 1: February 6th, 2024
Day 2: February 7th, 2024
Day 3: February 8th, 2024

Ideas Lab Virtual Sessions
Day 4: February 16th, 2024
Day 5: February 23rd, 2024
Day 6: March 1st, 2024

https://apply.knowinnovation.com/nasabiosignatures/

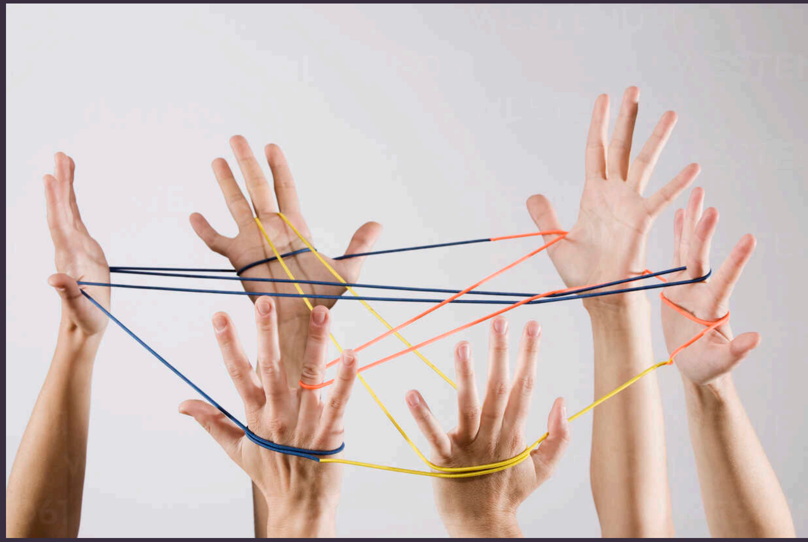


Future Directions :

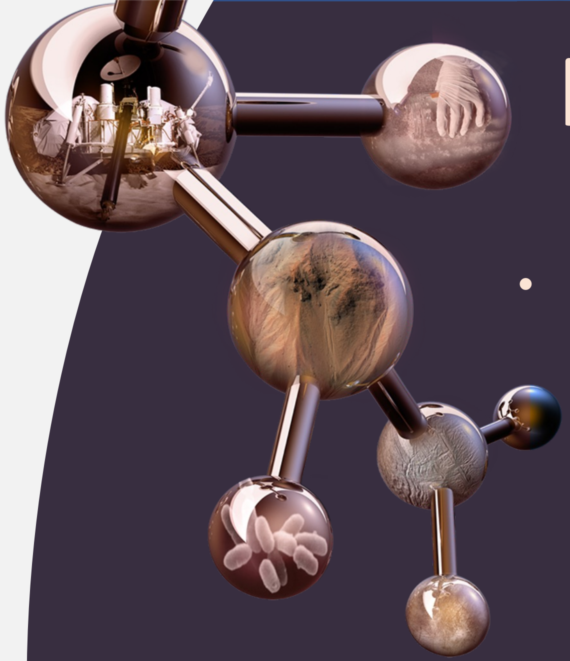
- Increased cross-divisional & cross-directorate activity in Astrobiology at NASA.

> The current divisional structure within the Science Mission Directorate largely predates the discovery of exoplanets and significant placement of the search for life as a cross-cutting theme for NASA science.

Goal: Raise visibility of astrobio program, increase connectivity. Look to bolster existing activities with new models for support of interdisciplinary, cross-divisional research projects.



- Interagency programs (NSF, USGS, NIH…).
- Revitalized international connections & collaborations.
- Public/private partnerships.



Future Directions :

(2/2)

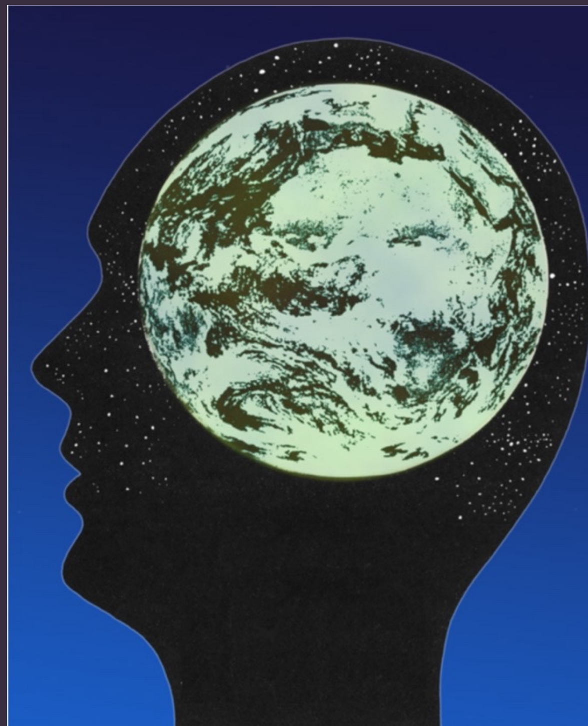
- Post discovery planning/imagining
  – communication.
  -- science.

If we succeed in “finding life” that is not the end but a new beginning for Astrobiology.
Comparative planetology -> comparative biospheres, biochemistries, etc.
What would that science look like?

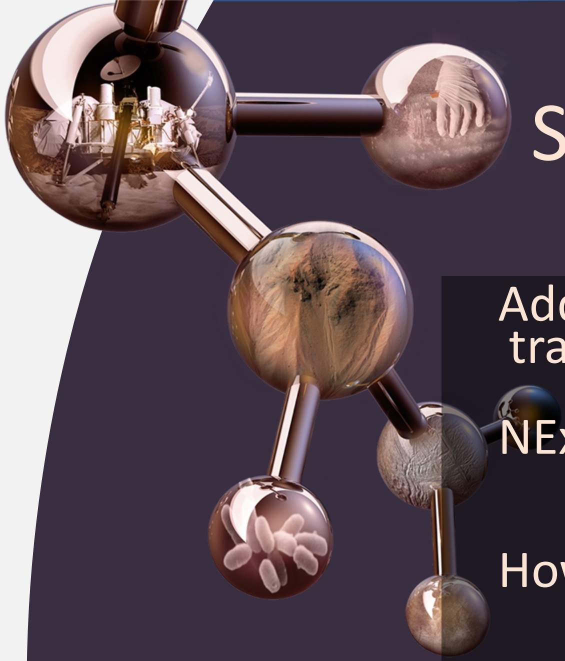
- Astrobiology & global sustainability/Anthropocene/ future of life/technosignatures

- Transformative potential of new technologies: AI, machine learning, networked smallsats…

- Ethical issues in fieldwork, exploration



Strategic input into existing programs:



Additional models of support and structure for RCNs: Are we maximizing openness, transparency, regular processes?

NExSS Review.

How does RCN structure affect overall cohesiveness of larger community?

Relationship with Astrobiology at NASA Centers.

Astrobiology input to missions.

Communications/Engagement,
- within NASA
- within our scientific community
- with the public(s)

Community building.

Example of Inter-Divisional Research Potential:

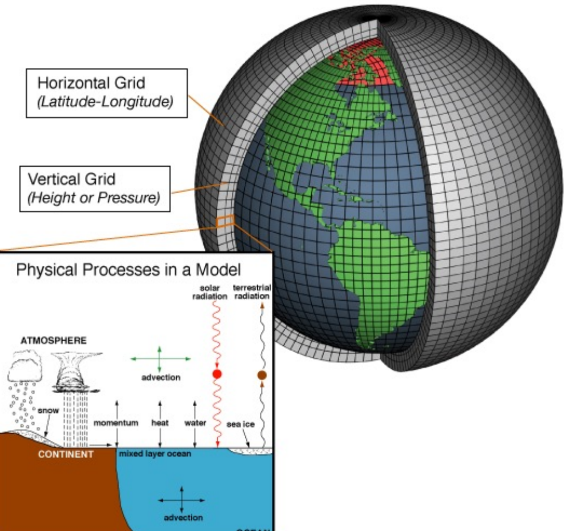
Was Venus the first habitable world of our solar system?

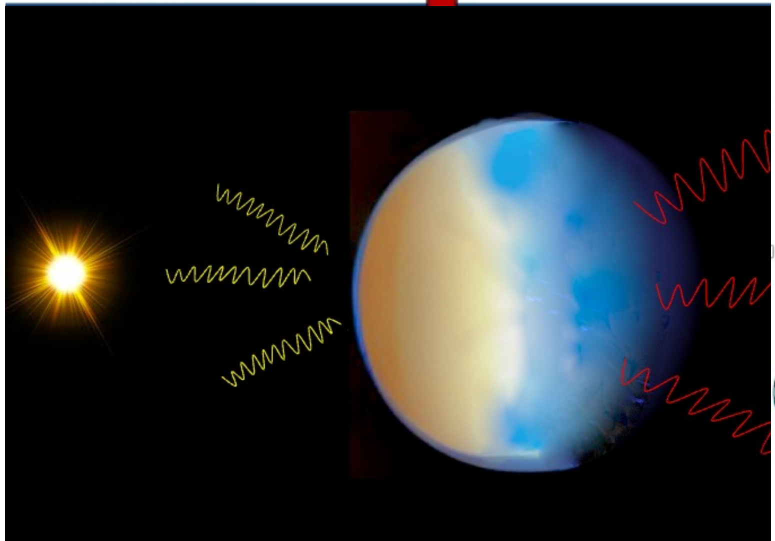
M. J. Way[1,2], Anthony D. Del Genio[1], Nancy Y. Kiang[1], Linda E. Sohl[1,3], David H. Grinspoon[4], Igor Aleinov[1,3], Maxwell Kelley[1], and Thomas Clune[5]

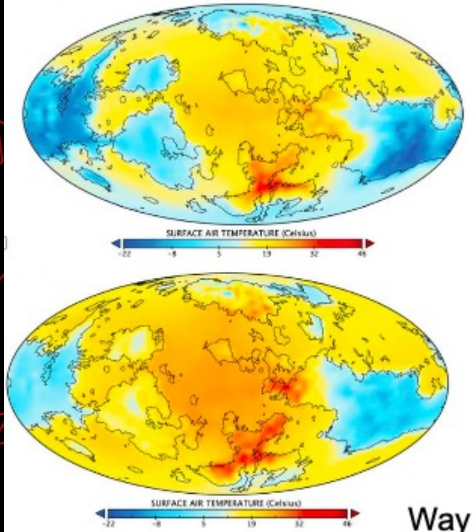
[1]NASA Goddard Institute for Space Studies, New York, New York, USA, [2]Department of Astronomy and Space Physics, Uppsala University, Uppsala, Sweden, [3]Center for Climate Systems Research, Columbia University, New York, New York, USA, [4]Planetary Science Institute, Tucson, Arizona, USA, [5]Global Modeling and Assimilation Office, NASA Goddard Space Flight Center, Greenbelt, Maryland, USA

Abstract Present-day Venus is an inhospitable place with surface temperatures approaching 750 K and an atmosphere 90 times as thick as Earth's. Billions of years ago the picture may have been very different. We have created a suite of 3-D climate simulations using topographic data from the Magellan mission, solar spectral irradiance estimates for 2.9 and 0.715 Gya, present-day Venus orbital parameters, an ocean volume consistent with current theory, and an atmospheric composit[...] estimated for early Venus. Using these parameters we find that such a world could have had mode[...] temperatures if Venus had a prograde rotation period slower than ~16 Earth days, despite an incident solar flux 46–70% higher than Earth receives. At its current rotation period, Venus's climate could have remained habitable until at least 0.715 Gya. These results demonstrate the role rotation and topography play in understanding the climatic history of Venus-like exoplanets discovered in the present epoch.

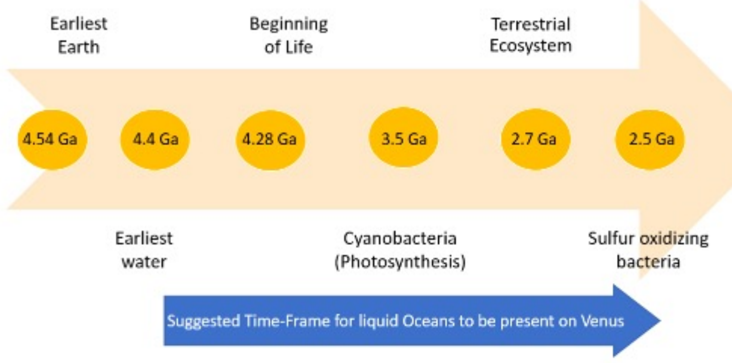
- Tools from Earth Science
- Data from Planetary & Helio
- Tested with future planetary missions
- Results relevant for Exoplanets, future space telescopes, etc.







Way et al. 2016



Neira et al. 2018

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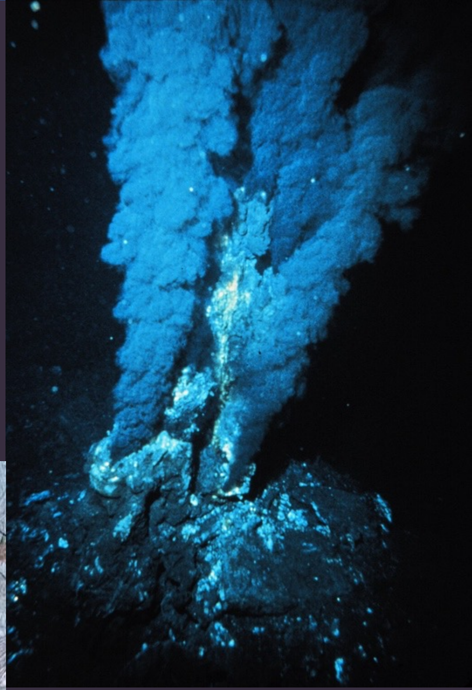
Earth Science Connections

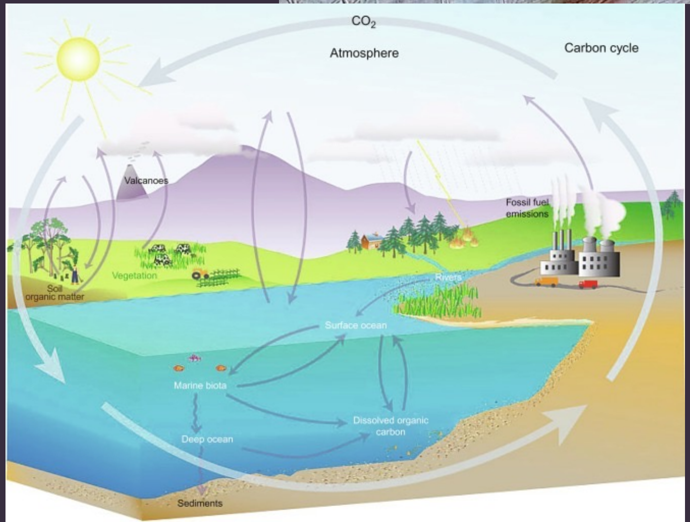


Ocean Worlds

- Hydrothermal Vents
- Ocean Drilling (joint workshop with NSF ?)

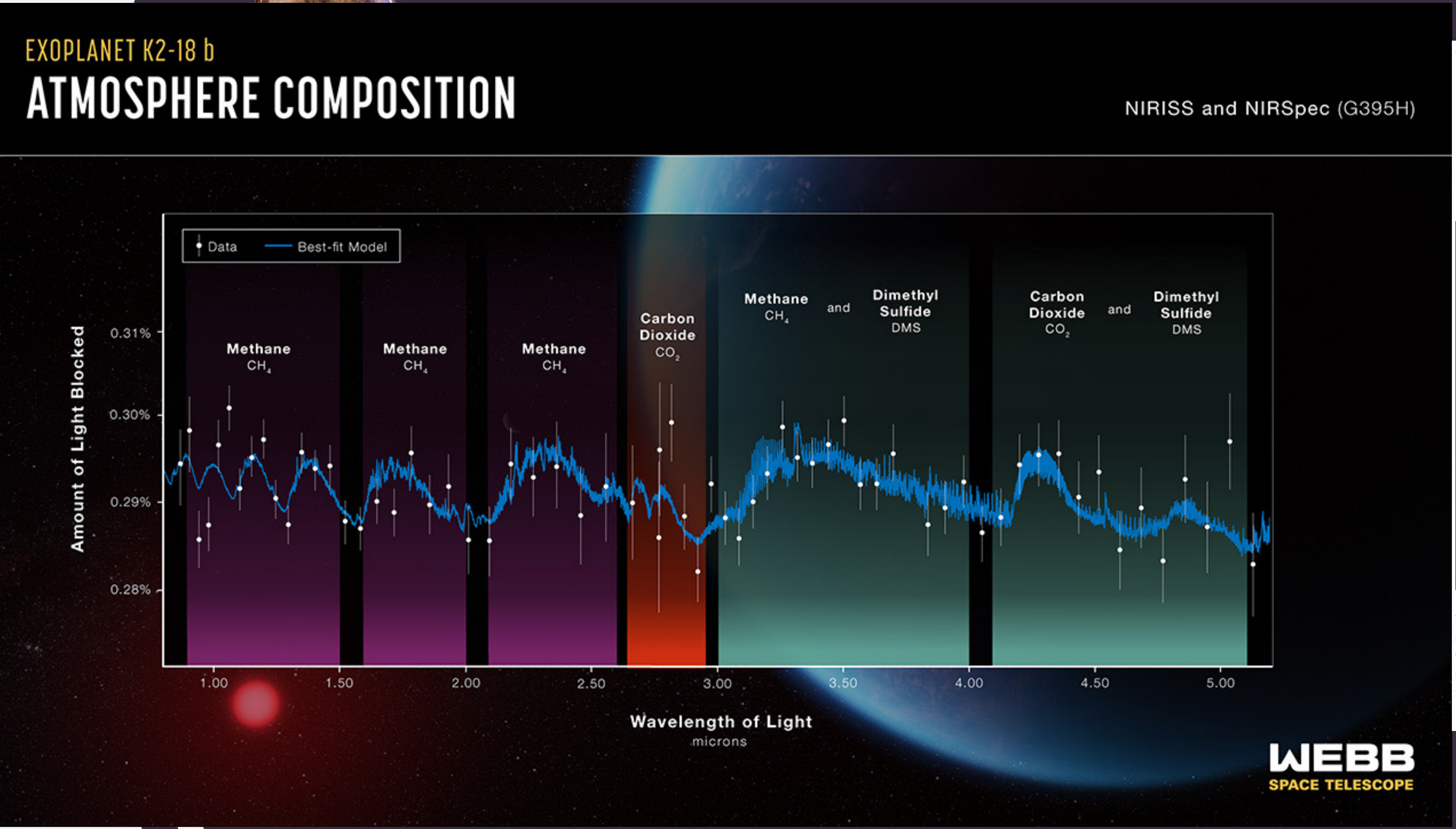
Cryospheres

Biogeochemical Cycles

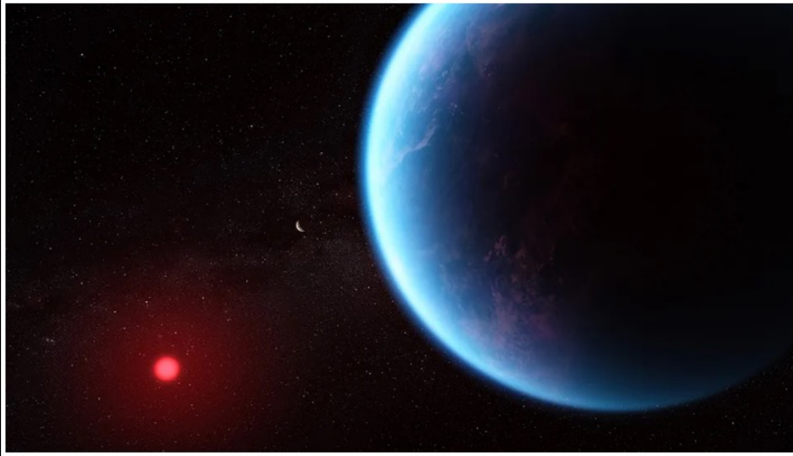


Climate Science

Communication Challenges

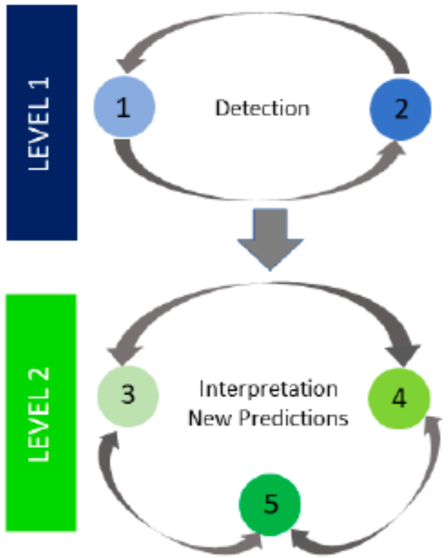


Webb Discovers Methane, Carbon Dioxide in Atmosphere of K2-18 b



This artist's concept shows what exoplanet K2-18 b could look like based on science data. K2-18 b, an exoplanet 8.6 times as massive as Earth, orbits the cool dwarf star K2-18 in the habitable zone and lies 120 light-years from Earth. A new investigation with NASA's James Webb Space Telescope into K2-18 b has revealed the presence of carbon-bearing molecules including methane and carbon dioxide. The abundance of methane and carbon dioxide, and shortage of ammonia, support the hypothesis that there may be a water ocean underneath a hydrogen-rich atmosphere in K2-18 b.
Illustration: NASA, CSA, ESA, J. Olmsted (STScI), Science: N. Madhusudhan (Cambridge University)

Standards of Evidence



Question 1: Have you detected an authentic signal?
Have you authenticated your signal, and is it statistically significant? Have you ruled out artifacts from the measurement, pre-processing and/or analysis process that might mimic a real signal?

Question 2: Have you adequately identified the signal?
Have you adequately ruled out other potential sources for this signal? For example, have you ruled out contamination in the environment, or other real phenomena that could produce a similar signal?

Question 3: Are there abiotic sources for your detection?
Is it likely that there is a current or past environmental process, other than life, that could be producing this signal? Have you ruled out these potential false positives for the biosignature?

Question 4: Is it likely that life would produce this expression in this environment?

Given what we know about the likely environment that an organism is operating in, or would have operated in, does it make physical and chemical sense that life would produce this potential biosignature?

Question 5: Are there independent lines of evidence to support a biological (or non-biological) explanation?
Are there other measurements that provide additional evidence, or allow you to predict and execute follow-on experiments, that will help discriminate between the life or non-life hypotheses?

CDSLU: Communicating Discoveries in the Search for Life in the Universe

Overview

If astrobiologists discover evidence of life beyond the Earth, how should these findings be shared with the public? Which communication strategies and techniques would best support public understanding of findings that are likely to be complex and highly specialized? Astrobiology faces a fundamental tension between the implications of finding evidence of biology or biological processes elsewhere in the universe, and explaining how observations or experiments used to accumulate that evidence will be subject to uncertainty and controversy. How might scientists and science communicators navigate this tension and communicate effectively about this uniquely compelling but challenging research?

This virtual workshop organized by NASA's Astrobiology Program (NAP) will bring together astrobiologists, science journalists, science communicators, and science content creators for a series of presentations, conversations, and activities aimed at building a greater shared understanding of the challenges and opportunities for each group that such an event might present. By creating a space to exchange perspectives, experiences, professional realities, and foster relationships between scientists and science communicators we hope to explore mutually-beneficial and socially responsible paths towards communicating the discovery of extraterrestrial life.

Summary

This virtual workshop will bring together the astrobiology and science communication communities to exchange perspectives about the potential discovery of life beyond Earth. Through a series of presentations, conversations, and activities the workshop will explore mutually-beneficial and socially responsible paths towards communicating the discovery of extraterrestrial life and creating a lasting community of shared interest.

Virtual Workshop Session Details

- Week 1
  February 5, 7, 9, 2024
- Week 2
  February 12, 14, 16, 2024
- *12:00 pm - 4:00 pm ET each day*

Application Deadline

November 15, 2023 by End of Day

Astrobiology Strategy 2025

We are starting to plan an activity to formulate a new Astrobiology Strategy

A decade since the previous one.

Much has happened:
-New Decadal Survey.
-Concrete evidence of habitable early environments on Mars.
-Dragonfly selection.
-Exoplanets (discovery that Trappist-1 has multiple planets in potentially HZ).
-Tremendous progress in understanding biology and environmental evolution of early Earth.

Include post-discovery science strategy?

Worth looking more than 10 years ahead?
20 years from now: Hopefully, samples back from many targets, HWO will be operating, perhaps we'll be planning a fleet of next generation telescopes, perhaps we'll have found multiple biosignatures (or not).
What laboratory & analytical techniques might we have access to?
What will our science look like?

Questions?