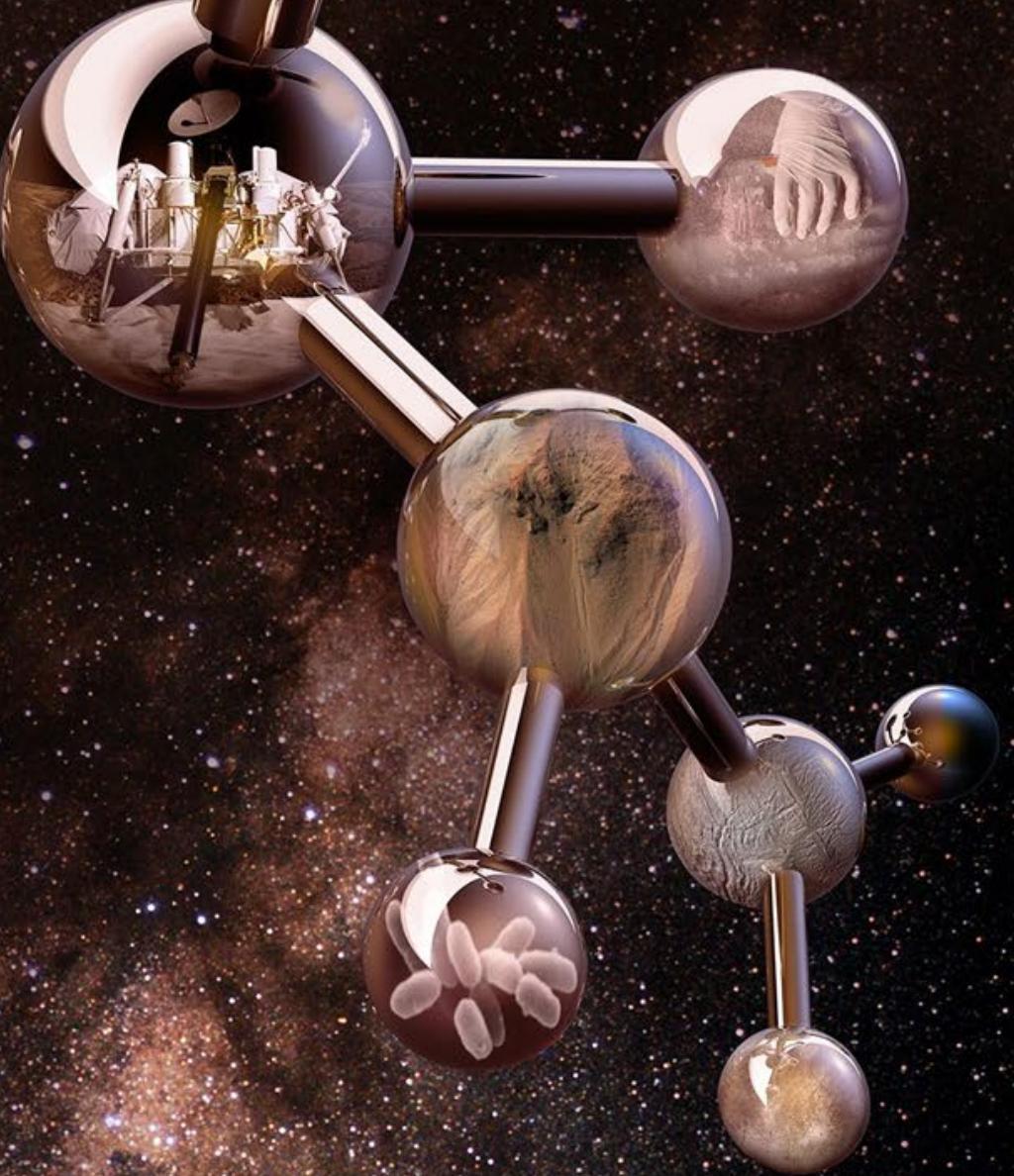


NASA Astrobiology Program Update

David Grinspoon
Senior Scientist for Astrobiology Strategy
CAPS, Irvine
October 24, 2023



Please allow me to introduce myself...

Science:

Evolution of terrestrial planet atmospheres, surfaces, hydrospheres & biospheres, Comparative climatology, Metabolic reactions in extreme planetary environments, Stable isotopes in nebulas & atmospheres, Large impacts, Icy moon atmospheres origin & evolution.

PI & Co-I: Exobiology & several other NASA research programs, NAI Co-I, NSF LExEn PI , NExSS Co-I, NIAC.

Missions:

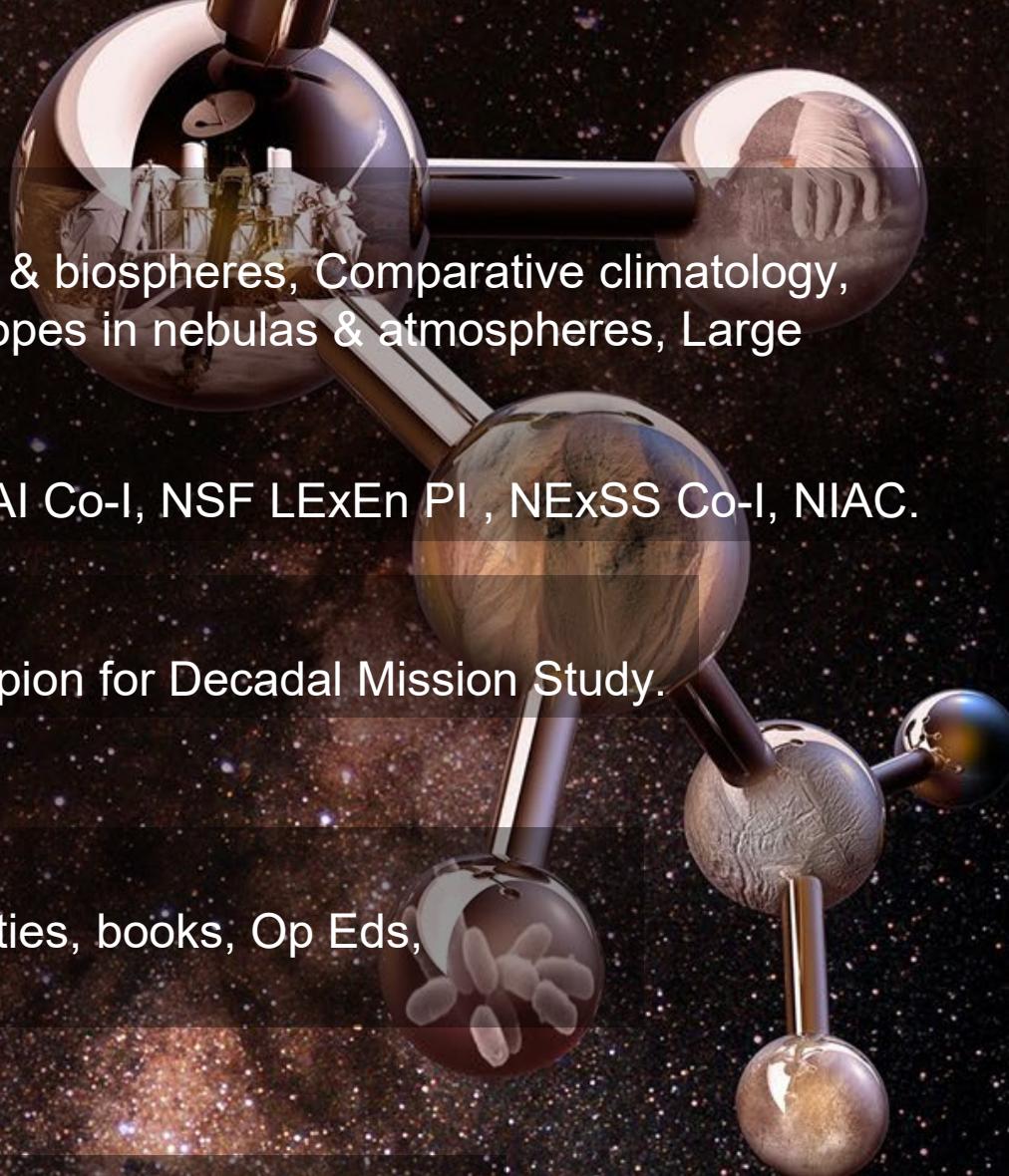
Venus Express IDS, MSL RAD Co-I, DAVINCI Co-I, Science Champion for Decadal Mission Study.

Education & Outreach:

Curator of Astrobiology at DMNS, Taught Astrobiology at 4 universities, books, Op Eds, magazine writing, podcasts, planetarium shows, online courses.

Other:

Inaugural Blumberg Chair, NASA SDTs, SSEs, Decadal Panels, White Paper author, etc.



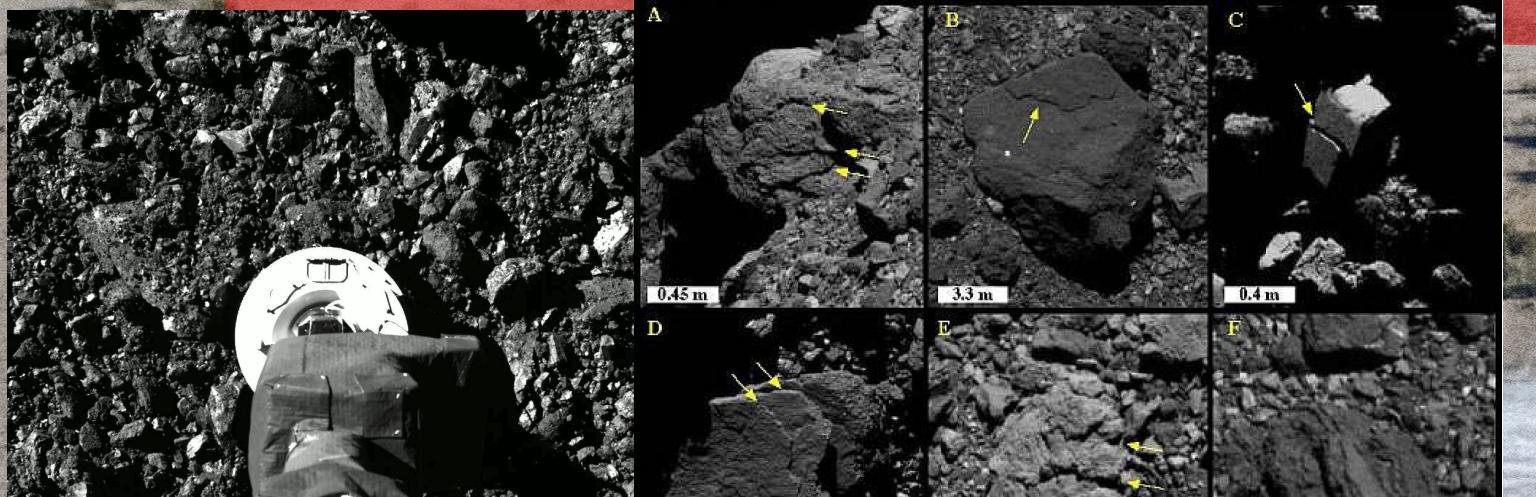
An exciting time for Astrobiology!



An exciting time for Astrobiology!

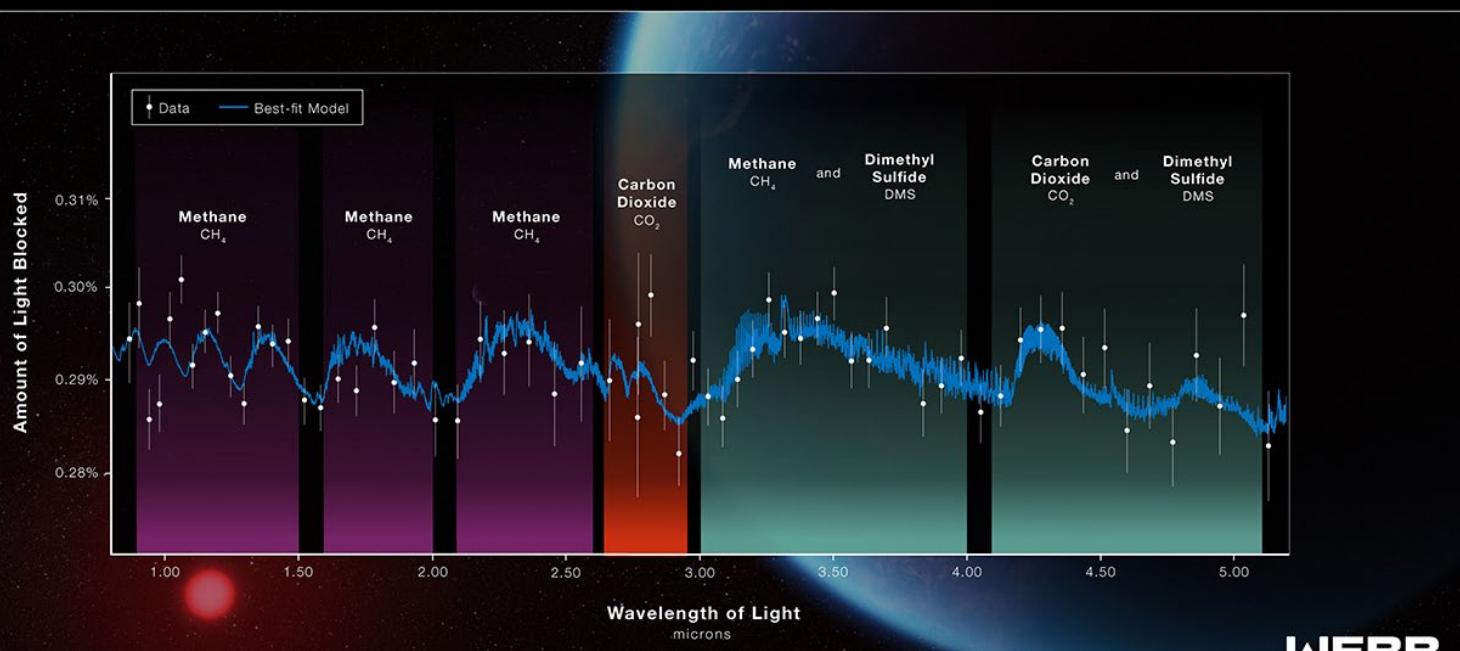


An exciting time for Astrobiology!

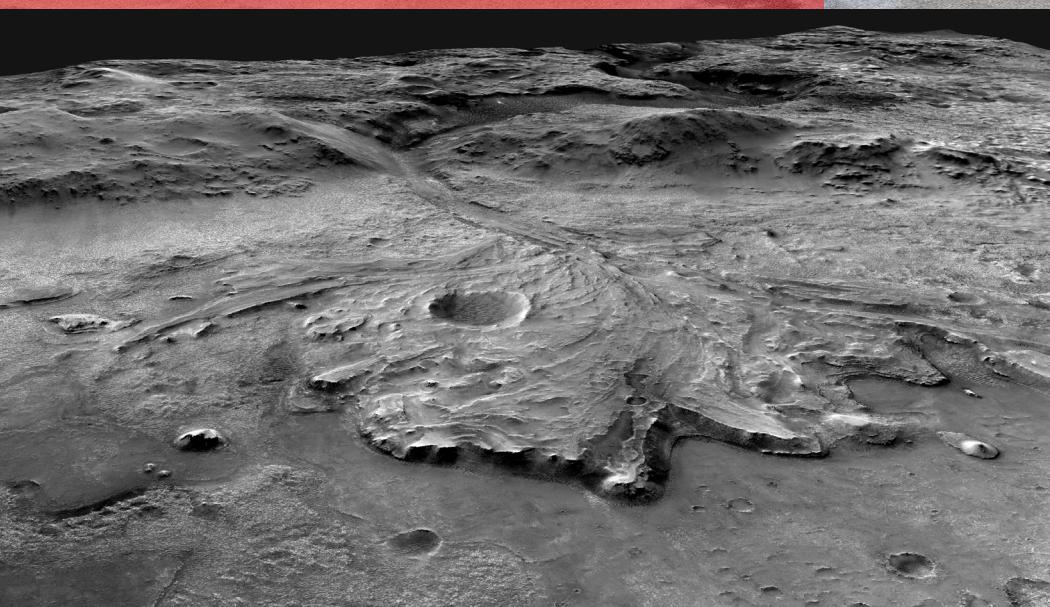
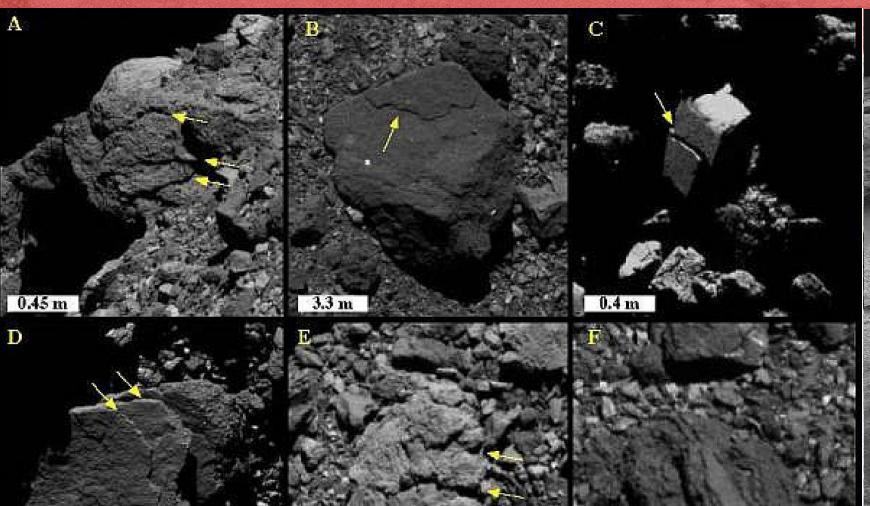


EXOPLANET K2-18 b ATMOSPHERE COMPOSITION

NIRISS and NIRSpec (G395H)

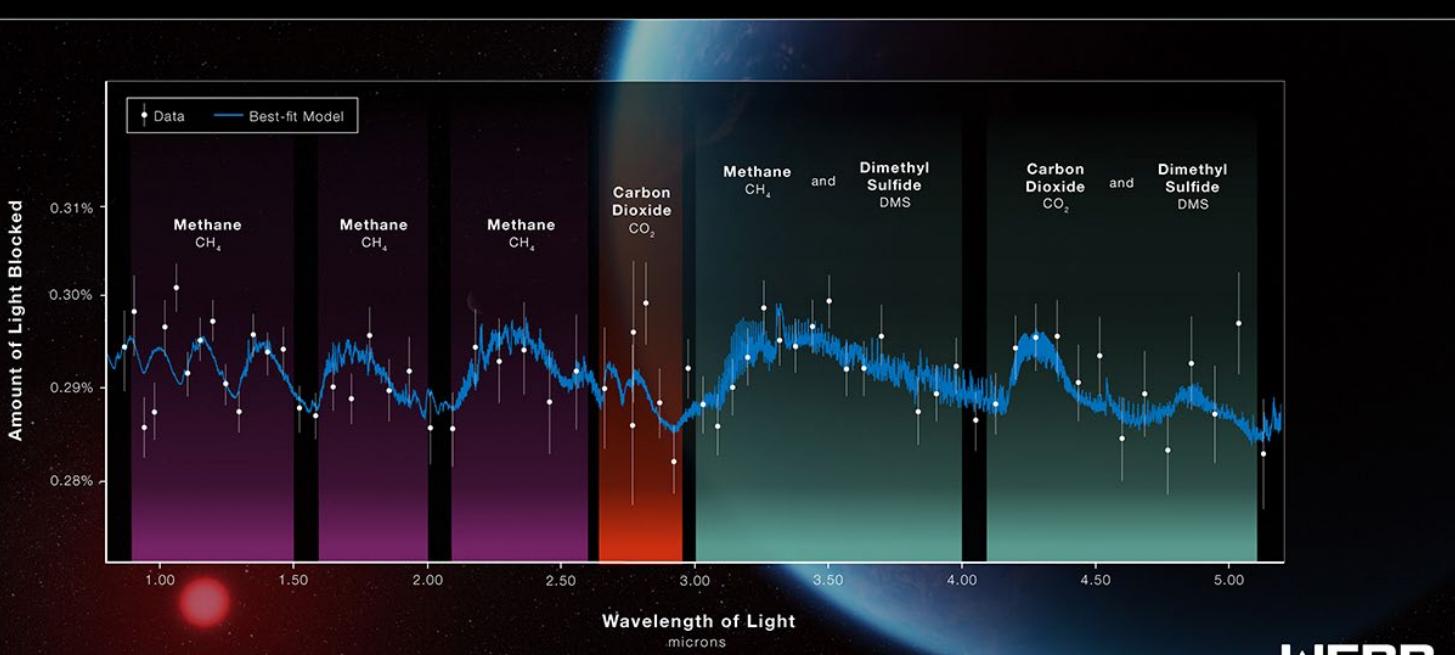


An exciting time for Astrobiology!

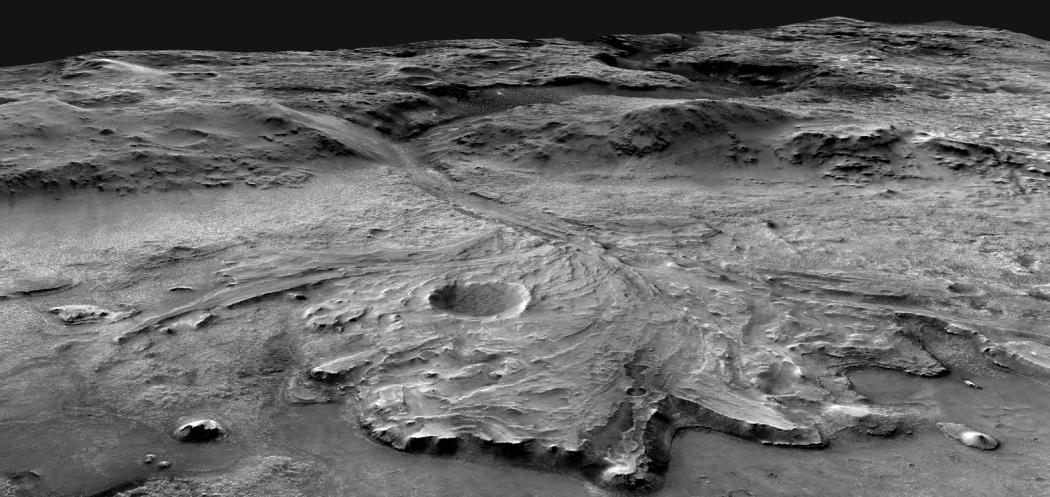
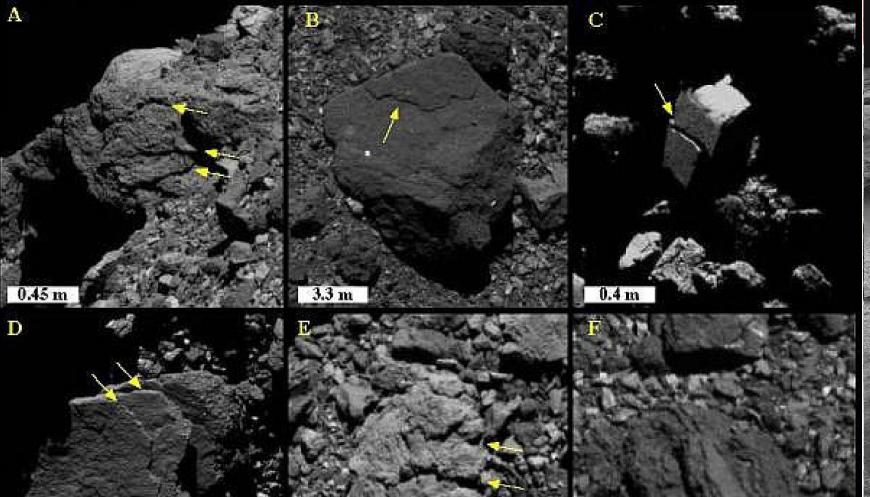


EXOPLANET K2-18 b ATMOSPHERE COMPOSITION

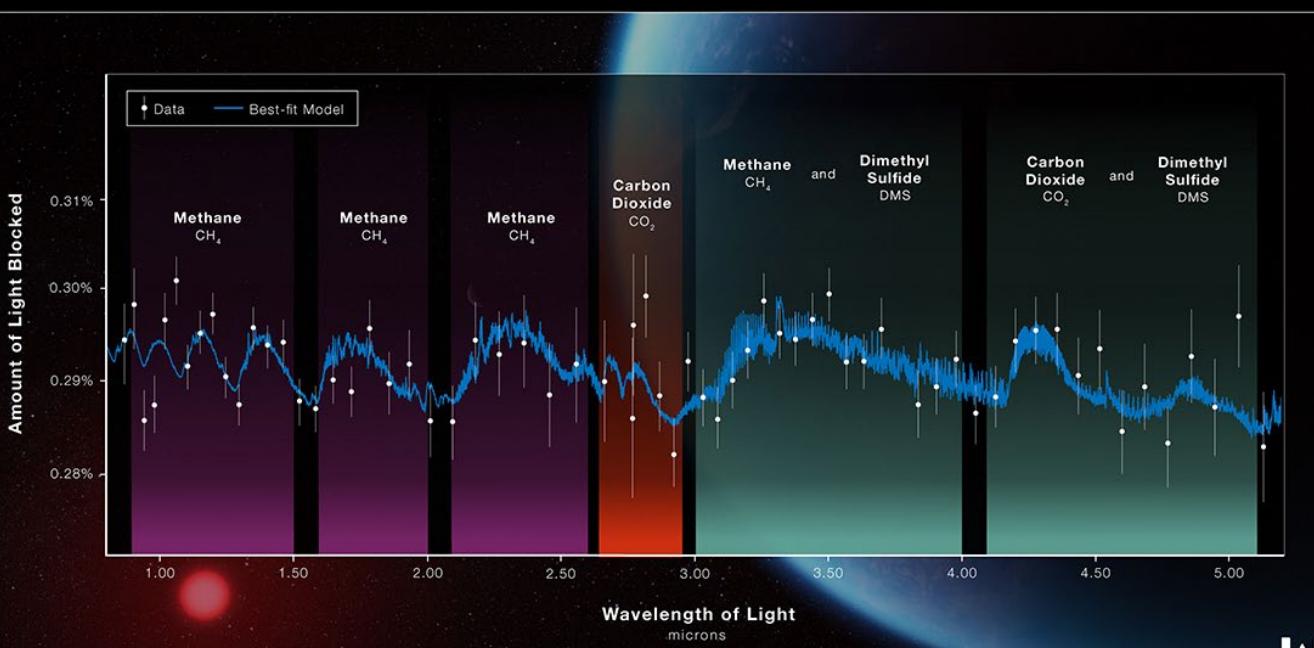
NIRISS and NIRSpec (G395H)



An exciting time for Astrobiology!



EXOPLANET K2-18 b ATMOSPHERE COMPOSITION





Senior Scientist for Astrobiology Strategy

This is a new position.

New leadership roles:

SSAS (David Grinspoon):

“Up and out”

Expand the astrobiology program within NASA and beyond.



Program Scientist for Astrobiology (Lindsay Hays)

“Down and in”

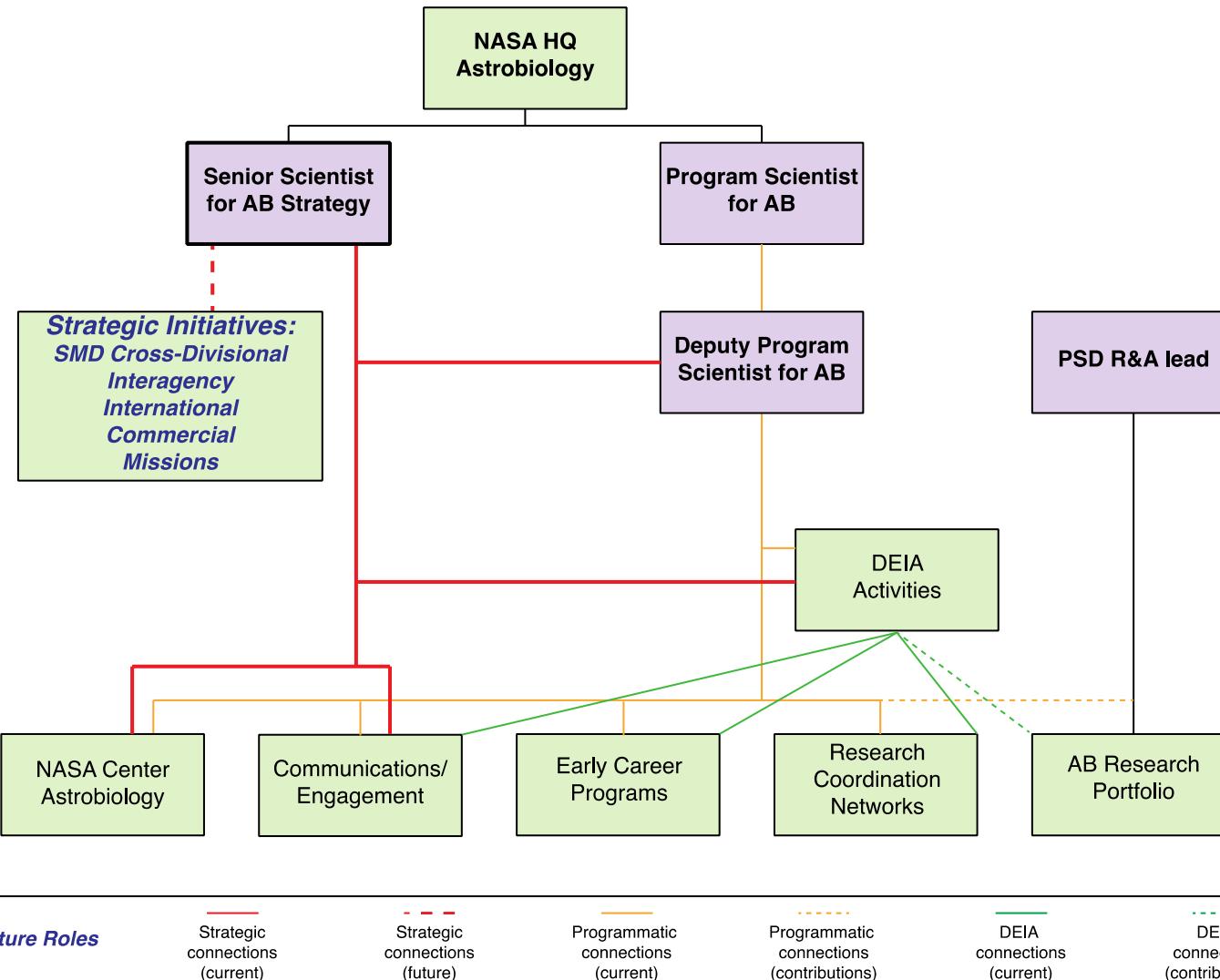
Manage existing research programs.

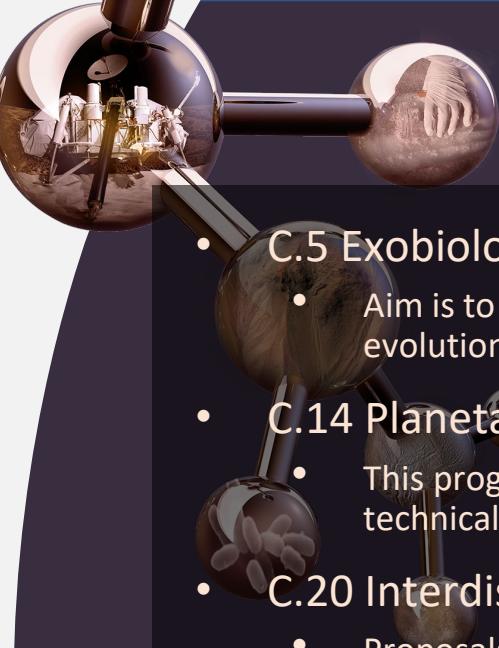


**Deputy Program Scientist for Astrobiology
(Becky McCauley Rench)**



New NASA Astrobiology Org Chart:





NASA Astrobiology Research Programs

Led by Lindsay Hays

- **C.5 Exobiology**
 - 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)**
 - 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)**
 - 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)**
 - 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.
 - Additionally contribute to:
 - PICASSO/MatISSE (instrument development)
 - FINESST (Graduate Student Grants)
 - ISFM (NASA Civil Servant research)
 - TWSC (workshop/conference)
 - Overlap with
 - Planetary Protection Research
 - Exoplanets Research Program

Research Coordination Networks

NASA rep is Lindsay Hays

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 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.



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.

The Nexus for Exoplanet System Science

nexss.info

The Network for Life Detection

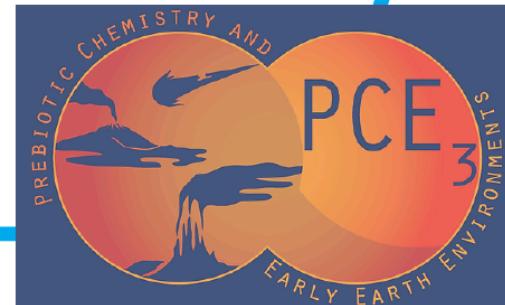
nfold.org



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

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.



Future Directions (Led by David Grinspoon) : (1/2)

- 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.



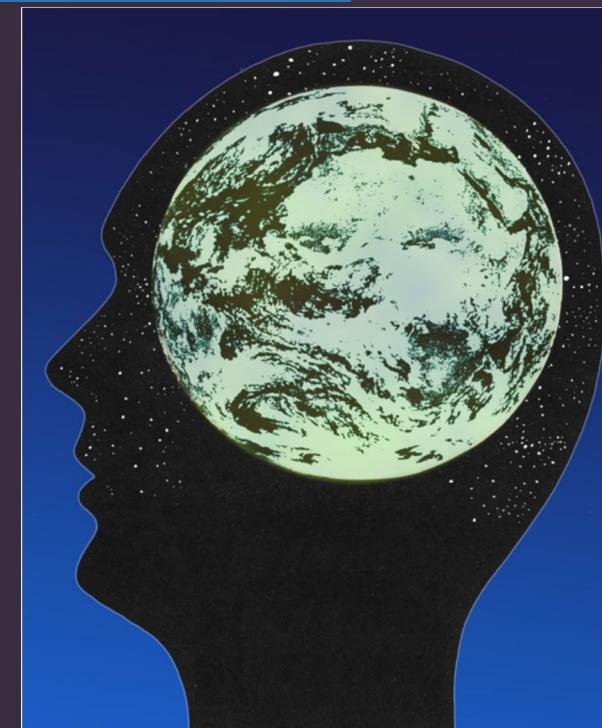


Future Directions (Led by David Grinspoon) : (2/2)

- 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





BEYOND PERMITS AND CODES OF CONDUCT – TOWARD RELATIONSHIPS

Based on 2021 headlines highlighting egregious oversampling on Native lands (BLM)...

The NASA AB Program has developed guidelines and policies to evolve geoethics and approaches to field research based on these and other values and principles:

- Scientific fieldwork is a privilege, not a right.
- All lands in the United States (and many lands beyond) are Indigenous lands
 - Whether or not the Tribe holds “legal” claim or is currently occupying them
- There’s a difference between permission to obtain samples (permits) and ethical conduct with respect to the lands/waters/skies.

The NASA AB Program is working to ensure the fieldwork we fund is in alignment with the values and ethics of being in right relationship with Indigenous communities who have, since time immemorial, occupied and stewarded the lands/waters/skies where we seek to do our research.

ROSES: APPENDIX C. PLANETARY SCIENCE RESEARCH PROGRAM

Language calls for proposers doing fieldwork to demonstrate:

- *Respect for the values of other users of the site by considering the impact that their work will have on the environment (e.g., sensitive ecosystems or historic properties of religious, cultural, or scientific significance)*
- *A research plan that reduces impact to the site (if any)*
- *The intention to obtain relevant permits and follow their guidelines*



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.



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 Propulsion Laboratory)

Example of Inter-Divisional Research Potential:



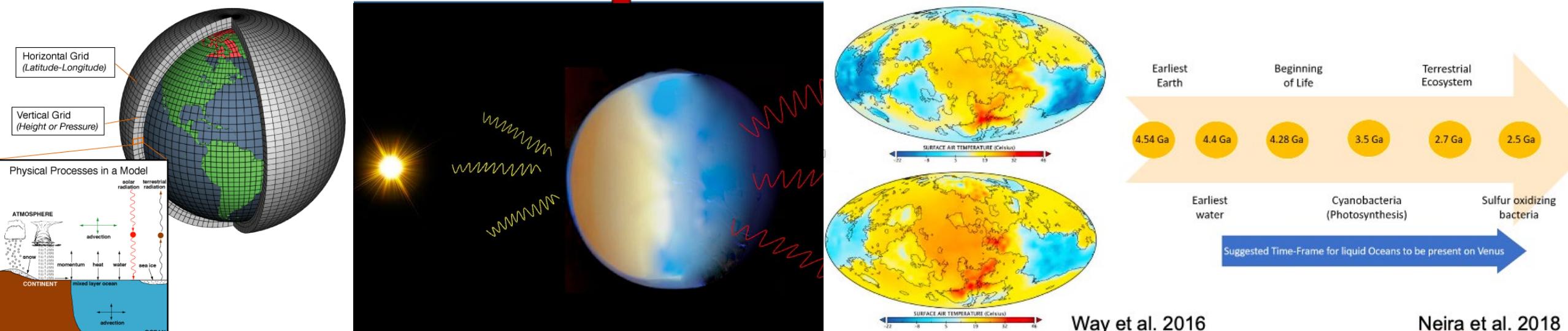
Was Venus the first habitable world of our solar system?

M. J. Way^{1,2}, Anthony D. Del Genio¹, Nancy Y. Kiang¹, Linda E. Sohl^{1,3}, David H. Grinspoon⁴,
Igor Aleinov^{1,3}, Maxwell Kelley¹, and Thomas Clune⁵

¹NASA Goddard Institute for Space Studies, New York, New York, USA, ²Department of Astronomy and Space Physics, Uppsala University, Uppsala, Sweden, ³Center for Climate Systems Research, Columbia University, New York, New York, USA, ⁴Planetary Science Institute, Tucson, Arizona, USA, ⁵Global 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 composition estimated for early Venus. Using these parameters we find that such a world could have had moderate 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.

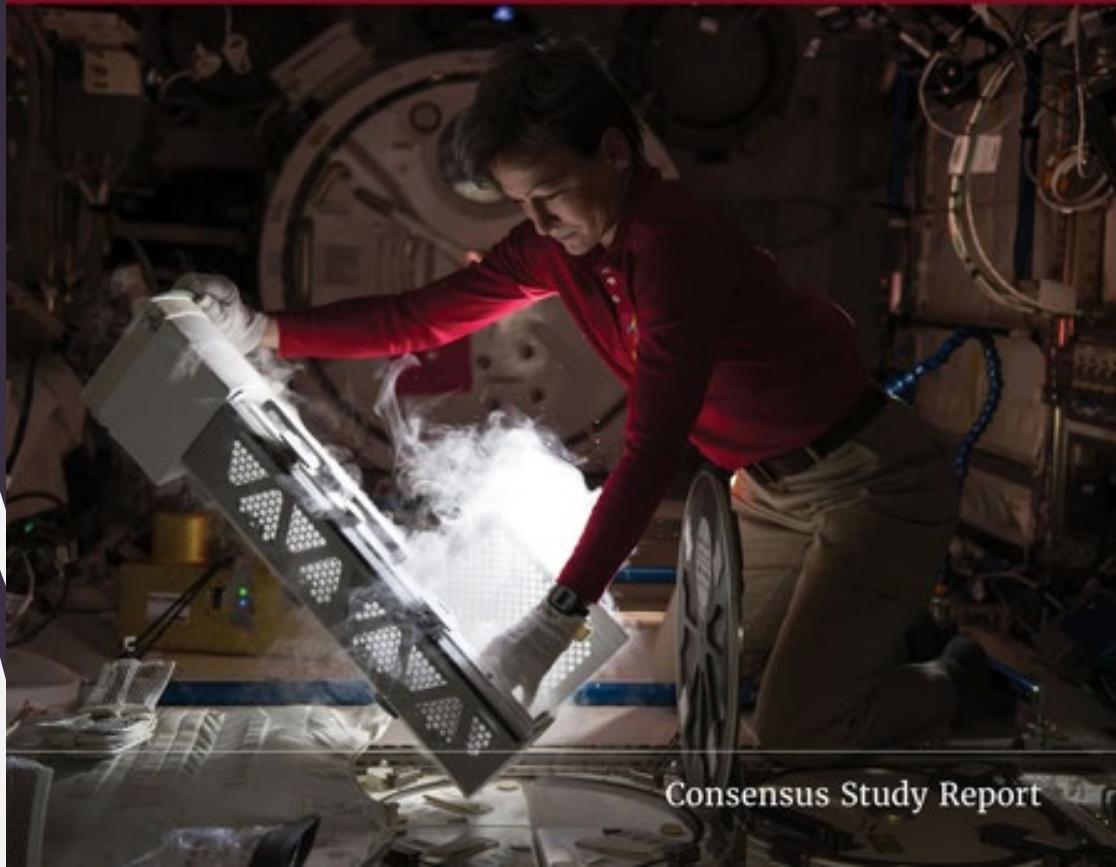




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Medicine

Thriving in Space

Ensuring the Future of Biological and Physical Sciences Research
Decadal Survey for 2023-2032

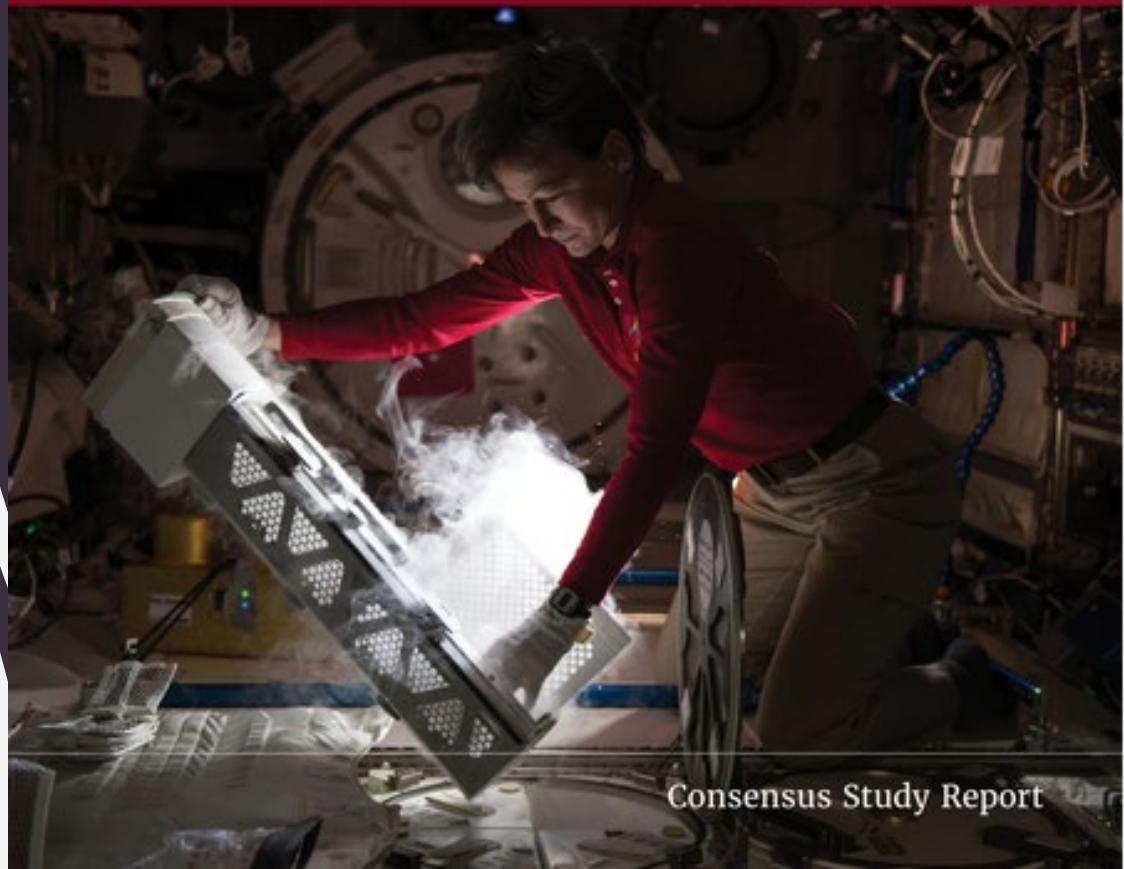


Consensus Study Report



Thriving in Space

Ensuring the Future of Biological and Physical Sciences Research
Decadal Survey for 2023-2032



Consensus Study Report

Angelos, E., D.K. Ko, S. Zemelis-Durfee, and F. Brandizzi. 2021. "Relevance of the Unfolded Protein Response to Spaceflight-Induced Transcriptional Reprogramming in *Arabidopsis*." *Astrobiology* 21(3):367–380.

Dong, C.Y. Fu, B. Xie, M. Wang and H. Liu. 2017. "Element Cycling and Energy Flux Responses in Ecosystem Simulations Conducted at the Chinese Lunar Palace-1." *Astrobiology* 17(1):78–86.

Ferl, R.J., J. Koh, F. Denison, and A.L. Paul. 2015. "Spaceflight Induces Specific Alterations in the Proteomes of *Arabidopsis*." *Astrobiology* 15(1):32–56.

Fu, Y., L. Li, B. Xie, C. Dong, M. Wang, B. Jia, L. Shao, et al. 2016. "How to Establish a Bioregenerative Life Support System for Long-Term Crewed Missions to the Moon or Mars." *Astrobiology* 16(12):925–936.

Grant, K.C., C.L.M. Khodadad, and J.S. Foster. 2014. "Role of *Hfq* in an Animal–Microbe Symbiosis Under Simulated Microgravity Conditions." *International Journal of Astrobiology* 13(1):53–61.

Haveman, N.J.S., and A.C. Schuerger. 2022. "Diagnosing an Opportunistic Fungal Pathogen on Spaceflight-Grown Plants Using the Minion Sequencing Platform." *Astrobiology* 22(1):1–6.

Horneck, G., R. Moeller, J. Cadet, T. Douki, R.L. Mancinelli, W.L. Nicholson, C. Panitz, et al. 2012. "Resistance of Bacterial Endospores to Outer Space for Planetary Protection Purposes—Experiment Protect of the Expose-E Mission." *Astrobiology* 12(5):445–456.

Paul, A.-L., A.K. Zupanska, D.T. Ostrow, Y. Zhang, Y. Sun, J.-L. Li, S. Shanker, W.G. Farmerie, C.E. Amalfitano, and R.J. Ferl. 2012. "Spaceflight Transcriptomes: Unique Responses to a Novel Environment." *Astrobiology* 12(1):40–56.

Poulet, L., J.P. Fontaine, and C.G. Dussap. 2018. "A Physical Modeling Approach for Higher Plant Growth in Reduced Gravity Environments." *Astrobiology* 18(9):1093–1100.

Schuerger, A.C., B.S. Amaradasa, N.S. Dufault, M.E. Hummerick, J.T. Richards, C.L. Khodadad, T.M. Smith, and G.D. Massa. 2021. "Fusarium *Oxysporum* as an Opportunistic Fungal Pathogen on *Zinnia Hybrida* Plants Grown on Board the International Space Station." *Astrobiology* 21(9):1029–1048.

Waters, S.M., S.M. Ledford, A. Wacker, S. Verma, B. Serda, J. McKaig, J. Varelas, P.M. Nicoll, K. Venkateswaran, and D.J. Smith. 2021. "Long-Read Sequencing Reveals Increased Occurrence of Genomic Variants and Adenosine Methylation in *Bacillus Pumilus* SAFR-032 After Long-Duration Flight Exposure Onboard the International Space Station." *International Journal of Astrobiology* 20(6):435–444.

Earth Science Connections



Ocean Worlds

Hydrothermal Vents

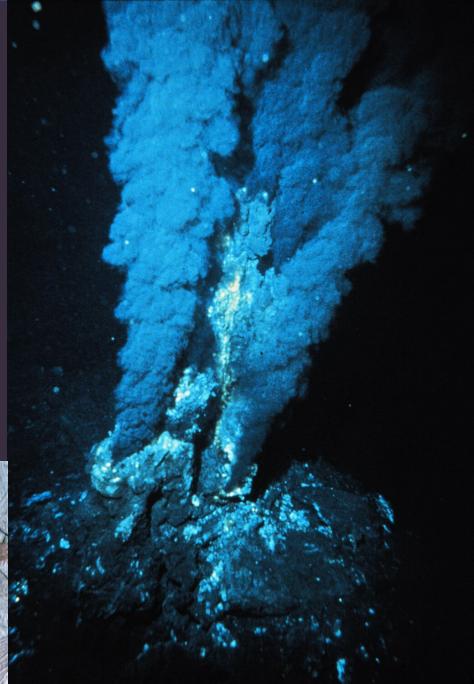
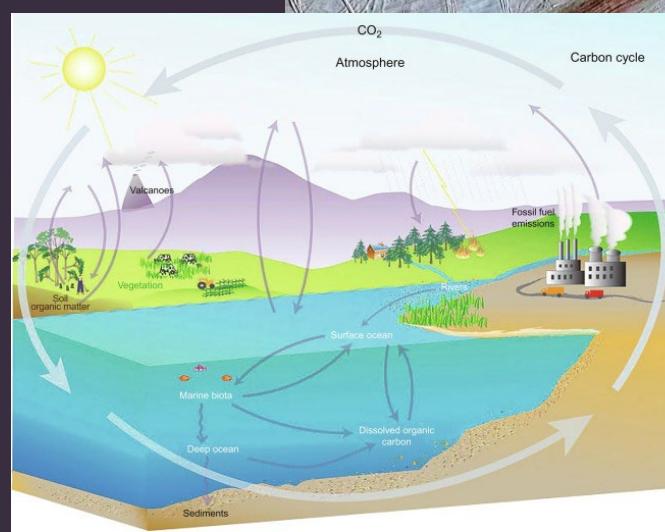
Ocean Drilling (joint workshop with NSF ?)



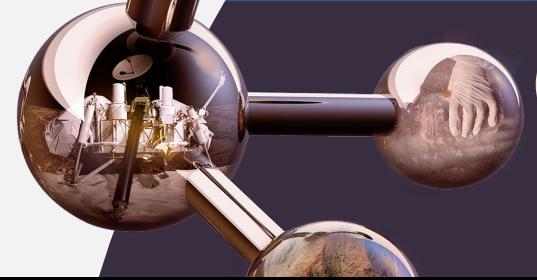
Cryospheres

Biogeochemical Cycles

Climate Science

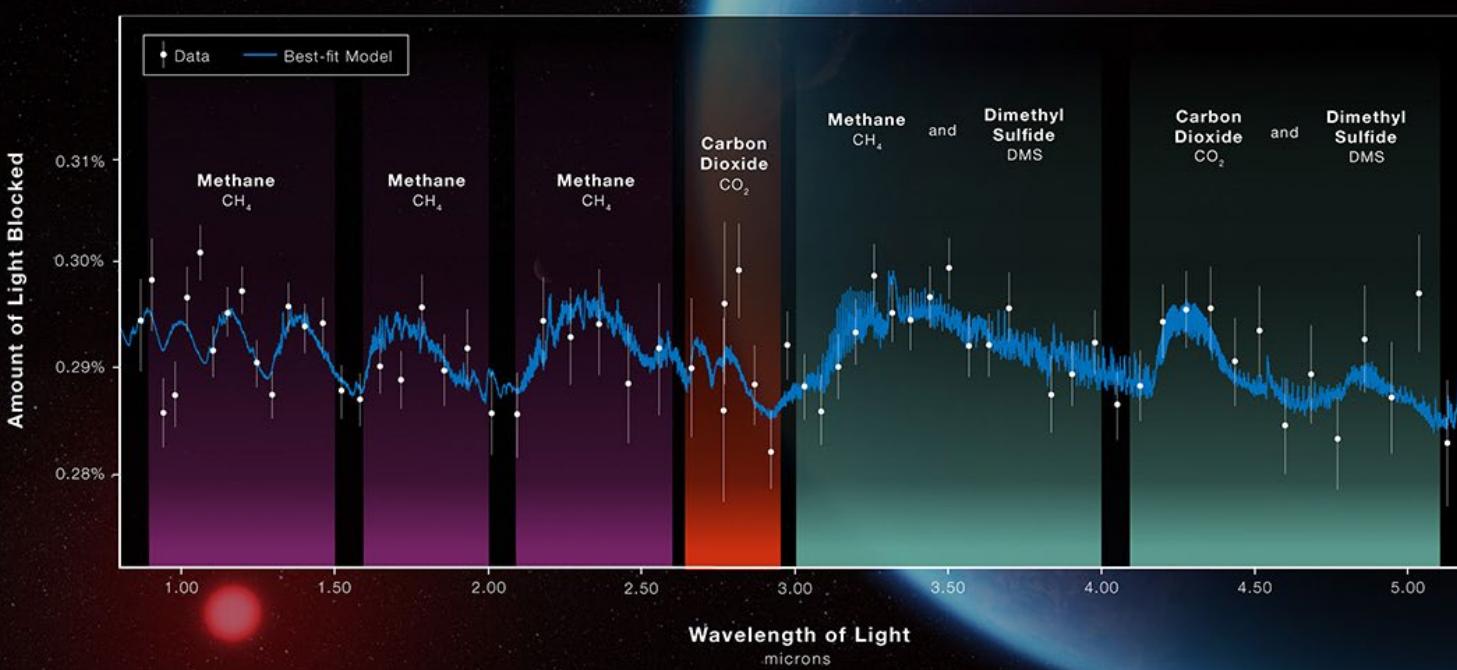


Communication Challenges

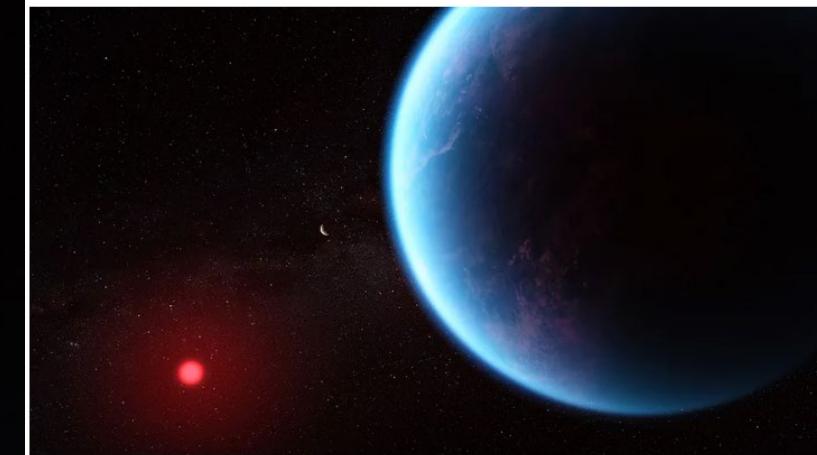


EXOPLANET K2-18 b ATMOSPHERE COMPOSITION

NIRISS and NIRSpec (G395H)



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



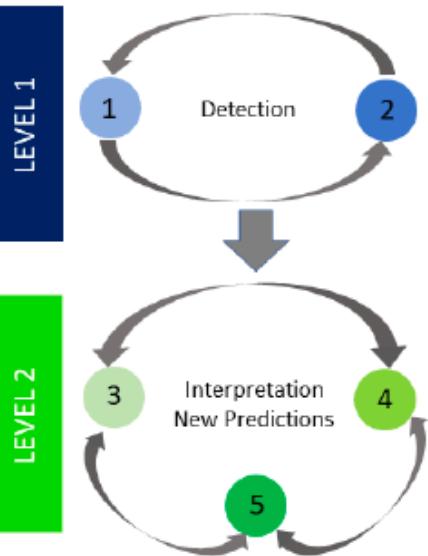
This artist's concept shows what exoplanet K2-18 b could look like based on science data. K2-18 b, an exoplanet 8.6 times as massive as Earth, orbits the cool dwarf star K2-18 in the habitable zone and lies 120 light-years from Earth. A new investigation with NASA's James Webb Space Telescope into K2-18 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)

WEBB
SPACE TELESCOPE



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?

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Independent Review of the Community
Report from the Biosignature
Standards of Evidence Workshop

Report Series—Committee on Astrobiology and
Planetary Sciences



Consensus Study Report



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



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



[ABOUT IMAGE](#)

PROGRAM NEWS

Applications Open: NASA/Library of Congress Chair in Astrobiology, Exploration, and Scientific Innovation

Applications are due by October 15, 2023.

Applications are now being accepted for the Baruch S. Blumberg NASA/Library Of Congress Chair In Astrobiology, Exploration, And Scientific Innovation. The position provides an opportunity for high-level scholarship to understand the interface between human society and the scientific exploration of the cosmos.

In the spirit of Barry Blumberg, whose life and work spanned multiple disciplines, the Blumberg Program is interested in the concept of exploration broadly defined to include any aspect of space exploration within the parameters of NASA's mission to "reveal the unknown for the benefit of humankind." The program is most interested in proposals that consider the philosophical, humanistic, legal, ethical, and policy dimensions of exploration.



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?