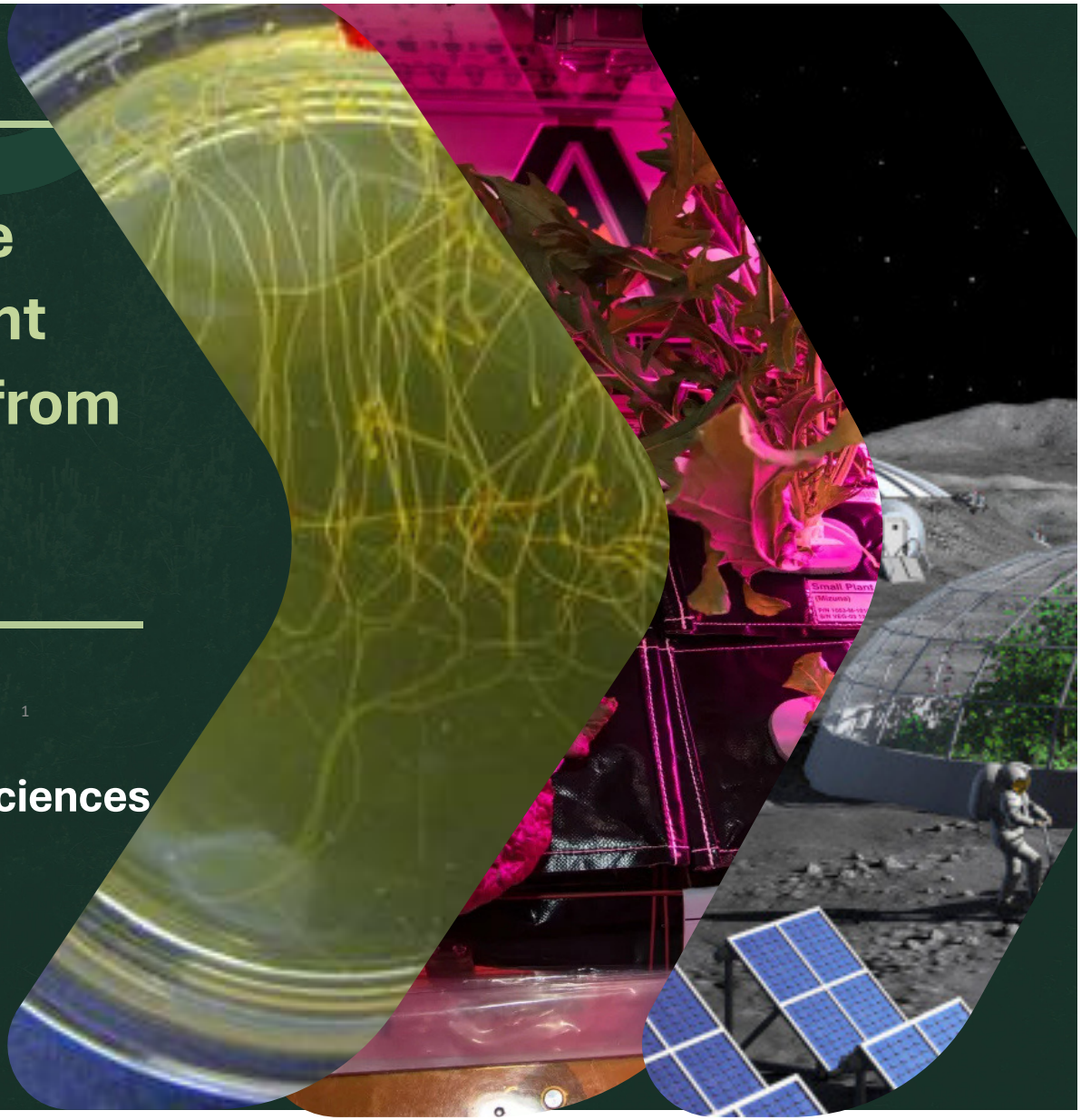
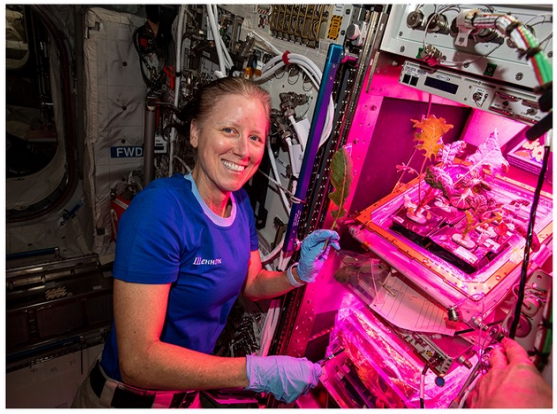
From Microgravity to a ‘More Complex Environment’: Plant Space Biology in Transition from Low Earth Orbit to the Moon

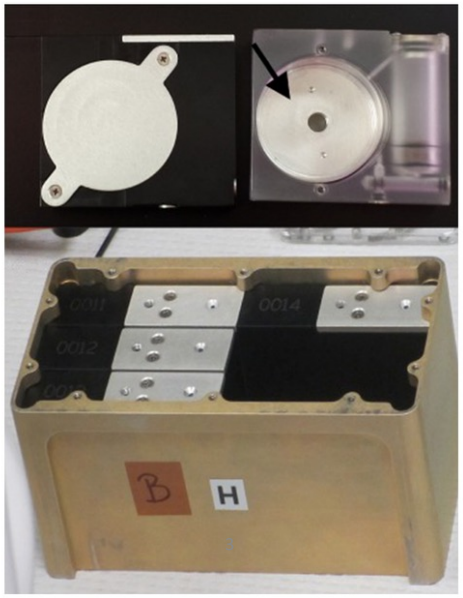


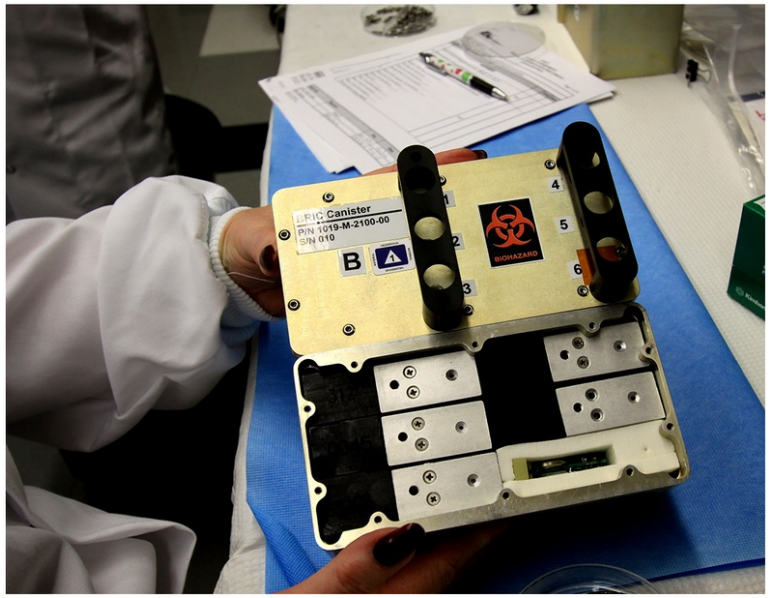
Paola Castaño
Egenis Centre for the Study of the Life Sciences
University of Exeter
ISHPSSB Porto - July 21, 2025



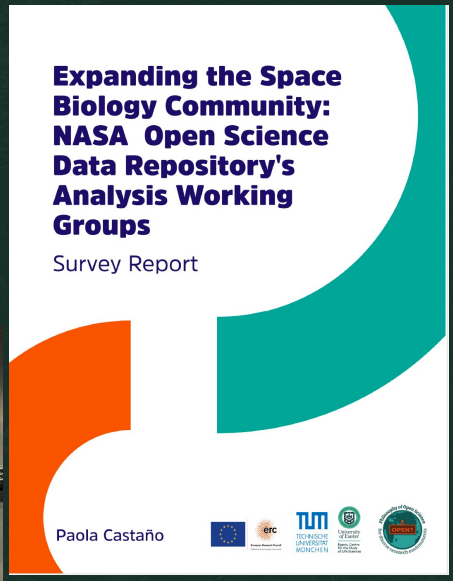



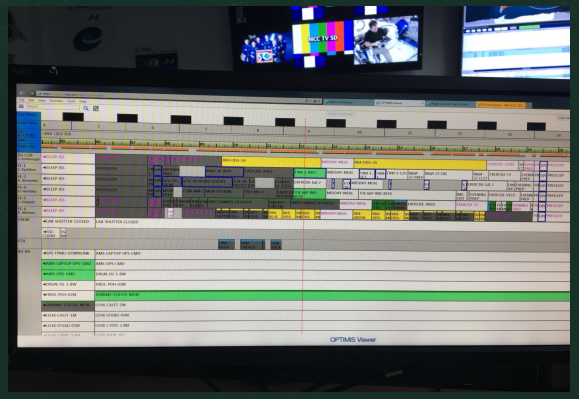

From top left: ESA (Concept), 2019; NASA (Concept), 2016; NASA (ISS Photo) 2021;
NASA (ISS Photo) 2021; NASA (ISS Photo), 2017, NASA (ISS Photo), 2016

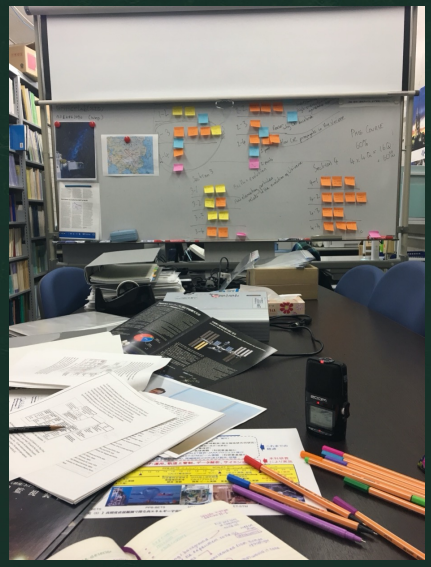




NASA 2014; Basu et al. 2017; NASA 2013



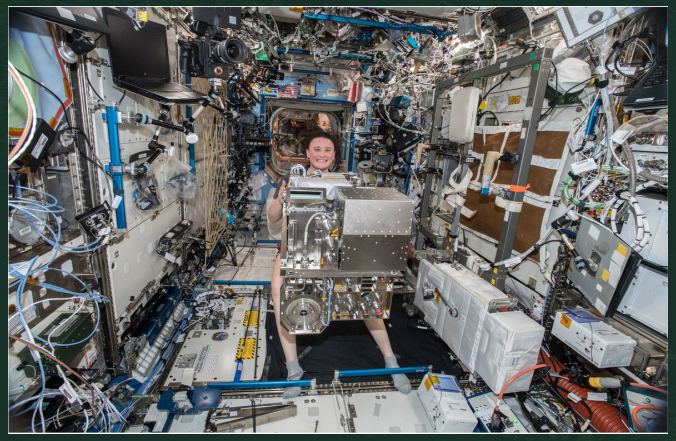




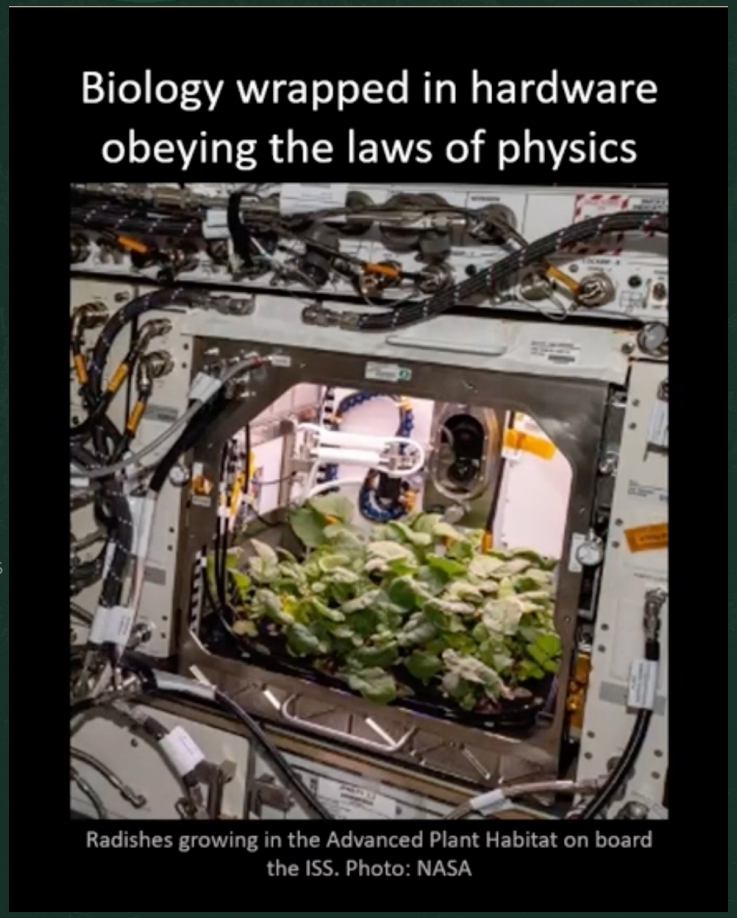
Paola Castaño 2015 - 2024

What is ‘Space’ as an Environment for Plant Biology Experiments?

Makoto Azuma, 2014

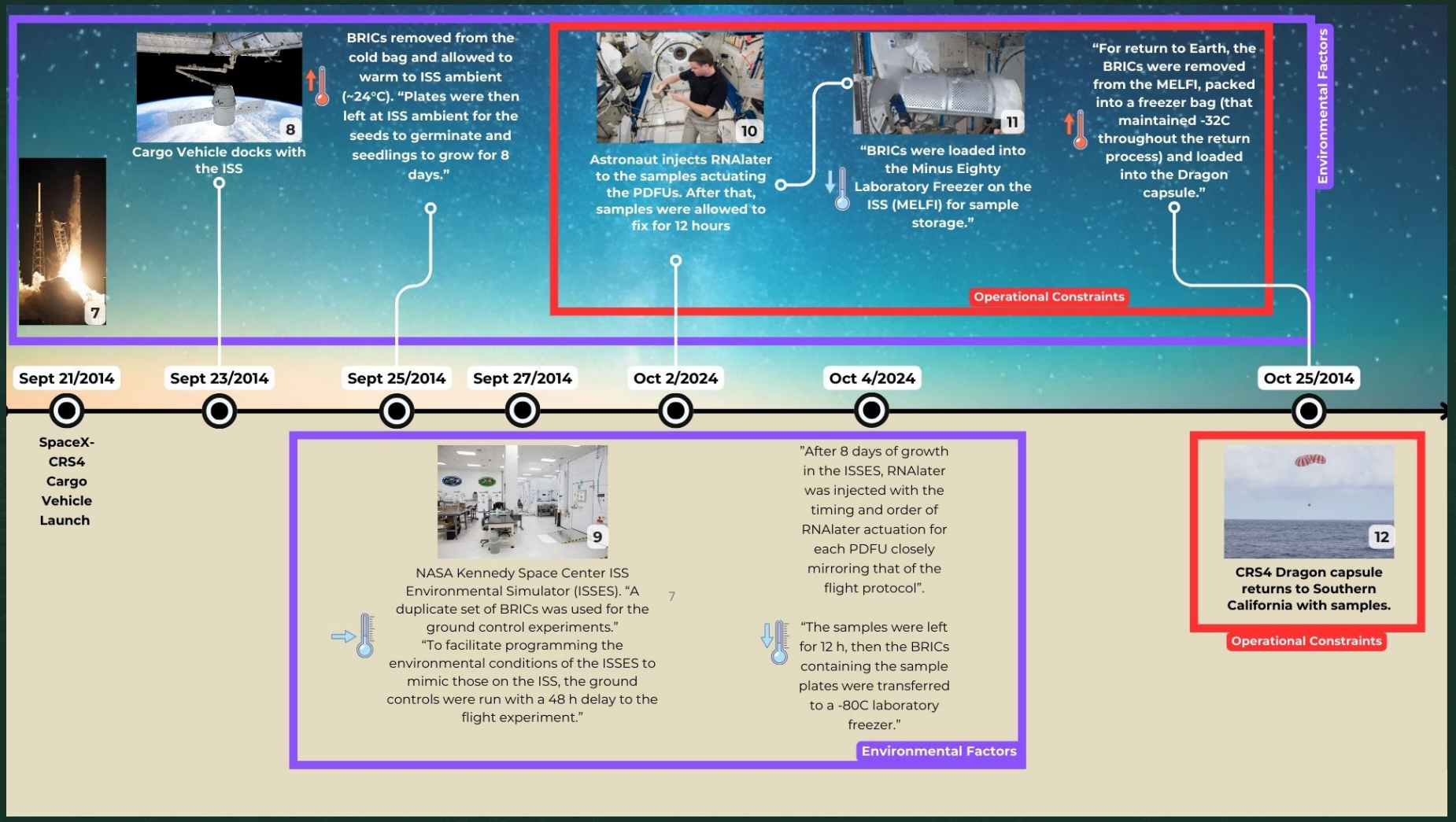


NASA, 2018

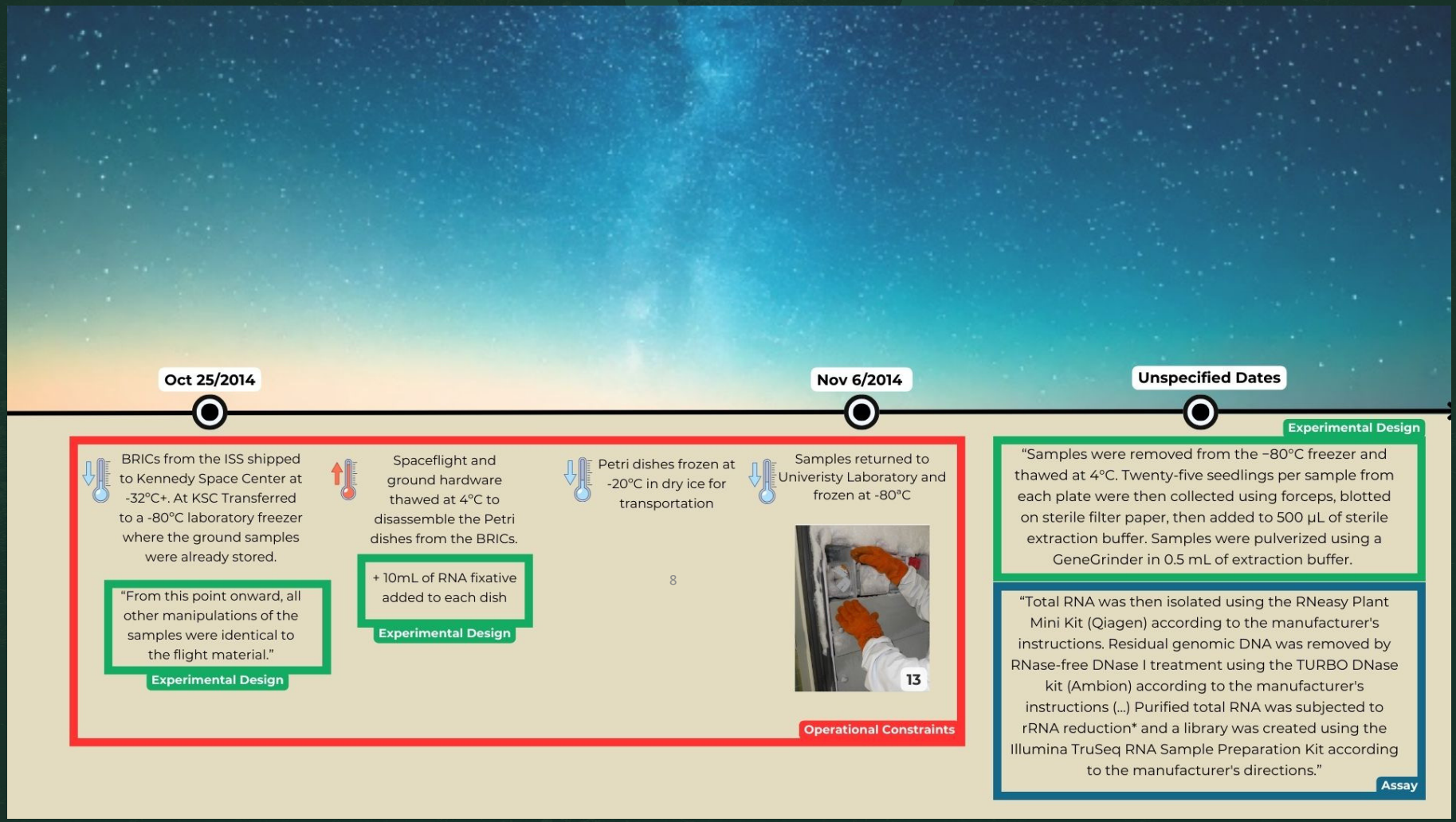


“Lo-fi” screen capture. Slide Simon Gilroy, Public Talk Space Science Week. National Academies of Sciences, Engineering and Medicine. April, 2025

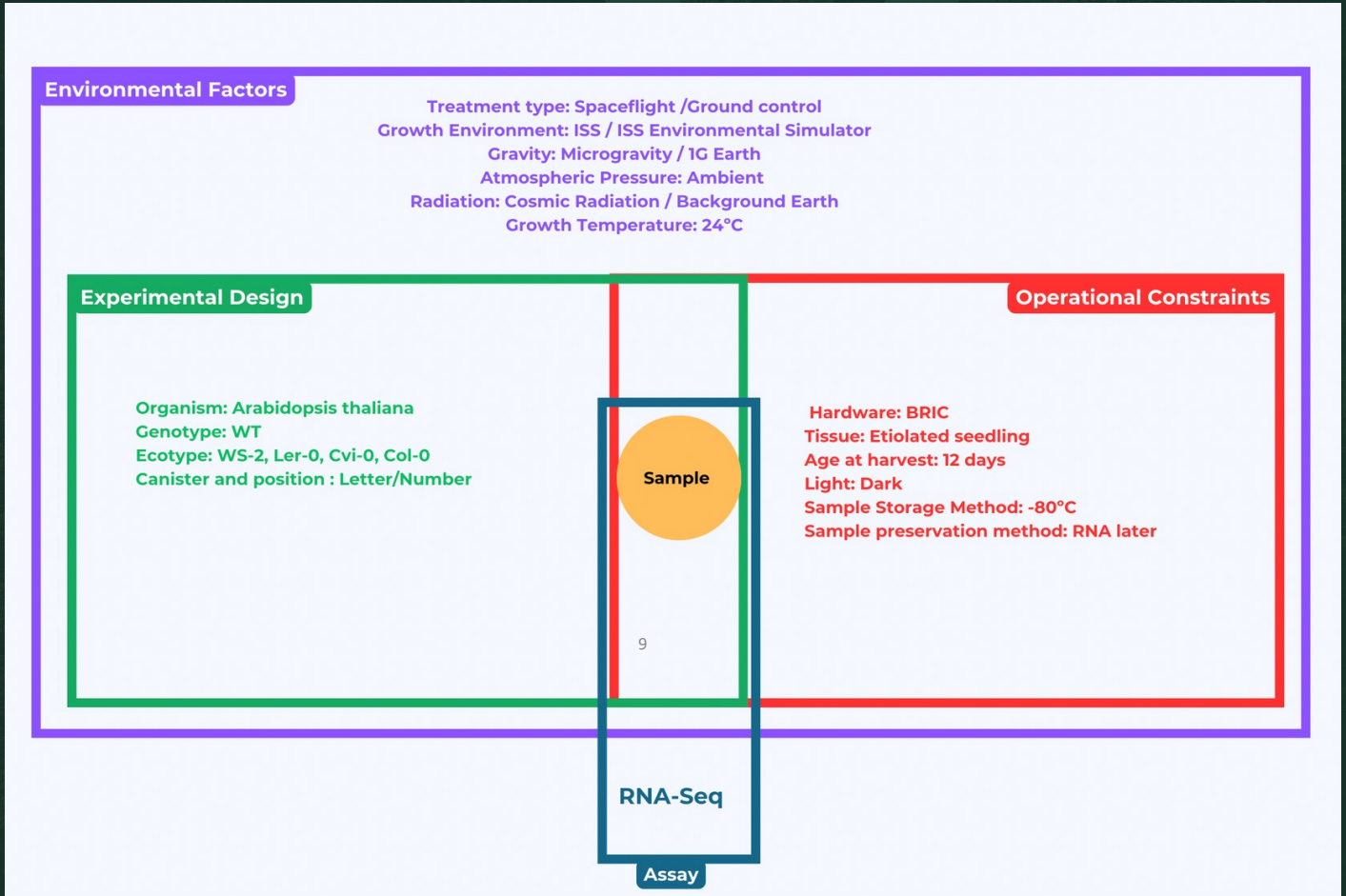
Reconstruction of the BRIC-19 experiment. Castaño and Leonelli (forthcoming). Pre-flight timeline for the BRIC-19 experiment. Figure by authors. Photos 1-4: Swanson 2014. Photo 5: NASA 2025. Photo 6: NASA 2014. All quotations describing the protocols from Choi et al. 2019. Protocols for the procedures and composition of materials marked with * are also specified by the authors in their publication.



Reconstruction of the BRIC-19 experiment. Castaño and Leonelli (forthcoming). Photos 7, 8, 10-12: NASA 2014. Photo 9: NASA Kennedy Space Center 2019. All quotations describing the protocols from Choi et al. 2019



Reconstruction of the BRIC-19 experiment. Castaño and Leonelli (forthcoming). Post-Flight timeline for BRIC-19 experiment. Figure by authors. Photo 13: Swanson 2014. All quotations describing the protocols from Choi et al. 2019.



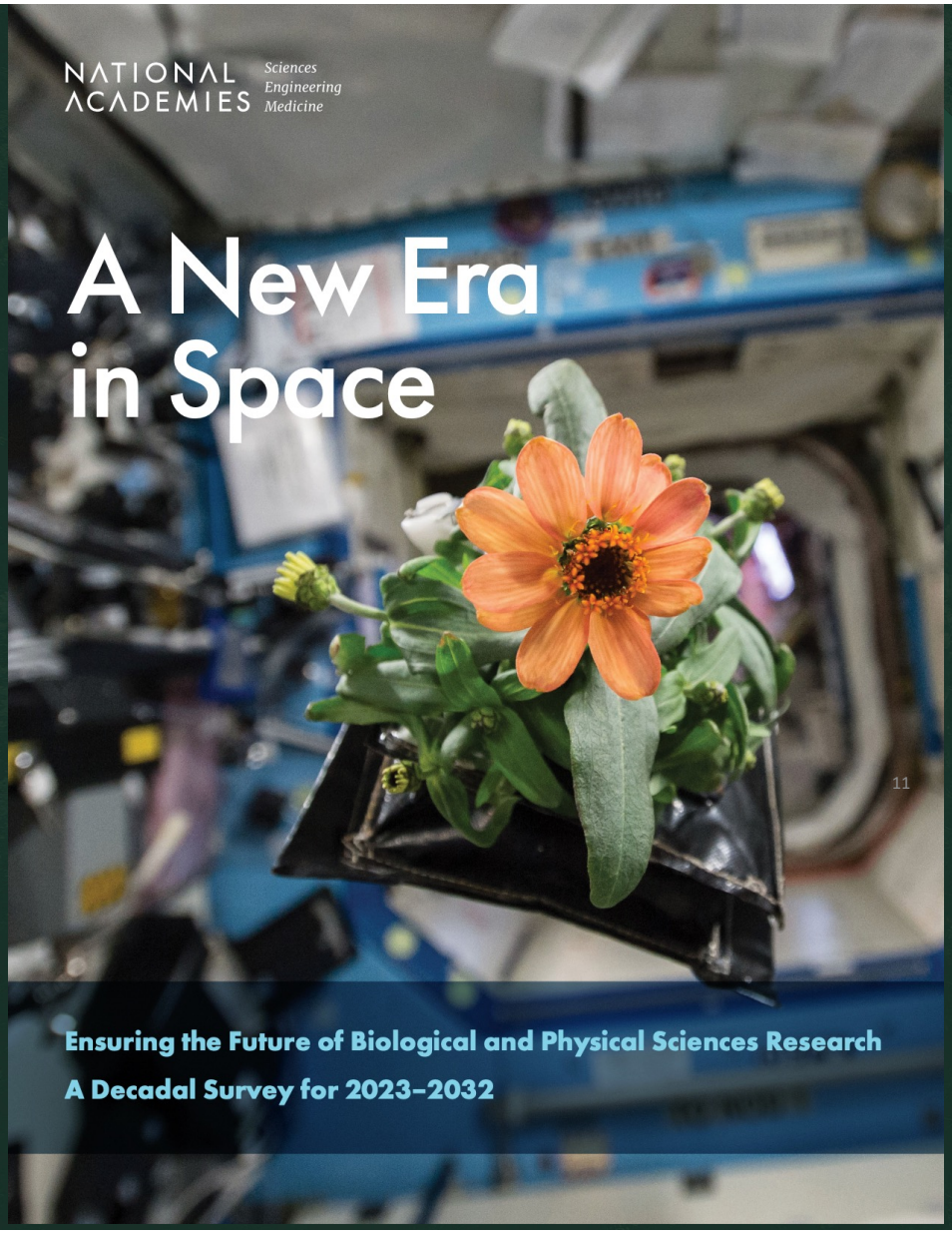
Castaño and Leonelli (forthcoming)

* Ch

“Scaling up”

NASA, 2017

Robert McCall, 1986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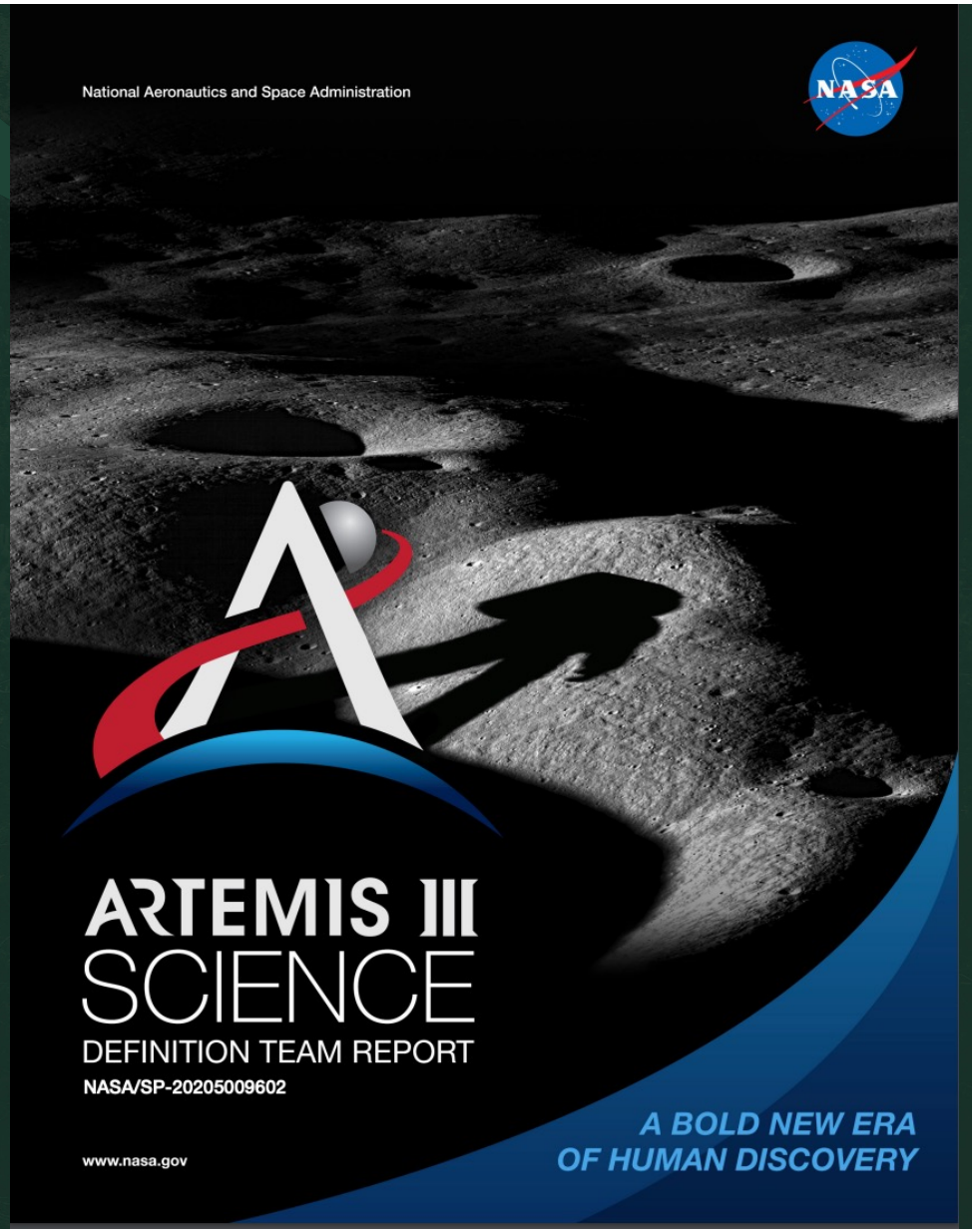
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communications biology

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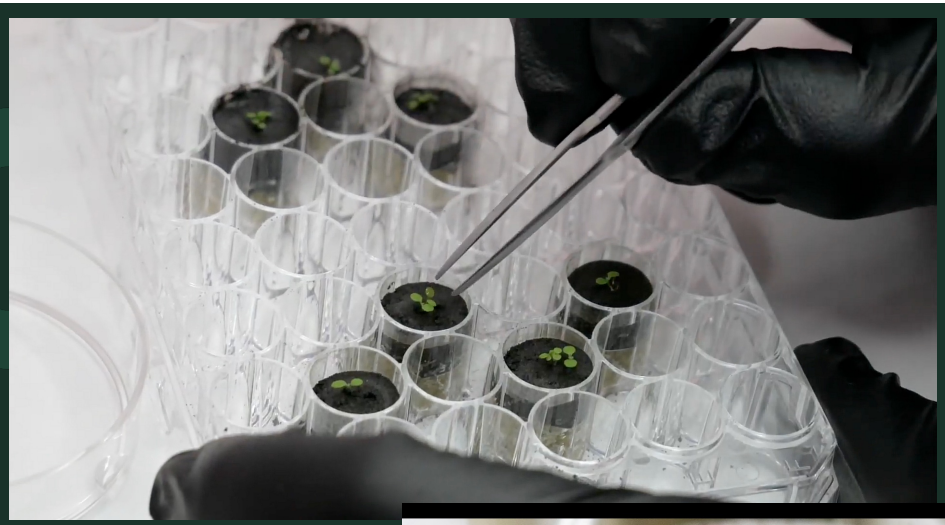
Plants grown in Apollo lunar regolith present stress-associated transcriptomes that inform prospects for lunar exploration

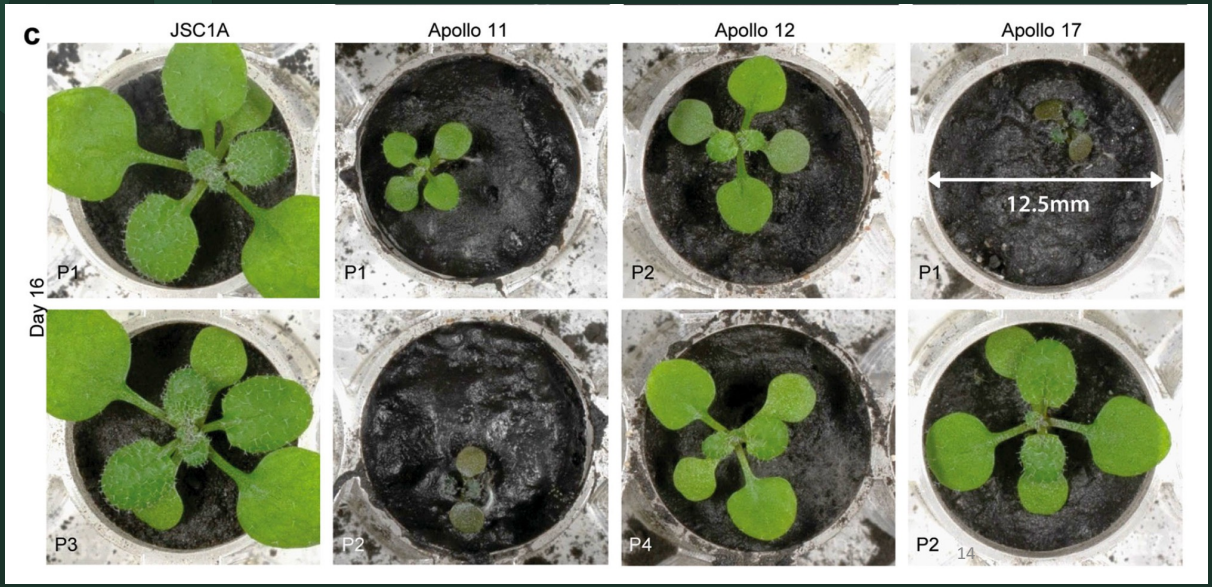
Anna-Lisa Paul, Stephen M. Elardo & Robert Ferl

Slides by Ana Lisa Paul from lecture “Growing Insight into Space: Plants are Enablers of Extraterrestrial Exploration”. Space Science Week – National Academies of Science, Engineering and Medicine, March 2024



They all germinated

Slides by Ana Lisa Paul from lecture “Growing Insight into Space: Plants are Enablers of Extraterrestrial Exploration”.
Space Science Week – National Academies of Science, Engineering and Medicine, March 2024

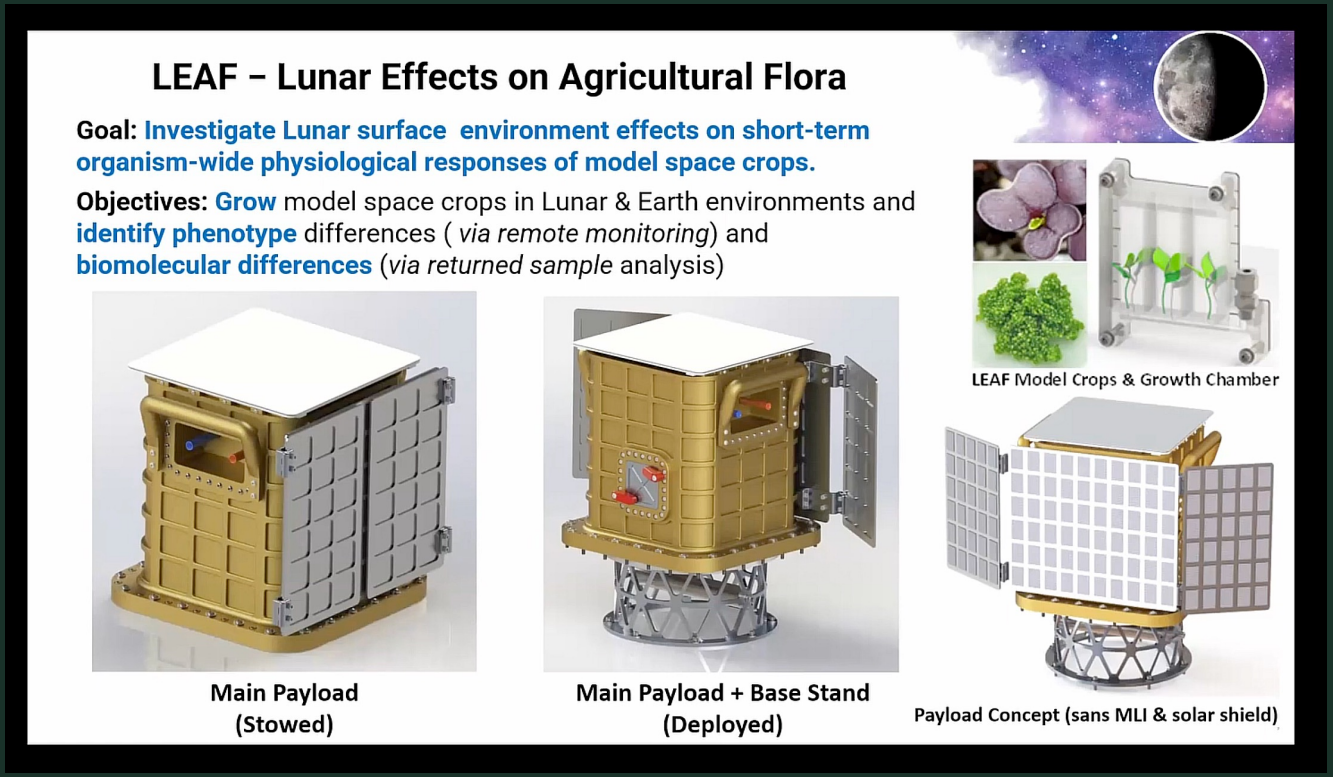


Paul et al 2022

“Terrestrial plants are capable of growth in lunar regolith as the primary support matrix. Soils derived from lunar regolith could therefore be used for plant production and experiments on the Moon. However, these data also demonstrated that lunar regolith was not a benign growth substrate” (Paulet al. 2022, 6) .

The plants ‘interpreted’ “lunar soils as highly ionic [similar to plant reactions to salt, metal and reactive oxygen species] and as eliciting oxidative stress.”

- Effect of elevated radiation and low gravity on growth, photosynthetic productivity and nutritional quality?
- Comparative resilience amongst the crops.
- Genomic traits that afford stress-resilience and space crop fitness for space.



Slide by Christine Escobar, 2024

7 MIN READ

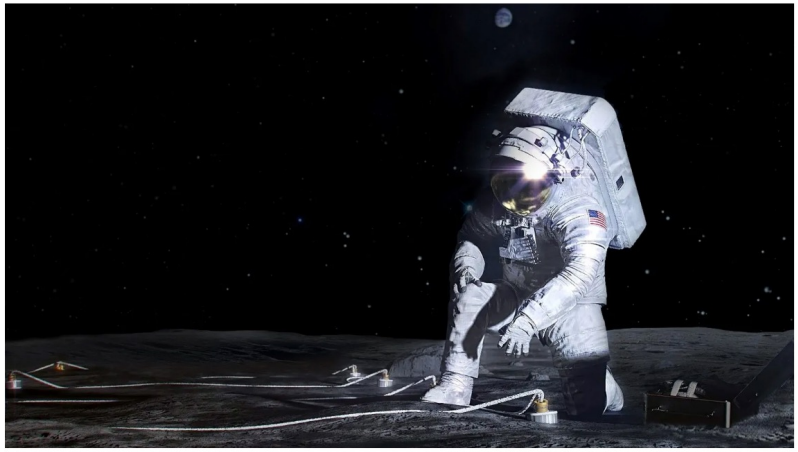
Scientists Grow Plants in Lunar Soil

Rob Ferl, left, and Anna-Lisa Paul looking at the plates filled part with lunar soil and part with control soils, now under LED growing lights. At the time, the scientists did not know if the seeds would even germinate in lunar soil.
UF/IFAS photo by Tyler Jones

NASA, 2022

4 MIN READ

NASA Selects First Lunar Instruments for Artemis Astronaut Deployment



Artist's concept of an Artemis astronaut deploying an instrument on the lunar surface.
Credits: NASA

NASA, 2024

- “Plants allow us to be explorers”, “When humans move as civilizations, we always take our agriculture with us.”
- Who and how?
- How to characterize this ‘more complicated’ Lunar environment?
- How do these scientists position themselves in the new context of Lunar exploration?

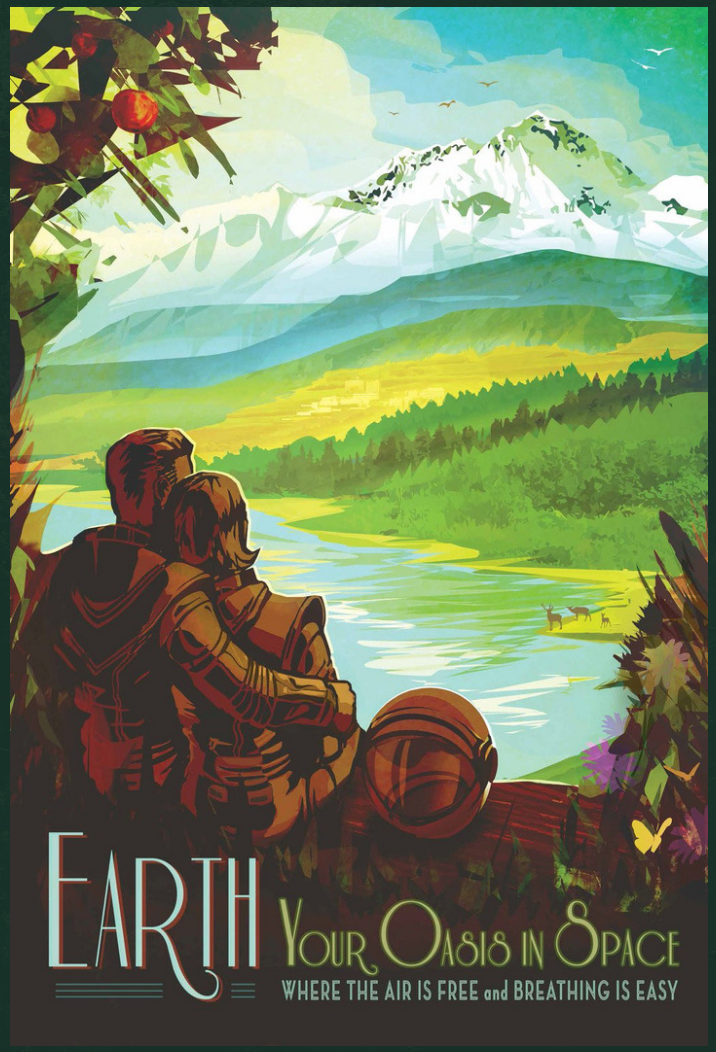
Futurism, 2014

How to characterize this key moment of transition in the plant space biology research program?

Screenshot News Clip about LEAF Experiment, 2024

- Lines of explanation: strategic response to incentives ("funding goes to the Moon = researchers go to the Moon" (Bourdieu 1975, Foster and Evans 2015), changes in theories, technologies.
- Shift in the understanding of environmental parameters and their biological effects, more intricate experimental designs, even less control in operations.
- Shift in the organizational practices and actors (Fuchs 1993) → Academia, industry, space agencies from different countries. New task uncertainties, interdependencies, and new lines of accountability.
- Shift in the integration of expertise → Return of ecology in relation to plant experimentation.
- Normative shift → New questions about the ethical dimensions of this research.

- How do plant space scientists understand responsible research practice in relation to their science, human habitation on the Moon, environmental damage, and commercial exploitation?
- Motivations for my next project: Understand these shifts in the experimental program in dialogue with the scientific community and find pathways to embed responsible research practices within it.



NASA Jet Propulsion Laboratory, 2015

Acknowledgments

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