The impact of the Chang'e-4 mission on Lunar exploration biology

Anna-Lisa Paul

Director, UF Interdisciplinary Center for Biotechnology
Research Professor, Department of Horticultural Sciences,
Program in Plant Molecular and Cellular Biology,
University of Florida Genetics Institute

UF UNIVERSITY of FLORIDA IFAS

UF ICBR

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Life Sciences Research on the Lunar Surface
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About Chang’e-4

1. First ever soft-landing on the far side of the moon
    - Jan. 2, 2019

2. Developed and launched by the China National Space Administration (CNSA) and the Chinese Lunar Exploration Program (CLEP)

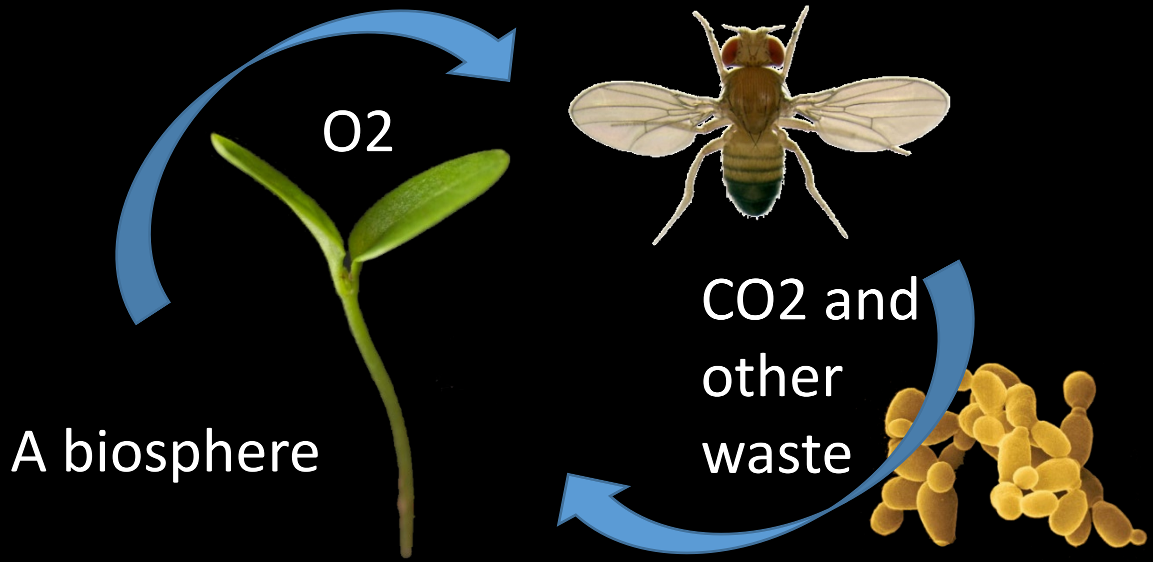
3. Science goals
    - Analyzing the lunar surface and subsurface composition
    - Assessing the radiation environment
    - Low frequency radio astronomy
    - Returning high-resolution images from terrain
    - An “outreach initiative” payload: a small biosphere containing designed and developed in collaboration with 28 Chinese universities

The first lander image from the far side of the moon – CLEP

The mini-biosphere of Chang’e-4

- Small Al alloy canister: 198 mm x 173 mm diameter
- Holds water, “soil”, air, two small cameras, and a temperature control system
- Seeds of cotton, brassica, potato, and arabidopsis, fruit fly eggs, and yeast cells
- Two canisters: one for moon, one for Earth control

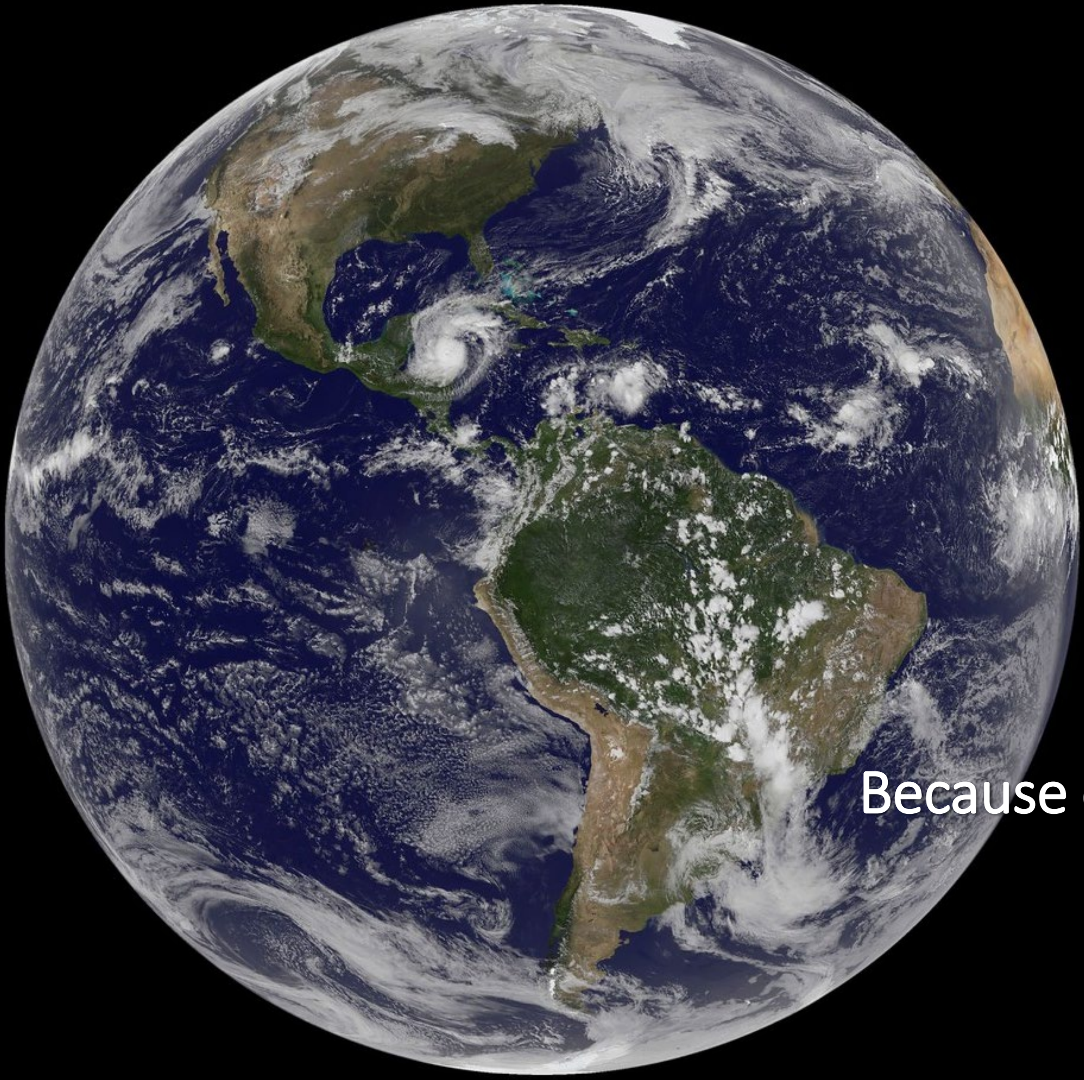
Chongqing University / CGTN.com

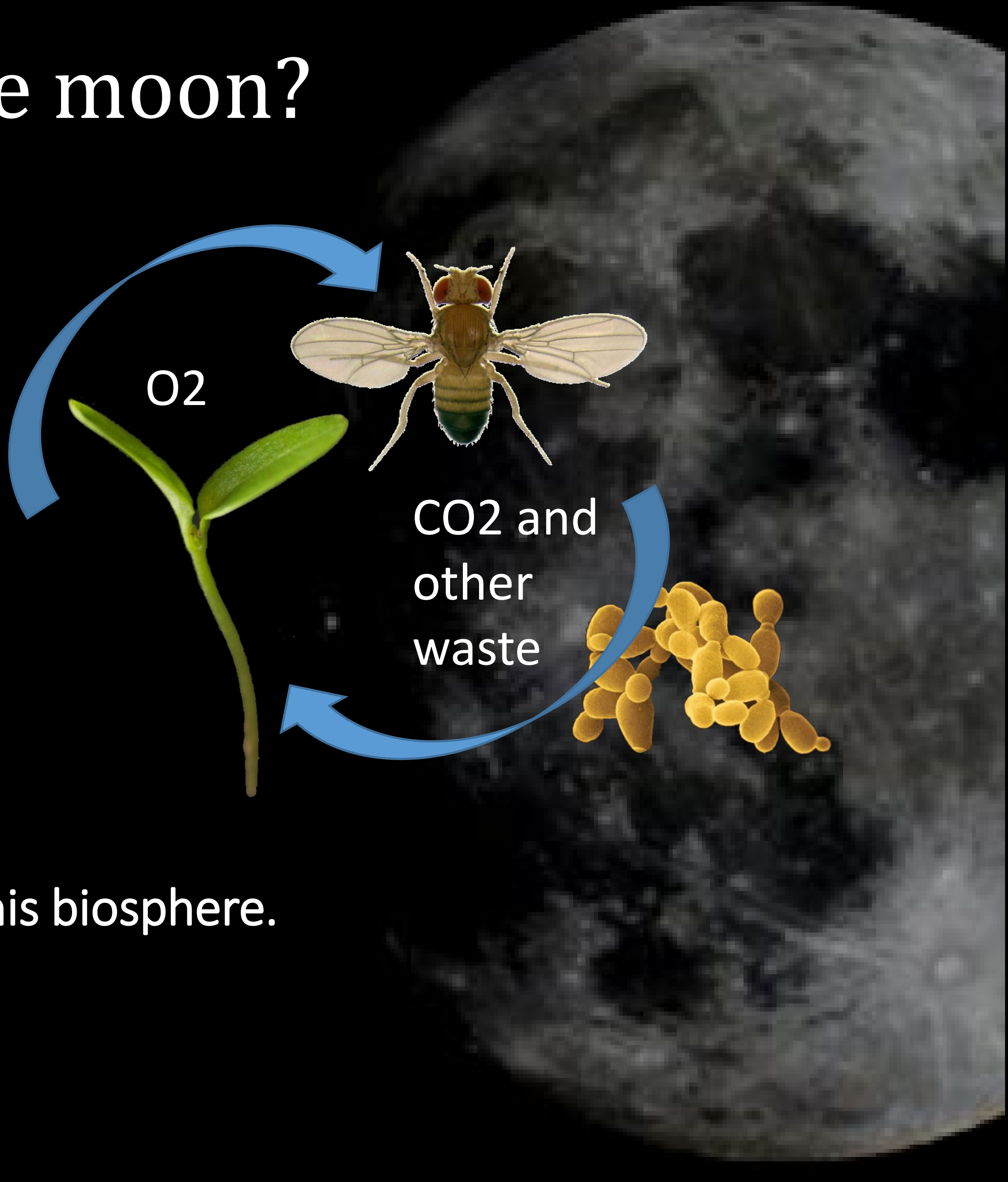


More on what they saw, but first…

Why a mini-biosphere to the moon?

It is a very difficult task.





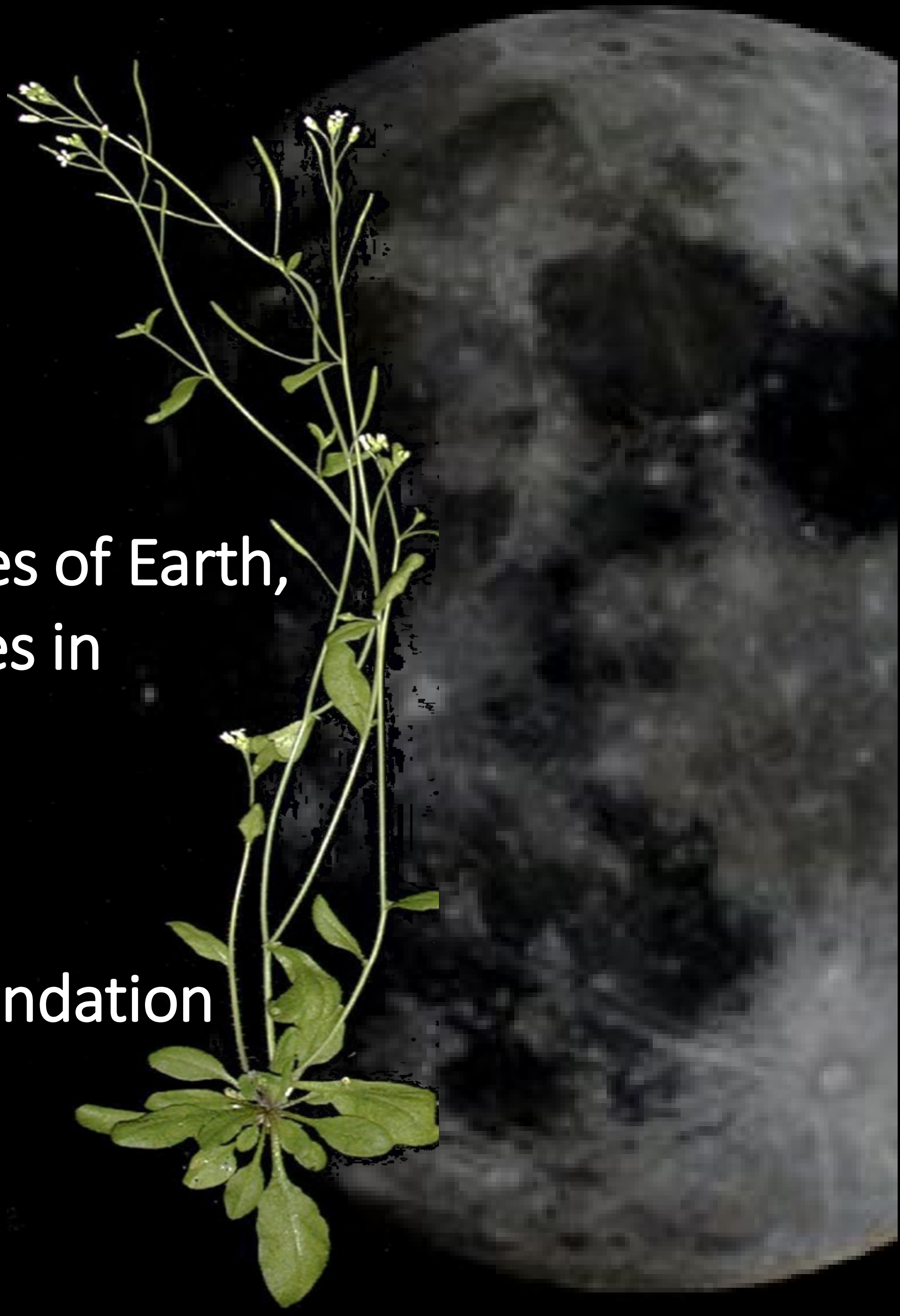
Because of this biosphere.

Humans are Explorers

- Tourists carry a picnic basket
- Explorers carry their biosphere

So before we can really explore past the confines of Earth, we need to understand how our biology behaves in extraterrestrial environments

Plants form the foundation



Extraterrestrial Challenges – Luna and beyond

The Journey

- The microgravity of spaceflight
- Restricted resources and altered atmospheres

Destination Luna

- Dangerous radiation hitting the surface
- No atmosphere means closed systems environments
- Gravity 1/6 that of Earth
- Days and nights 2 weeks long
- Temperatures range from around -150 C to +150 C
- Almost everything we need we must bring from Earth
  - ISRU – what can we obtain from the moon?

Testing the extraterrestrial waters

The Journey

- International Space Station
  - Microgravity
  - Restrictive habitats and resources

Planetary Destinations

- International Space Station
  - Artificial partial gravity w ISS centrifuges
- Specialized laboratory and engineering environments
  - Cosmic radiation profiles
  - Altered atmospheres and pressures
  - Habitat engineering and in-situ resource utilization testing
- Planetary analog environments
  - Antarctica
  - Arctic
  - Deserts

International teams,
many research groups.


A-L Paul / R.J. Ferl
CARA ISS experiment


Future Exploration Greenhouse,
EDEN ISS - NMIII Antarctica

Testing in the Lunar environment

So far humans have been tourists, but we are aiming for more

Lunar Surface Science Workshop – January 20-21, 2021 (plants and their microbiome)

https://www.hou.usra.edu/meetings/lunarsurface2020/program/lunarsurface7_program_descriptions.pdf

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Can terrestrial life live on the moon for more than a brief visit?

Chang’e-4 took the first step to answer this question.

The Chang'e-4 mini-biosphere

Seeds of cotton, brassica, potato, and arabidopsis, along with fruit fly eggs and yeast cells

Close-up of Biosphere canister on Earth
(Image: CNSA/Chongqing University)

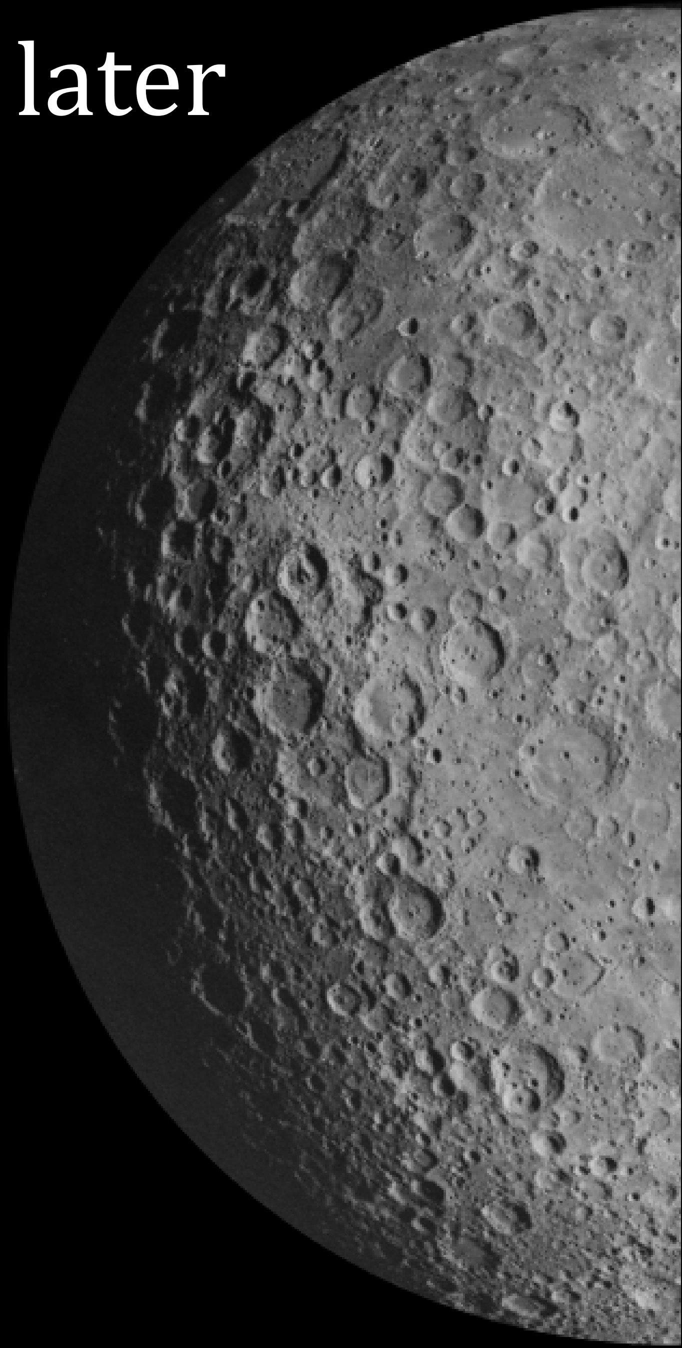
January 3 - landing on Moon
biosphere powered
water injected
photography of interior begins

January 12 - start of Lunar night
biosphere cools to -62 C

The Chang’e-4 mini-biosphere – 9 days later

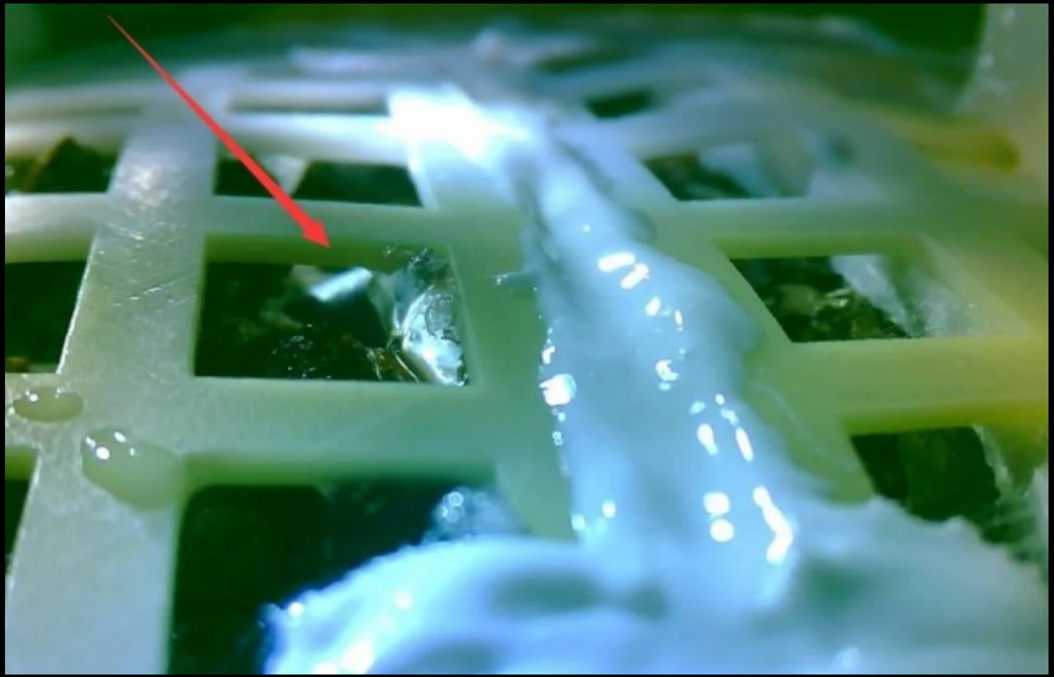
In that time, a cotton seed sprouted

A cotton seed sprouting in the Chang’e4 mini biosphere – CNSA / Chongqing University



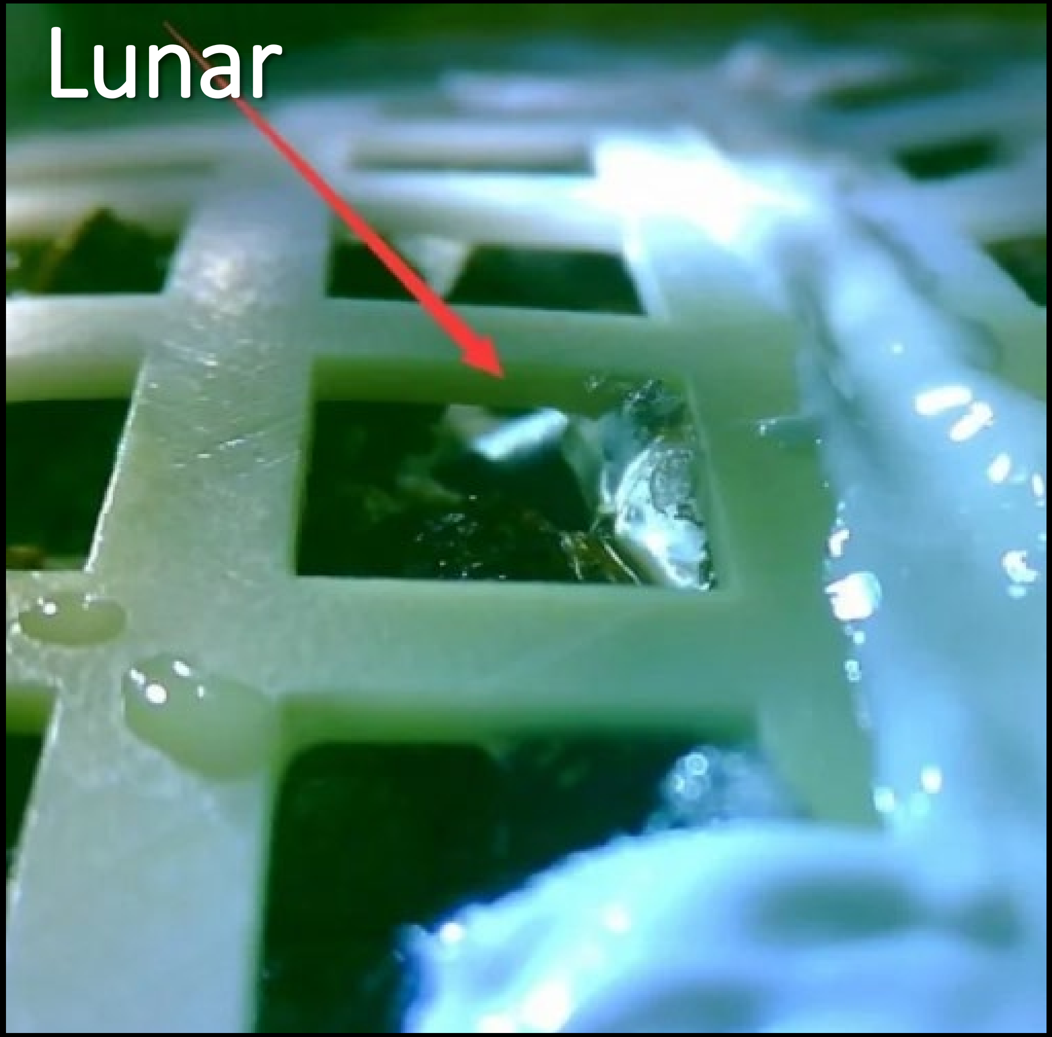
"This (mission) has achieved the first biological experiment on the moon of human history, to sprout the first bud on the desolate moon. And with time moving on, it'll be the first plant with green leaves on the moon,"

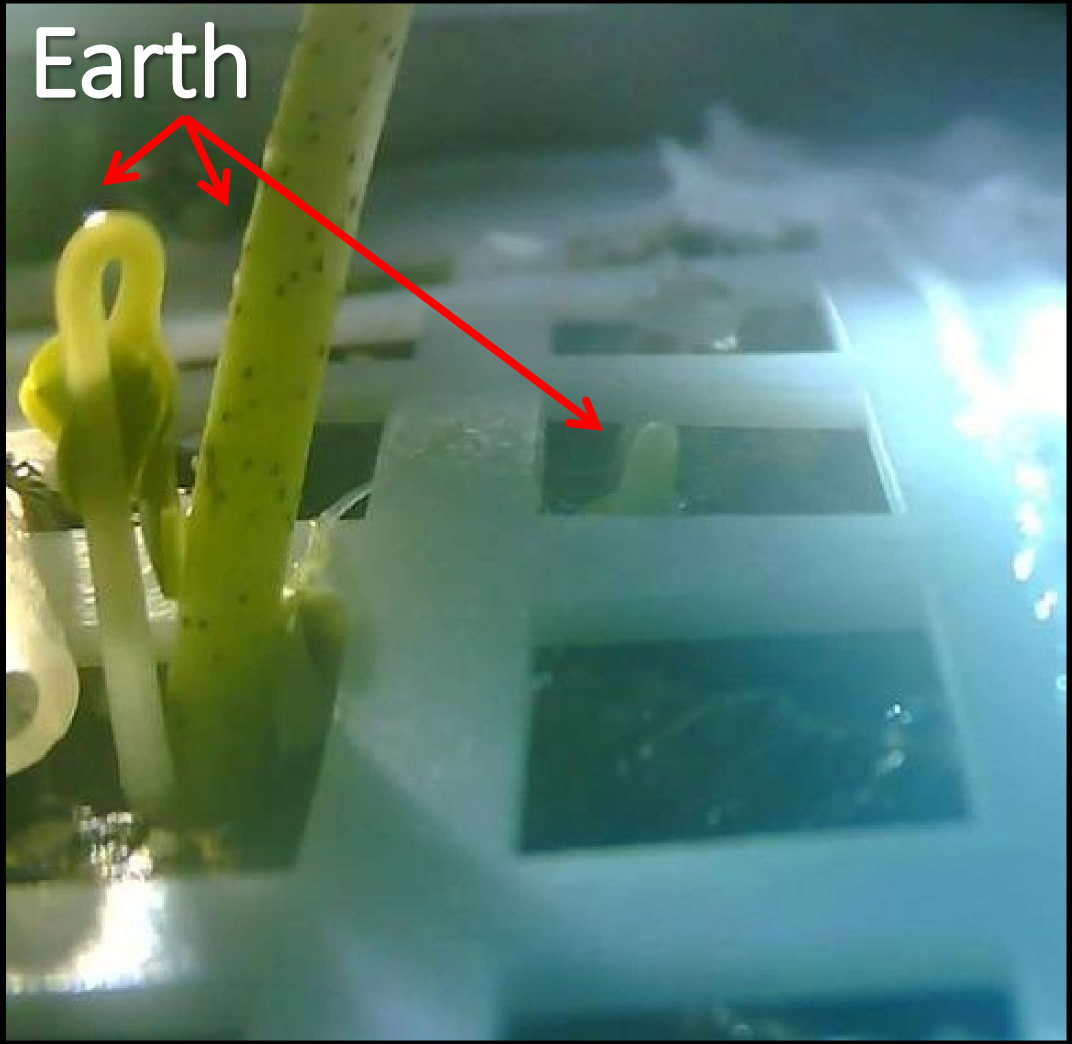
- Xie Gengxin, dean of Institute of Advanced Technology at Chongqing University



The biggest contribution is not in the intrinsic science, but in the context of lessons learned and inspiration

The Chang'e-4 seedling:
Lunar-grown compared to Earth-grown control





What do the images reveal?

Just this Botanist's opinion…

Cotton seedling from Chang'e-4

Typical terrestrial growth

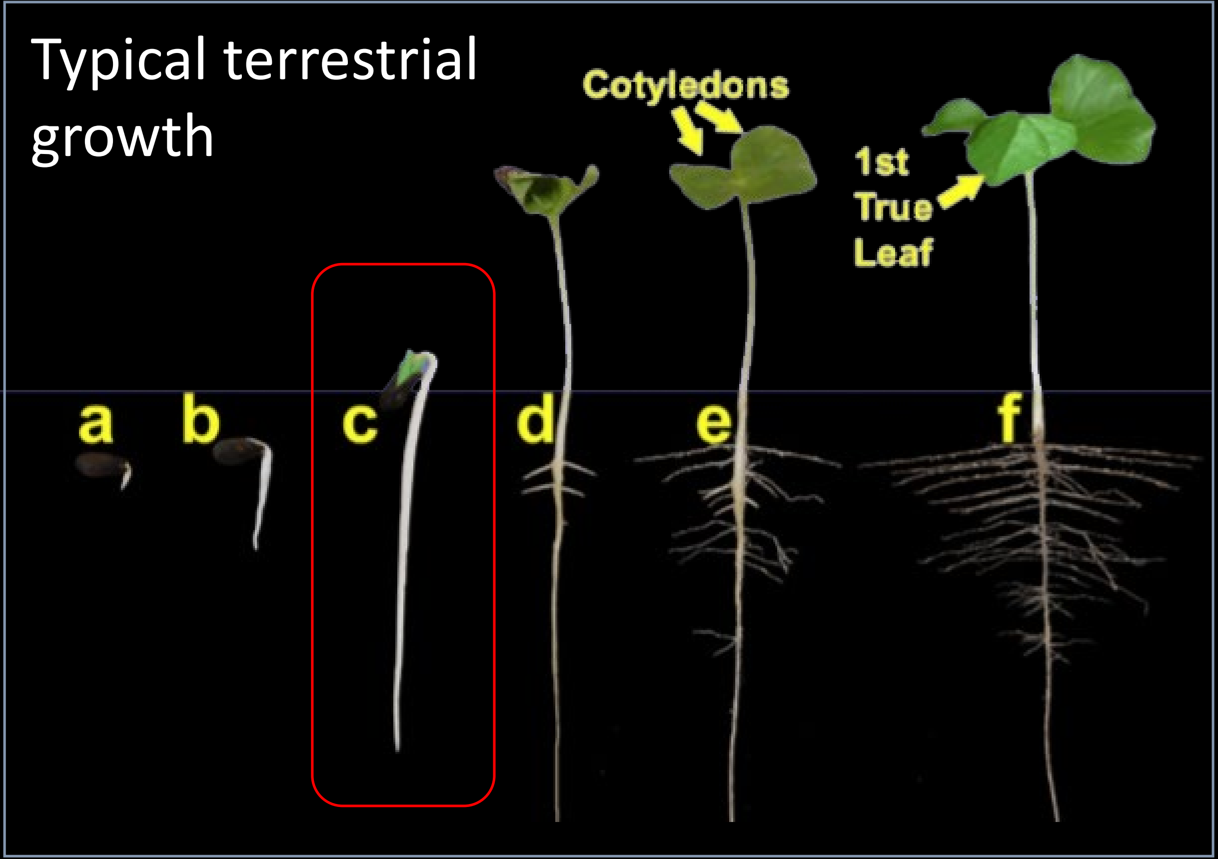


Figure 2. Germination and early seedling development. Root growth dominates the early growth of the plant.

Figure 5. Thick shank in a cotton seedling. Soil crusting, compaction or other mechanical factors can cause thick shank.

3D image reconstruction of the cotton sprout – CNSA / Chongqing University

Figures from:
Cotton Growth and Development – Ritchie et al. University of Georgia Cooperative Extension

Chang’e-4 provided Exploration Lessons

- Difficult to manage resources, especially in small volumes
- Imaging is vitally important; multiple angle cameras essential, frequent imaging to establish timeline
- Important to enable survival over the Lunar night
- Reduced gravity may impact water behavior more than anticipated; fluid physics
- Need multiple internal sensors to monitor temperature, gasses, volatiles
- Need multiple opportunities to conduct experiments, not a one and done.

Chang'e-4 provided inspiration for the world

- To innovate
- To persevere
- To work together
- To inspire those around us
- To go boldly

Thank You

Anna-Lisa Paul
alp@ufl.edu

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