

Evaluating In Situ Resources For Biological Payloads In A Lunar Lander



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Robert J. Ferl



And many others...

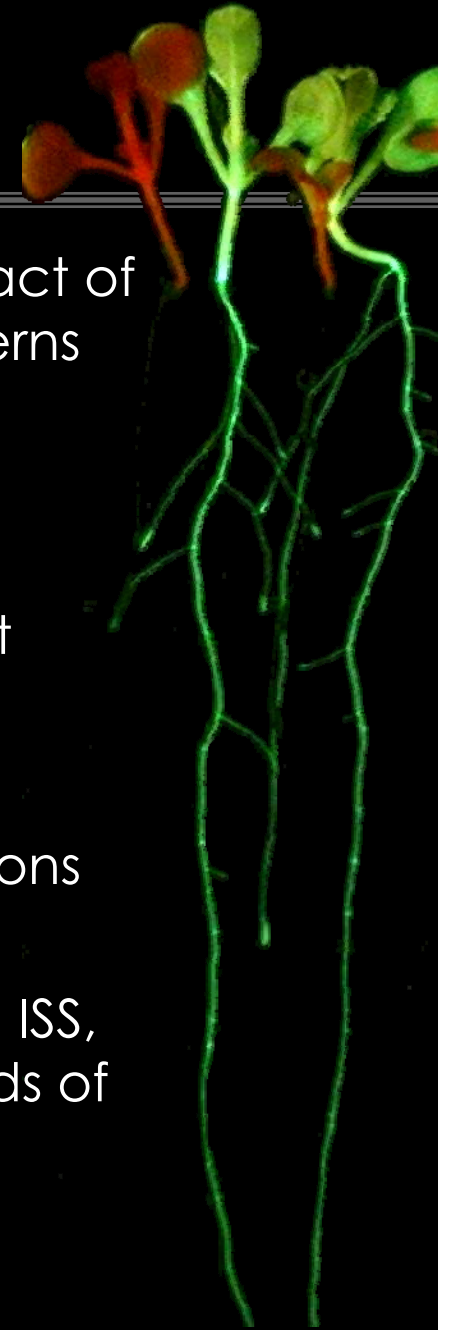
Biological Questions for the Moon

- What are the limits of terrestrial biology across the solar system?
 - Can include exobiology, astrobiology...
- What is the **biological impact** of the Lunar environment
 - Radiation
 - Gravity
 - Circadian issues
 - Mineral environment
 - ISRU from biological perspective
 - Habitat environment
 - Atmospheric pressure
 - Gas compositions and volatiles – all spaceflight relevant as well

Biology then and now

- First trips to the moon – Biology primarily human (and their biology)
 - Human physiology and backward contamination
 - Anything from the moon that could harm earth life?
 - Walkinshaw et al. : regolith treatments benign to plants
- Next trips to the moon –
- 30+ years of extraordinary progress in molecular biology
 - Genomes, genes, transcriptional profiling, metabolic profiling...
 - Powerful new tools to assay the biological response of an organism
- Genes control adaptation to the environment, therefore
- A change in gene expression patterns reflect the response and inform the adaptation

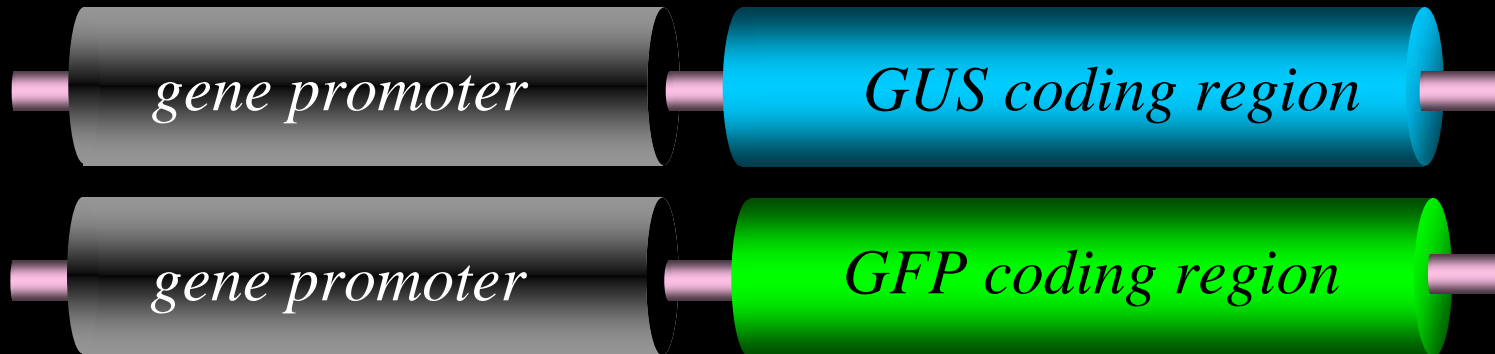
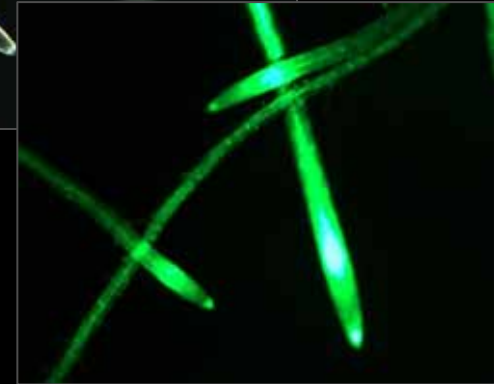
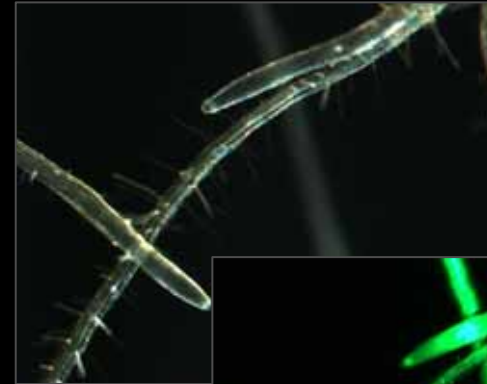
What genes can tell you...



- Gene expression patterns reflect the biological impact of an environment. A change in gene expression patterns reflect the response and inform the adaptation
- Spaceflight
 - STS93 – reporter genes indicate changes on orbit
 - Our current experiment
 - Telemetric data collection
 - Technologies appropriate for planetary missions
- Low Pressure
 - An environment we modulate routinely – shuttle, ISS, CEV proposed... yet plants respond with hundreds of changes in gene expression.
- Parabolic Flight
- Anything...

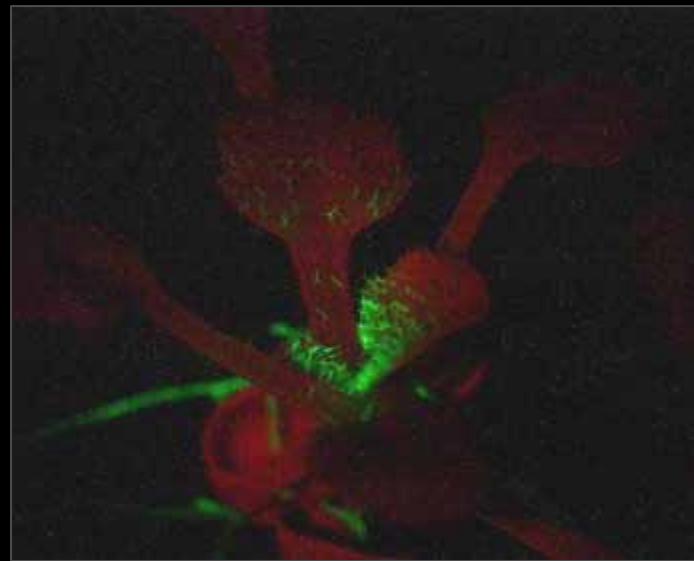
Reporter Gene Technology

- Reporter gene – an artificial gene engineered with a sensing portion of a natural gene (promoter) coupled with the coding part of another gene.
- When the reporter gene is activated, it makes a product that you can see.



Engineering Telemetric Science

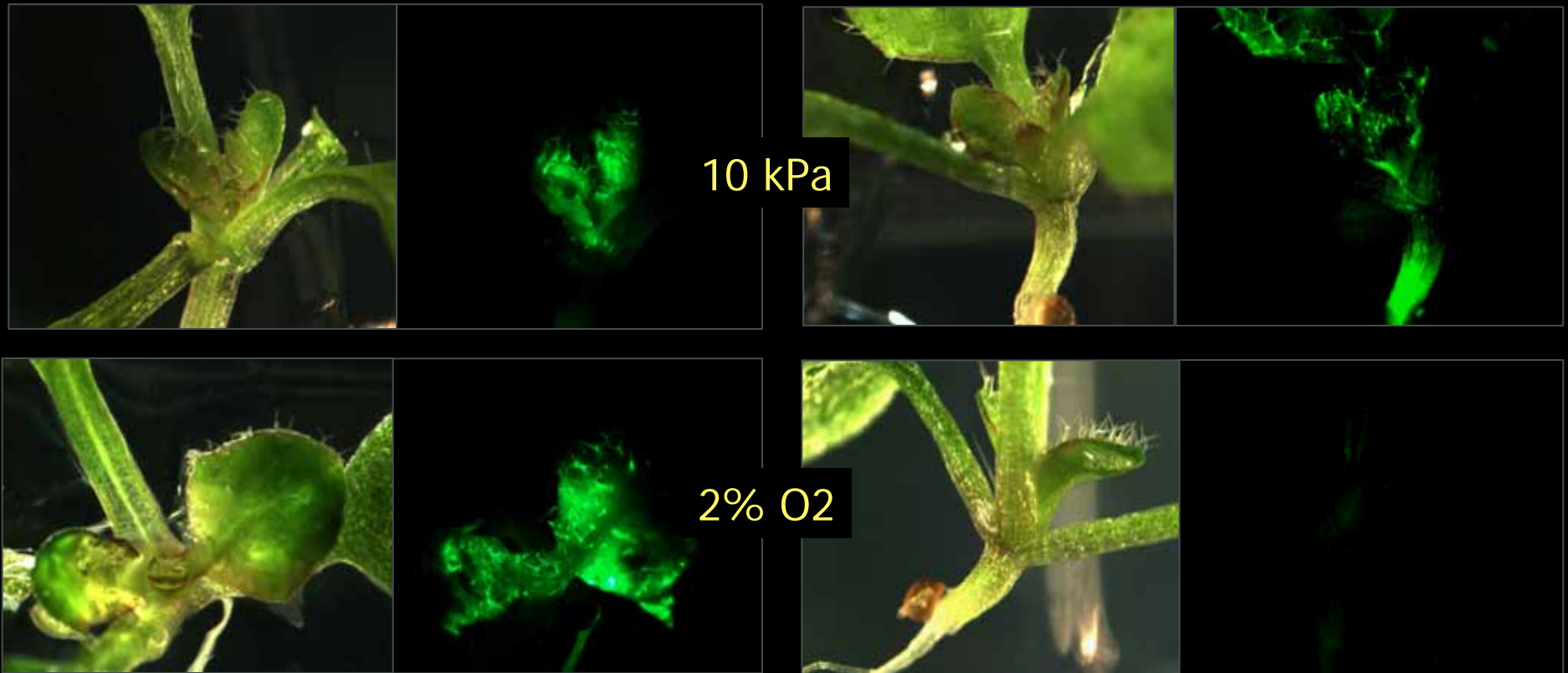
- GFP (Green Fluorescent Protein) reporters make a fluorescent gene product – changes in gene expression can be captured in real-time with digital cameras.
- Digital images can be transmitted from the site of the experiment to the site of the researcher.



Response to low atmospheric pressure...

plants do well, but to do so, they respond to environment by changing gene expression patterns

Different reporter genes record different tissue-specific responses to the same environment



Alcohol dehydrogenase :: GFP
induced by hypoxic stress

Cold Response 78 :: GFP
induced by hypobarica, but not hypoxia

Biological Payloads for the moon

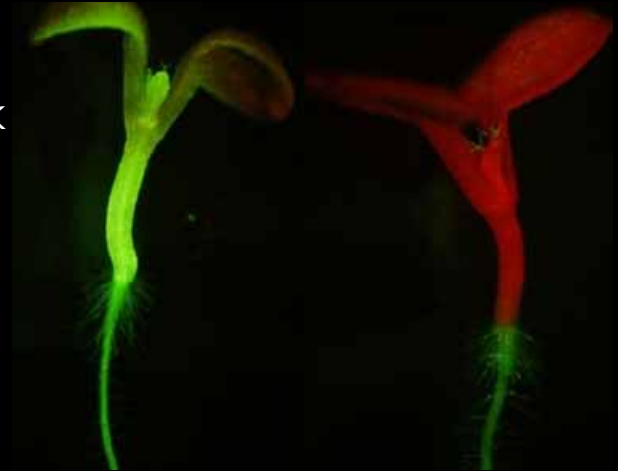
- In a long term mission, humans, and their attending biology will need to utilize local resources for support
 - Resources affect biology (regolith)
- Prior to mounting a long term mission...
 - Understand the biological impact of the lunar environment, especially local resources
 - Design tools and approaches to evaluate them



Family Mountain and edge of South Massif;
Harrison Schmitt works alongside the lunar rover.
Apollo 17-NASA

Reporting from remote environments – Lunar preludes

- Spaceflight, shuttle ISS
 - Imager development and deployment for mid deck locker and express rack.
 - Solving interface issues for power, growth, data collection and transfer via established orbital communications links
- Analog deployment
 - Prototype development for other vehicles and busses
 - Surface deployable landers and drop-offs
 - Orbital satellites
 - Explores the trades among engineering, biology, data rates and science return
 - What can we learn about a place before we send humans there?
 - Prelude to pre-deployment greenhouse and life support applications



Houghton Crater on Devon Island

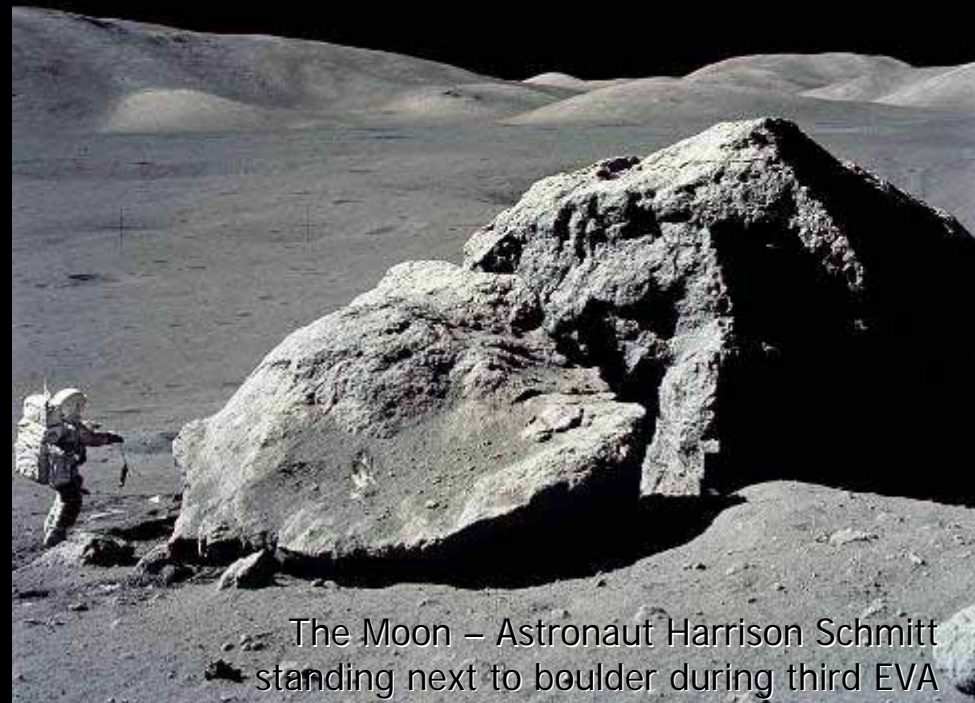


Houghton Crater – Lunar Analog site



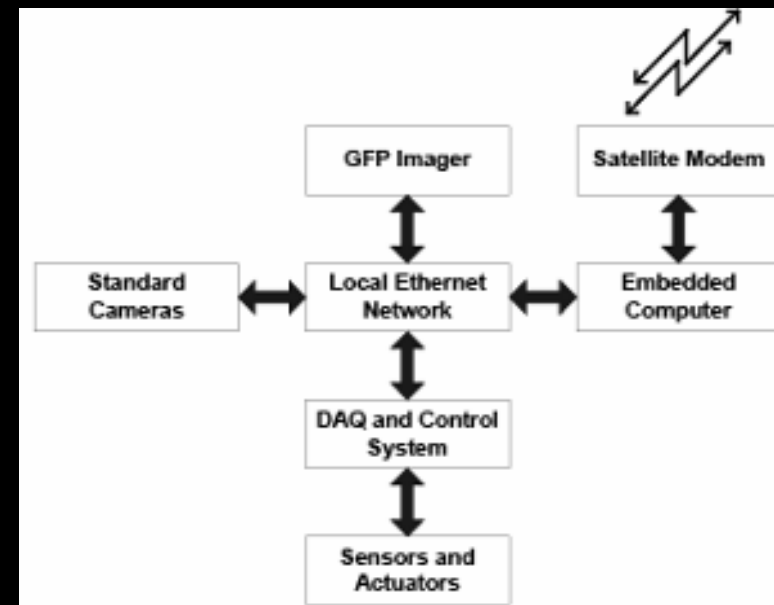
HMP serves as a Mars and Moon Analog Site

Moon



Arabidopsis plants growing in JSC-1a Lunar simulant in the Green House at Houghton Crater

The Arthur Clarke Mars Greenhouse at the Haughton Mars Project Research Station



- CSA team:

- Alain Berinstain
- Matthew Bamsey
- Philip Neron
- Thomas Graham

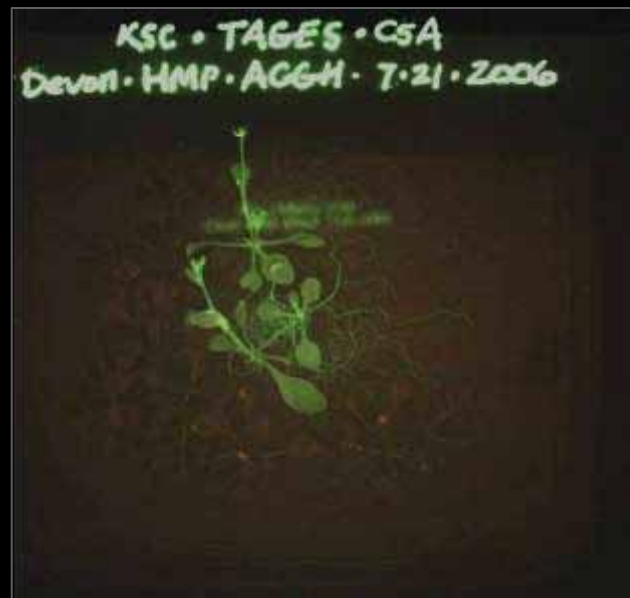
- HMP P.I.s:

- Pascal Lee, Alain Berinstain, Stephan Braham

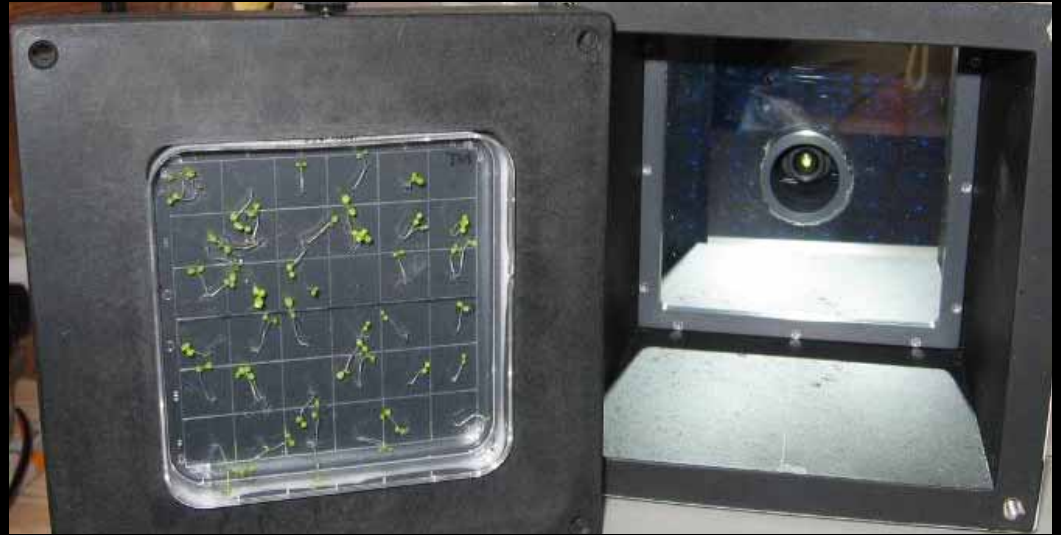
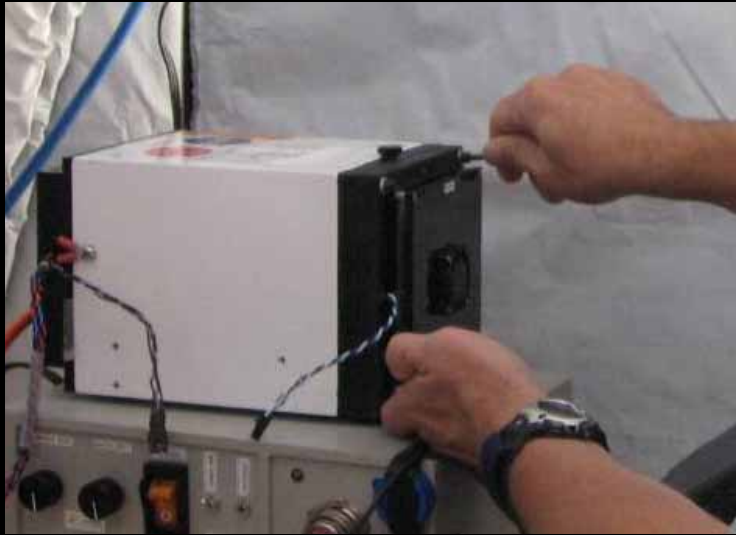


Testing Planetary Analogs – Mars/Lunar analog site: Haughton Crater in Canadian High Arctic

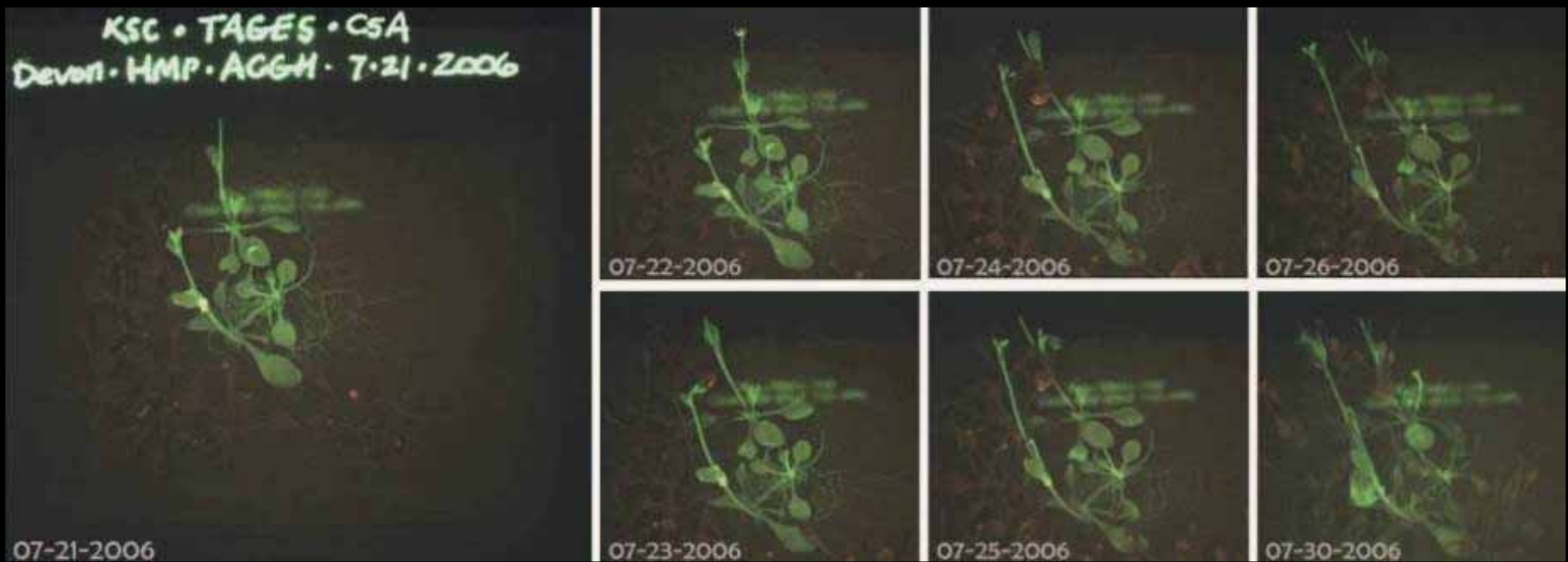
- A prototype of the spaceflight hardware designed for the telemetric collection of GFP
- The TAGES Imager was integrated into the Arthur Clarke Mars Greenhouse, tested successfully, then left behind.
- Commands were sent remotely from KSC and then images collected autonomously.



The TIS-II GFP Imager



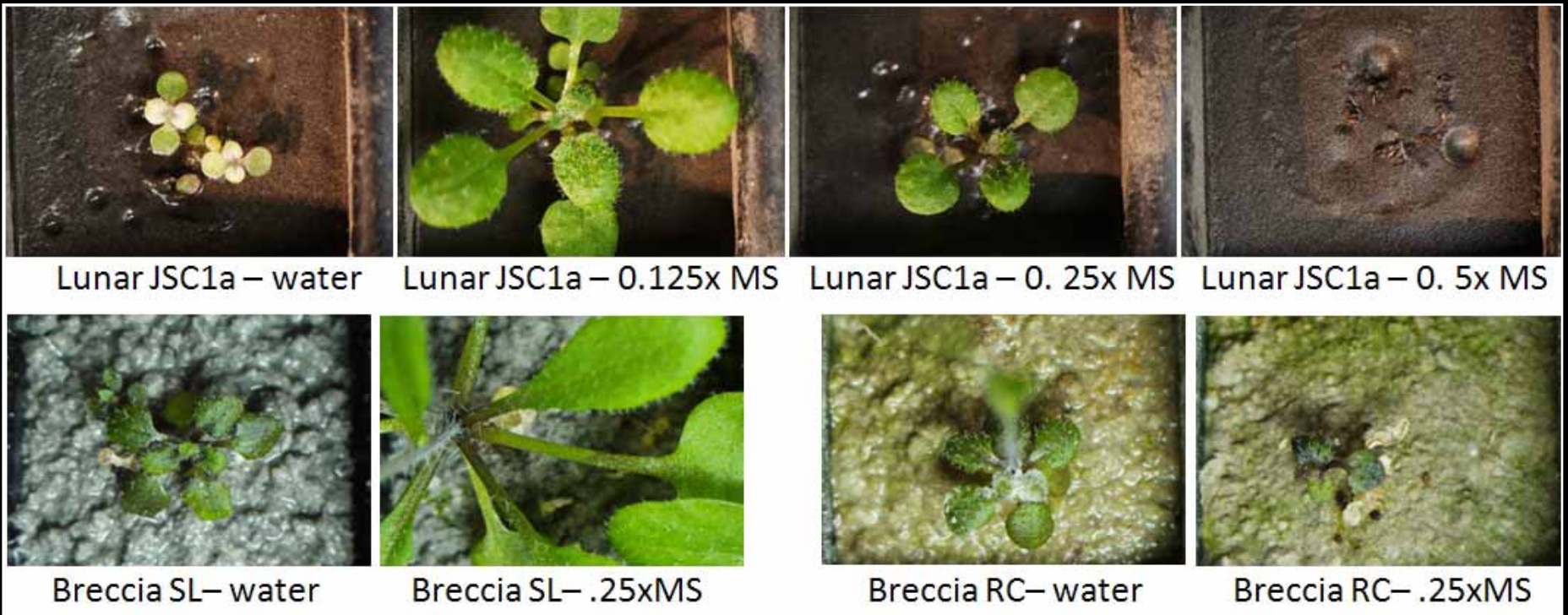
Automated collection of GFP images from the Arthur Clarke Mars Greenhouse over time



TIS-II GFP Imager pictures taken autonomously by the ACGH and remotely downloaded as part of the sensor and image data packets.

These data were collected through the middle of August, 2006.

Local Breccias from Haughton Crater compared to JSC1a



Although plants will grow very well in JSC1a Lunar regolith simulant (with the right amount of nutrient supplements) this is not always true of natural breccias fines collected from the impact site of Haughton Crater on Devon Island....

...materials from 2008 season still under evaluation.

Conclusions

We have molecular tools of discovery now that were unimagined when we first went to the moon

Those tools have been and continue to be vetted in:

spaceflight

spaceflight analogs – parabolic flight aircraft

planetary analogs – like

Haughton Crater

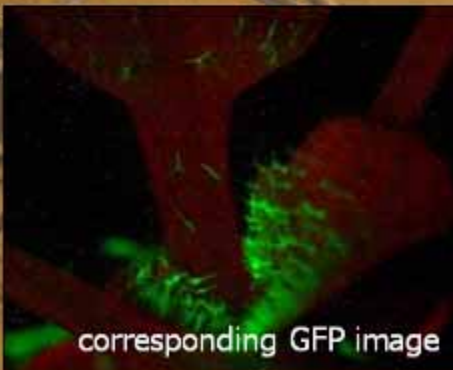
Applying these tools to the experiments on the moon now may reveal things we did not even know to ask...



Future Experiment – Planetary Lander Mission

A lander mission will employ the biological and technical engineering developed for the telemetric science we have characterized in terrestrial analogs.

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