NASA AMES ACADEMY 2009

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NASA Lunar Science Forum 2010

CLUSTER:

Creative Lunar Utilization Systems to Transform Extraterrestrial Regolith

ISRU:

IN-SITU RESOURCE UTILIZATION

GOAL AND HYPOTHESIS

Goal: To compare the growth of plants in microbial altered lunar regolith simulant (JSC-1A) and determine whether it has created a habitable soil environment.

Hypothesis: Adding microbes to lunar regolith simulant will aid in the growth of plants by freeing up the necessary elements.

LUNAR REGOLITH SIMULANT

Table C.1. Chemical compositions of JSC-1 and lunar soil 14163.

Oxide	JSC-1 (ash) (wt%)	Lunar soil 14163 (wt%)
SiO_2	48.77	47.3
TiO_2	1.49	1.6
Al_2O_3	15.65	17.8
Fe_2O_3	1.71	0.0
FeO	8.88	10.5
MgO	8.48	9.6
CaO	10.44	11.4
Na_2O	2.93	0.7
K_2O	0.81	0.6
MnO	0.19	0.1
Cr_2O_3	–	0.2
P_2O_5	0.66	–
Total	100.01	99.8

Note the complete absence of Fe_2O_3 in the lunar soil, whereas JSC-1 contains a percentage of this compound.

PLANT GROWTH:

MODIFYING REGOLITH FOR PLANT CULTIVATION

PAENIBACILLUS POLYMYXA 9a

- A siliceous bacteria
- A root-colonizing bacteria that increases plant strength, growth, and yield
- Promotes rhizobacteria = A heterogeneous group of bacteria shown to increase the health or longevity of plants
- Similar microbe: *Paenibacillus* sp. IMBG 156 was shown to free up elements such as iron, silicon, and potassium when inoculated (Kozyrovska et al. 2006)

INOCULATION

- Inoculation was shown to make plants more resistant to drought conditions or abiotic stress
- Those growing in inoculated soil developed more quickly and flowered earlier than their counterparts

NOSTOC

- A genus of cyanobacteria that grows in fresh water and terrestrial environments
- Can survive in a desiccated state for years and recover after re-hydration
- Fixes atmospheric nitrogen in the presence of oxygen
- In the nitrogen-poor lunar regolith, *Nostoc* may provide the *Arabidopsis thaliana* with the nitrogen needed to grow and *P. polymyxa* with the ability to multiply

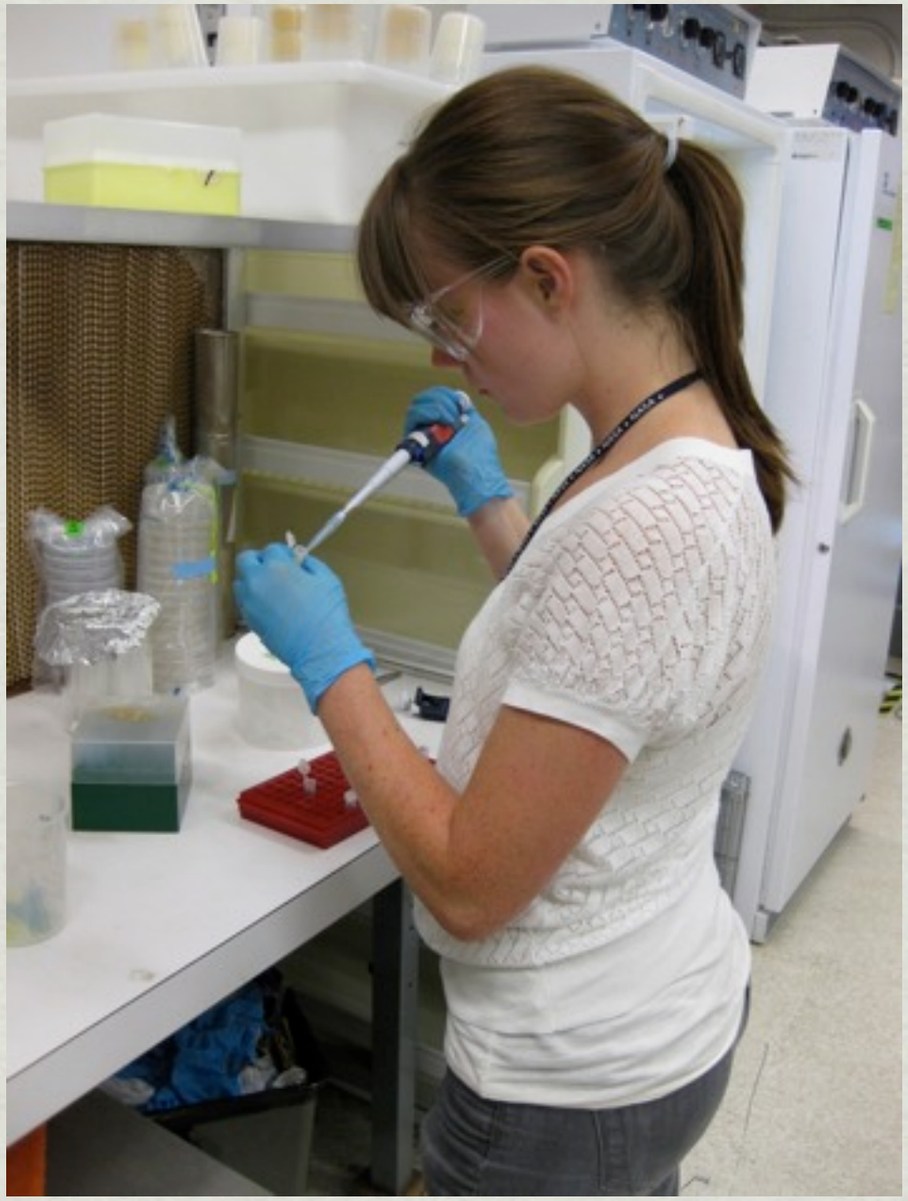
ARABIDOPSIS THALIANA

- Ideal Test Specimen
- Rapid life cycle
  - Leaves above surface of the soil in 14 days
  - Full life cycle in 6 weeks
- Small size
- Small genome fully characterized
- Easily modified
  - Our strain has been modified with a transgene to signal adverse environmental conditions

EXPERIMENTAL SET-UP:

Seeds:	Y	Y	N
Soil:	N	Y	Y
Control (0 microbes)	Growth Media DI water	Growth Media Growth Media	DI water Growth Media
Paenibacillus polymyxa (1 microbe)	*P. polymyxa* DI water	*P. polymyxa* *P. polymyxa*	DI water *P. polymyxa*
Paenibacillus polymyxa & *Nostock* (2 microbes)	*P. polymyxa* DI water	*P. polymyxa* *P. polymyxa* & *Nostock*	DI water *P. polymyxa* & *Nostock*

Seeds:	N
Soil:	N
Control (0 microbes)	DI water DI water

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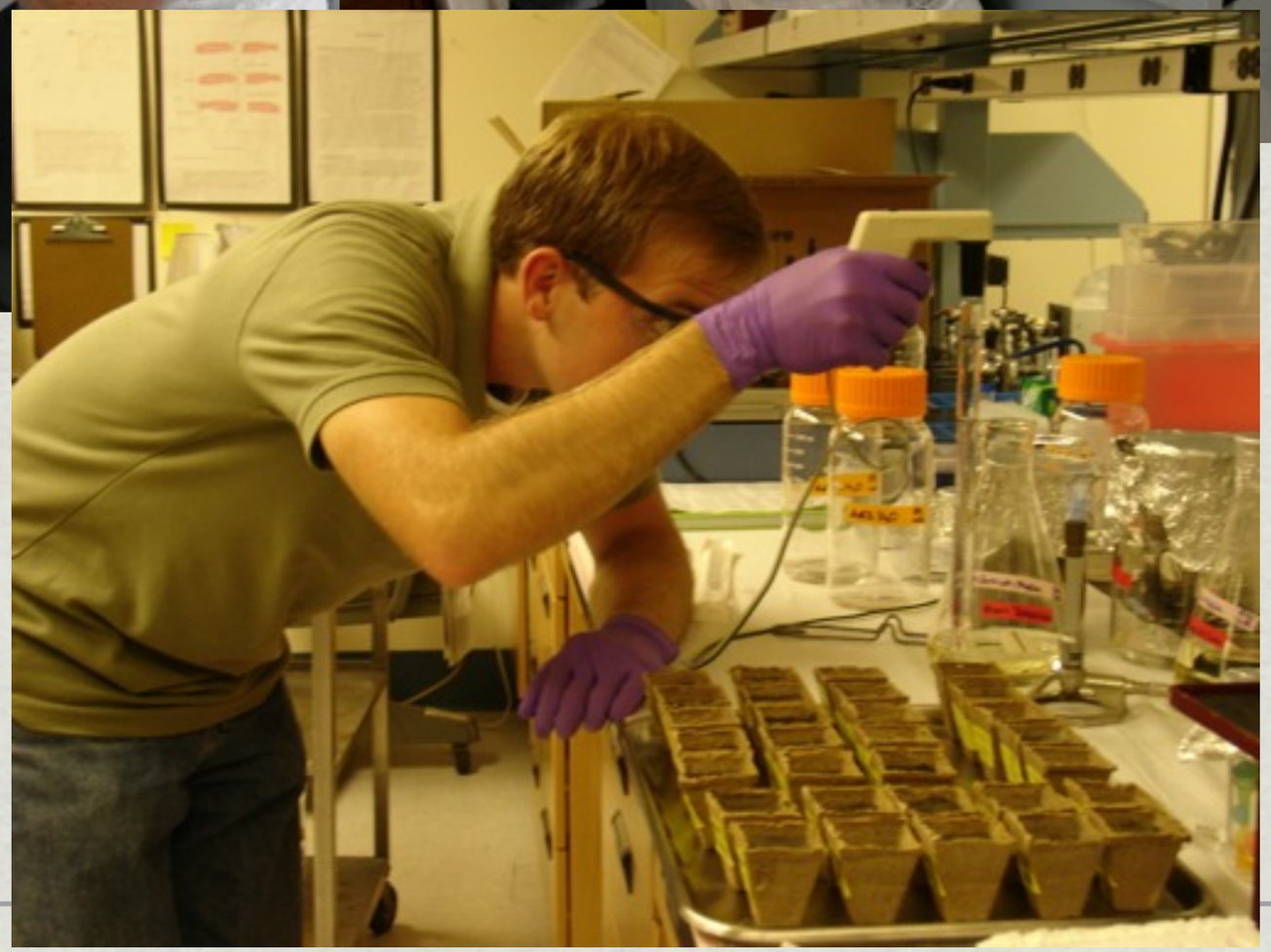
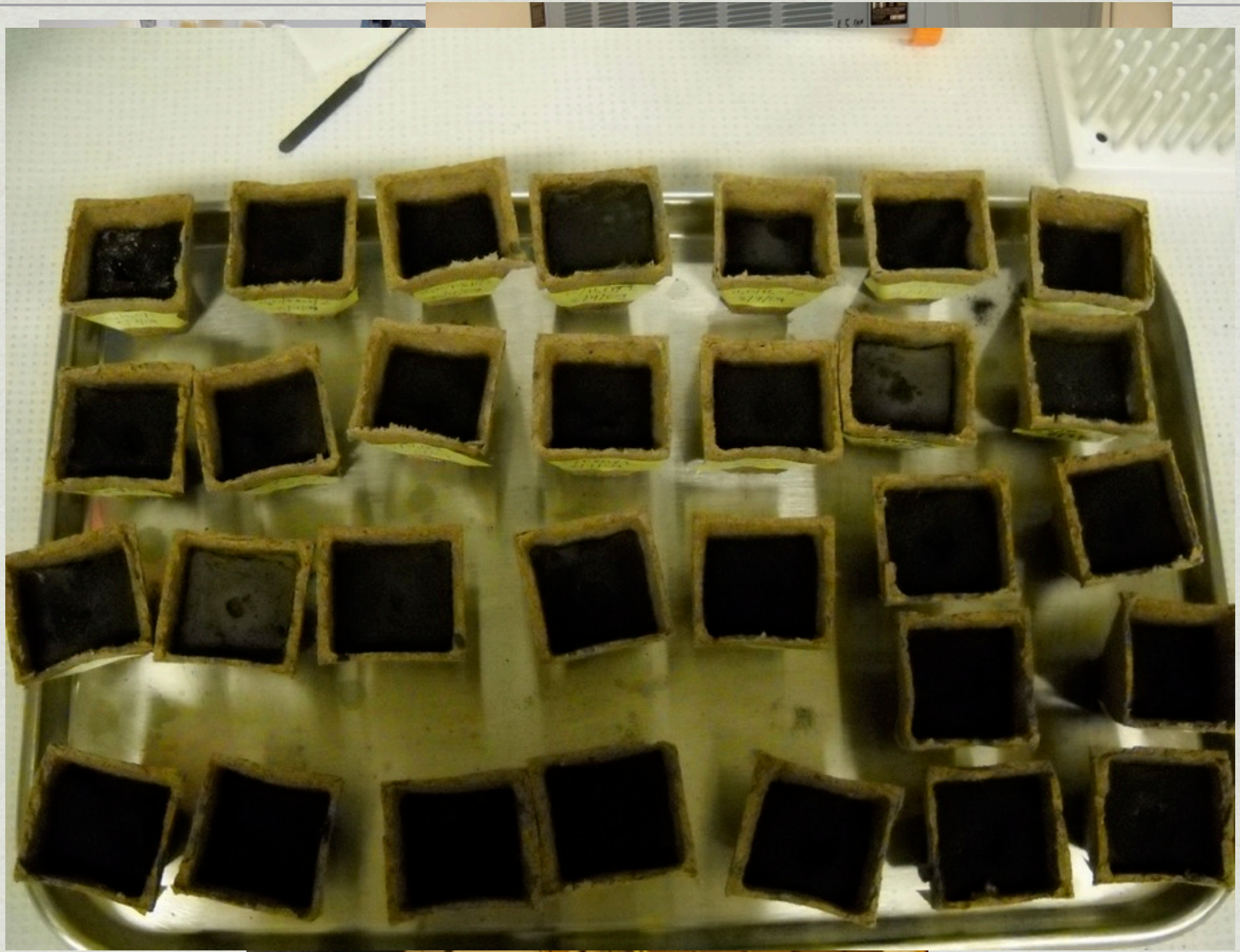
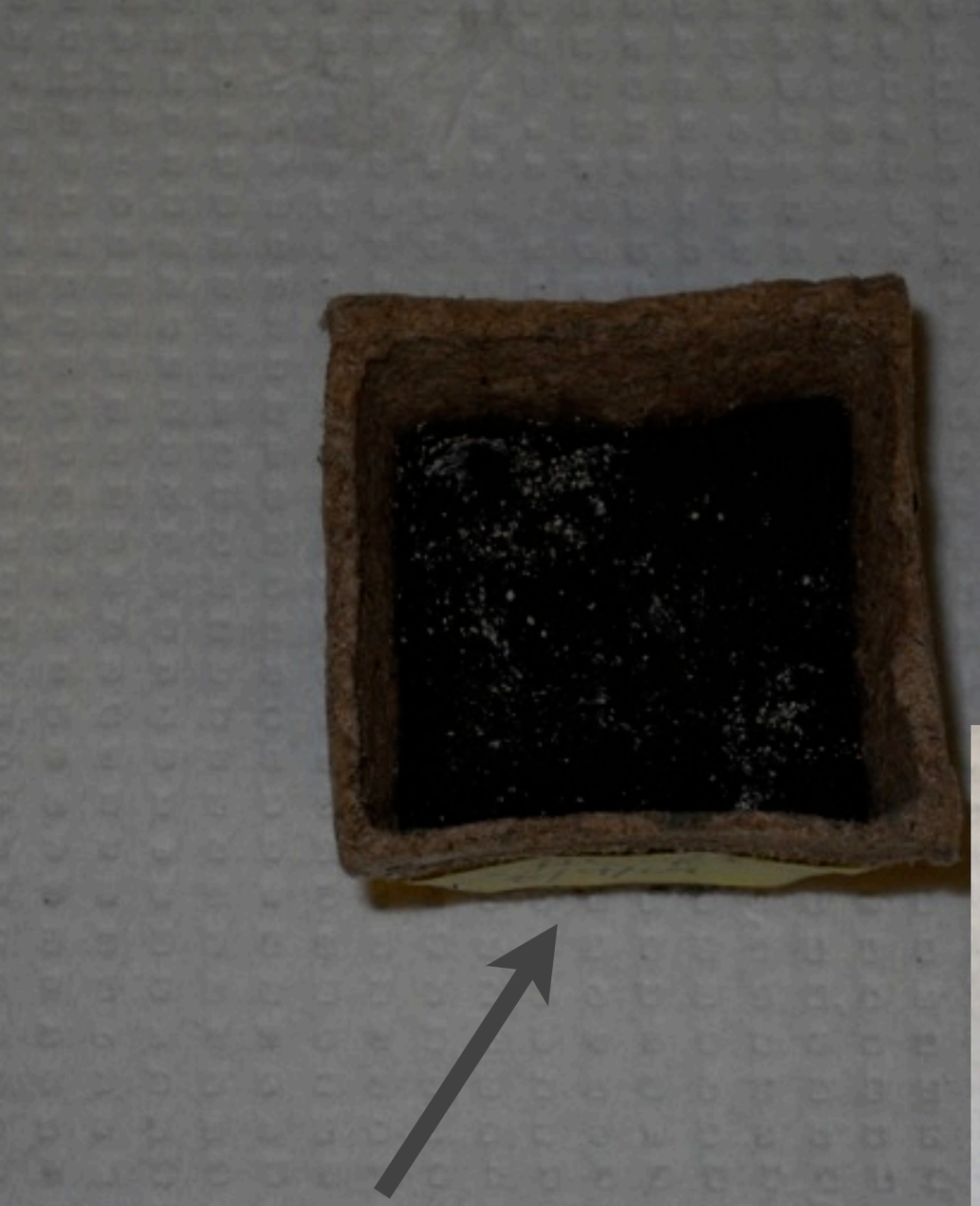


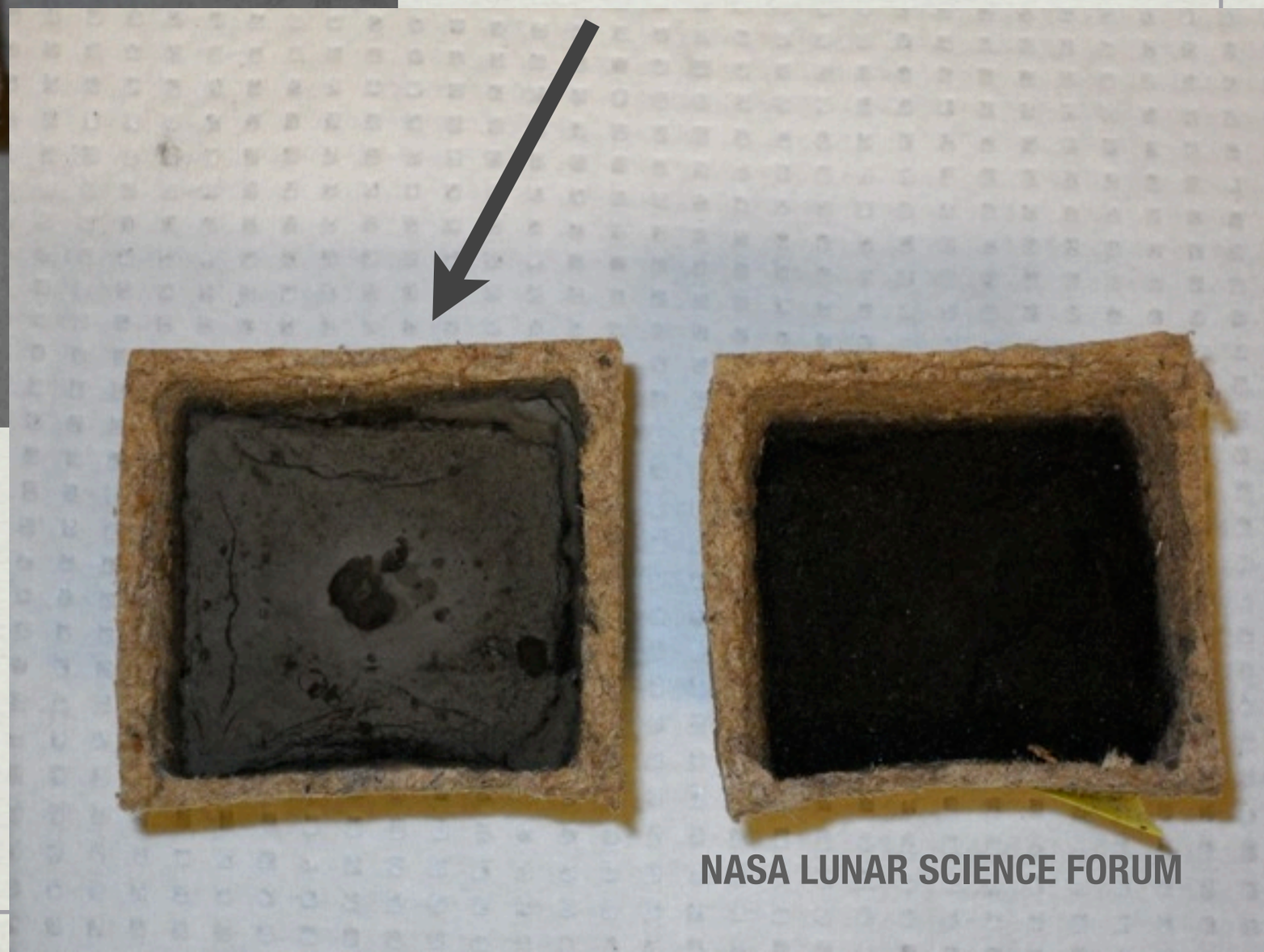


OBSERVATIONS

- Two forms of growth not expected:
  - White, fibrous growth on three samples
  - White flecks on at least 2 samples
- Changes in top layer of regolith:
  - Lighter, cake-like texture
  - Occured SOLELY in experiments NOT inoculated with microbes



WHITE FLAKES



CAKE-LIKE LAYER

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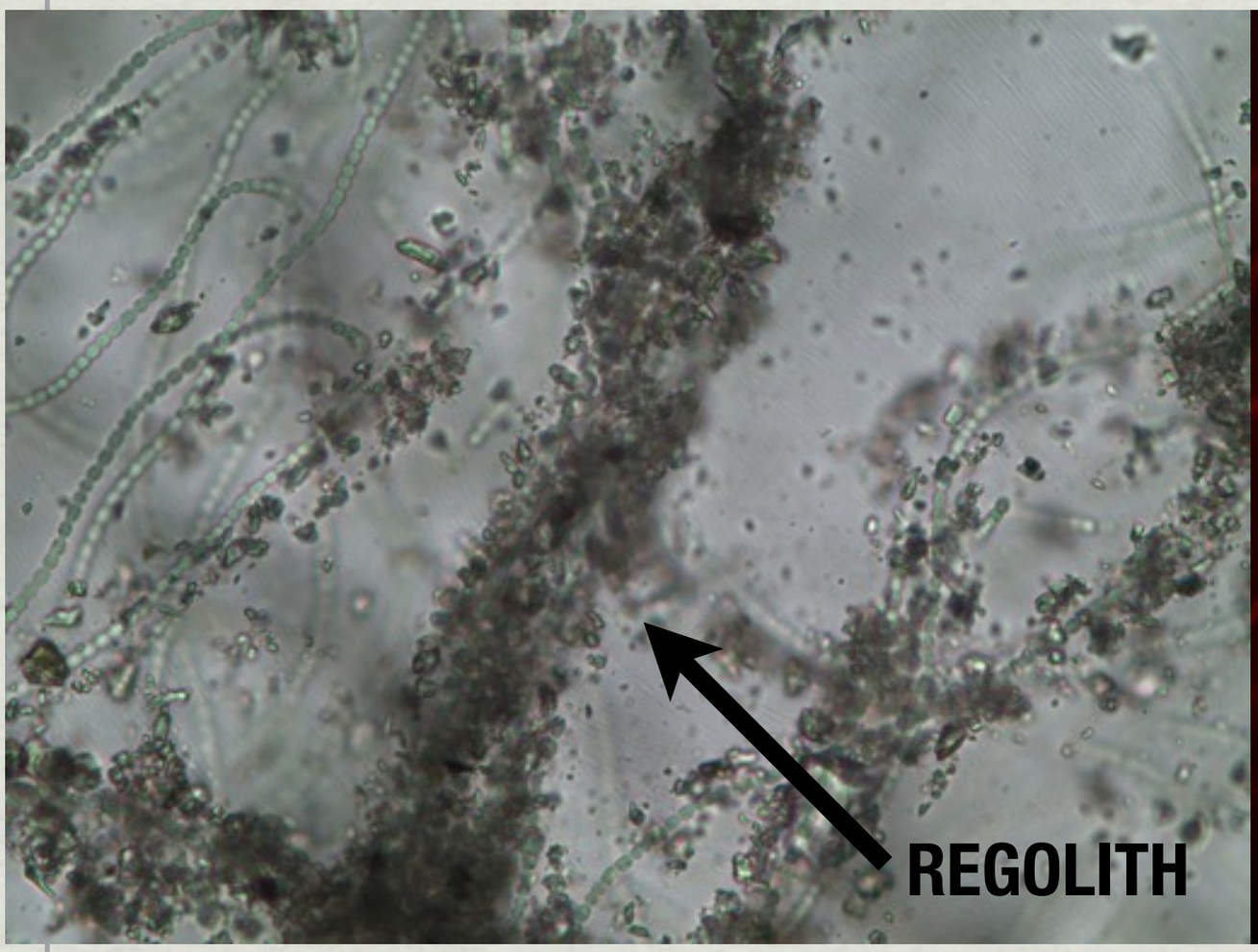
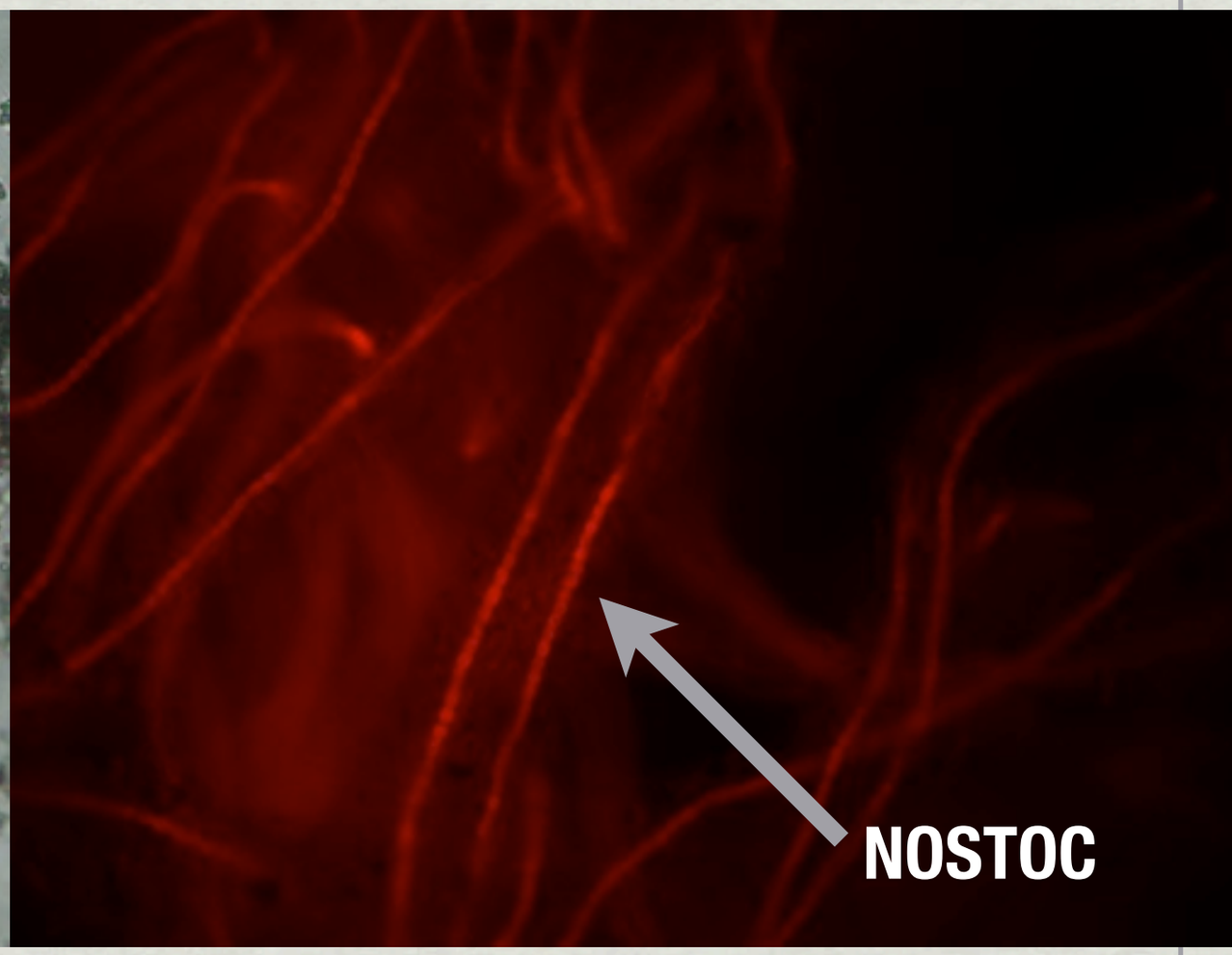
EVIDENCE OF GROWTH

Trial to determine optimal slurry composition

Added microbes and incubated, covered, for 3 weeks



MICROGRAPH OF TRIAL SLURRY



FLUORESCENT MICROGRAPH OF TRIAL SLURRY

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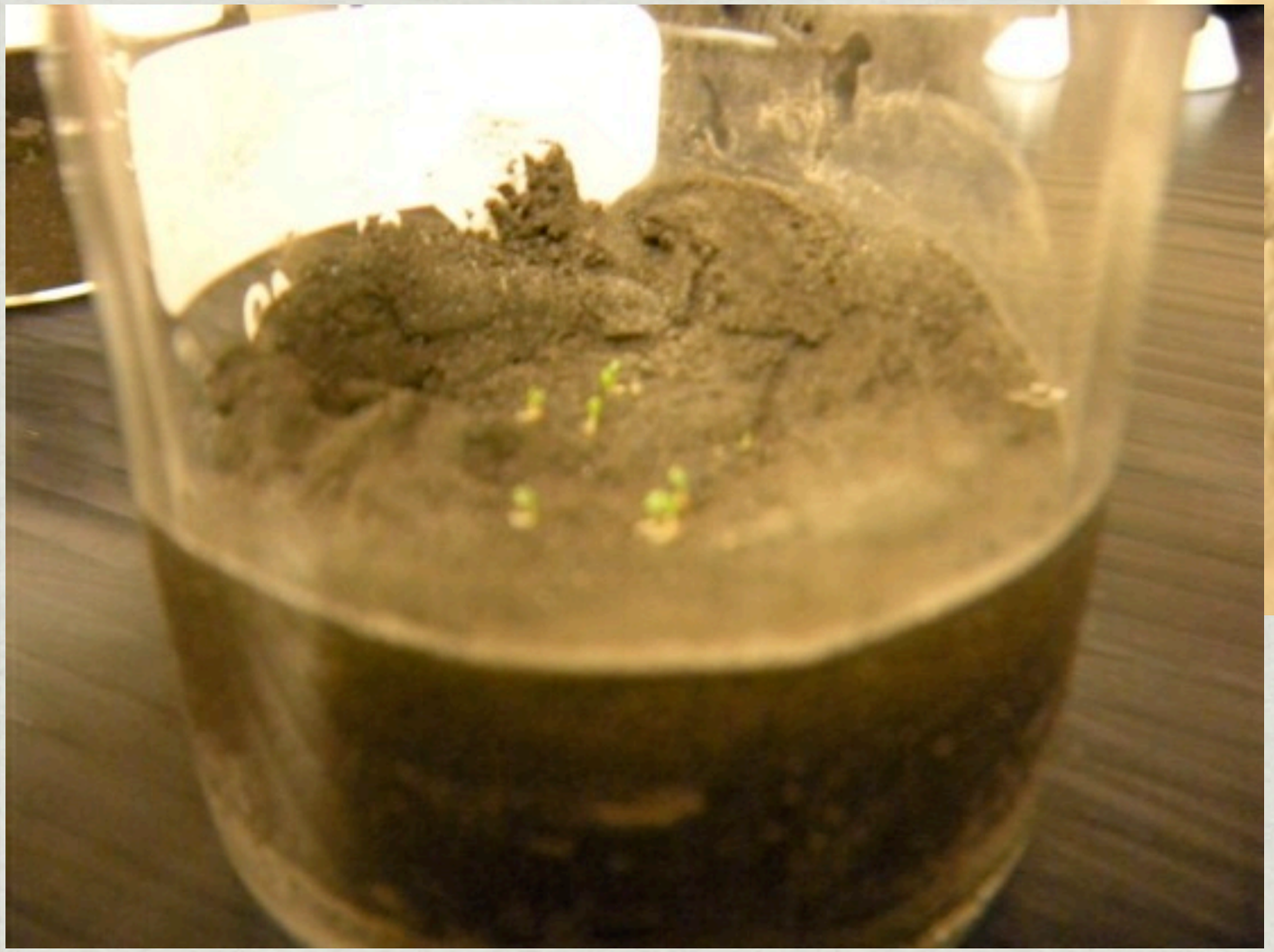
PLANTS!



TOP VIEW

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THANK YOU:

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