Maintaining Relationships in Closed Environments: Plant/Microbe Mutualisms

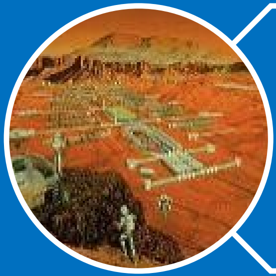
Gary W. Stutte
Space Life Science Laboratory
Exploration Park, Florida

18-22 September, 2016, Canberra, ACT, Australia

Background

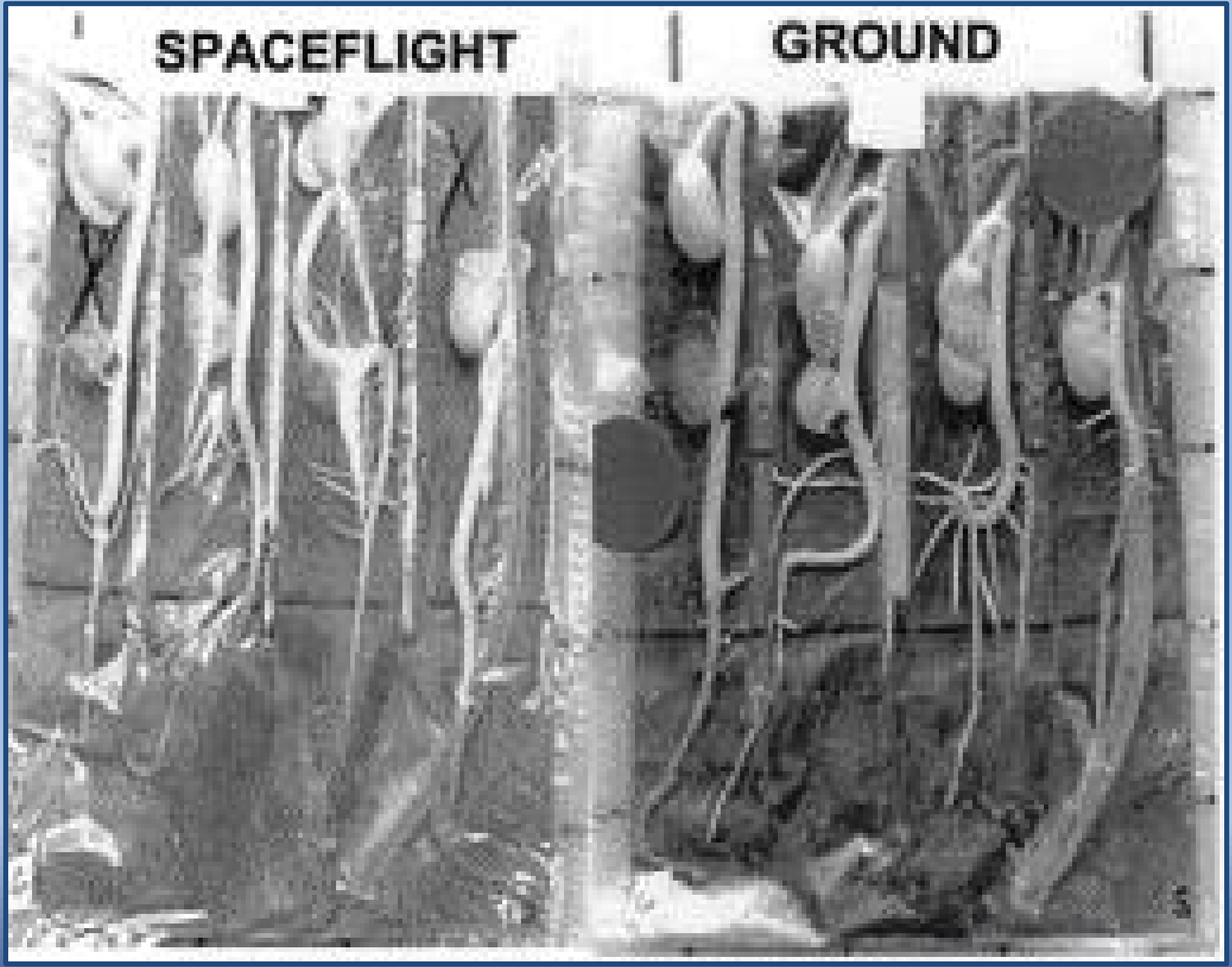
Ground

Flight



Speculation

Background: Microgravity environment is conducive to preferential growth of microorganisms and potential pathogens



Soybean seedlings from day 7 harvest on STS-97*From Ryba-White, et al.2001. Plant Cell Physiol. 42;657-664.*

Background: Microbial grown occurs on sanitized seed/rooting materials when exposed to ISS ambient conditions.

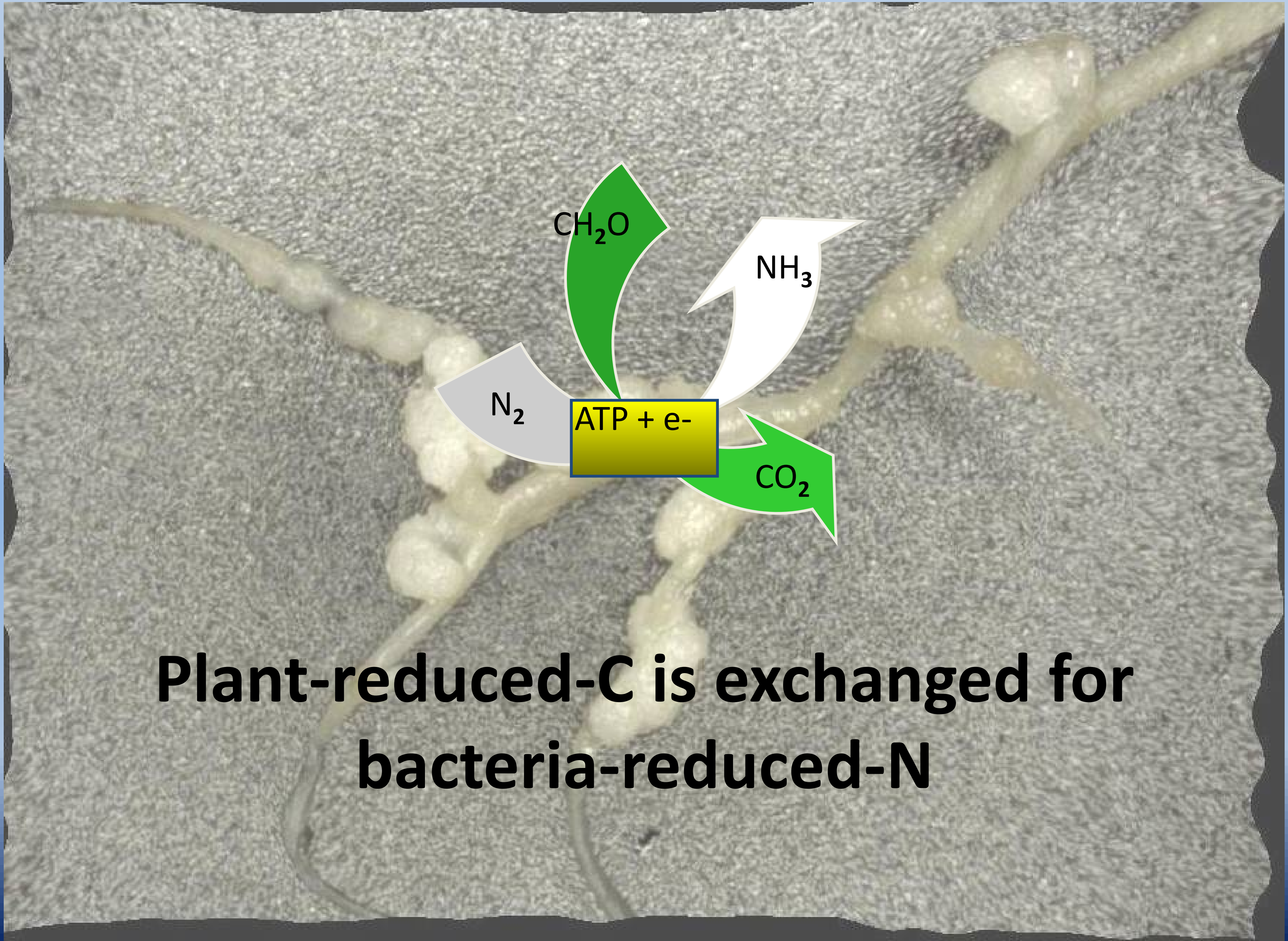
(NASA ISS image of zinnia plants grown in VEGGIE, 2016).

Wheat grown in non-sterile conditions had diverse rhizosphere, high germination, and no pathogenicity.

Frazier et al., 2003; Stutte et al., 2004)

Plant/Microbe Mutualisms are critical to survival on Earth and may play similar role for long duration space missions.

- ✓ Legumes to 20% of the protein in our diets though direct or are important crops and provide up indirect consumption.
- ✓ Understanding the nodulation process and its genetic machinery may have broad implications for decreasing resupply costs on long duration space missions in improving agriculture , reducing dependence on chemical nitrogen fertilizers.
- ✓ Little research on plant/microbe interactions in microgravity exists.



Plant-reduced-C is exchanged for bacteria-reduced-N

SyNRGE

Symbiotic Nodulation in a Reduced Gravity Environment

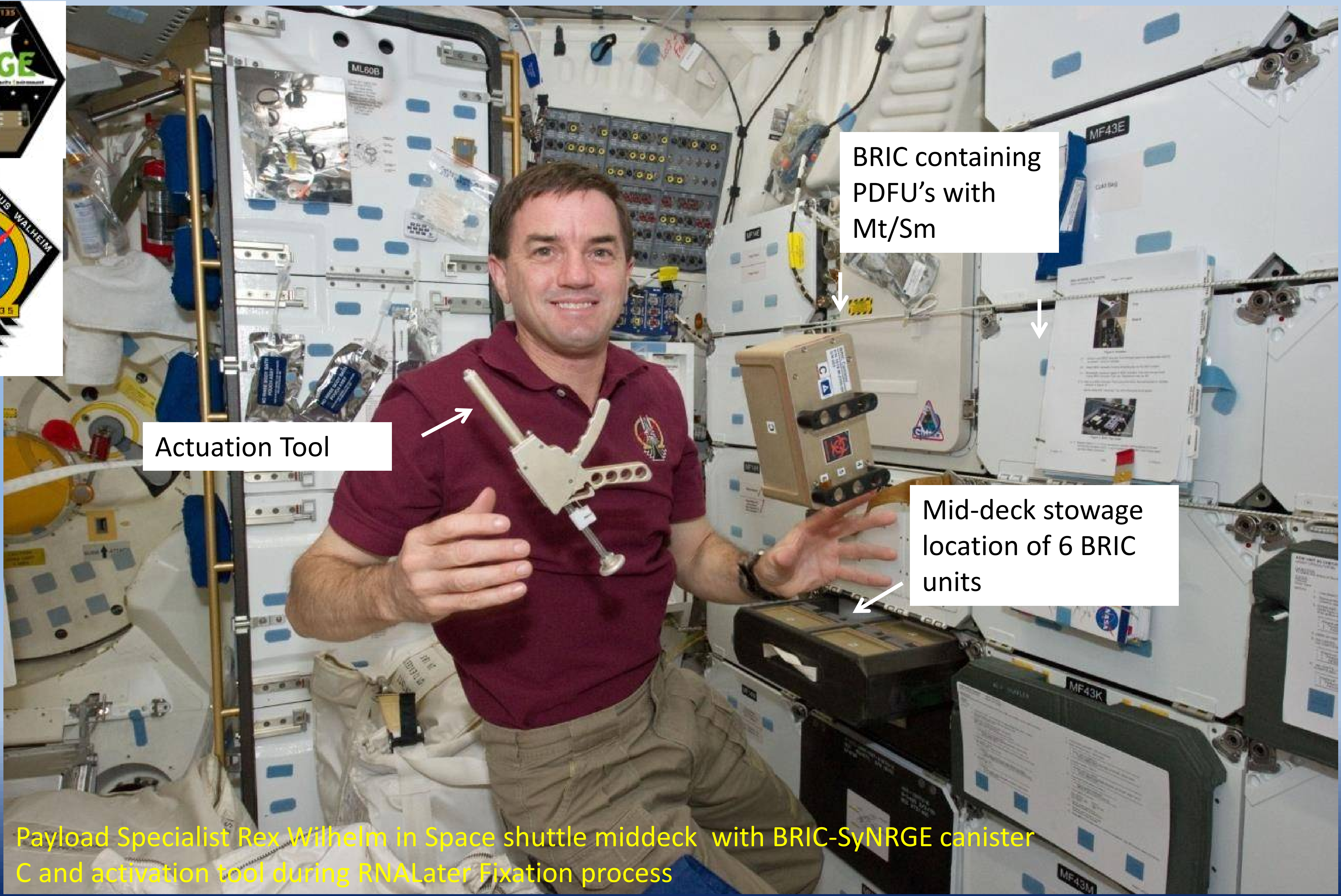
Effect of Microgravity on Early Events of Biological Nitrogen Fixation in Medicago truncatula

Gary W. Stutte, Ph.D[1] and Michael Roberts, Ph.D

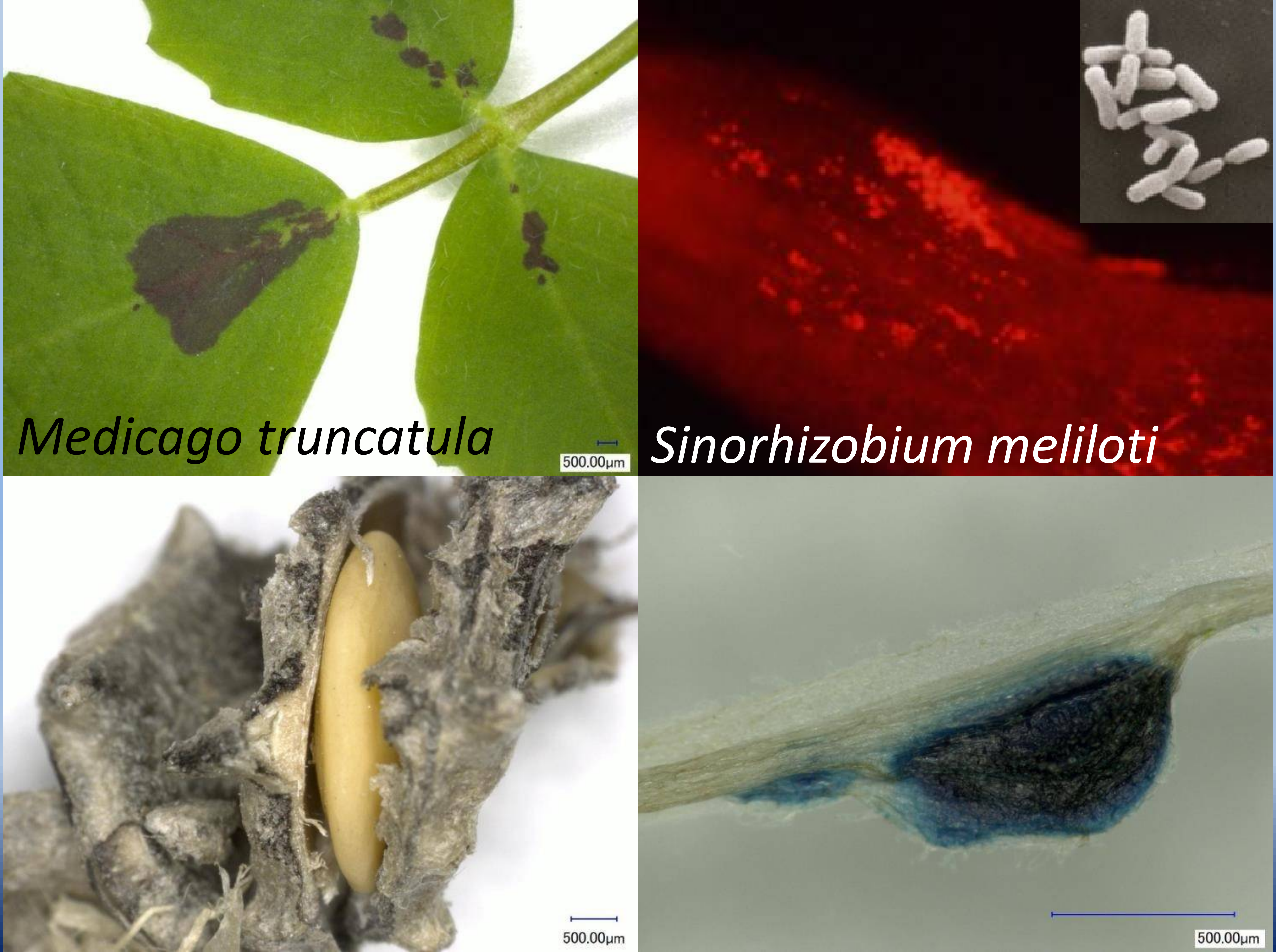
QinetiQ-NA, Space Life Science Laboratory

Kennedy Space Center, FL 32899

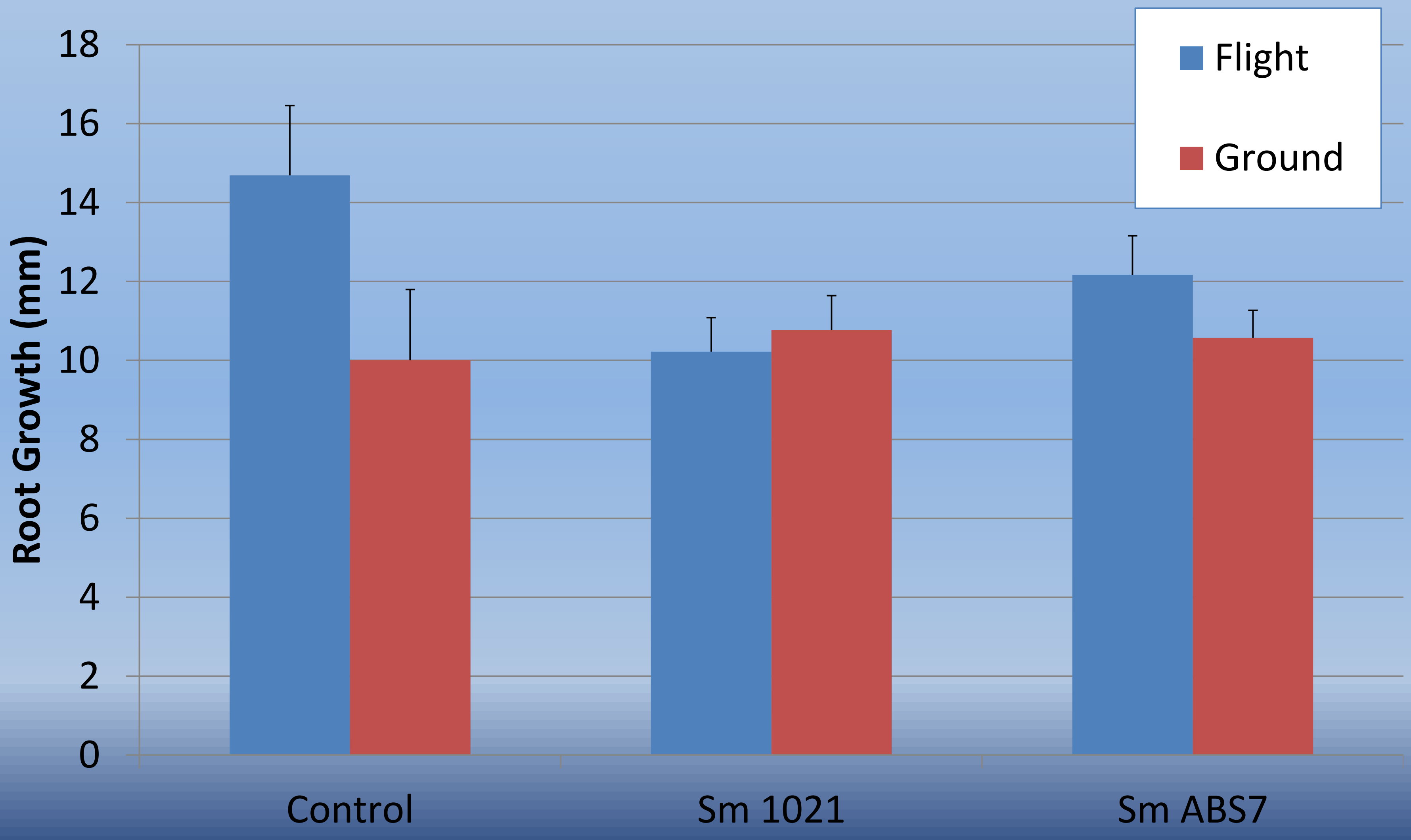
International Life Sciences Research Announcement: Research Opportunities for Flight Experiments in Space Life Sciences on the ISS (ILSRA-2009)Cooperative Agreement Number: NNX10AR090A



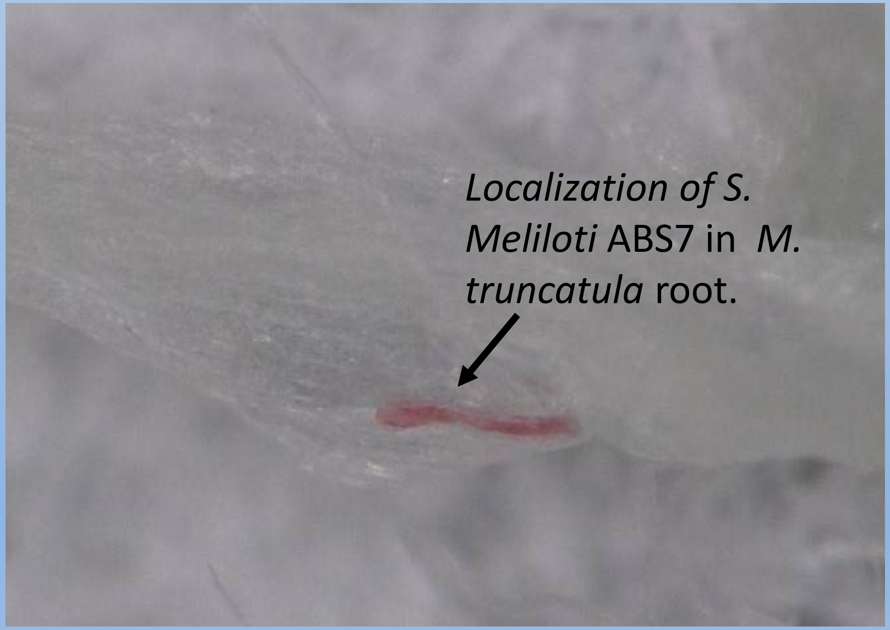
Payload Specialist Rex Wilhelm in Space shuttle middeck with BRIC-SyNRGE canister C and activation tool during RNALater Fixation process


Medicago truncatula
500.00µm
Sinorhizobium meliloti
500.00µm
500.00µm

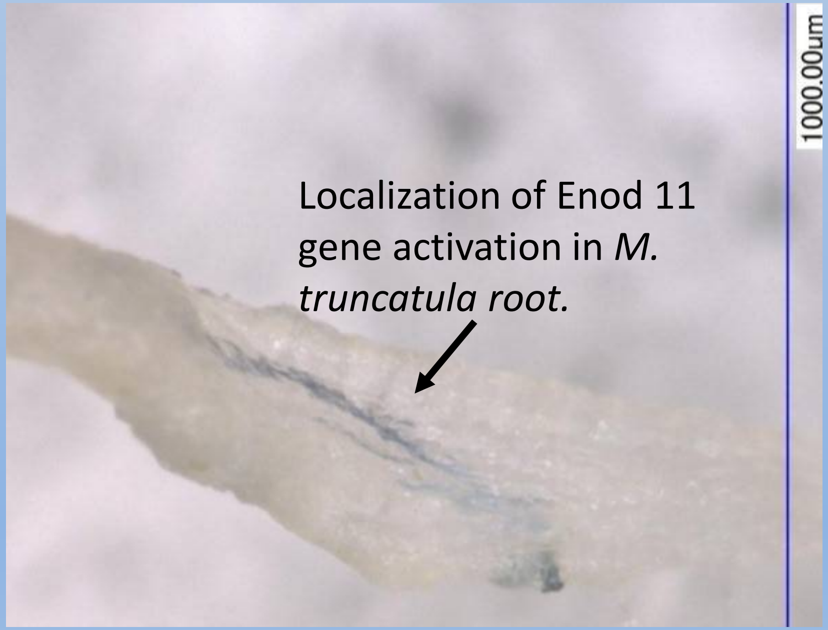
Effects of Microgravity on growth of *M. truncatula cv.* Jemalong A17 (Enod11::gus) inoculated with two strains of *S. meliloti.*



Localization of S. meliloti infection of M. truncatula roots and activation of ENOD11 gene in µ*g* necessary for nodule formation, and subsequent biological nitrogen fixation.

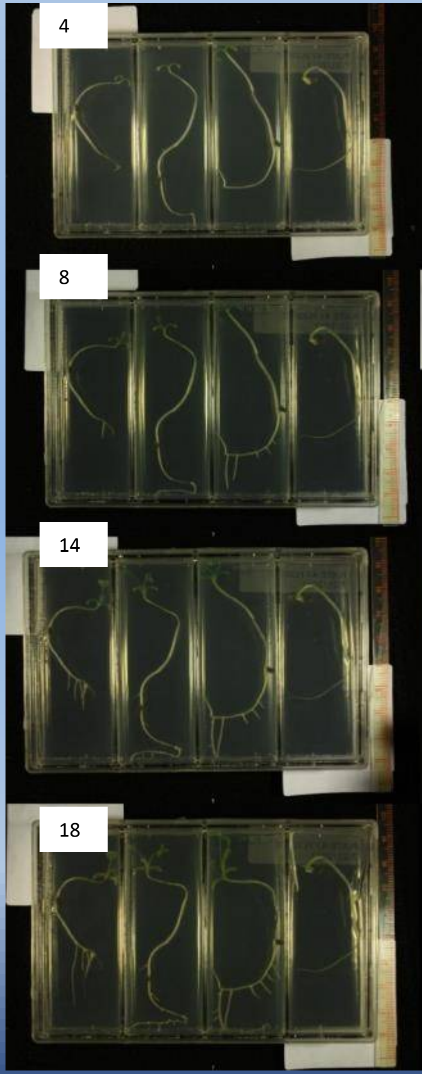


*M. truncatula (*Enod11::gus) inoculated with *S. meliloti* ABS7 with a hemA::LacZ marker. The stained area indicates site of *S. meliloti* infection in the etiolated *M. truncatula* root.

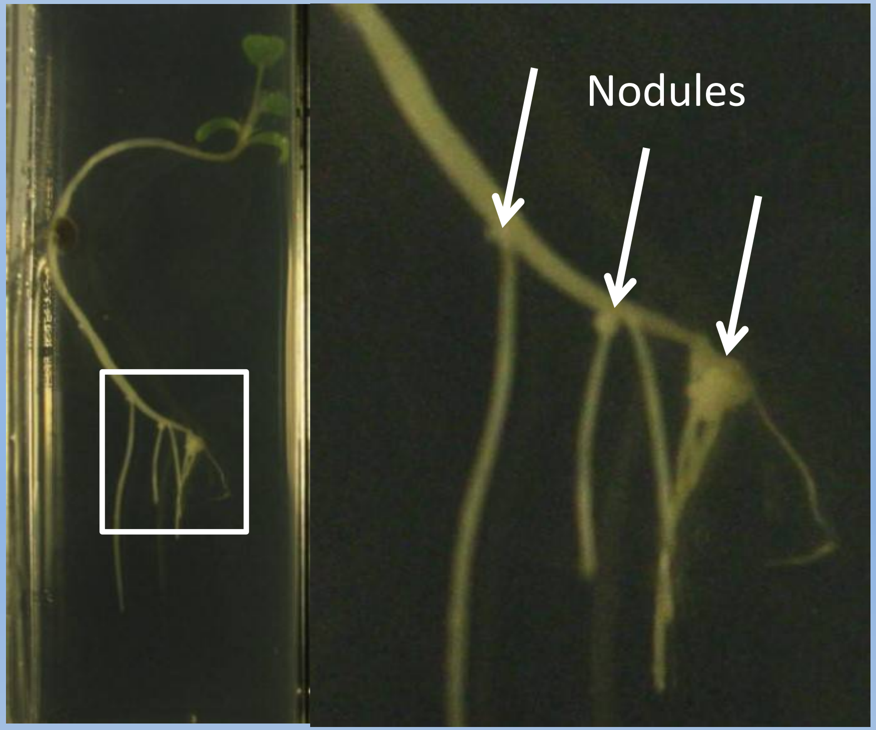


*M. truncatula (*Enod1::Gus) inoculated with *S. meliloti ABS7* with a hemi::LacZ marker. The stained area indicates site of *Enod11:gus* gene activation in the etiolated *M. truncatula* root.

H_o: Microgravity exposure reduces the susceptibility of the host plant (*M. truncatula)* to form nodules



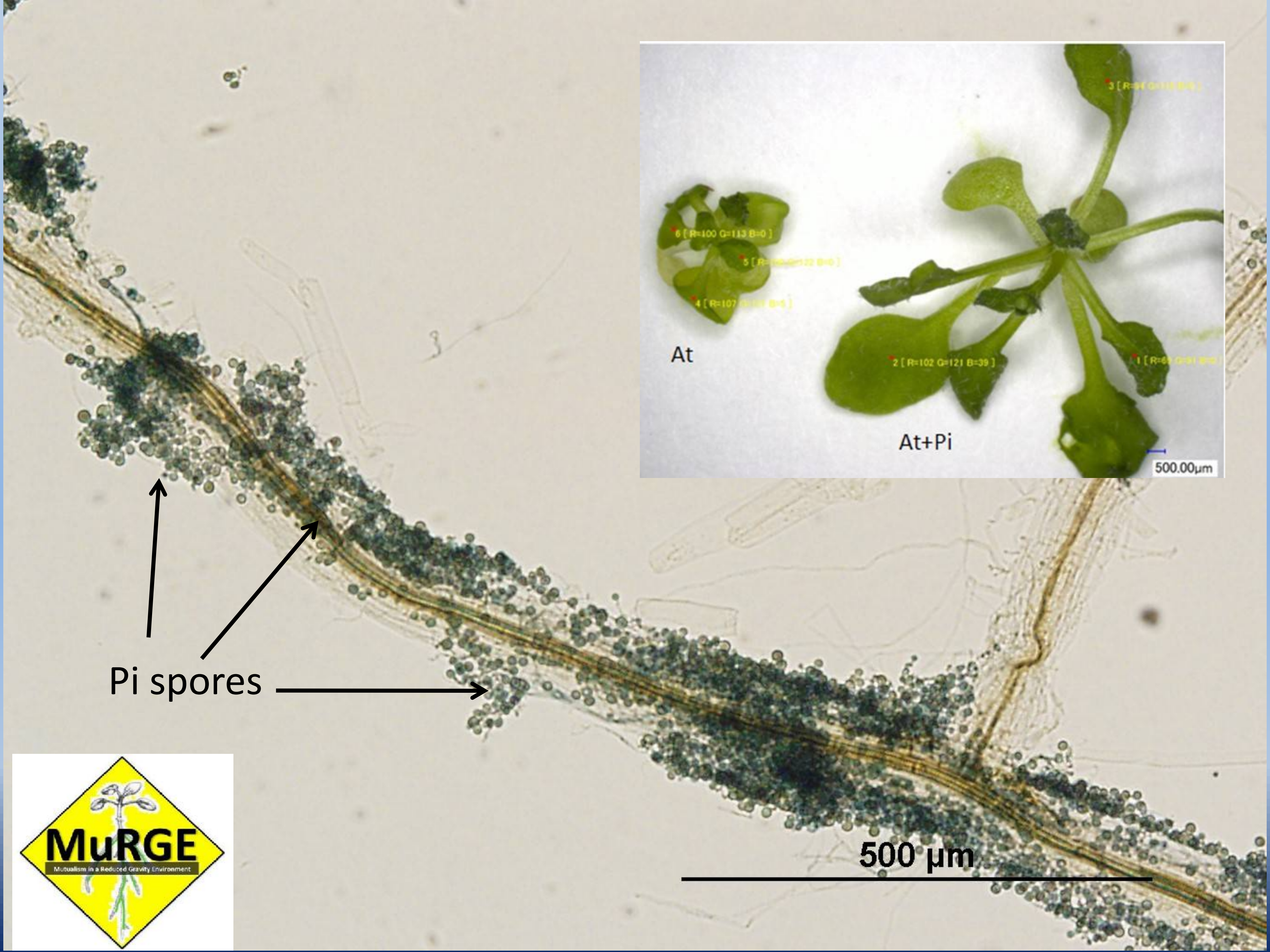
M.Truncatula Jemalong 17 (Enod11::Gus) growth and nodule formation



M. truncatula cv Jemalong 17 (*Enod11::gus*) germinated in microgravity and inoculated with *S.meliloti* ABS7 cultured in microgravity at 18 days after inoculation. Roots of *M. truncatula* were inoculated within 8 hours of landing, and cultured on buffered nodulation media (BNM), which contains no carbon or nitrogen source in Nunc™ 4-well plates.

MUTUALISM IN A REDUCED GRAVITY ENVIRONMENT (MURGE): PIRIFORMOSPORA INDICA: ARABIDOPSIS THALIANA INTERACTIONS IN MICROGRAVITY

Gary Stutte and Mike Roberts, co-investigators, CSS Dynamac


At
At+Pi
500.00µm
Pi spores
500 µm
MuRGE
Mutualism in a Reduced Gravity Environment

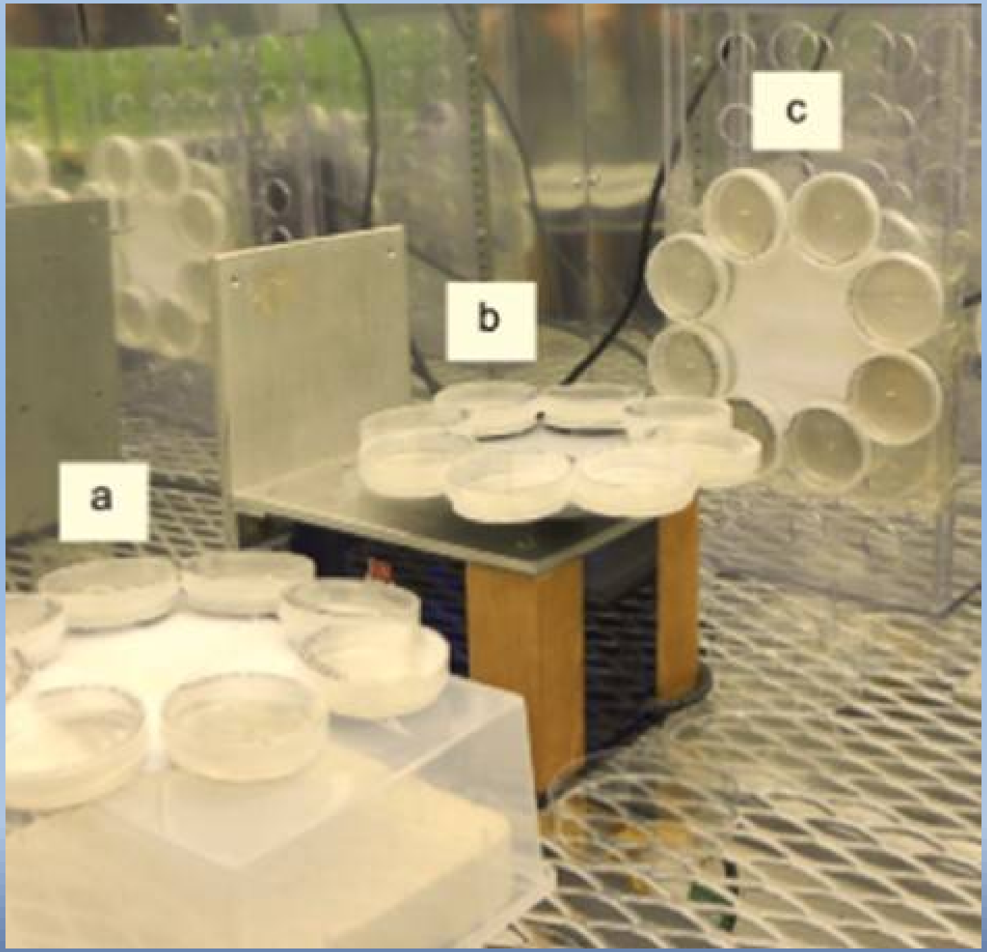
P. indica shows strong biostimulatory effect on a number of species

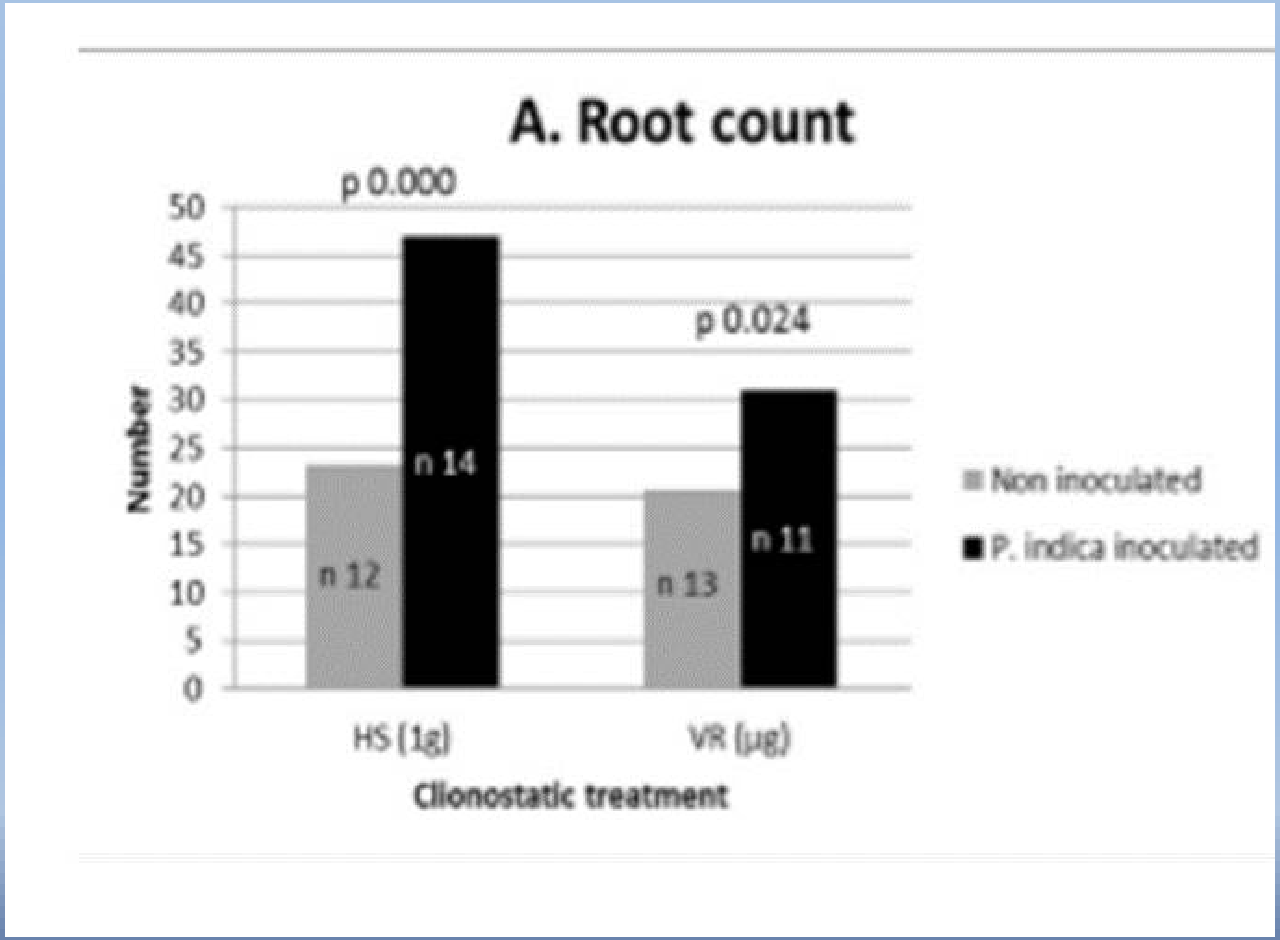
TOMATO:
More uniform germination, increased root branching, denser root hairs, and 15% increased in seedling biomass observed.

LETTUCE:
More uniform germination, increased root branching, larger leaves, and 55% increased in seedling biomass observed.

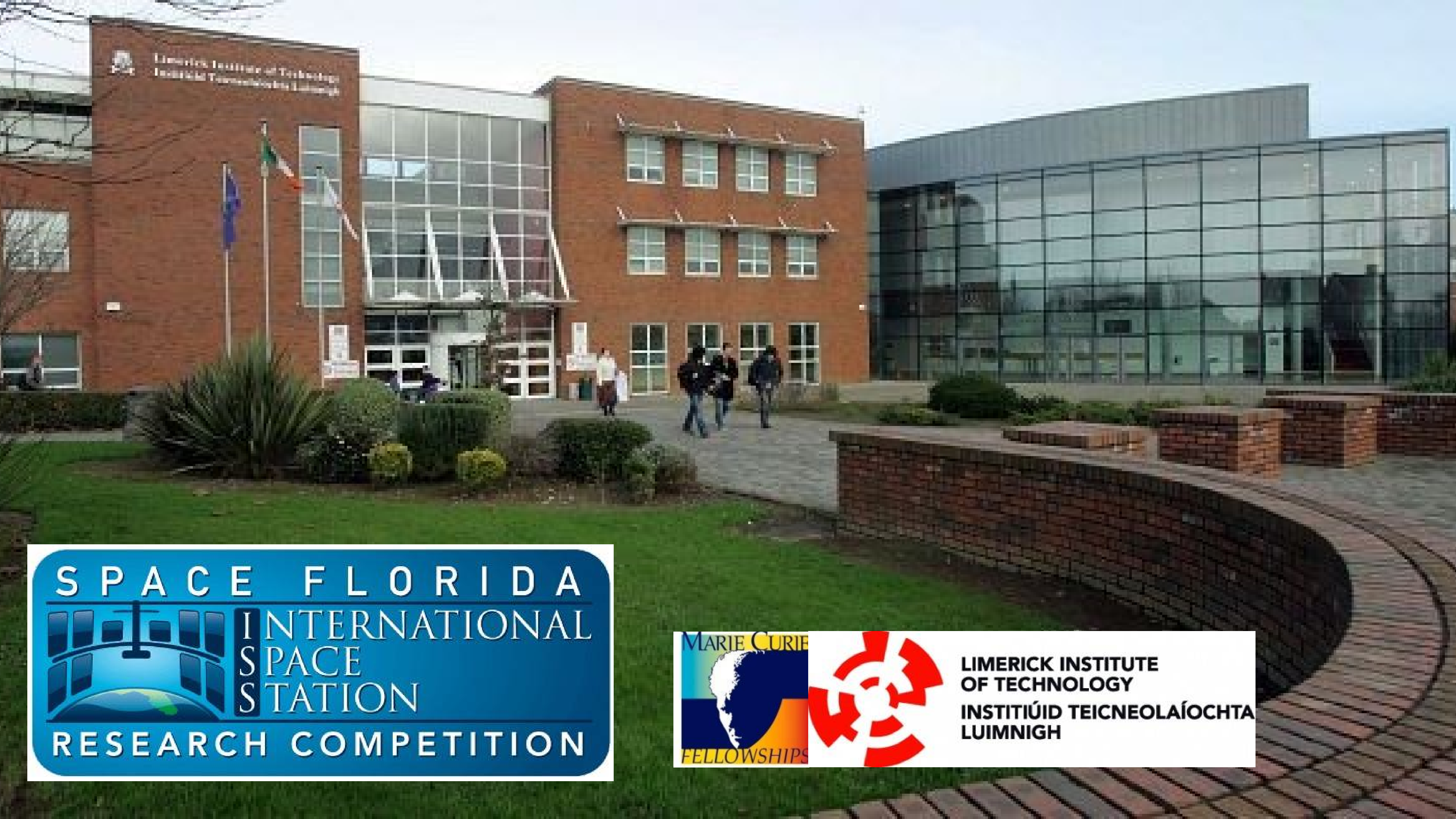
MuRGE
Mutualism in a Reduced Gravity Environment

Biostimulatory effect of *P. indica* retained, but reduced in magnitude under simulated microgravity conditions.





Hayes, Stutte, McKeon-Bennett, and Murray. 2014. Grav. Space Res. 2:21-33


SPACE FLORIDA
INTERNATIONAL SPACE STATION
RESEARCH COMPETITION
MARIE CURIE
FELLOWSHIPS
LIMERICK INSTITUTE OF TECHNOLOGY
INSTITIÚID TEICNEOLAÍOCHTA LUIMNIGH


SyNRGE3
LIT

NanoCube Plant Growth Chamber

- 10 cm x 10 cm x 15 cm
- Power to NanoLab via USB port (3.2 W)
- 4 white LED's (15 µmol m^2 s^{-1} PAR)
- 4 growth channels (2 plants/channel)
- Monitor temp and CO2
- Fixation capabilities
- Imaging
- Data storage on board
- Periodic data download/access

SyNRGE^3 launched on SpaceX in September, 2014.

Eight *M. truncatula* plants were launched that had been inoculated with either *S. meliloti* or *P. indica*

- Lights failed to turn on on-orbit resulting in etiolation of plants.
- Tissue was returned after ~ 2 weeks after landing and microbes recovered.
- Viability of Sm and Pi to develop mutualism retained.

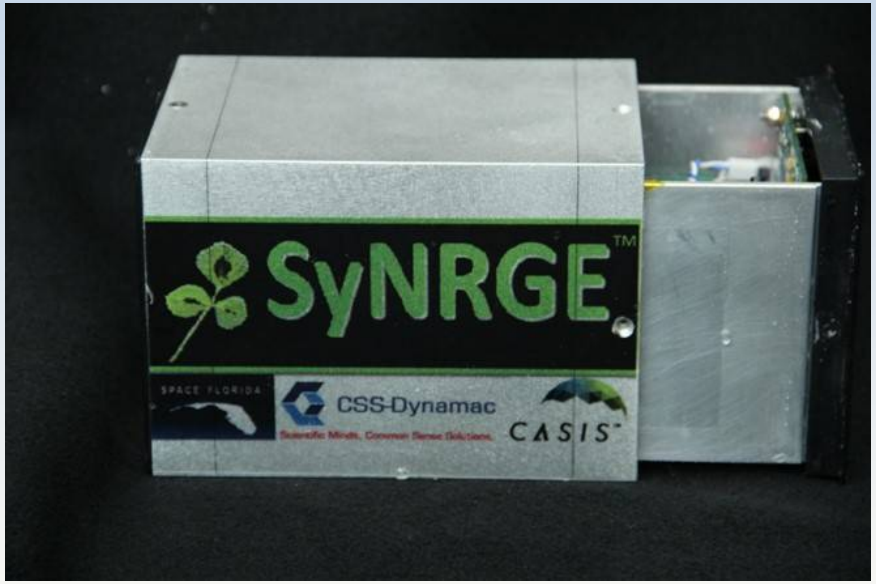
SPACE FLORIDA INTERNATIONAL SPACE STATION RESEARCH COMPETITION

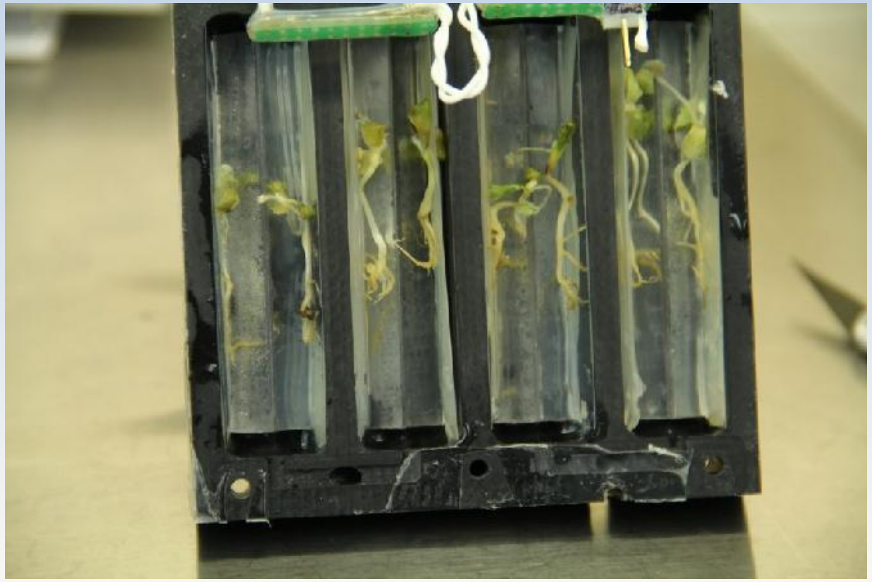
SyNRGE3 sponsored by Space Florida/Nanoracks ISS Research Competition

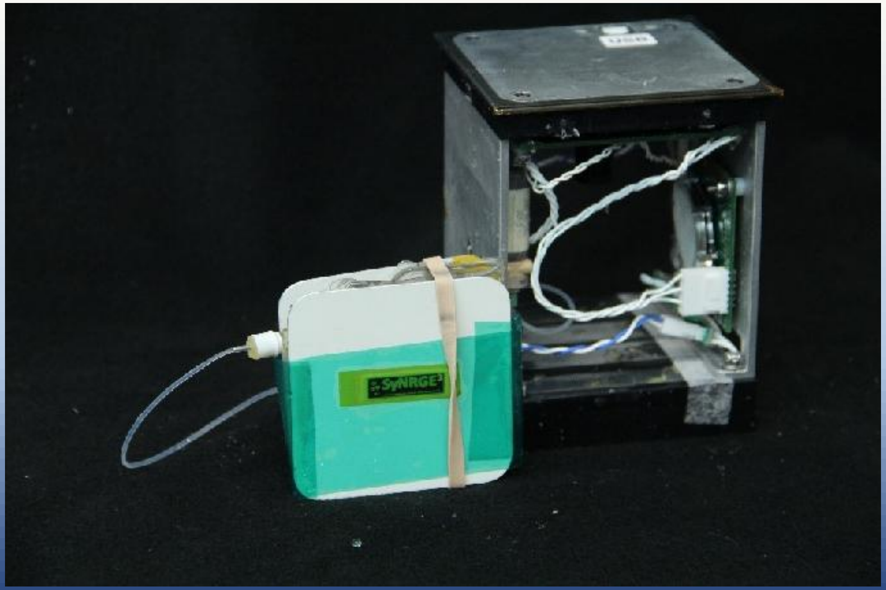
SyNRGE Plant Growth Chamber (SPGC).

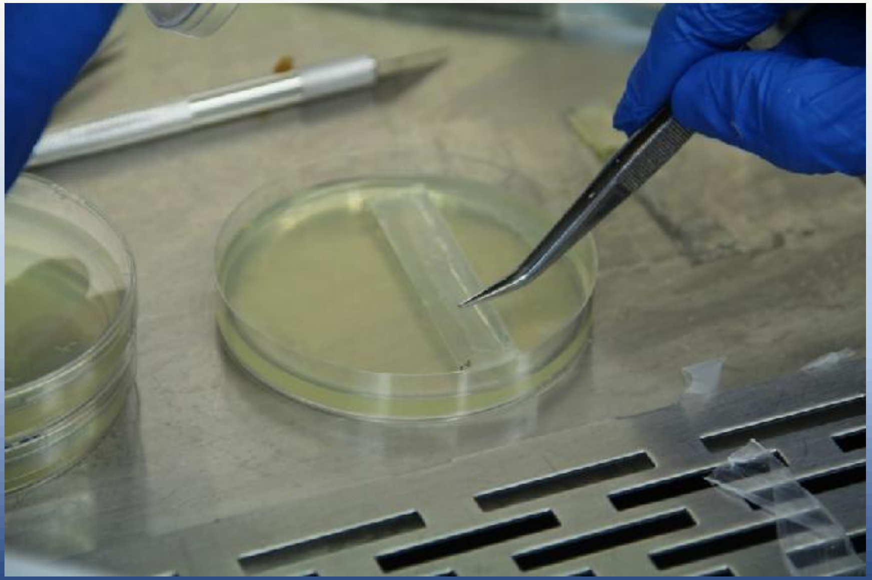
SyNRGE Plant Growth Chamber (SPGC) launched on SpaceX CRS-8 on 8 April to ISS, and it was installed in NanoLab on ISS on 11 April, 2016.

SyNRGE PGC Experiment Return, May, 2016

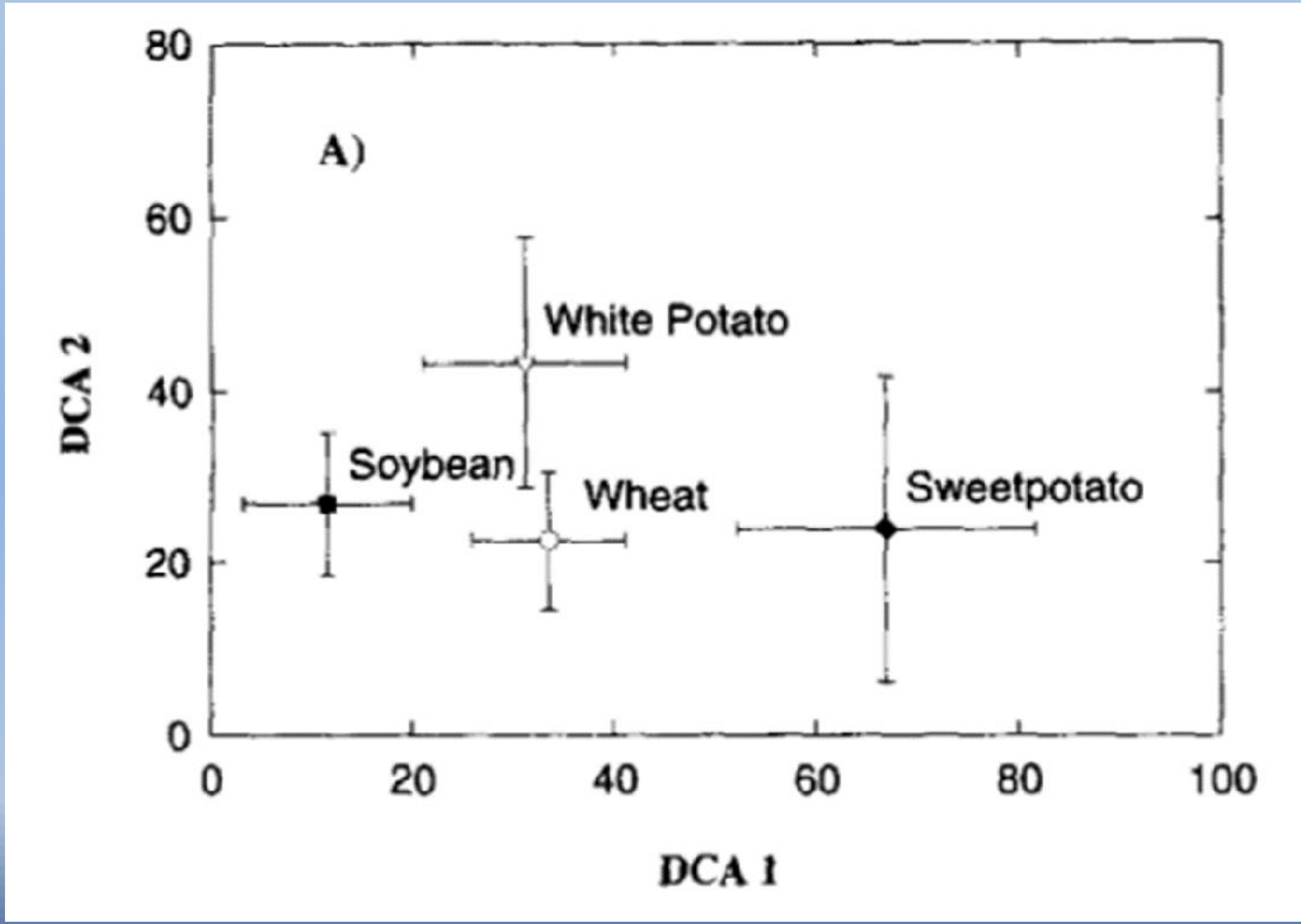








Will the plant/microbe relationship improve when we stop meddling?



(Garland, 1996; Morales, et al., 1996 ;Jenkins, et al, 2000; Frazier et al., 2013; Roberts, et al, 2004)

Thank You!

SyNRGE

CASIS™

SPACE FLORIDA

NANORACKS
Economical Space Research

CSS-Dynamac
Scientific Minds. Common Sense Solutions.

LIMERICK INSTITUTE OF TECHNOLOGY
INSTITIÚID TEICNEOLAÍOCHTA LUIMNIGH

MICRO AEROSPACE SOLUTIONS

Shannon ABC
applied biotechnology centre

CONTROLLED ENVIRONMENT LABORATORY FOR LIFE SCIENCES · CELLS

MARIE CURIE FELLOWSHIPS

NASA

Esc
Engineering Services Contract

ISSR&D CONFERENCE 2016

Questions?