Microbialites, Microgravity and More: UF Research Efforts at SLSL

Jamie Foster
University of Florida
jfoster@ufl.edu

- 104,000 sq ft research facility

- Completed in Aug 2003

- 25 research labs

SPACE FLORIDA

UF Researchers at the Space Life Sciences Lab

Dr. Jamie Foster

Dr. Wayne Nicholson

Microbiology and Cell Science

Dr. Patricia Fajardo-Cavazos

Dr. Rob Ferl

Dr. Anna-Lisa Paul

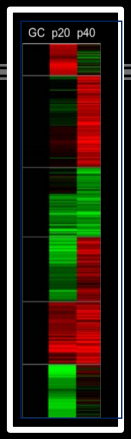
Horticulture Science

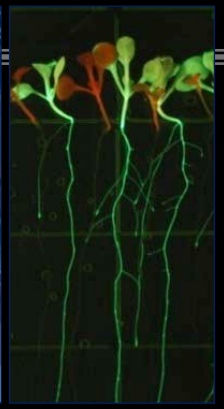
Giorgio Casaburi, PhD
Artemis Louyakis (G)
Joany Babilonia (G)
Lexi Duscher (G)
Mary Bishop (U)
Kimberley Cranmore (U)
Rachelle Bonjawo (HS)

Dr. Andy Schuerger

Plant Pathology

Dr. Rob Ferl and Dr. Anna-Lisa Paul





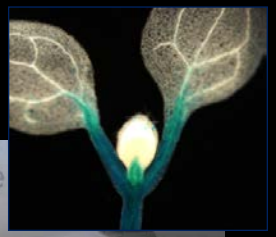
Genomic effects of spaceflight and other novel environments on *Arabidopsis*

Five spaceflight experiments **launched on: STS-93, STS-129, STS-130, STS-131**

- **Investigations of signal transduction and gene expression**
  - **Telemetric imaging from orbit with GFP reporter genes**
  - **Transcriptome analyses from post-flight processing**

Department of Horticulture Sciences
Plant Molecular and Cellular Biology

- Examining the limitations of moving terrestrial biology to other planets
- Exploring the molecular response to novel environments

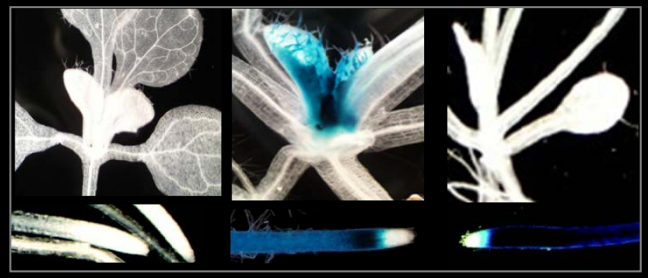


Parabolic Flight Experiments

Planetary analog experiments

Space Biology Program of
Robert J. Ferl and Anna-Lisa Paul, University of Florida

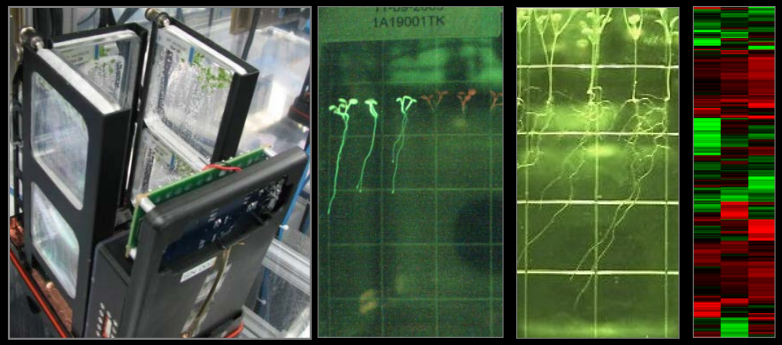
STS-93



1999
- GUS Reporter gene technology
- Calcium Signal transduction
- Partial transcriptome

STS-129

STS-130



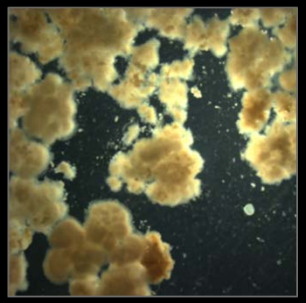
2009-2010
- GFP Reporter gene technology – live ISS imaging
- Organ-specific Plant transcriptome
- Root skewing on orbit

STS-131

2010
- BRIC-16
- Undifferentiated cells vs seedlings
- Seedling and cell culture transcriptome

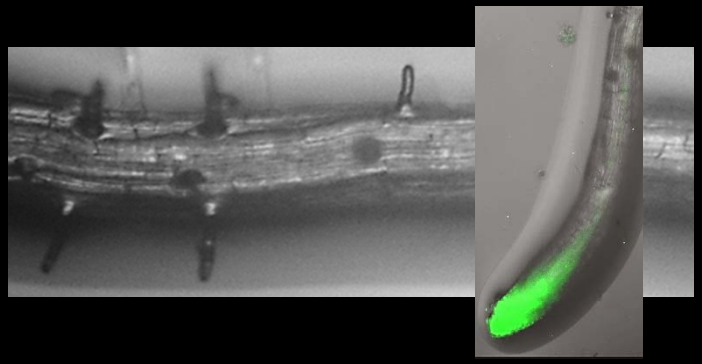
Space Biology Program of
Robert J. Ferl and Anna-Lisa Paul, University of Florida

SpaceX-2



2013
- BRIC-17
- Undifferentiated cell cultures
- Gravity sensing and stress-response mutant lines

SpaceX-3 CASIS



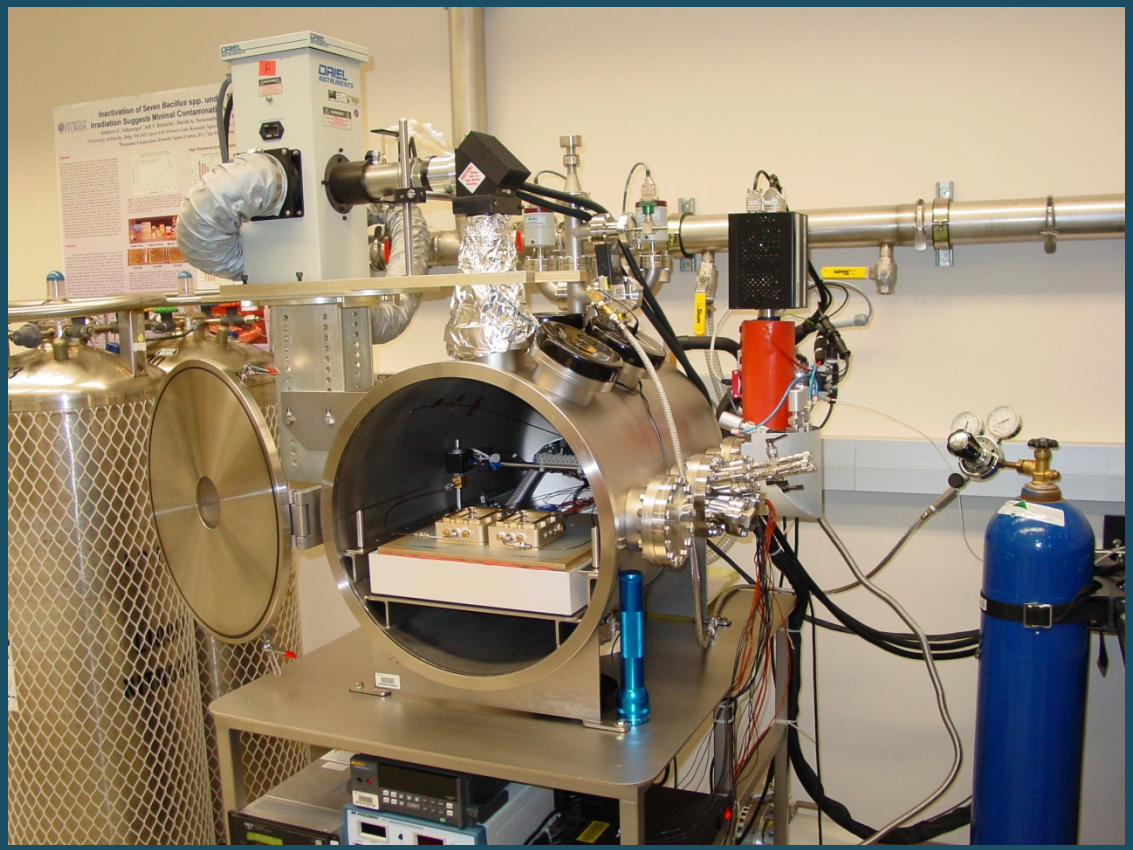
2014
- Microscopic GFP Reporter gene technology – live ISS imaging with LMM
- Orbital root growth patterns in varying light conditions

SPACEX

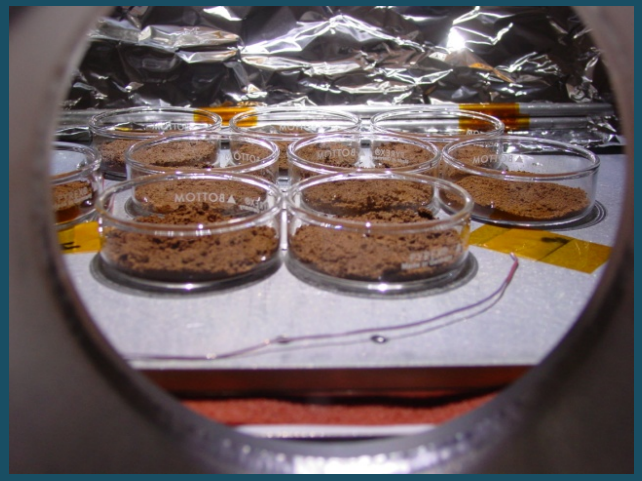
DRAGON

2014 – 2016 Upcoming Flights
- Organ-specific Arabidopsis transcriptome with cell wall remodeling mutants
- Epigenetic change in Arabidopsis thaliana in response to spaceflight

Survival, Growth, & Evolution of Earth Microbes under Martian Conditions



Dr. Andrew C. Schuerger

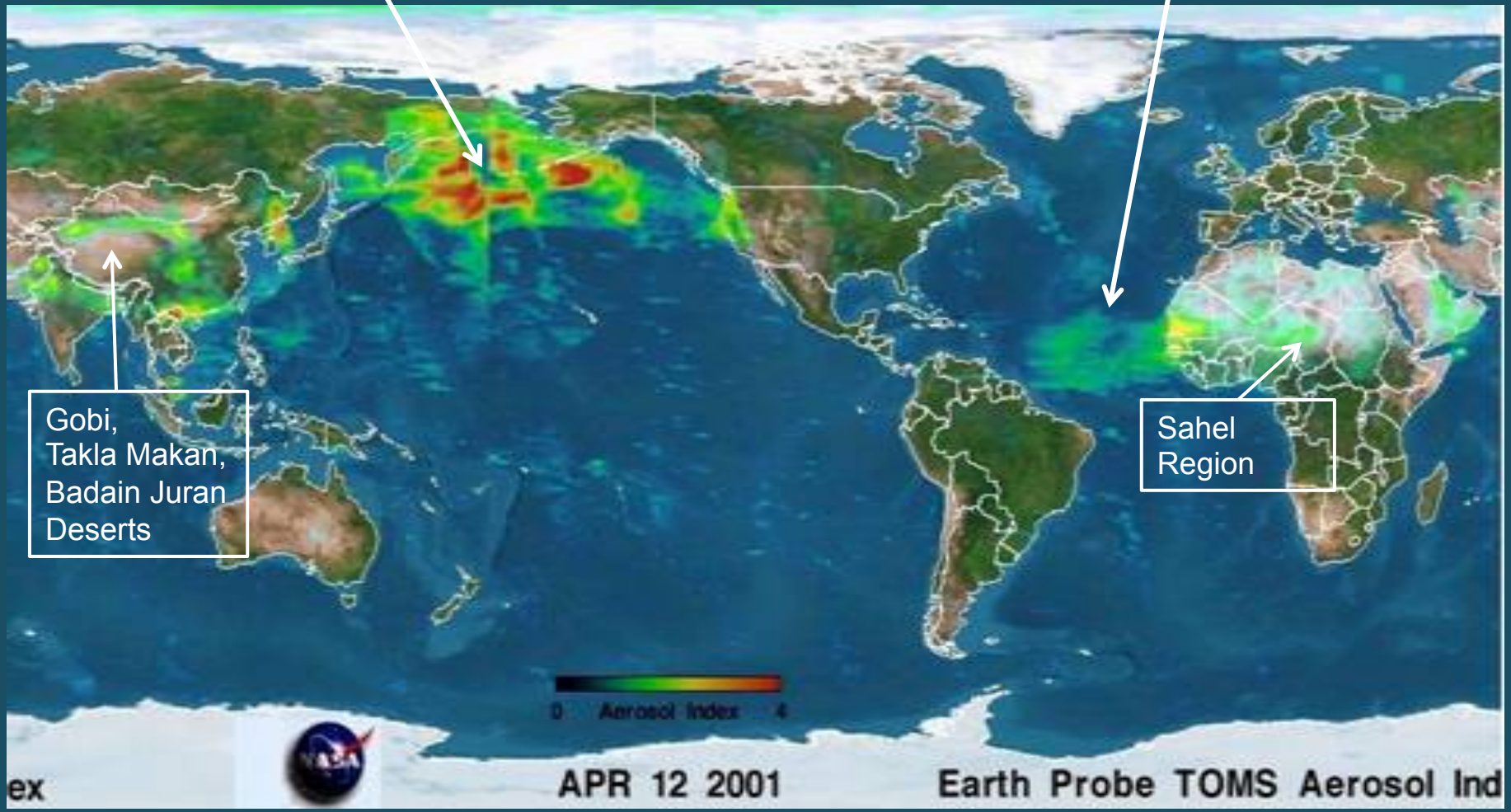


- Pressure: down to 0.1 mb
- Temp: -100 to +160 C (programmable)
- Gases: CO_2; O_2/N_2; Mars mix (top 5 gases)
- UV-VIS-NIR: equatorial to polar fluence rates
- Dust loading from *tau* 0.1 to 3.5

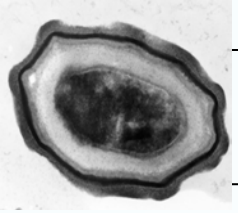
Global Dust Circulation Patterns

Asian Peak = Feb. to April
56 Mt/yr reaches USA

African Peak = Aug. & Sept.
50 Mt/yr hits Florida



DART = Dust at Altitude Recovery Technology



Bacillus subtilis Molecular Biology

Wayne Nicholson; WLN@ufl.edu

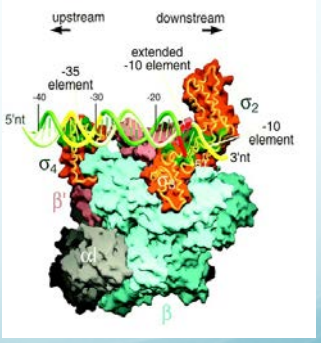
- Astrobiology
  - Interplanetary transport of spores
  - Survival/growth/evolution in space, on Mars
  - Planetary Protection

Microbiology of the human spaceflight environment

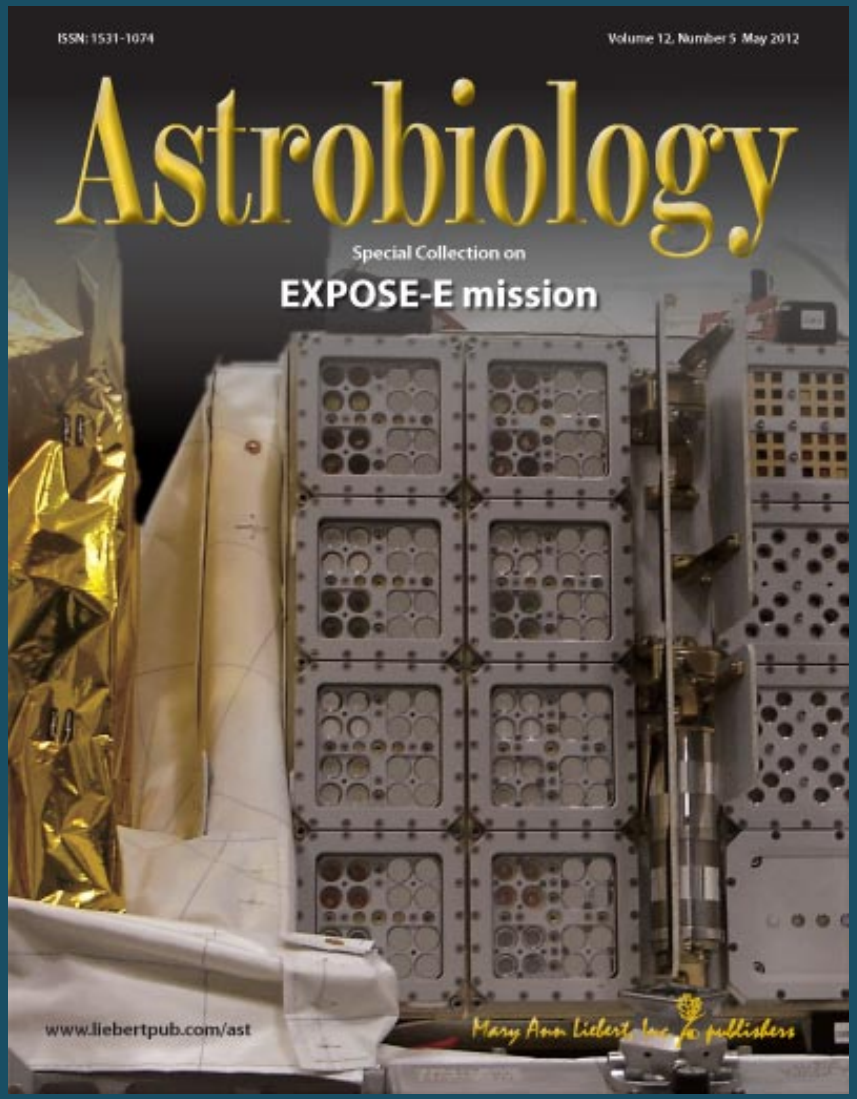
Mutations to multiple antibiotic resistance on ISS

Bacterial stress responses to the spaceflight environment

- RNA Polymerase Structure/Function
  - Rifampicin resistance mutations in *rpoB*
  - Global phenotype/transcriptome alterations



Dr. Wayne Nicholson



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Resistance of Bacterial Endospores to Outer Space for Planetary Protection Purposes—Experiment PROTECT of the EXPOSE-E Mission

Gerda Horneck,[1] Ralf Moeller,[1] Jean Cadet,[2] Thierry Douki,[2] Rocco L. Mancinelli,[3] Wayne L. Nicholson,[4] Corinna Panitz,[5] Elke Rabbow,[1] Petra Rettberg,[1] Andrew Spry,[6] Erko Stackebrandt,[7] Parag Vaishampayan,[8] and Kasthuri J. Venkateswaran[8]

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DOI: 10.1089/ast.2011.0739

Mutagenesis in Bacterial Spores Exposed to Space and Simulated Martian Conditions: Data from the EXPOSE-E Spaceflight Experiment PROTECT

Ralf Moeller,[1] Günther Reitz,[1] Wayne L. Nicholson,[2] the PROTECT Team, and Gerda Horneck[1]

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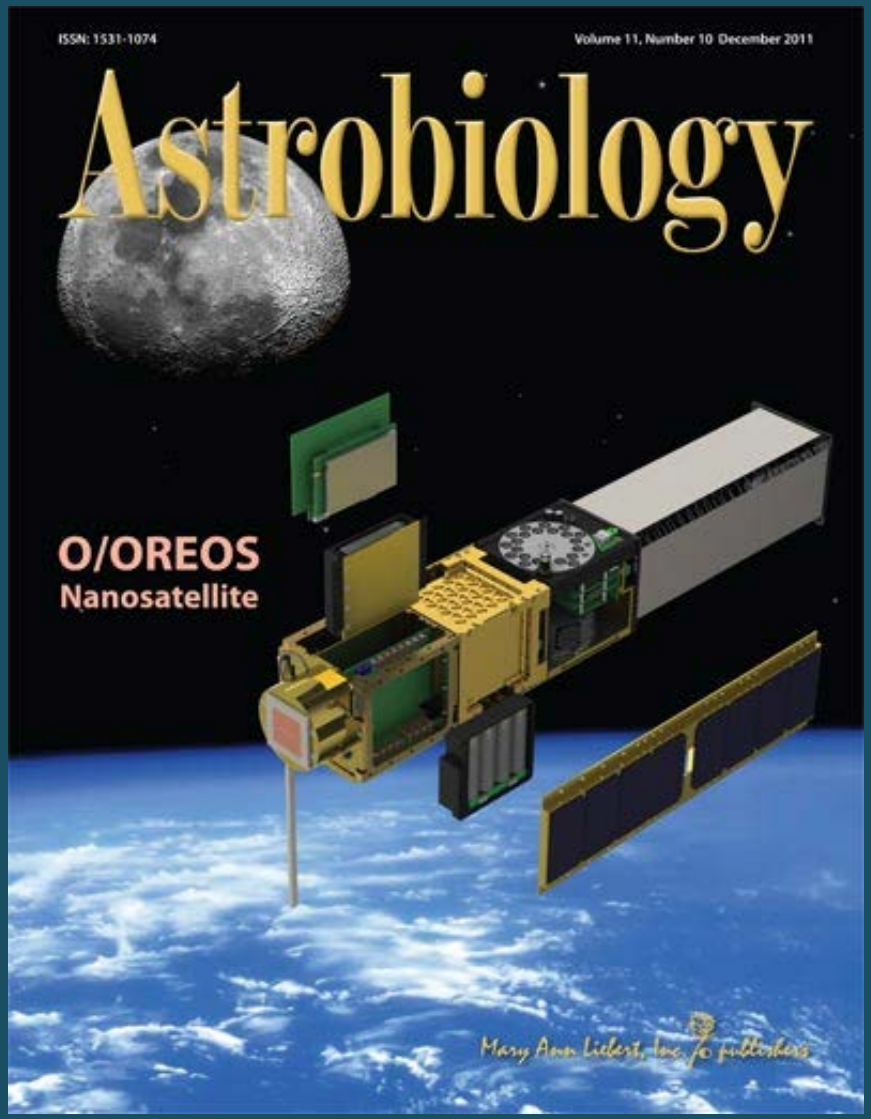
Transcriptomic Responses of Germinating *Bacillus subtilis* Spores Exposed to 1.5 Years of Space and Simulated Martian Conditions on the EXPOSE-E Experiment PROTECT

Wayne L. Nicholson,[1] Ralf Moeller,[2] the PROTECT Team, and Gerda Horneck[2]

Dr. Wayne Nicholson



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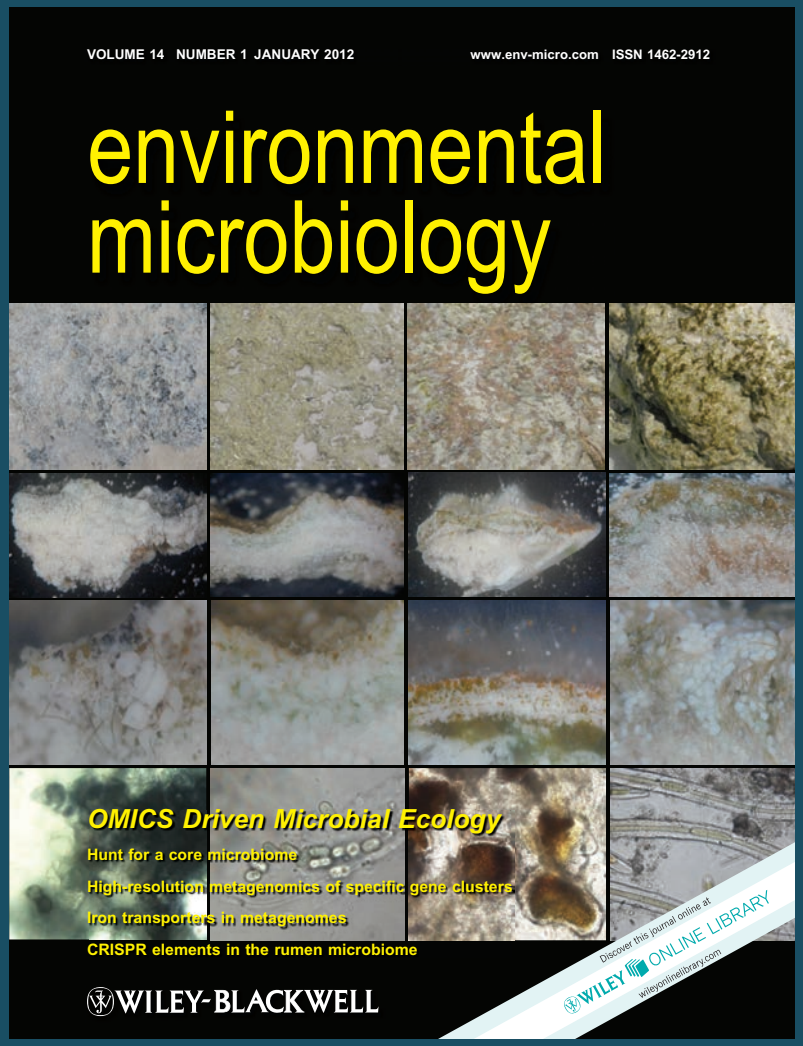
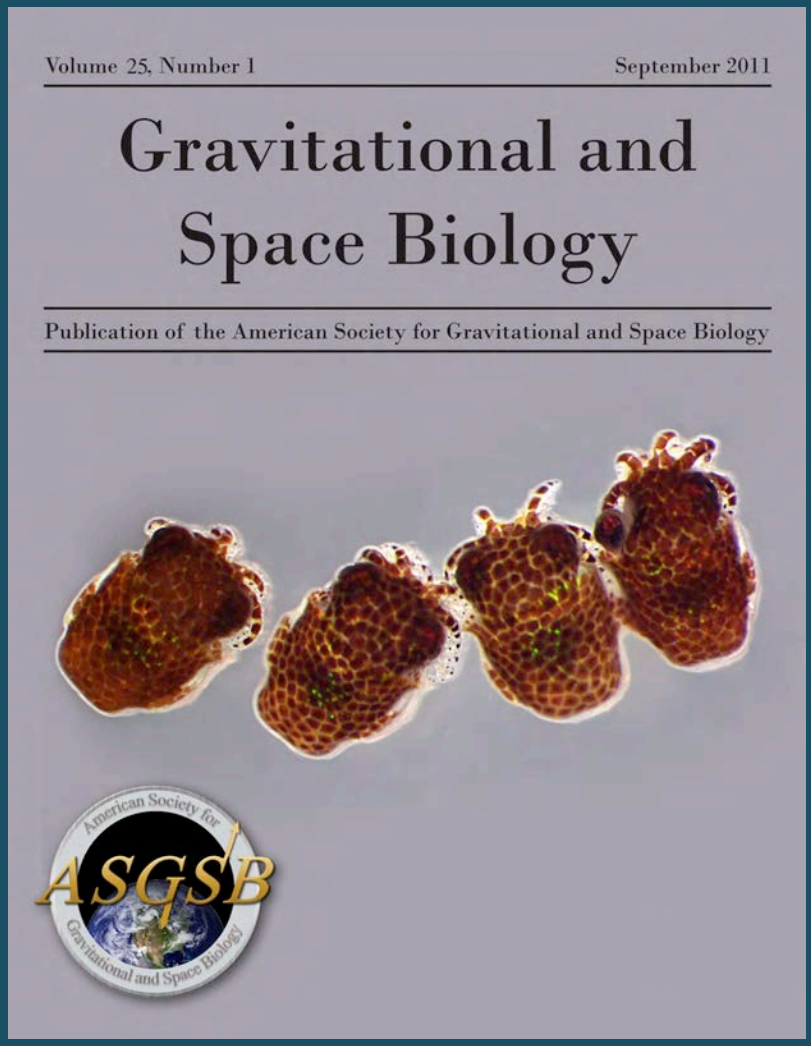
The O/OREOS Mission: First Science Data from the Space Environment Survivability of Living Organisms (SESLO) Payload

Wayne L. Nicholson,[1] Antonio J. Ricco,[2] Elwood Agasid,[2] Christopher Beasley,[2] Millan Diaz-Aguado,[2] Pascale Ehrenfreund,[3] Charles Friedericks,[2] Shakib Ghassemieh,[2] Michael Henschke,[2] John W. Hines,[2] Christopher Kitts,[4] Ed Luzzi,[2] Diana Ly,[2] Nghia Mai,[2] Rocco Mancinelli,[4] Michael McIntyre,[2] Giovanni Minelli,[2] Michael Neumann,[5] Macarena Parra,[2] Matthew Piccini,[2] R. Mike Rasay,[5] Robert Ricks,[2] Orlando Santos,[2] Aaron Schooley,[2] David Squires,[2] Linda Timucin,[2] Bruce Yost,[2] and Anthony Young[5]

Jamie Foster
Department of Microbiology and Cell Science



Modern Microbialites



Microgravity & host-microbe interactions

What are microbialites?

Microbialites are organosedimentary structures predominantly accreted by sediment trapping, binding, and/or in situ precipitation as a result of the growth and metabolic activity of microorganisms

STROMATOLITES

Laminated internal organization

THROMBOLITES

Clotted internal organization

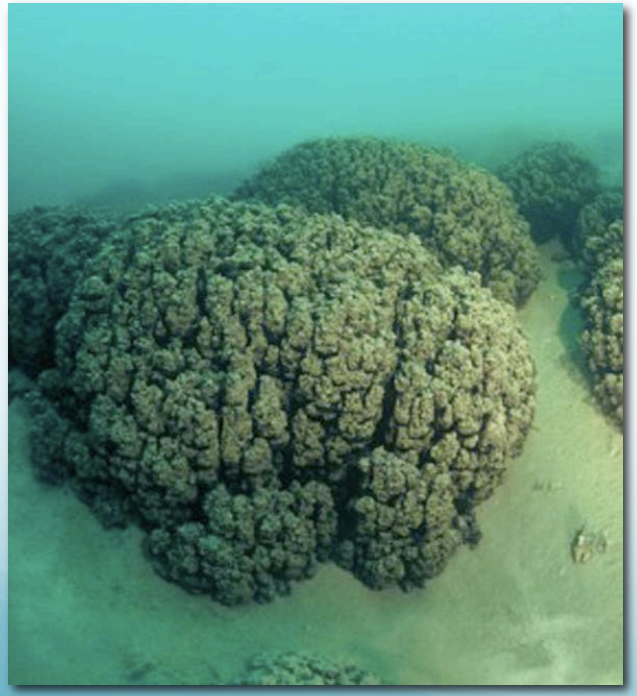
ONCOLITES

Concentrically laminated internal organization

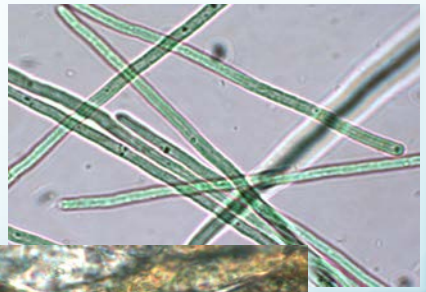
Microbialites are found in across the globe in hypersaline and highly erosive marine settings, in marine waters and in a variety of freshwater systems, ranging from hot springs to lakes with high levels of dissolved salts

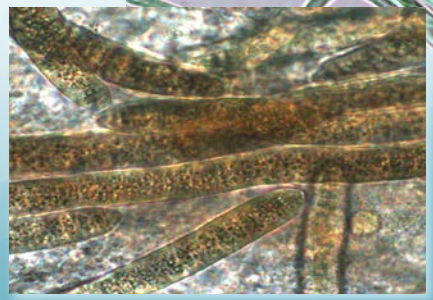
Why are modern microbialites important ecosystems to study?

- Sequesters carbon as $CaCO_3$ microstructures in marine and freshwater ecosystems; insight into the effects of climate change on carbonate precipitation



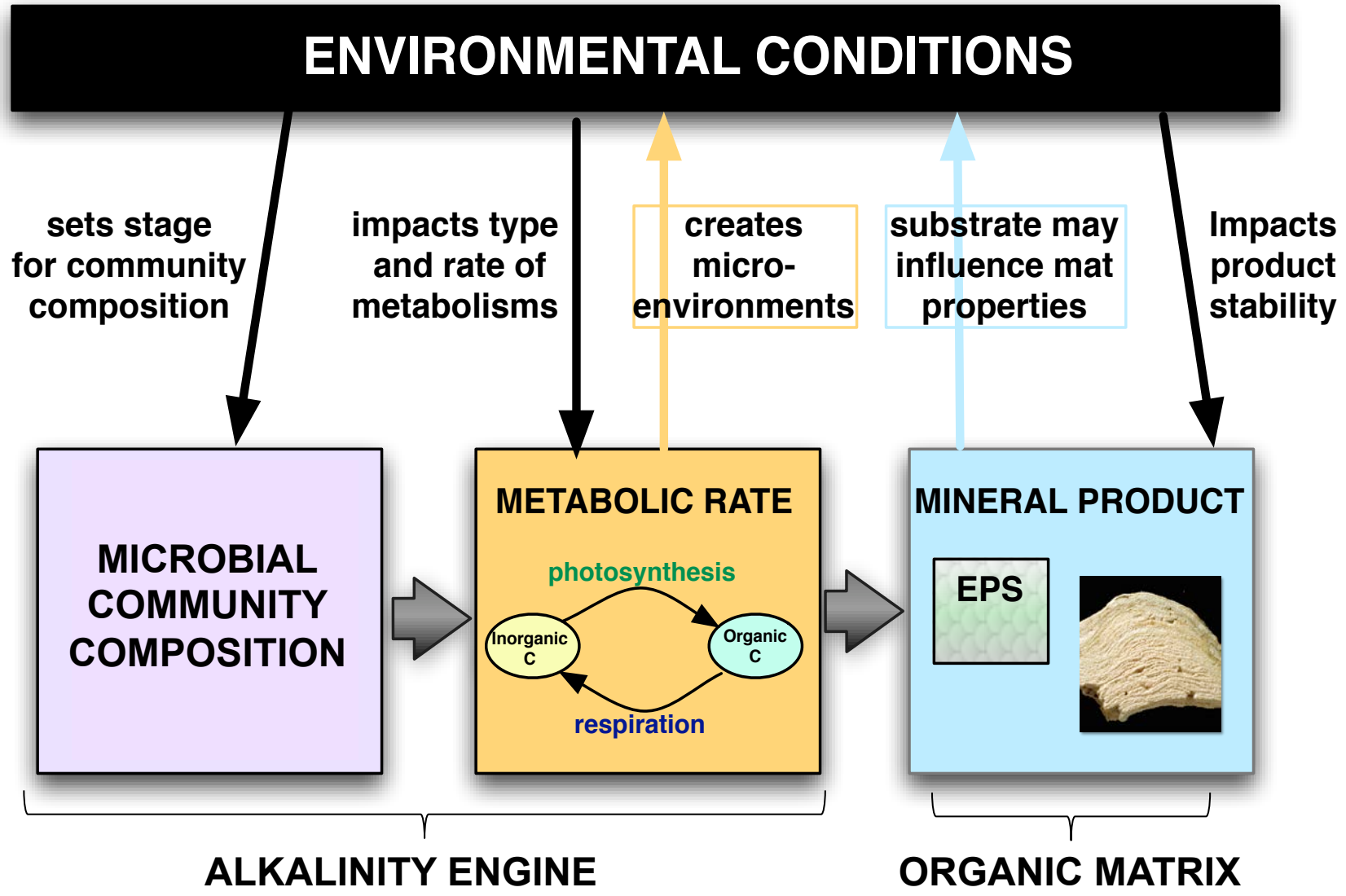
- Dominated by cyanobacteria which are often tolerant to environmental stress and change





- detection of biosignatures

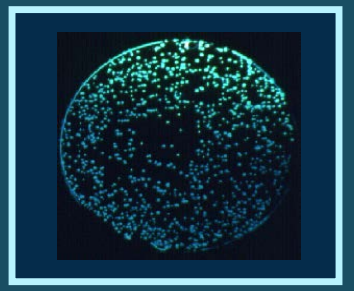
Microbes, Metabolisms and Minerals: How do they fit together?



Modified from Dupraz et al., 2009

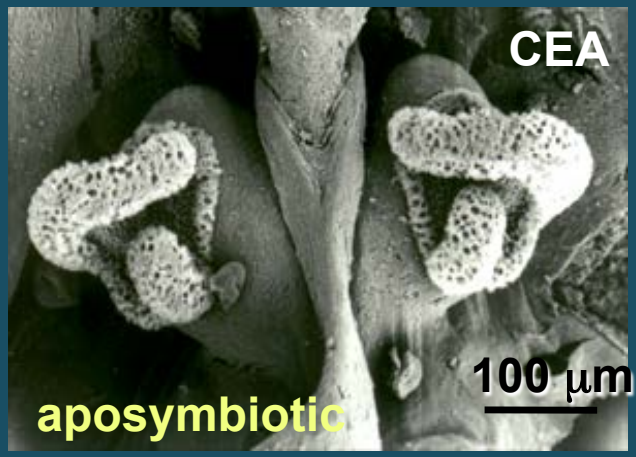
Effects of Microgravity on animal-microbe interactions

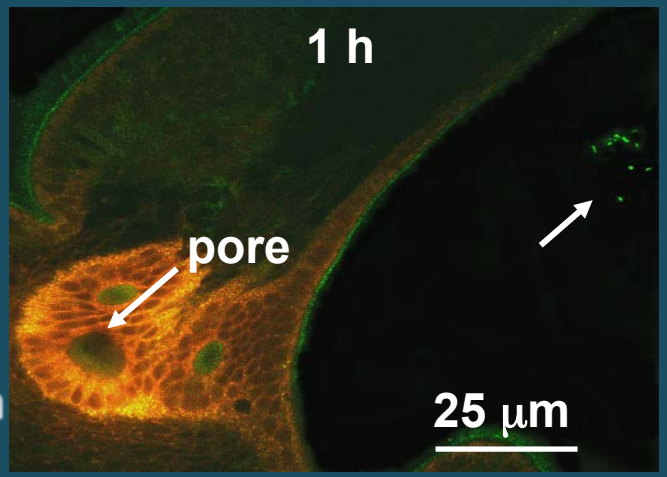
Euprymna scolopes

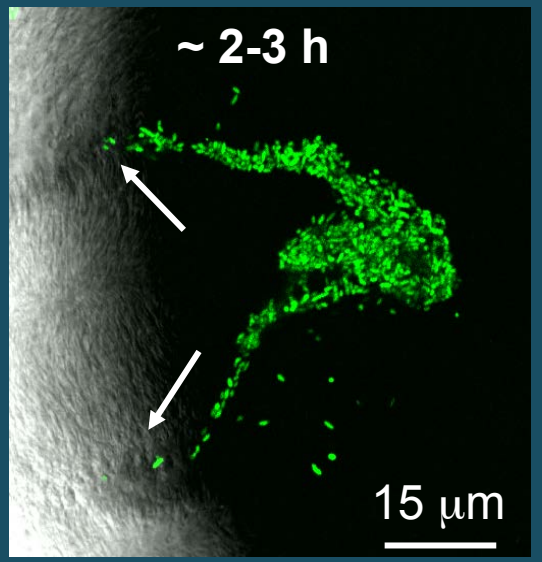


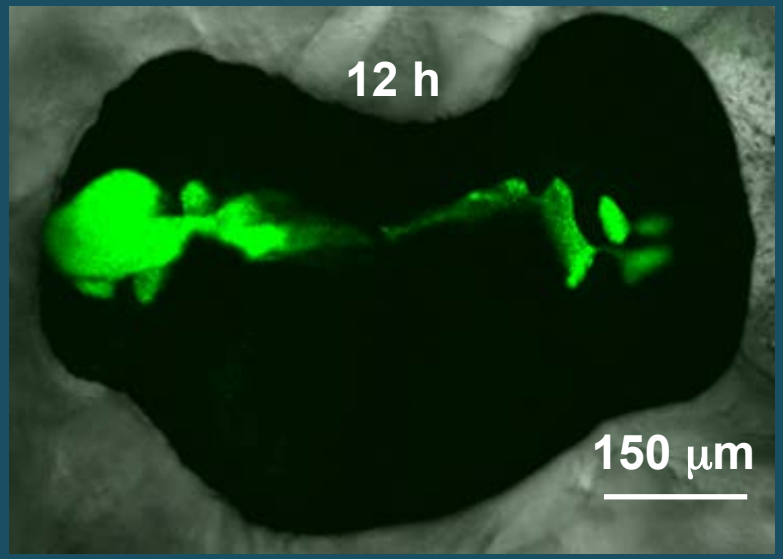
Vibrio fischeri

Ciliated Epithelial Appendages (CEA)









Bacteria undergo quorum sensing once inside light organ and become luminescent

Colonization occurs within 12 h

12 h threshold time window

Long-term Goals of Research

Goal 1. Assess the impact of microgravity on beneficial bacteria associated with the normal development of animal tissues

Are there changes in animal development?

Do “good” bacteria go “bad”?

Goal 2. By removing gravity as a constant, are there new insights into the animal-bacterial interactions?

Does gravity obscure aspects of symbiosis and animal development?

Funding Sources

Florida Space Grant Consortium

NASA Astrobiology
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NASA Planetary Protection
NASA Mars Fundamental Research
NASA Graduate Student Research Program
NASA Earth Space Science Fellowship

IFAS
Emerging Pathogen Institute