

# GeneLab: “Omics” Data Systems for Space Biology Research

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<http://genelab.nasa.gov>





# Agenda



**I. Introduction**

**II. GeneLab Motivation**

**III. GeneLab Data Systems**

**IV. Summary**



# What is GeneLab?

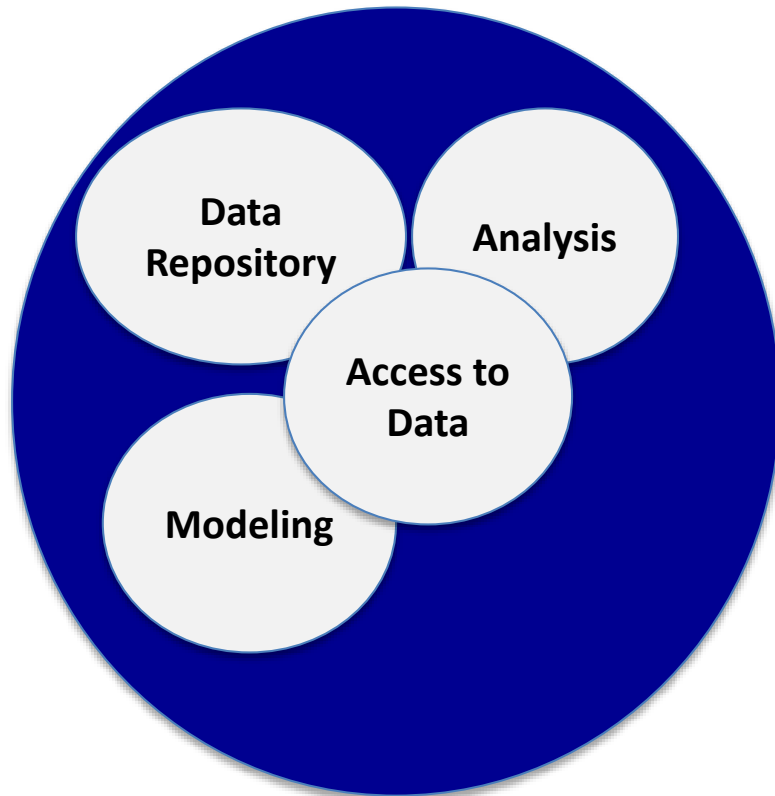
- new *systems approach* to space biology research
- open science and open data platform



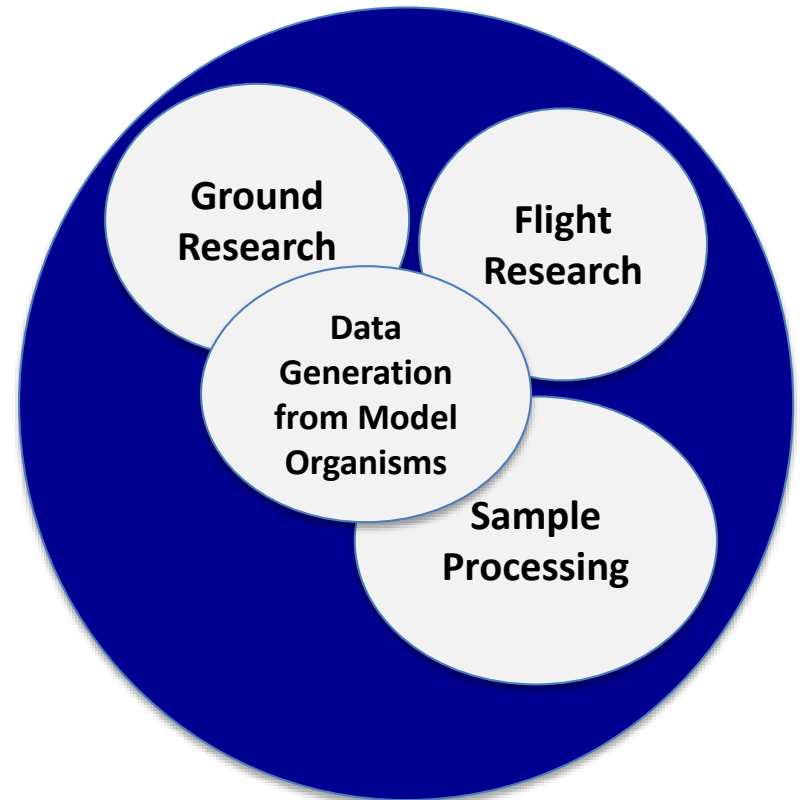
# GeneLab Structure



## Data Systems & Repository



## Research & Development





# GeneLab Motivations



# ISS Based Research



- New technologies to produce high quality Omics data from research missions aboard the ISS
- Limited access and high demand for the ISS platform
- Facilitate Systems biology to predict and/or mitigate changes due to microgravity



NASA astronaut Barry "Butch" Wilmore setting up the Rodent Research-1 Hardware in the Microgravity Science Glovebox aboard the International Space Station



# GeneLab Motivations



- **Maximize ROI for ISS Utilization**
- **Create a PI Multiplier Effect**
- **Leverage NASA and External Partner Strengths**
- **Maximize Utilization of Cutting Edge Bioanalytical Tools and Techniques**
- **Speed the Pathway to Translation**



# GeneLab Goals

1. Develop an integrated repository and bioinformatics data system
2. Enable the discovery and validation of molecular networks using next-generation omics technologies.
3. Engage the broadest possible community
4. Strengthen international partnerships





# Concept of Operations



## Experiment on ISS

Crew performs experimental protocol and harvests tissues.



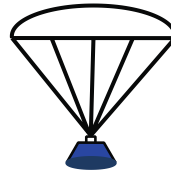
## Launch

Experiment is prepared and launched according to approved NRA.



## Return to Earth

Material sent back to earth for processing in investigators lab. Controls (ground and/or flight) processed at the same time.



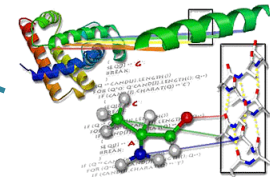
## Process Samples

Extracted DNA, RNA and/or protein sent to validated omics center to generate sequence, transcript or protein expression data.



## Data Sharing

Data shared with larger scientific community. Results feedback to GeneLab and other databases accelerating scientific discovery by leveraging a bigger community.



## Data Collection & Hosting

Data returned to investigator or GeneLab for analysis. Raw data uploaded into GeneLab database for public viewing.

## Next Generation Research

Iterative research solicitations for experiments utilizing GeneLab data for ground validation and next generation flight research.

## GeneLab Data Systems

## Modeling and Validation

Computational modeling and wet lab validation.



# Mission Types



Mission	Type	Definition	Example
<b>Dedicated</b>	<b>Reference Data</b>	Mission is entirely dedicated to GeneLab objectives; the Science Definition Team (SDT) defines the experiment and requirements; SDT is selected through the NASA Research Announcement process	TBD
<b>Collaborative</b>	<b>Data &amp; Sample Sharing</b>	GeneLab obtains specimens/samples from the existing PI space flight and ground control experiment	Rodent Research (Mouse)
	<b>Data &amp; Sample Augmentation</b>	GeneLab provides supplemental funding to a PI experiment to increase the quantity of specimens and perform processing to obtain dedicated sample; augmentation requires NASA SLPS experiment review approval process	BRIC-19 (plant), BRIC-20 (plant)  (BRIC=Biological Research in Canisters)
<b>Individual</b>	<b>PI Mission</b>	Funded and planned PI experiments	Data Submission



# Current Collaborative Missions



Year	Payload	Mission Type
2015	<b>BRIC-19</b> Dr. Simon Gilroy University of Wisconsin-Madison Space Biology NRA Award	<b>Augmentation, Plant</b>
	<b>BRIC-20</b> Dr. Sarah Wyatt Ohio University Space Biology NRA Award	<b>Augmentation, Plant</b>
	<b>RR-1</b> Dr. Ruth Globus NASA Validation Mission for Rodent Habitat	<b>Sample Sharing, Rodent</b>

(RR: Rodent Research ; BRIC: Biological Research In Canisters)



# GeneLab Data Systems



# GeneLab Phased Data Implementation



## Overview 2014-2021

Begin Implementation

**We Are Here**

Full Implementation

1.0

### Phase 1

Searchable Data  
FY2014 – 2015

### Phase 2

Data Acquisition  
FY2015-2016

### Phase 3

System Integration  
FY2017 – 2018

### Phase 4

Implementation  
FY2019 – 2021

#### GLDS

- Public website
- Searchable data repository

#### Science

- Pre-Flight validation, rodent proteomic profiling
- Collaborate with two flight experiments

#### GLDS

- Link to public databases

#### Science

- Data analysis from initial ground and flight studies

#### GLDS

- Integrated Platform

#### Science

- Outreach
- Dedicated flight experiments

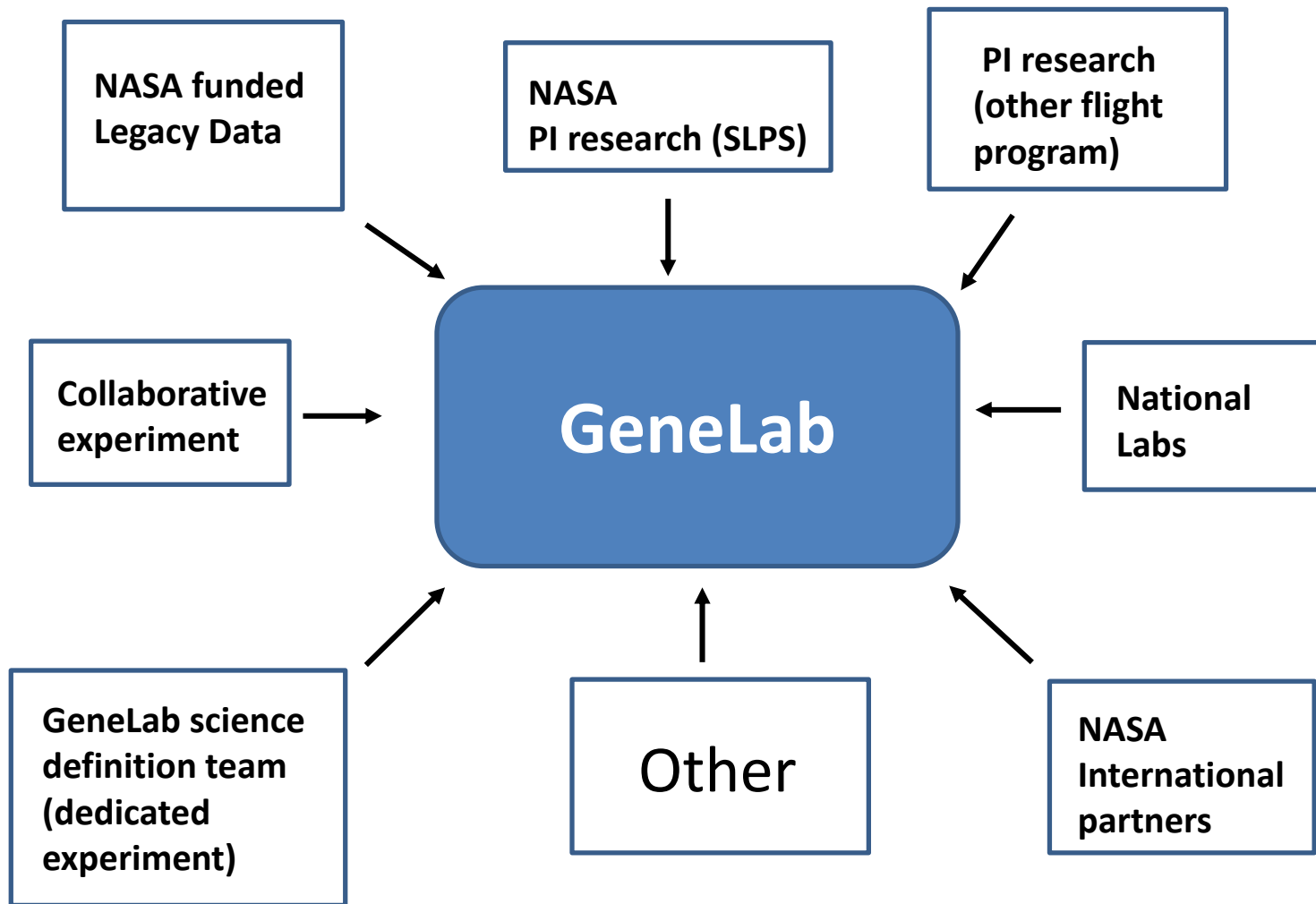
- Community engagement

- Development of analytical and modeling tools

- Ongoing dedicated flight experiments



# Anticipated Sources of Data

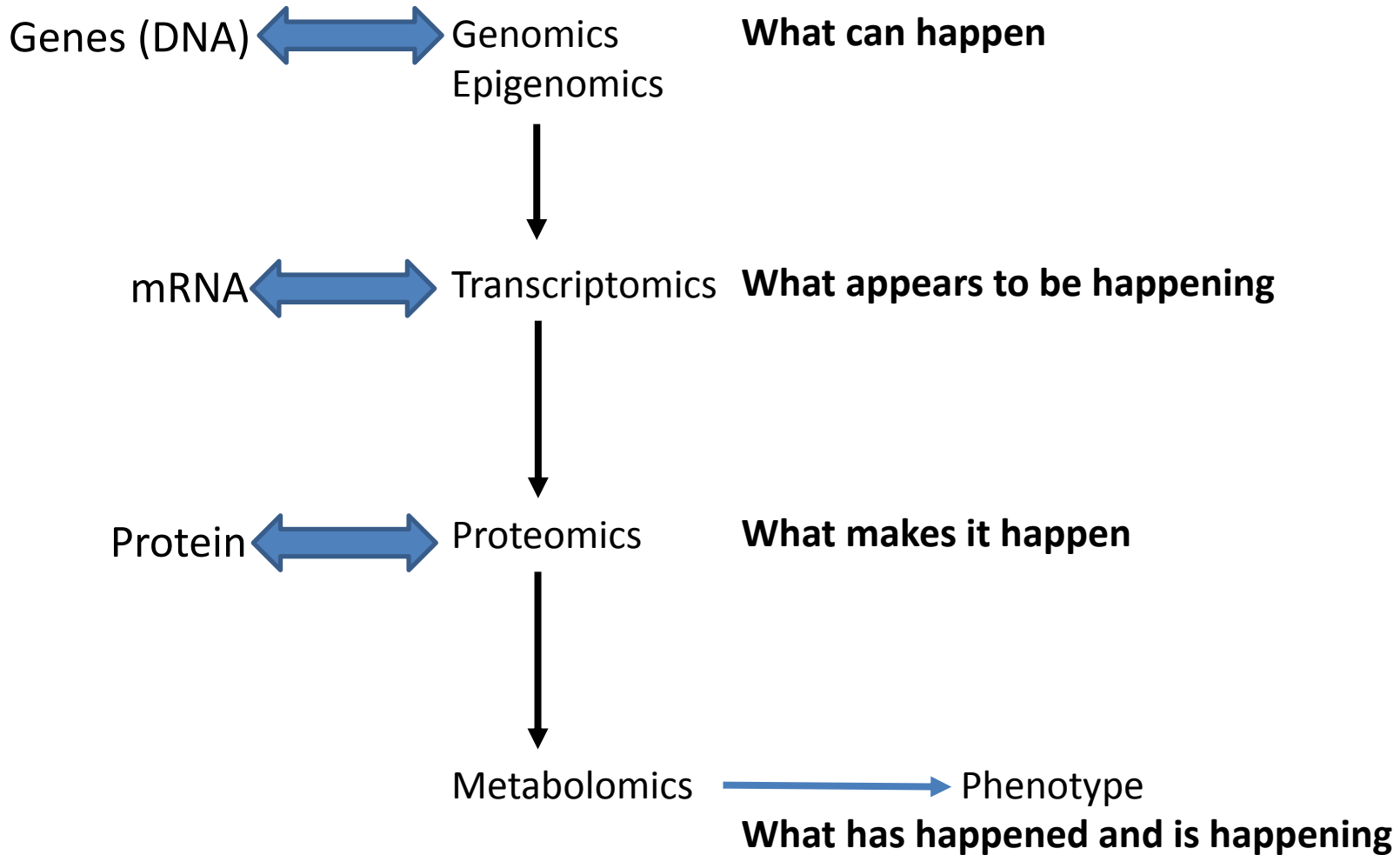




# Types of Analyses

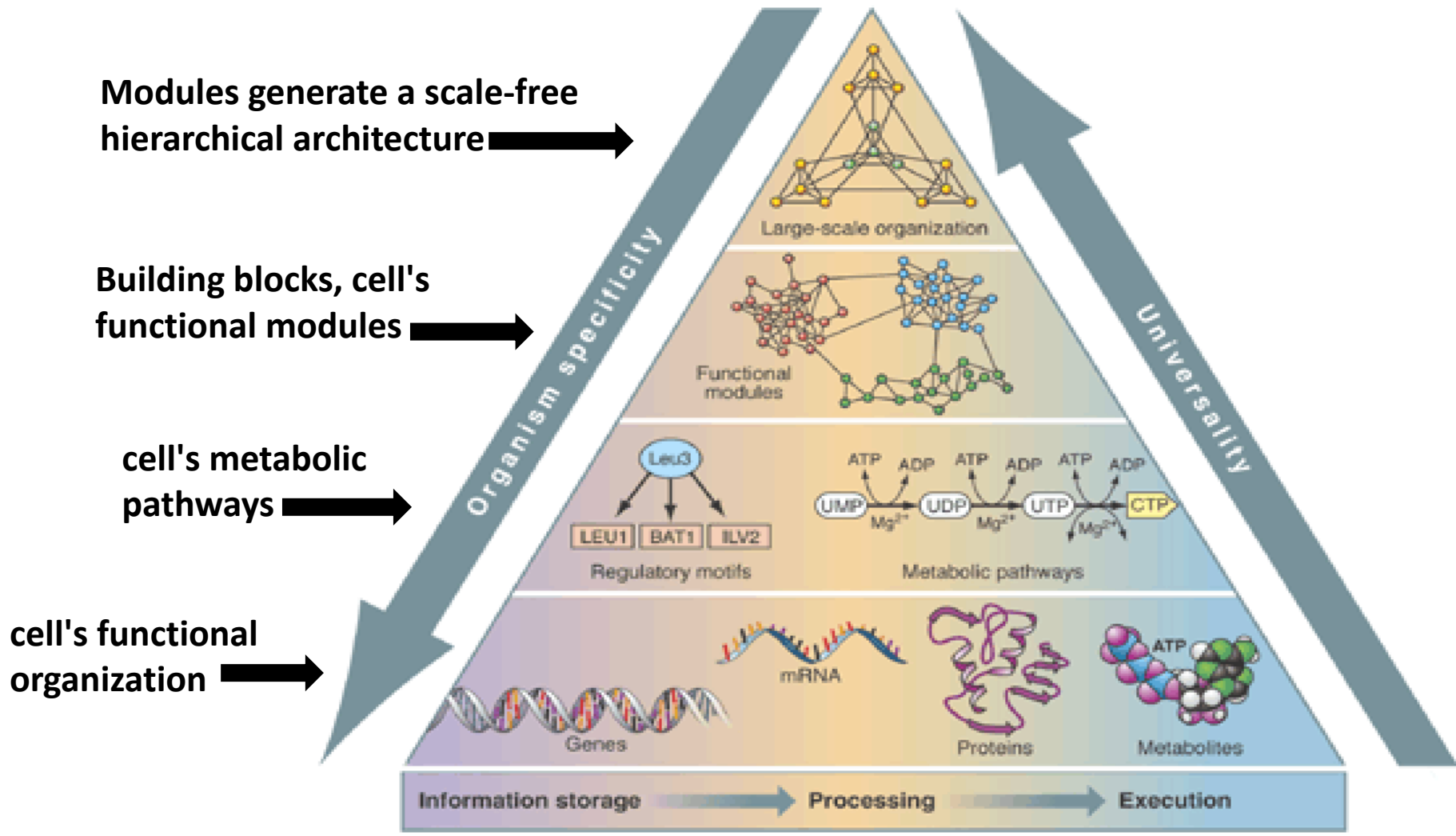
## Building Blocks of life

## Functional States





# Systems Biology



(from Oltvai-Barabasi, Science, Oct 02)





# GeneLab Data Systems v1.0

<http://genelab.nasa.gov/data>



- Omics Data Repository (22 dataset online)
- Basic study metadata search

GeneLab Open Science for Exploration

Home Data Submit Data Contact Us Search Data

All Studies page 1 of 1

**Effects of spaceflight on murine skeletal muscle gene expression**

Organisms	Factors	Assay Types	Release Date	Description
Mus musculus	Gravity	transcription profiling	Dec-28-2008	Spaceflight results in a number of adaptations to skeletal muscle, including atrophy and shifts towards faster muscle fiber types. To identify changes in gene expression that may underlie these adaptations, microarray expression analysis wa...

**Root transcriptome remodeling of Arabidopsis in response to high levels of magnesium sulfate**

Organisms	Factors	Assay Types	Release Date	Description
Arabidopsis thaliana	treatment time genotype treatment	transcription profiling	Sep-17-2010	Martian regolith (unconsolidated surface material) is a potential medium for plant growth in bioregenerative life support systems during manned missions on Mars. However, hydrated magnesium sulfate mineral levels in the regolith of Mars can...

**Candida albicans response to spaceflight (NASA STS-115)**

Organisms	Factors	Assay Types	Release Date	Description
Candida albicans	growth condition	transcription profiling	Nov-01-2013	This study presents the first global transcriptional profiling and phenotypic characterization of the major human opportunistic fungal pathogen, <i>Candida albicans</i> , grown in spaceflight conditions. Microarray analysis revealed that <i>C. albican</i> ...

**Transcription profiling of rat to study the effect of hindlimb unloading on healing of medial collateral ligaments 3 weeks after injury**

Organisms	Factors	Assay Types	Release Date	Description
Rattus norvegicus	protocol type clinical treatment	transcription profiling	Mar-10-2004	A recent physiological study established that hindlimb unloading of rats at 3 and 7 weeks inhibits healing of injured ligaments, resulting in a badly aligned, discontinuous collagen matrix. Using tissue from these rats, we focused on the 3...

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2 search results for "PAO1"

**Response of Pseudomonas aeruginosa PAO1 to low shear modeled microgravity**

Organisms	Factors	Assay Types	Release Date	Description
Pseudomonas aeruginosa	culture	transcription profiling	Jul-29-2010	Anticipating the risk for infectious disease during space exploration and habitation is a critical factor to ensure safety, health and performance of the crewmembers. As a ubiquitous environmental organism that is occasionally part of the h...

**Transcriptional and proteomic response of Pseudomonas aeruginosa PAO1 to spaceflight conditions involves Hfq regulation and reveals a role for oxygen**

Organisms	Factors	Assay Types	Release Date	Description
Pseudomonas aeruginosa PAO1	culture	transcription profiling	Jun-28-2011	Characterization of bacterial behavior in the microgravity environment of spaceflight is of importance towards risk assessment and prevention of infectious disease during long-term missions. Further, this research field unveils new insights...



# GeneLab Data Systems v1.0

<http://genelab.nasa.gov/data>




- Omics Data Repository
- Basic study metadata search
- Study metadata display

**GeneLab** Home Data Submit Data Contact Us Search Data

Open Science for Exploration

**Transcriptional and proteomic response of *Pseudomonas aeruginosa* PAO1 to spaceflight conditions involves Hfq regulation and reveals a role for oxygen**

 **2 Datasets available:**  
 Microarray Data Files  
 ISA-TAB Metadata file

<b>GeneLab Accession Number</b>	GLDS-15																																																
<b>Source Accession Number</b>	<a href="#">E-GEOD-22684</a>																																																
<b>Contacts</b>	<table border="1"> <thead> <tr> <th>Name</th> <th>Role</th> <th>Organization</th> <th>Email</th> </tr> </thead> <tbody> <tr> <td>Pieter Monsieus</td> <td>submitter</td> <td></td> <td></td> </tr> <tr> <td>Aur�lie Crabb�</td> <td></td> <td></td> <td></td> </tr> <tr> <td>Michael Schurr</td> <td></td> <td></td> <td></td> </tr> <tr> <td>Pieter Monsieus</td> <td></td> <td></td> <td></td> </tr> <tr> <td>Lisa Morici</td> <td></td> <td></td> <td></td> </tr> <tr> <td>Jill Schurr</td> <td></td> <td></td> <td></td> </tr> <tr> <td>James Wilson</td> <td></td> <td></td> <td></td> </tr> <tr> <td>Mark Ott</td> <td></td> <td></td> <td></td> </tr> <tr> <td>George Tsapralis</td> <td></td> <td></td> <td></td> </tr> <tr> <td>Heidi Stefanyshyn-Piper</td> <td></td> <td></td> <td></td> </tr> <tr> <td>Cheryl Nickerson</td> <td></td> <td></td> <td></td> </tr> </tbody> </table>	Name	Role	Organization	Email	Pieter Monsieus	submitter			Aur�lie Crabb�				Michael Schurr				Pieter Monsieus				Lisa Morici				Jill Schurr				James Wilson				Mark Ott				George Tsapralis				Heidi Stefanyshyn-Piper				Cheryl Nickerson			
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<b>Organisms</b>	<a href="#">Pseudomonas aeruginosa PAO1</a>		
<b>Study Design Factor(s)</b>	<b>Factor</b> culture	<b>Ontology: Concept</b> <a href="#">cell culture</a>	
<b>Assay(s)</b>	<b>Assay Type</b> <a href="#">transcription profiling</a>	<b>Device Type</b> <a href="#">DNA microarray</a>	<b>Device Platform</b>
<b>Project</b>	<b>Project Identifier</b>	Microbe	
	<b>Project Link</b>	<a href="http://sda.jsc.nasa.gov/scripts/experiment/exper.aspx?exp_index=1329">http://sda.jsc.nasa.gov/scripts/experiment/exper.aspx?exp_index=1329</a>	
	<b>Project Type</b>	Flight	
	<b>Flight Program</b>	Space Shuttle	
	<b>Experiment Platform</b>	Shuttle Life Sciences Research (Middeck), Group Activation Packs (GAPS)	
	<b>Space Program</b>	NASA	
	<b>Managing NASA Center</b>	Ames Research Center (ARC)	
	<b>Mission Name</b>	<b>Start Date</b>	<b>End Date</b>
	STS-115	Sep-09-2006	Sep-21-2006
			<a href="http://sda.jsc.nasa.gov/scripts/mission/miss.aspx?mis_index=198">http://sda.jsc.nasa.gov/scripts/mission/miss.aspx?mis_index=198</a>
<b>Publications</b>	Crabb� A, Schurr MJ, Monsieus P, Morici L, Schurr J, Wilson JW, Ott CM, Tsapralis G, Pierson DL, Stefanyshyn-Piper H, Nickerson CA, Transcriptional and proteomic responses of <i>Pseudomonas aeruginosa</i> PAO1 to spaceflight conditions involve Hfq regulation and reveal a role for oxygen, PubMed ID 21169425, DOI 21169425		

<http://genelab.nasa.gov>



# GeneLab Data Systems v1.0

<http://genelab.nasa.gov/data>



- Omics Data Repository
- Basic study metadata search
- Study metadata display
- **Data retrieval**

[DEMO](#)

**GeneLab**  
Open Science  
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**Datasets for Study: [Transcriptional and proteomic response of Pseudomonas aerugi...](#)**

**Microarray Data Files**  
Microarray Data Files Compressed collection of raw or processed data files associated with this study. Formats are platform specific. Please view the associated ISA-TAB metadata files to get formatting details.

File Download Links:  
[GLDS-15\\_microarray\\_E-GEOD-22684.raw.1.zip](#) ( 5733111 bytes )

**ISA-TAB Metadata file**  
ISA-TAB Metadata file ISA-TAB is the metadata collection format utilized by GeneLab. Further description and tools can be found at [www.isa-tools.org](http://www.isa-tools.org)

File Download Links:  
[GLDS-15\\_metadata\\_E-GEOD-22684.zip](#) ( 8177 bytes )



# Summary



- GeneLab will serve as an open access database containing “Omic” datasets for model organisms relevant to spaceflight, allowing cross-species comparison
- Will provide a tool for basic research to translate into discovery utilizing ISS research



# Call to Action

- **Visit** the gene lab site: <http://genelab.nasa.gov>
- **Sign up** for the gene lab mailing list  
at: <http://genelab.nasa.gov/community.html>
- **Share/Submit** your data sets:  
<http://genelab.nasa.gov/data/>



# Acknowledgements



## **Ames GeneLab Team**

Richard S. Thompson

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Yung Nguyen

Oana Marcu

## **Ames Rodent Research**

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## **University of Wisconsin-Madison**

Simon Gilroy