GeneLab: "Oomics" Data Systems for Space Biology Research

Kaushik Chakravarty, Terri G. Thompson, Daniel C. Berrios, Jon C. Rask, Homer W. Fogle, San-Huei Lai, Rick Chen, Christopher K. Middour, Jon D. Welch, Joseph C. Coughlan

http://genelab.nasa.gov
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
- Data Repository
- Analysis
- Access to Data
- Modeling

Research & Development
- Ground Research
- Flight Research
- Data Generation from Model Organisms
- Sample Processing

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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

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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

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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

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The Concept of Operations for GeneLab includes the following steps:

1. **Launch**: Experiment is prepared and launched according to approved NRA.
2. **Experiment on ISS**: Crew performs experimental protocol and harvests tissues.
3. **Return to Earth**: Material sent back to earth for processing in investigators lab. Controls (ground and/or flight) processed at the same time.
4. **Process Samples**: Extracted DNA, RNA and/or protein sent to validated omics center to generate sequence, transcript or protein expression data.
5. **Data Collection & Hosting**: Data returned to investigator or GeneLab for analysis. Raw data uploaded into GeneLab database for public viewing.
6. **Data Sharing**: Data shared with larger scientific community. Results feedback to GeneLab and other databases accelerating scientific discovery by leveraging a bigger community.
7. **GeneLab Data Systems**: Iterative research solicitations for experiments utilizing GeneLab data for ground validation and next generation flight research.
8. **Modeling and Validation**: Computational modeling and wet lab validation.
9. **Next Generation Research**: GeneLab Data Systems

GeneLab Data Systems

Data Collection & Hosting

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

Data Sharing

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

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.

Return to Earth

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Process Samples

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

Launch

Experiment is prepared and launched according to approved NRA.

Experiment on ISS

Crew performs experimental protocol and harvests tissues.

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## Mission Types

<table>
<thead>
<tr>
<th>Mission</th>
<th>Type</th>
<th>Definition</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dedicated</strong></td>
<td><strong>Reference Data</strong></td>
<td>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</td>
<td>TBD</td>
</tr>
<tr>
<td><strong>Collaborative</strong></td>
<td><strong>Data &amp; Sample Sharing</strong></td>
<td>GeneLab obtains specimens/samples from the existing PI space flight and ground control experiment</td>
<td>Rodent Research (Mouse)</td>
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<tr>
<td></td>
<td><strong>Data &amp; Sample Augmentation</strong></td>
<td>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</td>
<td>BRIC-19 (plant), BRIC-20 (plant) (BRIC=Biological Research in Canisters)</td>
</tr>
<tr>
<td><strong>Individual</strong></td>
<td><strong>PI Mission</strong></td>
<td>Funded and planned PI experiments</td>
<td>Data Submission</td>
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### Current Collaborative Missions

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

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

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GeneLab Data Systems
Overview 2014-2021

Phase 1
Searchable Data
FY2014 – 2015

GLDS
- Public website
- Searchable data repository

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

Phase 2
Data Acquisition
FY2015-2016

GLDS
- Link to public databases

Science
- Data analysis from initial ground and flight studies

Phase 3
System Integration
FY2017 – 2018

GLDS
- Integrated Platform

Science
- Outreach
- Dedicated flight experiments

Phase 4
Implementation
FY2019 – 2021

- Community engagement
- Development of analytical and modeling tools
- Ongoing dedicated flight experiments

We Are Here
Anticipated Sources of Data

GeneLab

- NASA funded Legacy Data
- NASA PI research (SLPS)
- PI research (other flight program)
- Collaborative experiment
- GeneLab science definition team (dedicated experiment)
- Other
- National Labs
- NASA International partners

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Types of Analyses

Building Blocks of life

Genes (DNA) ↔ Genomics
↔ Epigenomics

Functional States

What can happen

mRNA ↔ Transcriptomics

What appears to be happening

Protein ↔ Proteomics

What makes it happen

Metabolomics → Phenotype

What has happened and is happening

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Systems Biology

- Modules generate a scale-free hierarchical architecture
- Building blocks, cell's functional modules
- Cell's metabolic pathways
- Cell's functional organization

(from Oltvai-Barabasi, Science, Oct 02)

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- Omics Data Repository (22 dataset online)
- Basic study metadata search
GeneLab Data Systems v1.0
http://genelab.nasa.gov/data

- Omics Data Repository
- Basic study metadata search
- Study metadata display
GeneLab Data Systems v1.0
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- Omics Data Repository
- Basic study metadata search
- Study metadata display
- Data retrieval

DEMO
• 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

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Call to Action

• **Visit** the gene lab site: [http://genelab.nasa.gov](http://genelab.nasa.gov)

• **Sign up** for the gene lab mailing list at: [http://genelab.nasa.gov/community.html](http://genelab.nasa.gov/community.html)

• **Share/Submit** your data sets: [http://genelab.nasa.gov/data/](http://genelab.nasa.gov/data/)
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