



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

**Afshin Beheshti, PhD**

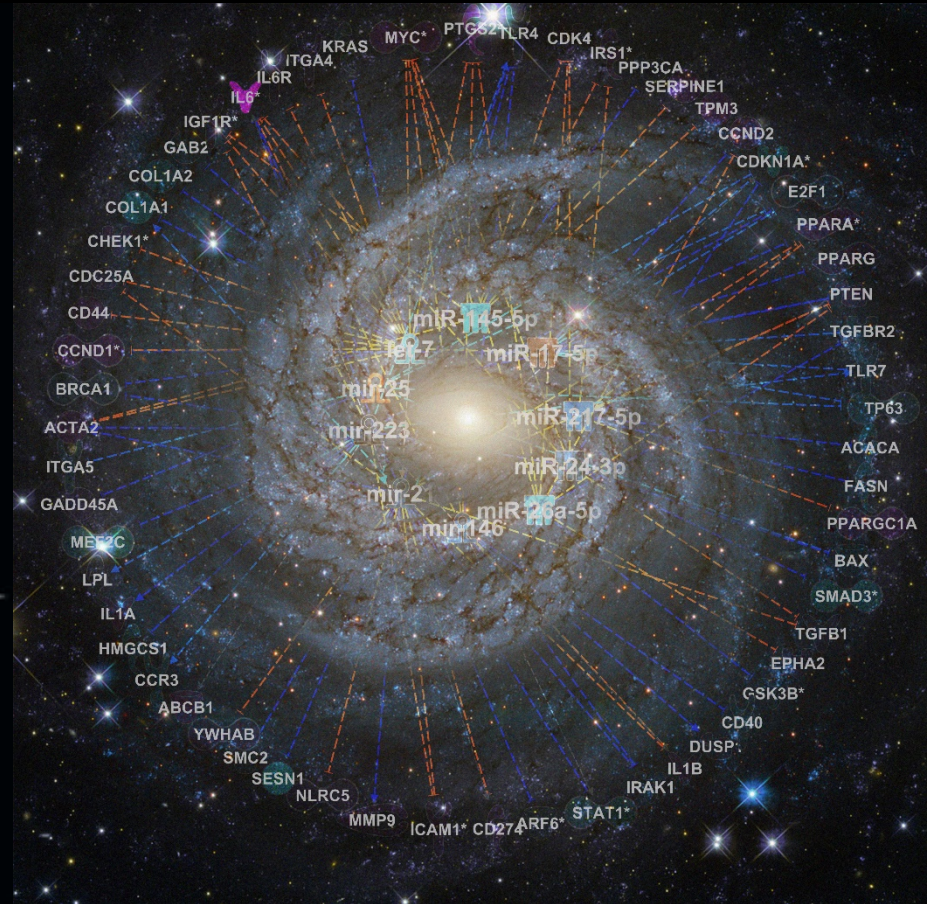
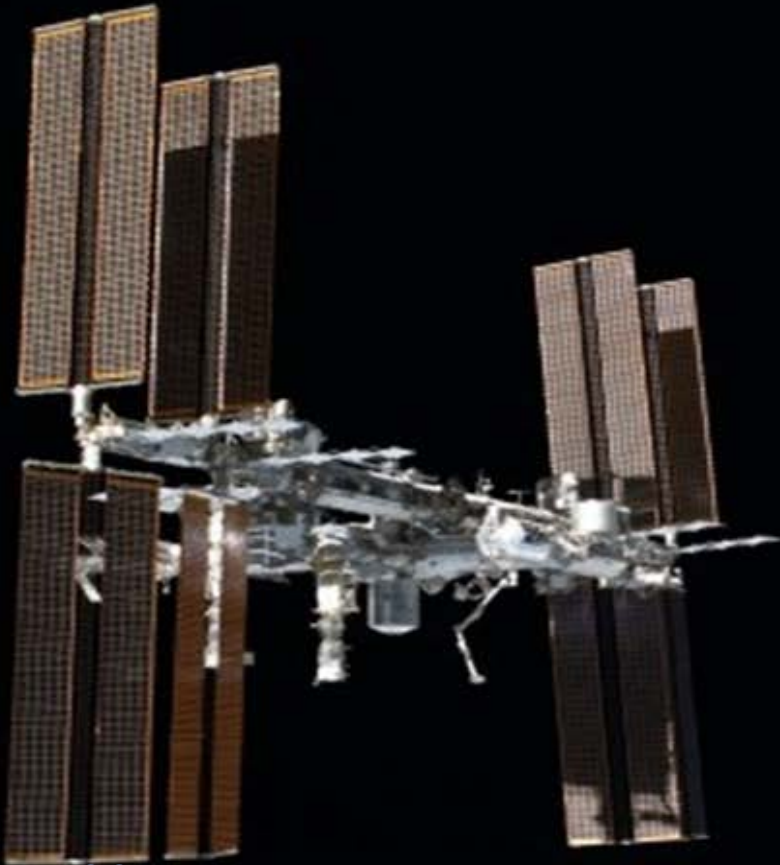
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**Jonathan Galazka, PhD: Project Scientist**

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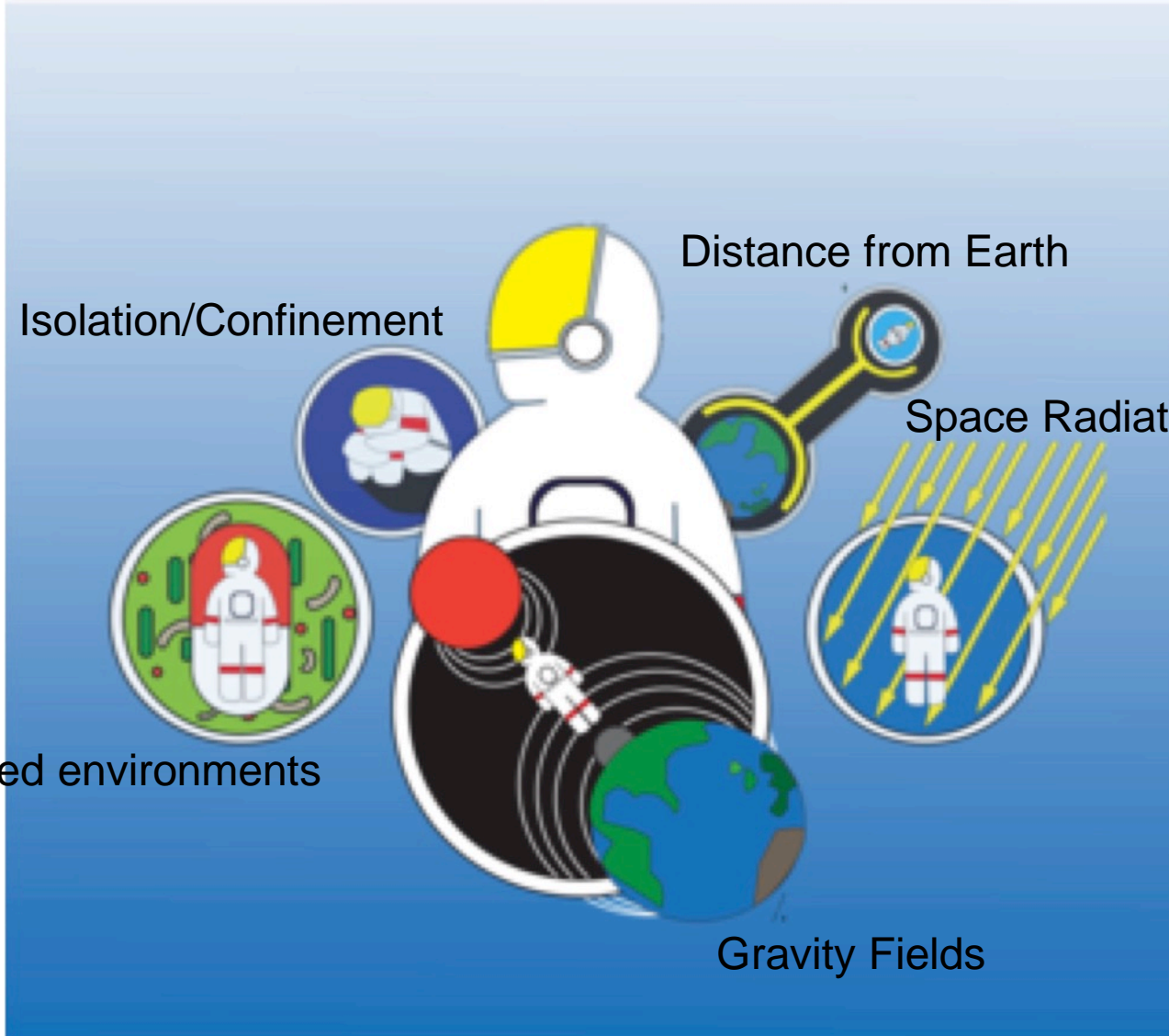
**The GeneLab Team**



ISS enabling capability for research in cellular and molecular biology includes equipment for *in situ*, on-orbit analysis of biomolecules

Applications of this growing capability range from biomedicine and biotechnology to the growing field of Omics

# Challenges of Spaceflight

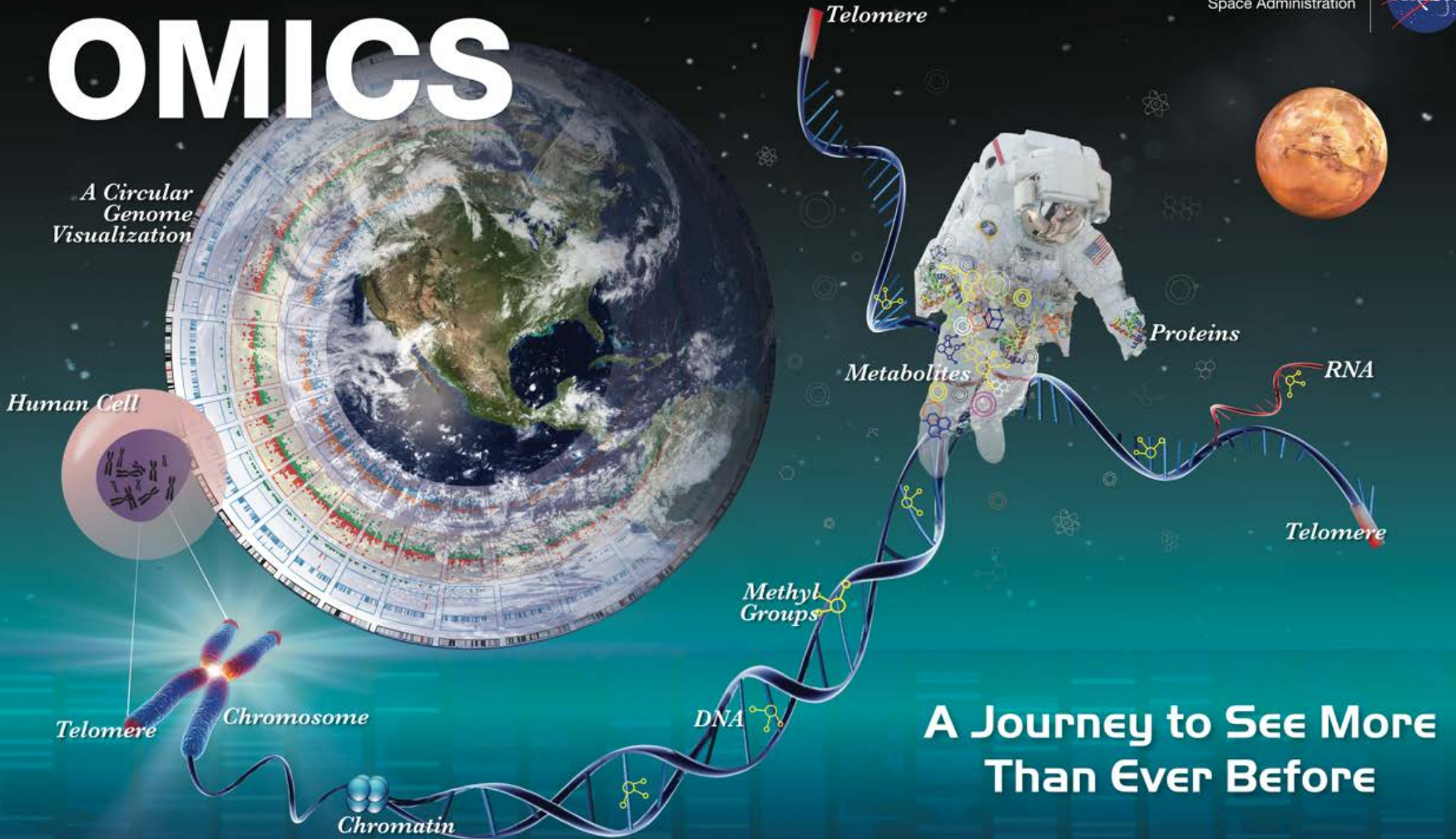




# OMICS

A Circular  
Genome  
Visualization

Human Cell



## A Journey to See More Than Ever Before



**Recapturing a Future  
for Space Exploration**

Life and Physical Sciences Research for a New Era

NATIONAL RESEARCH COUNCIL  
OF THE NATIONAL ACADEMIES

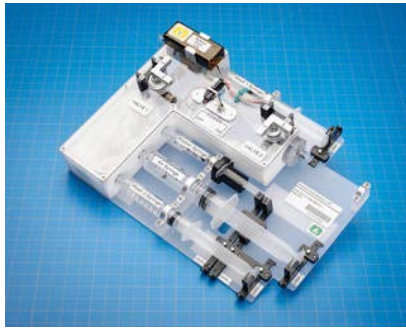
*“...genomics, transcriptomics, proteomics, and metabolomics offer an immense opportunity to understand the effects of spaceflight on biological systems...”*

*“...Such techniques generate considerable amounts of **data that can be mined and analyzed** for information by multiple researchers...”*

# Omics Acquisition in Space is Now a Reality



This is truly an exciting time for cellular and molecular biology, omics and biomedicine research on ISS with these amazing additions to the suite of ISS Laboratory capabilities.



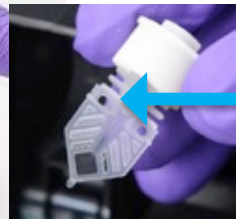
**Sample Preparation Module**



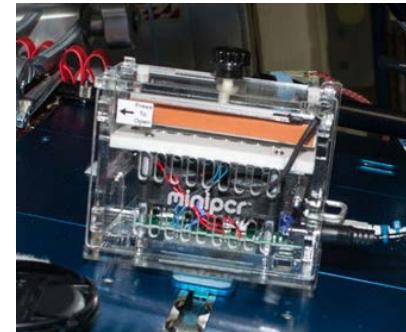
**Oxford Nanopore MinION Gene Sequencer**



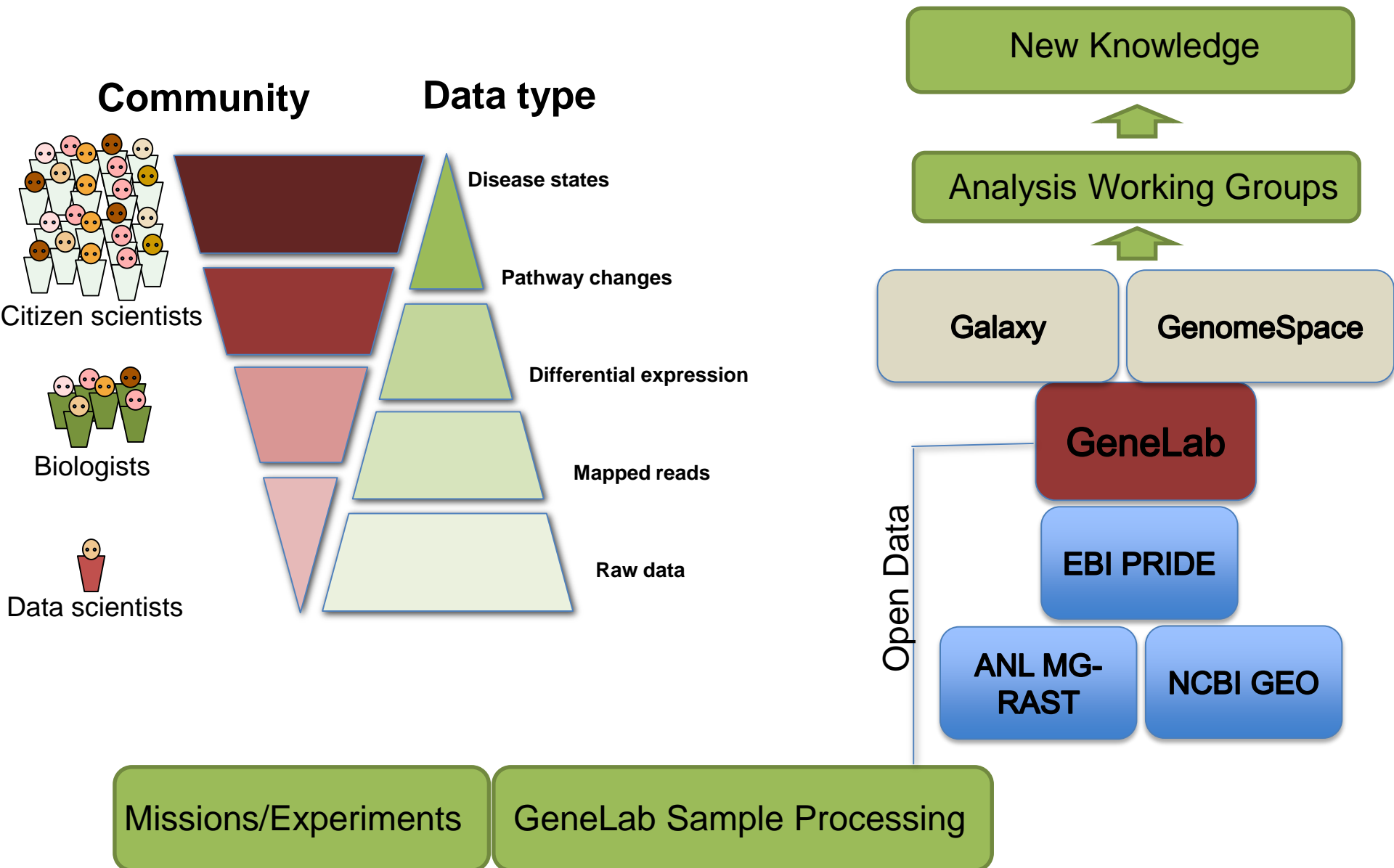
**Cepheid Smart Cycler qRT-PCR**

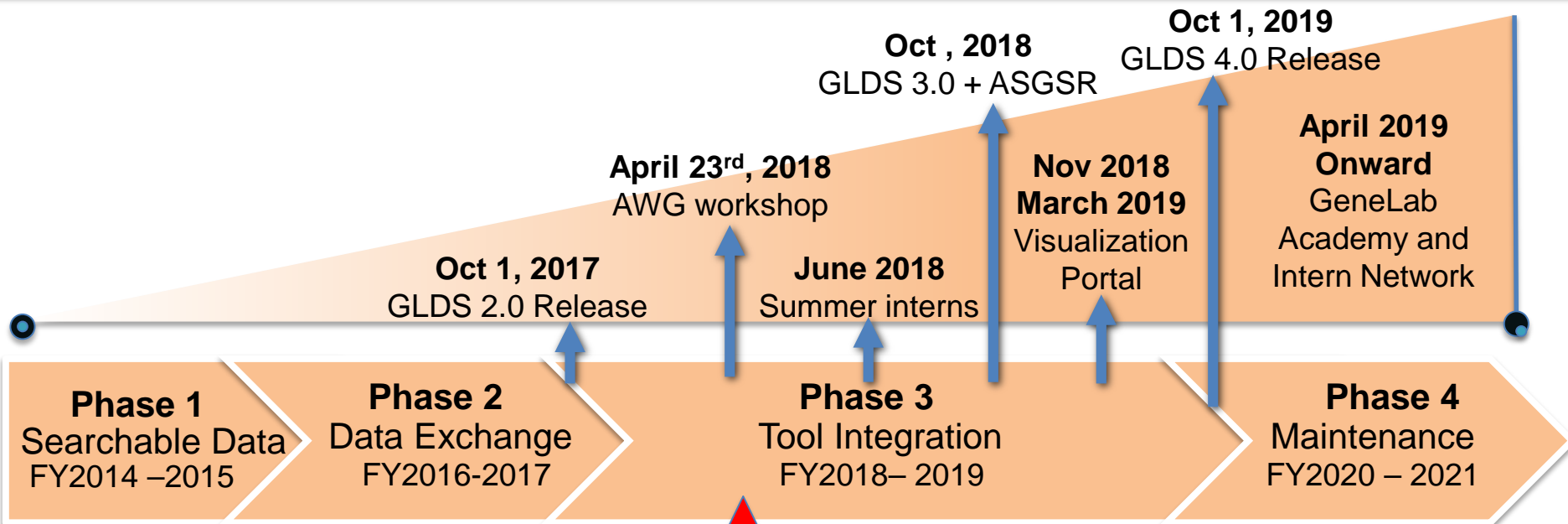


Reaction tube containing lyophilized chemical assay bead (proprietary)



**Mini-PCR**



**Data System**

- ✓ Public Website
- ✓ Searchable Data Repository
- ✓ Top Level Requirements
- ✓ New Data and Legacy Data

**Data System**

- ✓ Link to Public Databases via Data Federation
- ✓ Integrated Search (e.g., data mashup)

**Data System**

- Integrated Platform across model organisms
- Build Community via AWG
- Provide access to biocomputational tools for omics analysis
- Provide collaboration framework and tools

**Open Source Maintenance**

- User community becomes primary provider of new tools/knowledge
- Maintain integrity of data, and data system



## Data federation/integration with heterogeneous bioinformatics external databases (GEO, PRIDE, MG-RAST)

**GeneLab**  
Open Science for Exploration

Home Repository Data Data Mining Tools Submit Data Help Workspa

mouse myostatin x Q

All  GeneLab  NIH GEO  EBI PRIDE  ANL MG-RAST

Search results for: **mouse myostatin** using filter(s):

Sort by Relevance 25

**Myostatin inactivation effects on myogenesis in vitro and in vivo**  
http://www.ncbi.nlm.nih.gov/geo/query/acc.cgi?acc=GSE28986

Key words: dystrophin, mdx mouse, Duchenne, fibrosis, dystrophy ABSTRACT Stim (MDSC) into myogenic, as opposed to lipofibrogenic, lineages is a promising therapeutic counteracting myostatin, a negative regulator of muscle mass and a pro-lipofibrotic fibrogenic capacity of MDSC from wild...

Organism: *Mus musculus* Accession: GSE28986 PI/Contact: Robert Gelfand Re

**The transcriptomic signature of myostatin inhibitory influence on the differenti**  
http://www.ncbi.nlm.nih.gov/geo/query/acc.cgi?acc=GSE59674

GDF8 (myostatin) is a unique cytokine strongly affecting the skeletal muscle phenoty molecular mechanism of myostatin influence on the differentiation of mouse C2C12 m technique. Treatment with exogenous GDF8 strongly affected the growth and devel proliferation and differentiatio...

Organism: *Mus musculus* Accession: GSE59674 PI/Contact: Zofia Wick Releas

**Development of gene expression signature for defining the cell potency of mu**  
genotypes  
http://www.ncbi.nlm.nih.gov/geo/query/acc.cgi?acc=GSE39765

In order to determine the cell potency, by identification of genes responsible for plur isolated from five week old male wild type(WT), C57B6J and another hypertrophied microarray analysis and compared this gene expression to that of a standard mouse and Mstn null mice using an esta...

Organism: *Mus musculus* Accession: GSE39765 PI/Contact: Bipasha Bose Rele

**Rodent Research-3-CASIS: Mouse liver transcriptomic proteomic and epigen**  
https://genelab-data.nci.nasa.gov/genelab/accession/GLDS-137

The Rodent Research-3 (RR-3) mission was designed to study the effectiveness of occurs during spaceflight. Myostatin is a protein secreted by myoblasts that inhibits block myostatin cause increases in muscle mass. The RR-3 experiment was sponso Advancement of Science in Space and ass...

Organism: *Mus musculus* Factor: Microarxiv Treatment Assay Type: transcription profilin p... Accession: GLDS-137

### Federated Search

**GeneLab**  
Open Science for Exploration

## Search Filters for GeneLab

Home Repository Data Data Mining Tools Submit Data Help Workspace

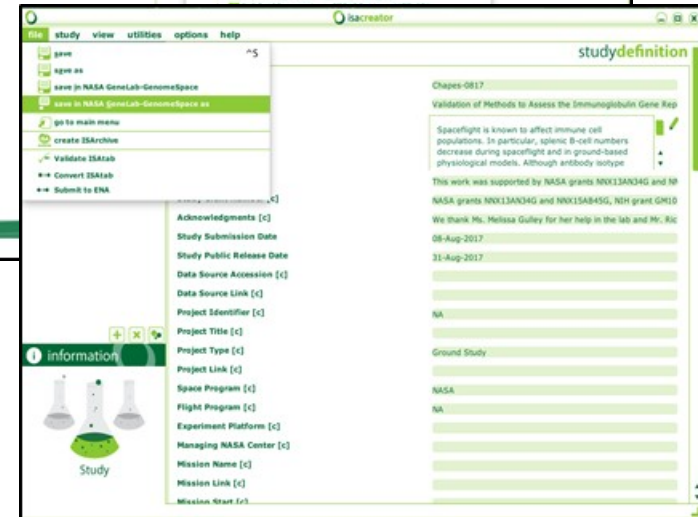
mouse x Q

All  GeneLab  NIH GEO  EBI PRIDE  ANL MG-RAST

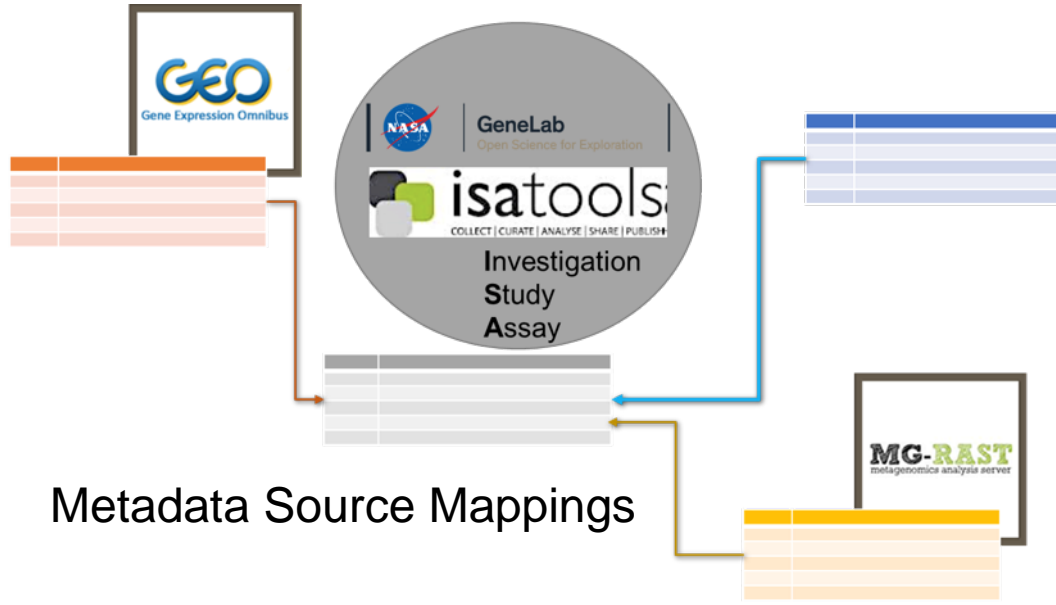
**Search Filters (GeneLab Only)**

Project Type	Factors	Organisms	Assay Type	Clear
<input checked="" type="checkbox"/> Ground	<input checked="" type="checkbox"/> Age	<input checked="" type="checkbox"/> <i>Mus musculus</i>	<input type="checkbox"/> deletion pool profiling	<p>Factor Name = Age' OR 'Study Factor Name = cage'</p> <p>Total Search Results Found: <b>3</b></p> <p style="text-align: right; border: 1px solid black; border-radius: 50%; width: 20px; height: 20px; display: flex; align-items: center; justify-content: center;">1</p> <p><b>carcinogenesis Risk</b></p> <p>modeling the carcinogenesis process or estimating cancer risks. ance increases with age. This effect is commonly attributed to a lifetime g middle-age the incidence begins to decelerate and for many tumor sites it actually</p> <p>tion profiling Accession: GLDS-88 PI/Contact: Christine Afshin Edward L...</p>
<input type="checkbox"/> Spaceflight	<input type="checkbox"/> Anatomical Stru	<input type="checkbox"/> <i>Mycobacterium ma</i>	<input type="checkbox"/> DNA methylation profiling	
<input type="checkbox"/> Spaceflight	<input type="checkbox"/> Antibiotic conce	<input type="checkbox"/> <i>Oryzias latipes</i>	<input type="checkbox"/> environmental gene survey	
<input type="checkbox"/> Spaceflight	<input type="checkbox"/> Atmospheric Pre	<input type="checkbox"/> <i>Pantoea conspicua</i>	<input type="checkbox"/> genome sequencing	
<input type="checkbox"/> Spaceflight	<input type="checkbox"/> Bed Rest	<input type="checkbox"/> <i>Pseudomonas aeru</i>	<input type="checkbox"/> metabolite profiling	
<input type="checkbox"/> Spaceflight	<input type="checkbox"/> Bleomycin Treat	<input type="checkbox"/> <i>Rattus norvegicus</i>	<input type="checkbox"/> protein expression profiling	
<input type="checkbox"/> Spaceflight	<input type="checkbox"/> cage	<input type="checkbox"/> <i>Rhodospirillum rubr</i>	<input type="checkbox"/> RNA methylation profiling	
<input type="checkbox"/> Spaceflight	<input type="checkbox"/> CANONT:Part	<input type="checkbox"/> <i>Saccharomyces ce</i>	<input type="checkbox"/> transcription profiling	
<input type="checkbox"/> Spaceflight	<input type="checkbox"/> cell culture	<input type="checkbox"/> <i>Staphylococcus</i>		
<input type="checkbox"/> Spaceflight	<input type="checkbox"/> clinical treatment	<input type="checkbox"/> <i>Staphylococcus aureus</i>		

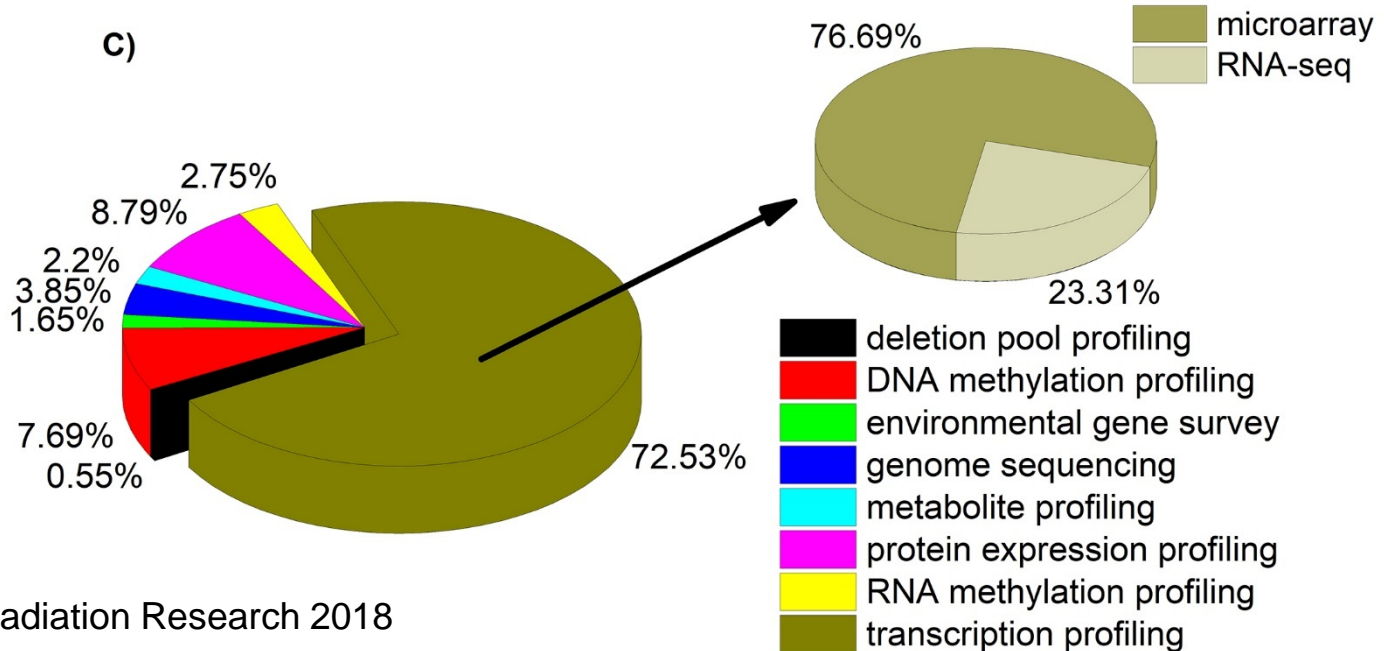
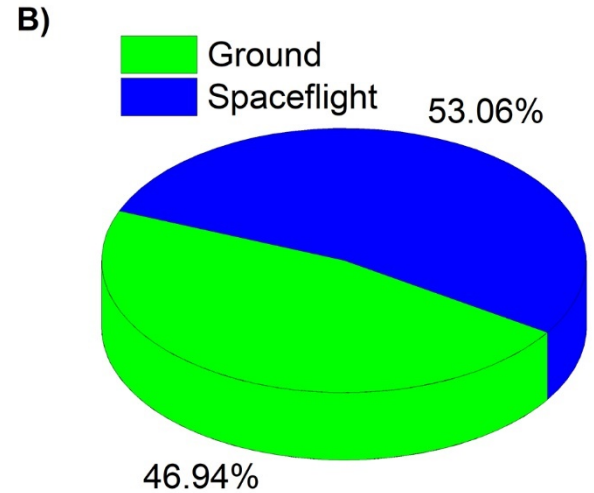
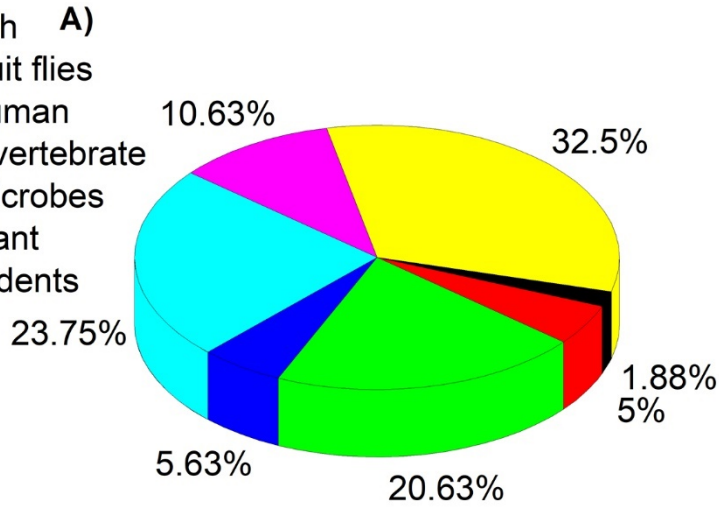
## GeneLab-GenomeSpace Integration with ISACreator for Streamlining Data Processing Operations



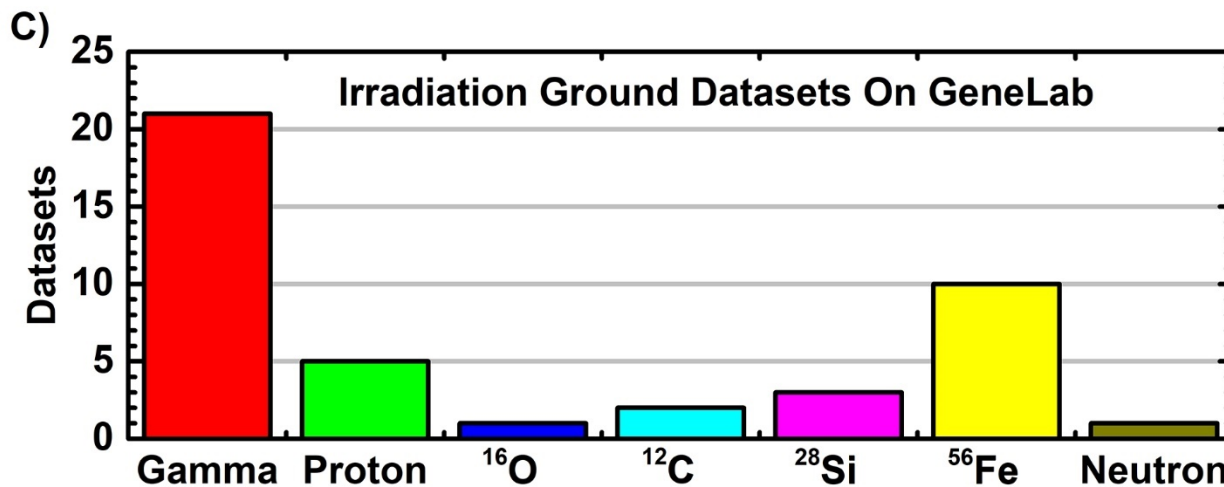
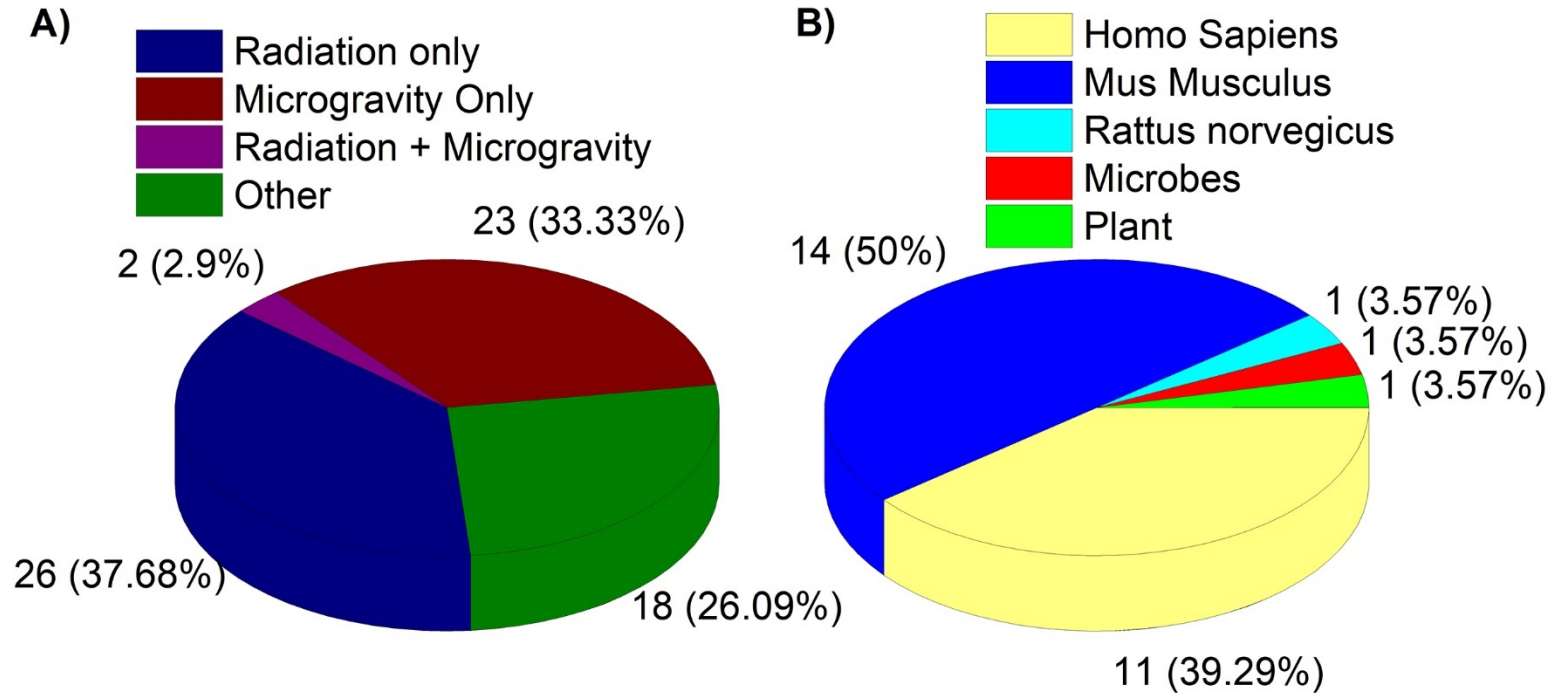
Metadata Source Mappings



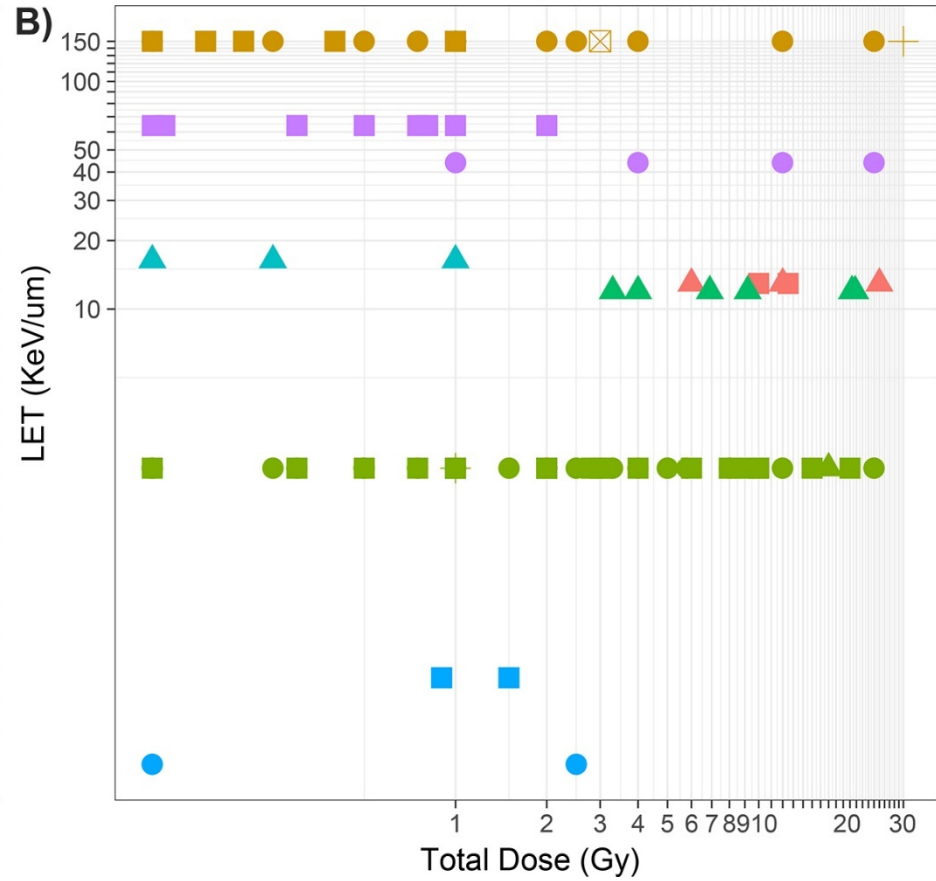
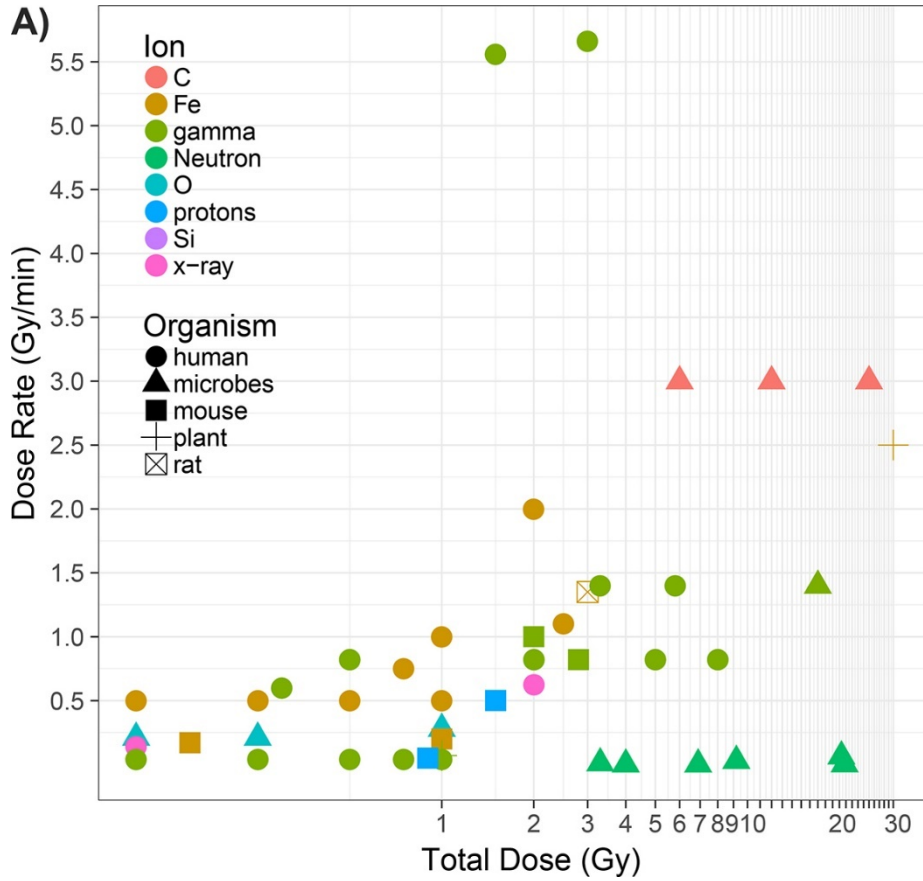
- fish
- fruit flies
- human
- invertebrate
- microbes
- plant
- rodents



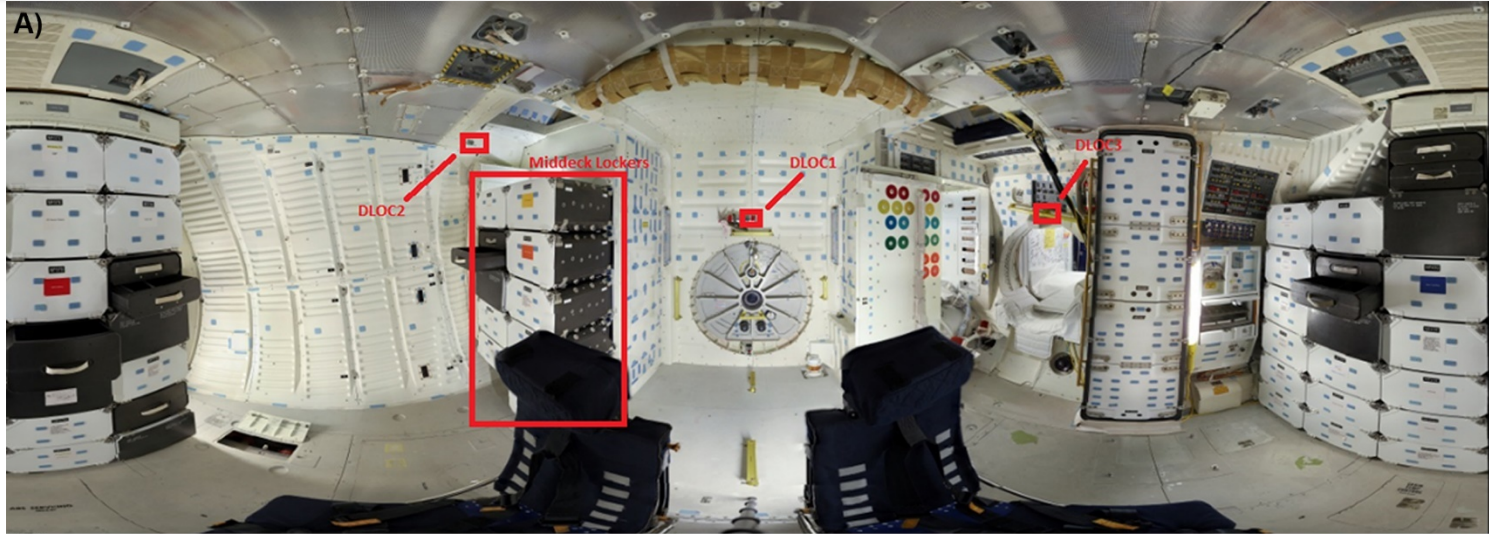
# 69 Ground Data Sets: Radiation and simulated microgravity



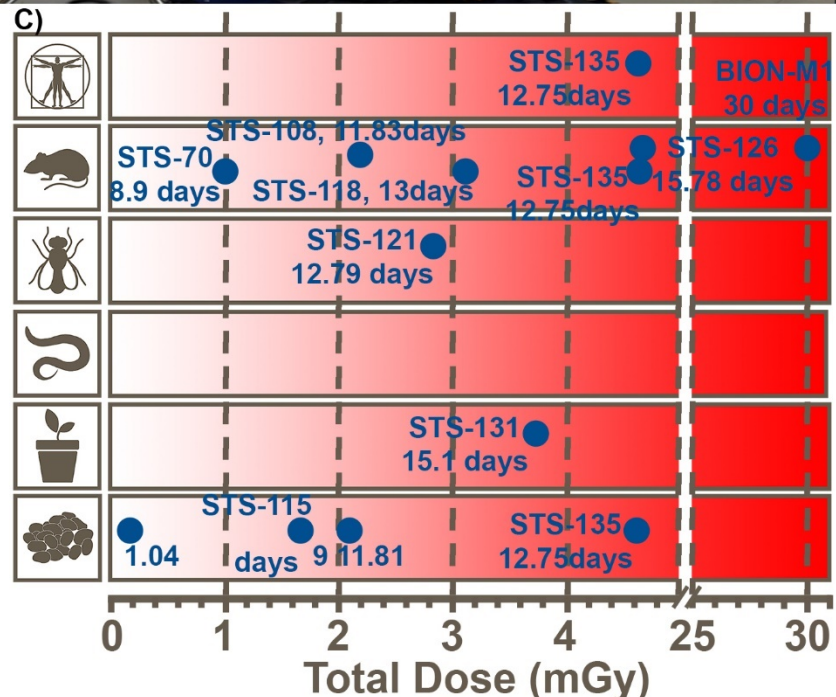
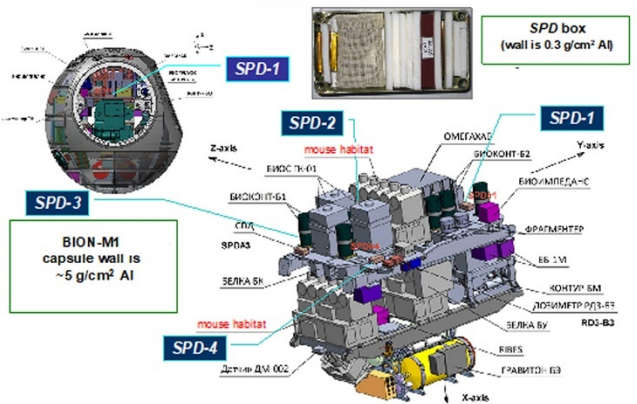
Beheshti et al.,  
Radiation Research  
2018



# Radiation Dosimetry for STS samples (ISS to follow)



B) Locations of Radiation Detectors and Animal Holders inside BION-M1



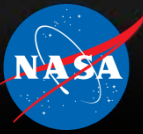


## User Account Mgmt., Access Controls (e.g., Private, Shared, Public Folders)

The image displays three overlapping screenshots of the GeneLab web interface:

- Top Left:** A search results page for "Dissecting Low Atmospheric Pressure Stress: Transcriptome Responses to the Components of Hypobaria in Arabidopsis [Experiment 2]". It shows a table with columns for Organisms, Factors, Assay Types, Release Date, and Description. Below it is another entry for "Global gene expression analysis highlights microgravity sensitive key genes in longissimus dorsi and tongue of 30 days space-flown mice".
- Top Right:** A login page titled "NASA GeneLab-GenomeSpace OpenID Login". It includes fields for USERNAME and PASSWORD, "Sign In" and "Cancel" buttons, and a "Register new NASA GeneLab user" link.
- Bottom:** A file browser view showing a directory structure. The path is "Home > Public > genelab > genelab-data". The main area displays a table of files:

Filename	Tags	Owner	Size	Last Modified
GLDS-1		genelab		
GLDS-10		genelab		
GLDS-100		genelab		
GLDS-101		genelab		
GLDS-102		genelab		
GLDS-103		genelab		
GLDS-104		genelab		
GLDS-105		genelab		
GLDS-106		genelab		
GLDS-107		genelab		
GLDS-108		genelab		
GLDS-109		genelab		
GLDS-11		genelab		
GLDS-110		genelab		
GLDS-111		genelab		
GLDS-112		genelab		
GLDS-113		genelab		



## Barriers to reproducible analysis of omics data:

1. Large files are difficult to move around and process
2. Workflows vary from user to user and details are sometimes poorly documented

## Galaxy platform:

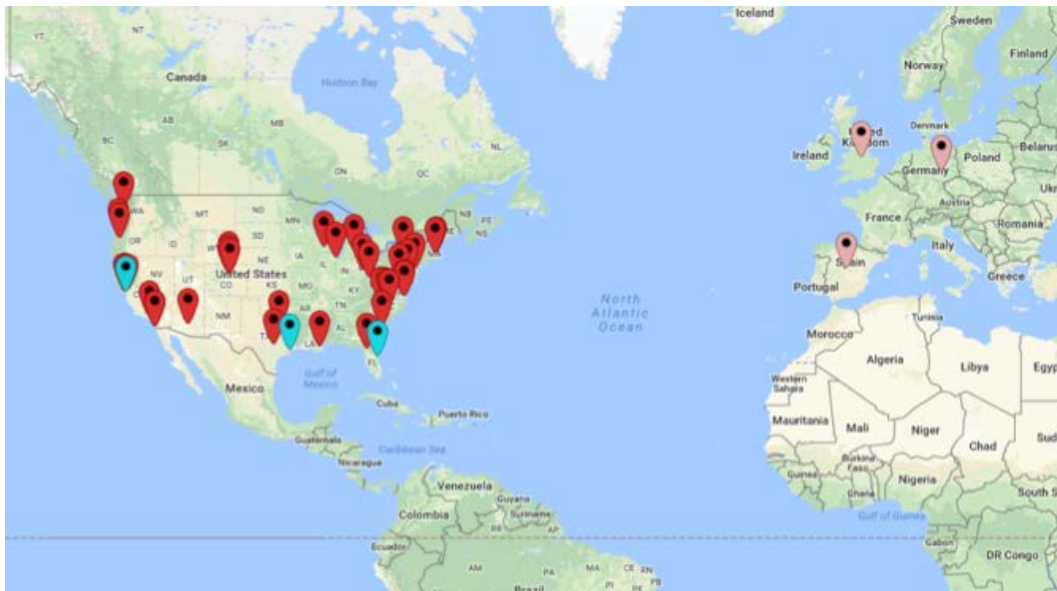
1. Open source, extensible platform for cloud based analysis of omics data
2. Allows any command line tool or script to be run and chained together into workflows
3. Workflows can published, shared and downloaded



Afgan et al. The Galaxy platform for accessible, reproducible and collaborative biomedical analyses: 2016 update. Nucleic Acids Research (2016)



- ~60 individuals
- 4 Groups: Plants, Microbes, Animals, Multi-omics
- Monthly meetings
- Deliverables:
  - Consensus pipelines for primary analysis of data (Microarray, RNASeq, Bisulfite sequencing, Proteomics, 16S metagenomics, Whole genome metagenomics)
  - Recommendations for visualization of data





## AWG (now)

### Analysis Pipelines

Goal is to identify the best pipeline

### Data to be added to GLDS or AWG scope

What additional data do you require to answer your scientific questions?

### Metadata to be added to GLDS

What environmental or other metadata do you need to answer your questions?

## Student interns

(June - Aug)

Implementation (ideally in Galaxy)

Processed data for posting on GeneLab

Post processed data to GeneLab

Public portal for visualization of GeneLab data

## AWG (June - ?)

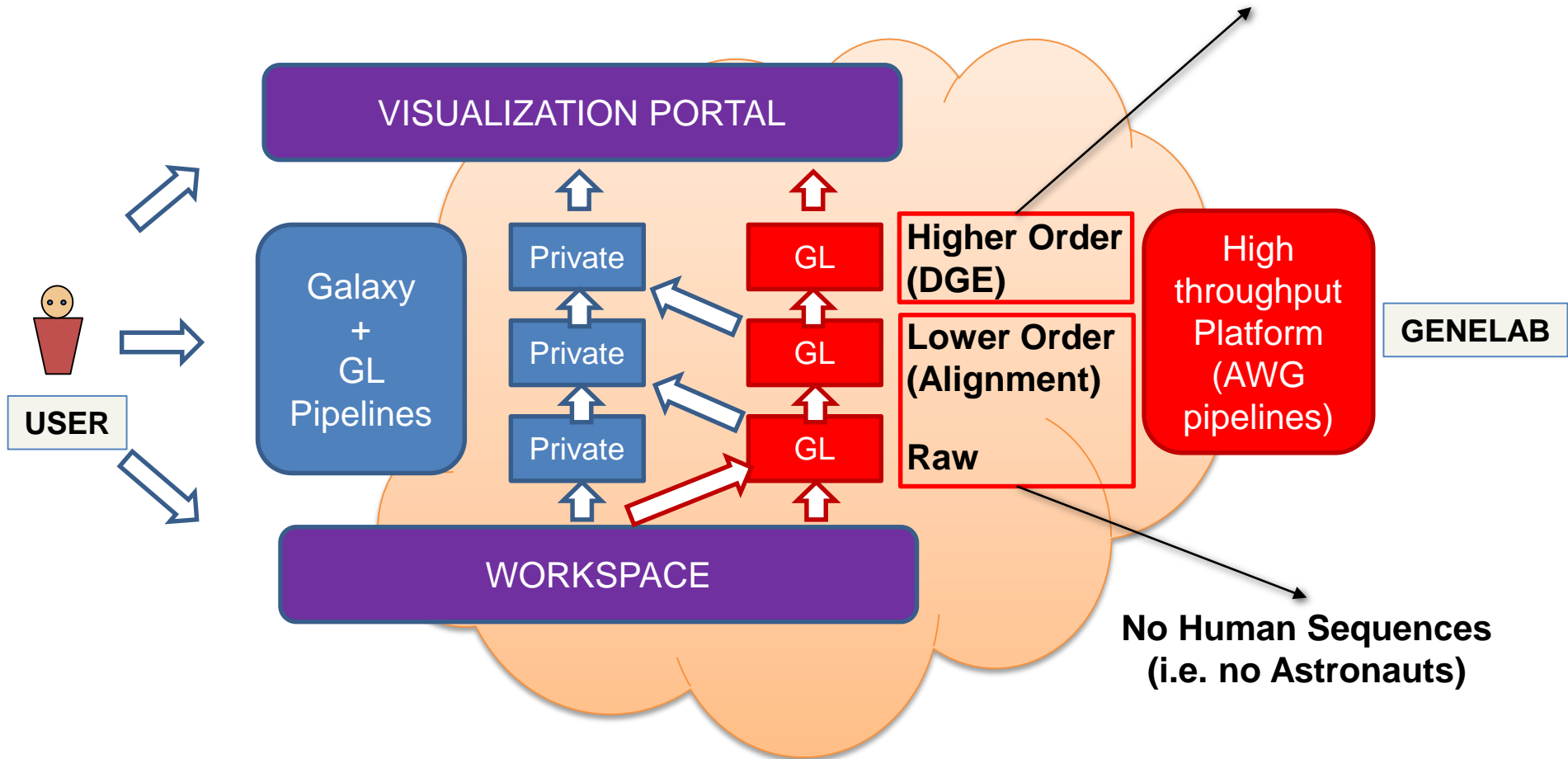
Visualization requirements and systems

Peer reviewed publication (s)

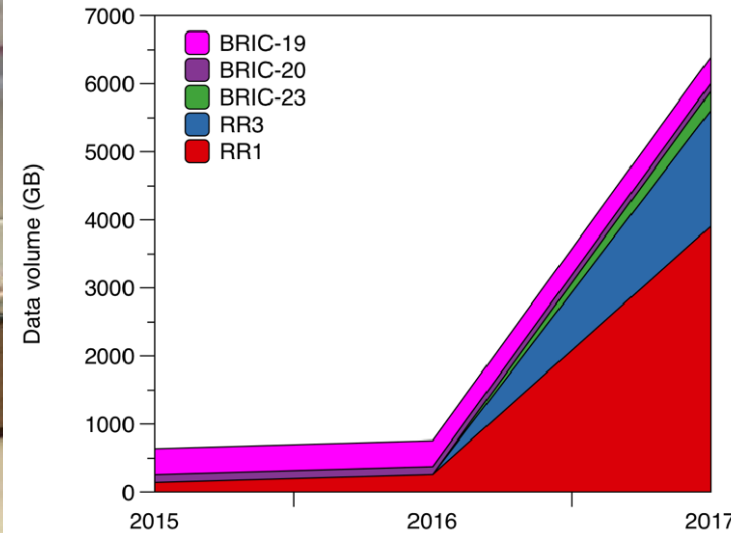
Questions

What questions can we answer with these datasets?

**Astronaut Data should be possible for Higher Order Data**  
Providing minimum metadata



- Expertise:
  - DNA/RNA/protein extraction
  - Animal work
- Develop standards for sample processing (species dependent)
- Responsible for ~50% of GeneLab data by volume



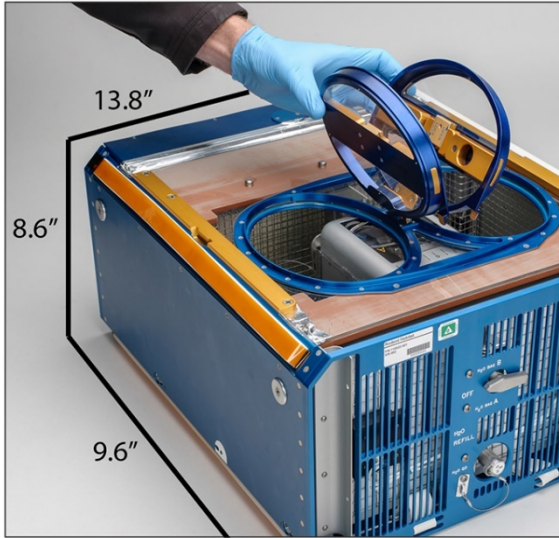


- Cage Effects with rodent experiments: Carbon Dioxide as an Environmental Stressor in Spaceflight
- Systems Biology analysis reveals biological spaceflight master regulators
- AWG related work determines novel systemic biological factors causing damage due to spaceflight

# Cage Effects with rodent experiments: Carbon Dioxide as an Environmental Stressor in Spaceflight

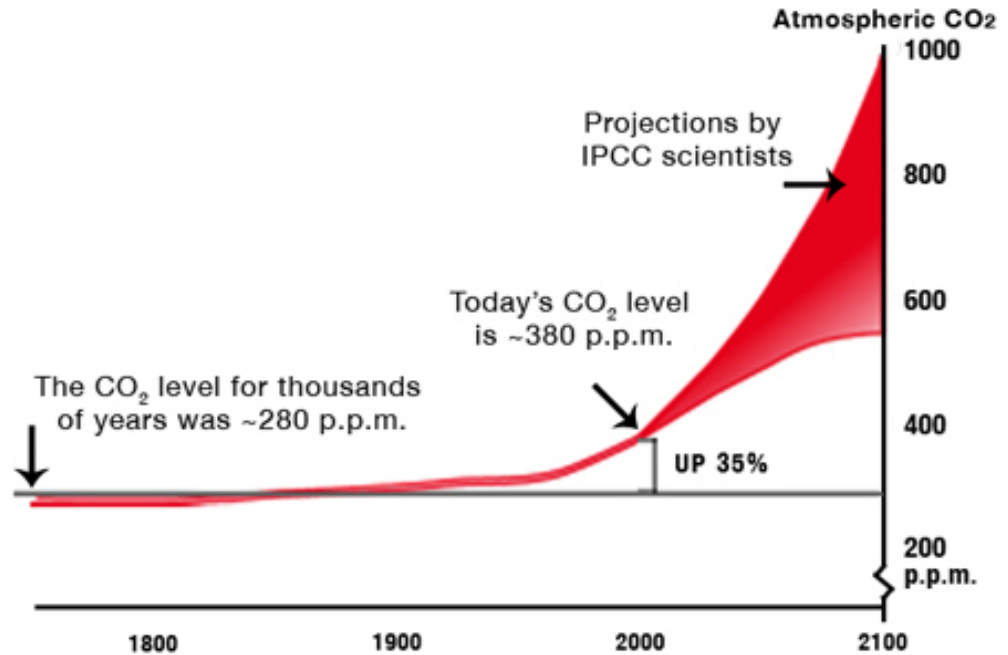
Beheshti A, Cekanaviciute E, Smith DJ, Costes SV. Global transcriptomic analysis suggests carbon dioxide as an environmental stressor in spaceflight: A systems biology GeneLab case study. *Sci Rep.* 2018;8(1):4191. doi: 10.1038/s41598-018-22613-1. PubMed PMID: 29520055; PMCID: PMC5843582.

## A) Cage Types



Animal Enclosure Module (AEM)

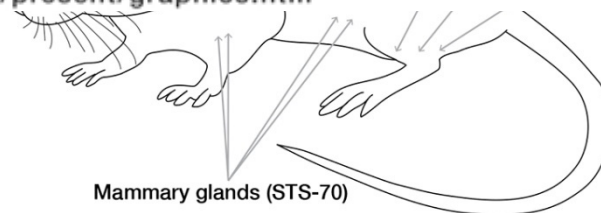
## Historic and Projected CO<sub>2</sub> Atmospheric Concentrations

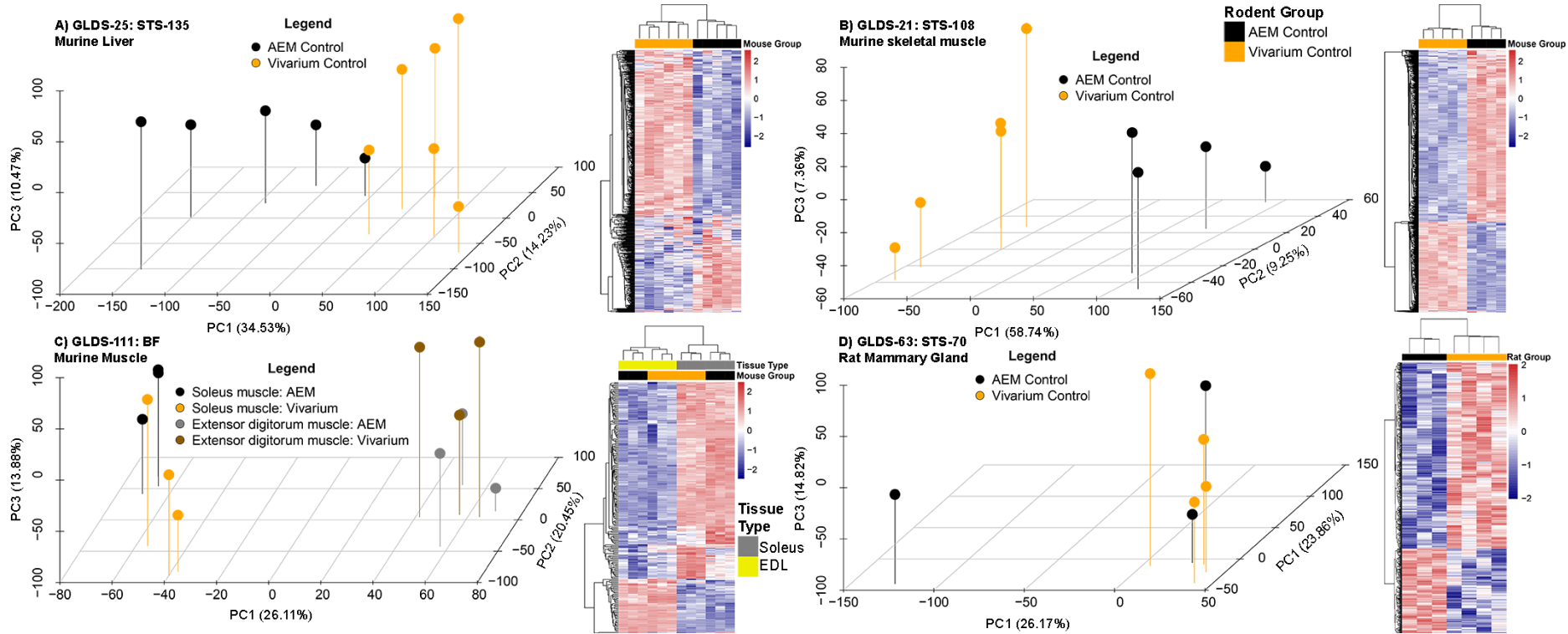


Source: IPCC  
<http://www.ipcc.ch/present/graphics.htm>

## B)

GeneLab Study	Mission	Species	CO <sub>2</sub> (ppm)	Du (d)	
GLDS-21	STS-108	mouse	~3000		
GLDS-111	BF	mouse	~600		
GLDS-111	BF	mouse	~600	30	extensor digitorum
GLDS-25	STS-135	mouse	~3000	13	liver
GLDS-63	STS-70	rat	~3000 (est)	9	mammary gland

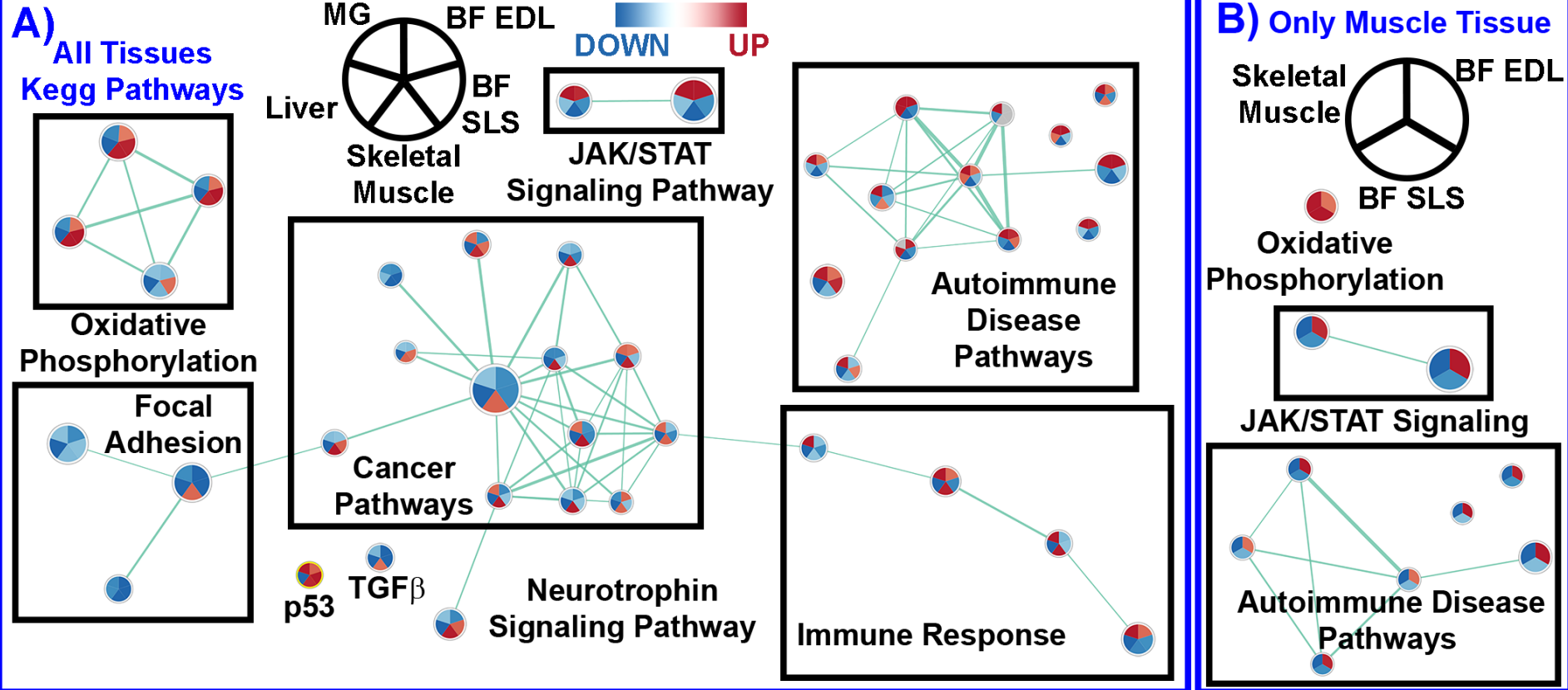




AEM = Animal Enclosure Modules (now referred to as Rodent Habitats)  
Vivarium = normal ground based rodent cages



# Major Pathways Regulated between Cages



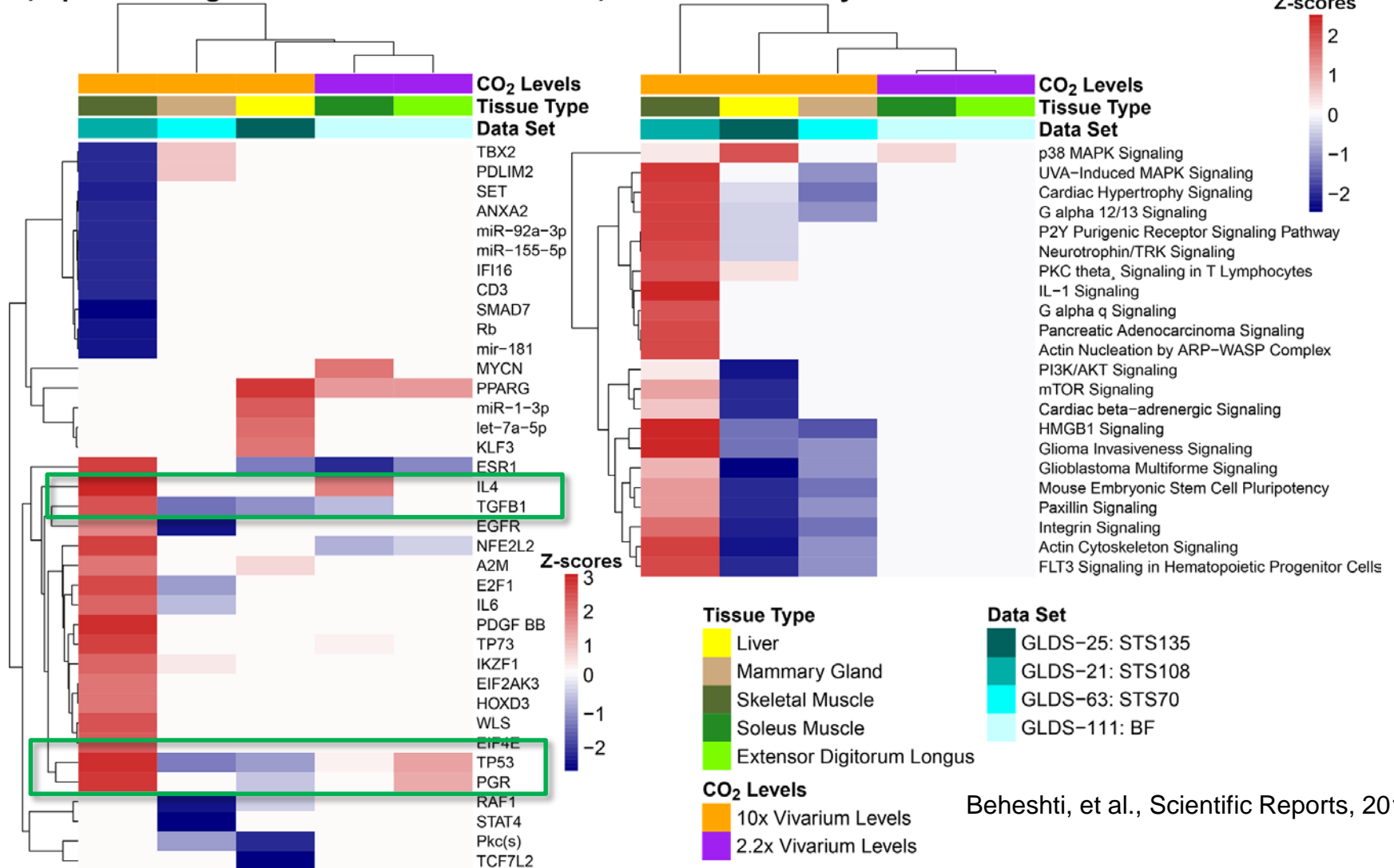
GSEA: Kegg Pathways (network displayed using EnrichmentMap plugin for Cytoscape)

# Upstream regulators and canonical pathways show response is tissue specific and highest for high CO<sub>2</sub>



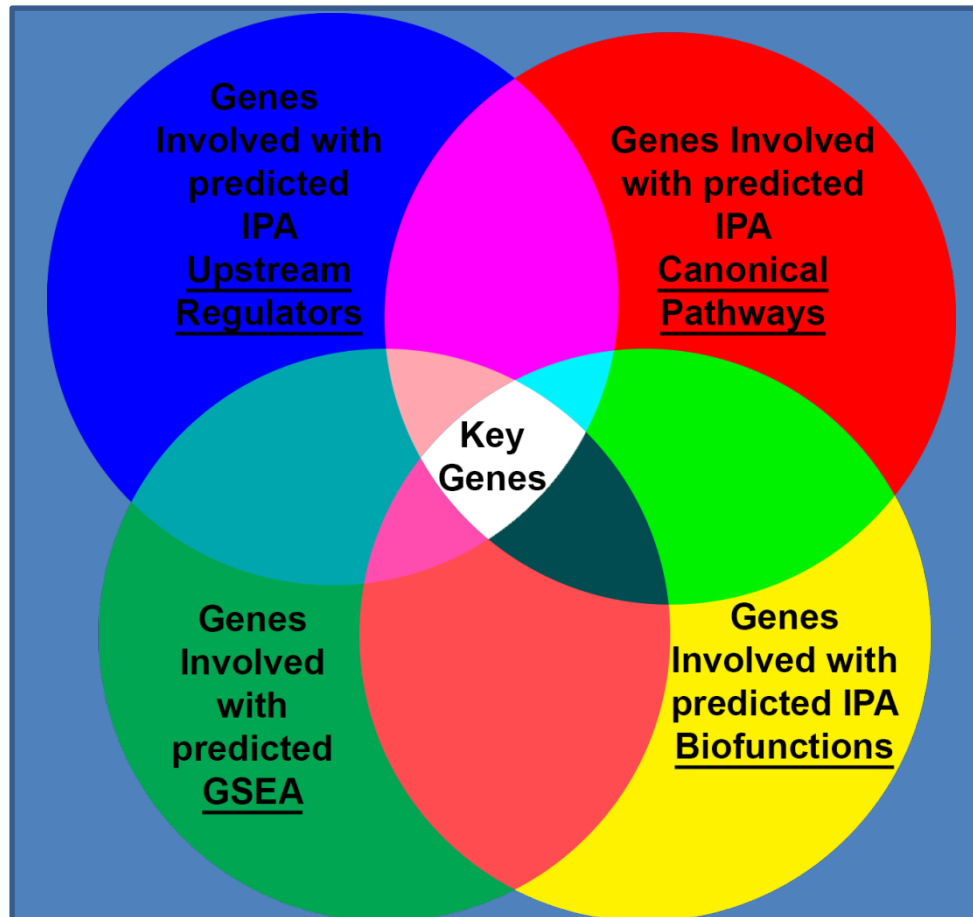
A) Upstream Regulators: AEM vs Vivarium

B) Canonical Pathways: AEM vs Vivarium



Beheshti, et al., Scientific Reports, 2018

Mild chronic hypoxia due to increased CO<sub>2</sub> levels could explain both the increase in immune responses and a reduction in metabolism – **Need to confirm with AEM experiments at ambient CO<sub>2</sub> levels.**



Beheshti, et al. Cancer Research 2015

Beheshti, et al. Oncotarget 2015

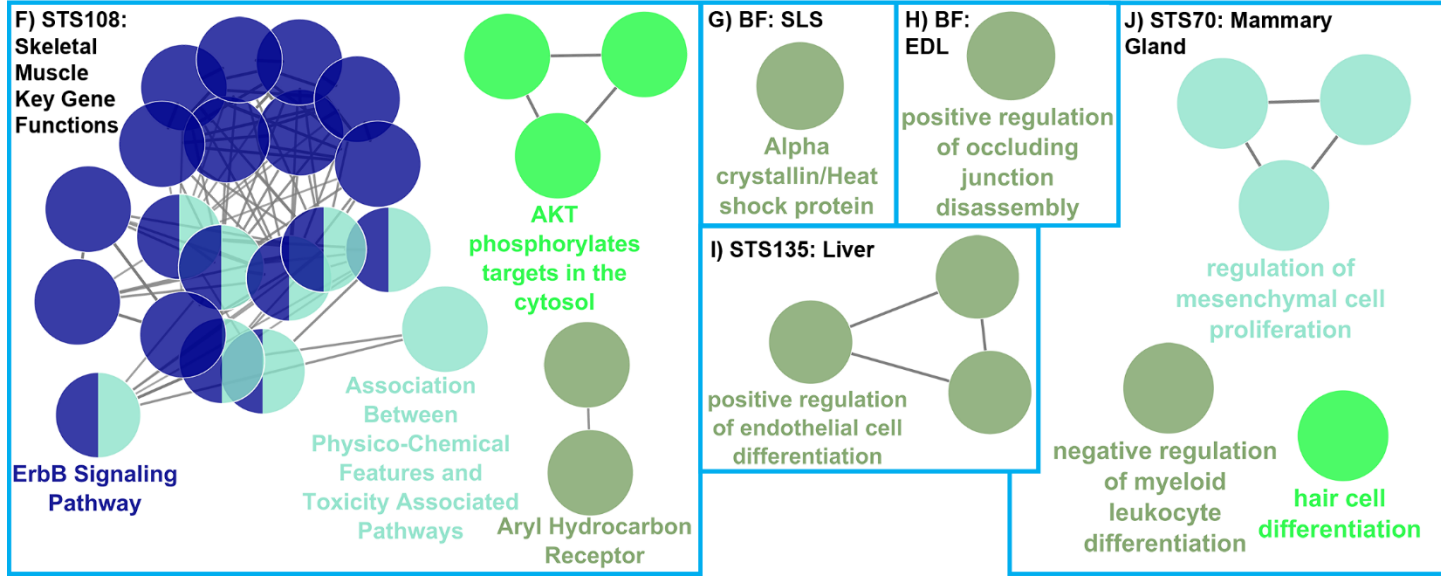
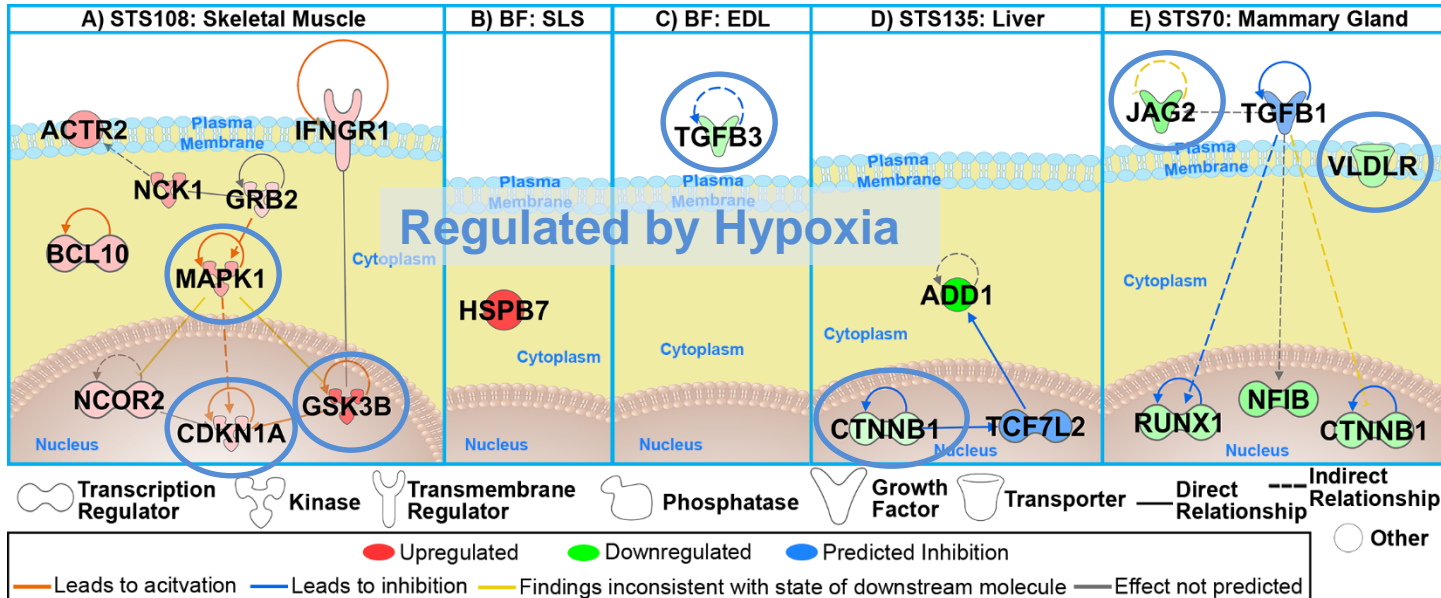
Beheshti, et al. Cancer Informatics 2015

Beheshti, et al, Radiat Res. 2014 & J. Radiat Res. 2015.

Ravi, Beheshti, et al. Cancer Research 2016

Beheshti, et al. Scientific Reports 2018

# Identifying Key Cage-Dependent Drivers

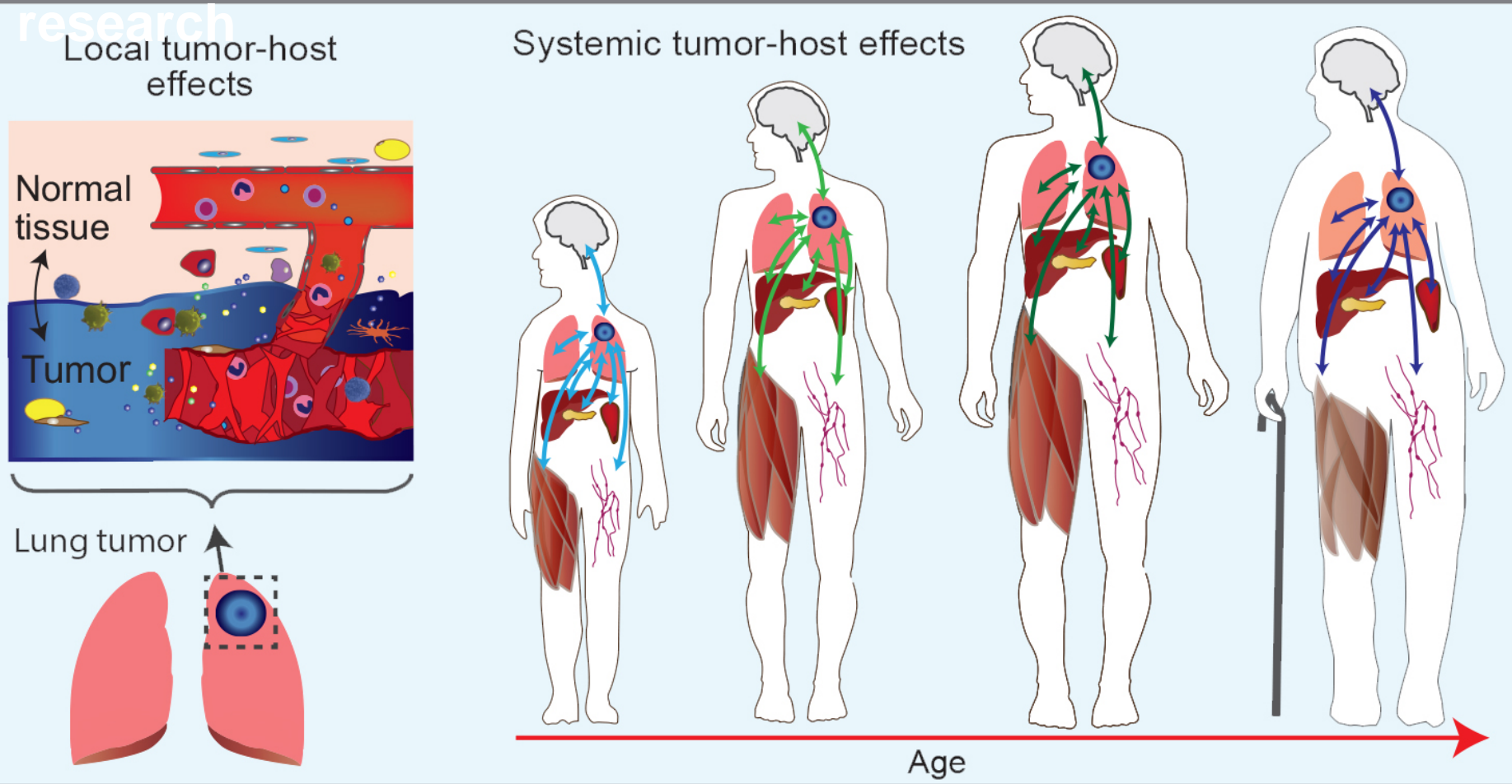


# **Systems Biology analysis reveals biological spaceflight master regulators**

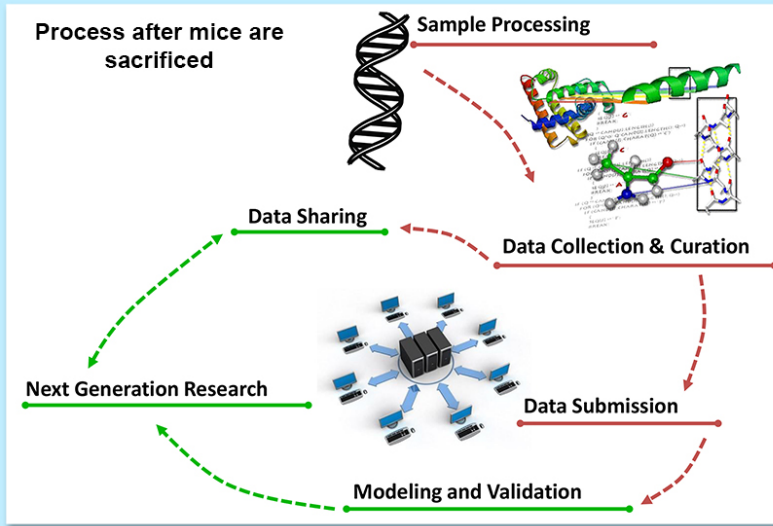
Beheshti, et al., PLOS One, in press

## General Approach to Studying a Systematic Response in the Host

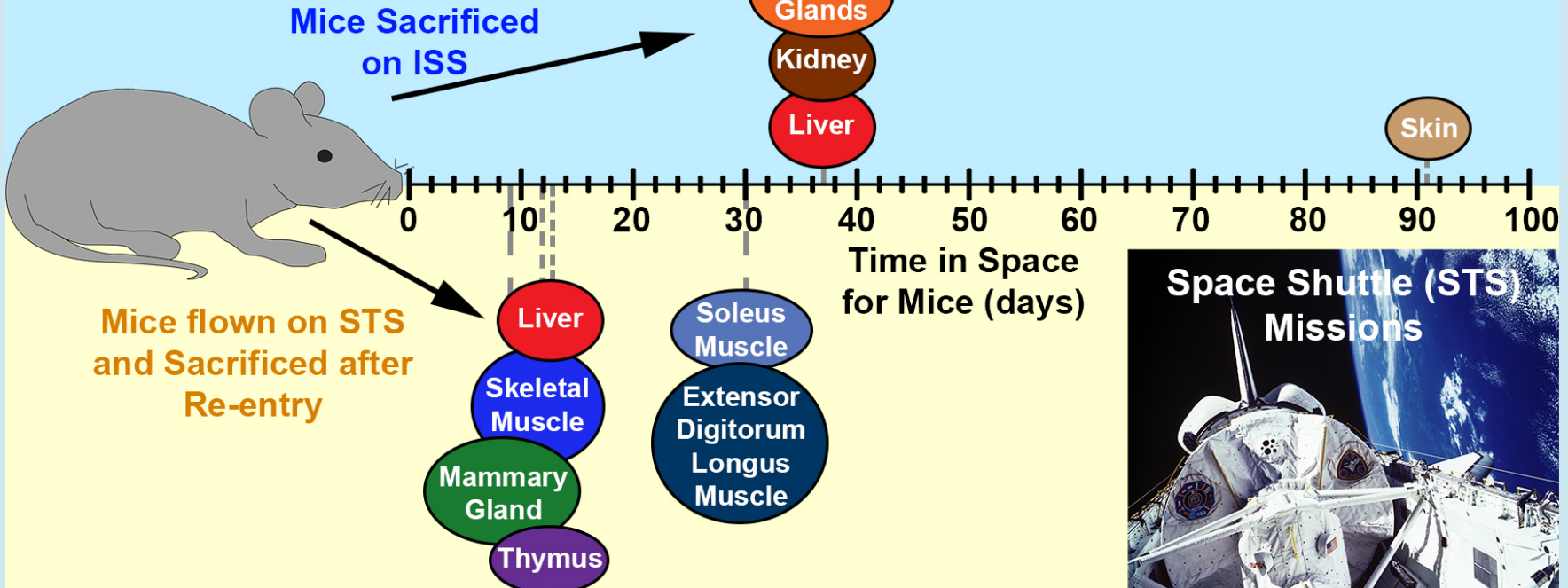
### An example for cancer



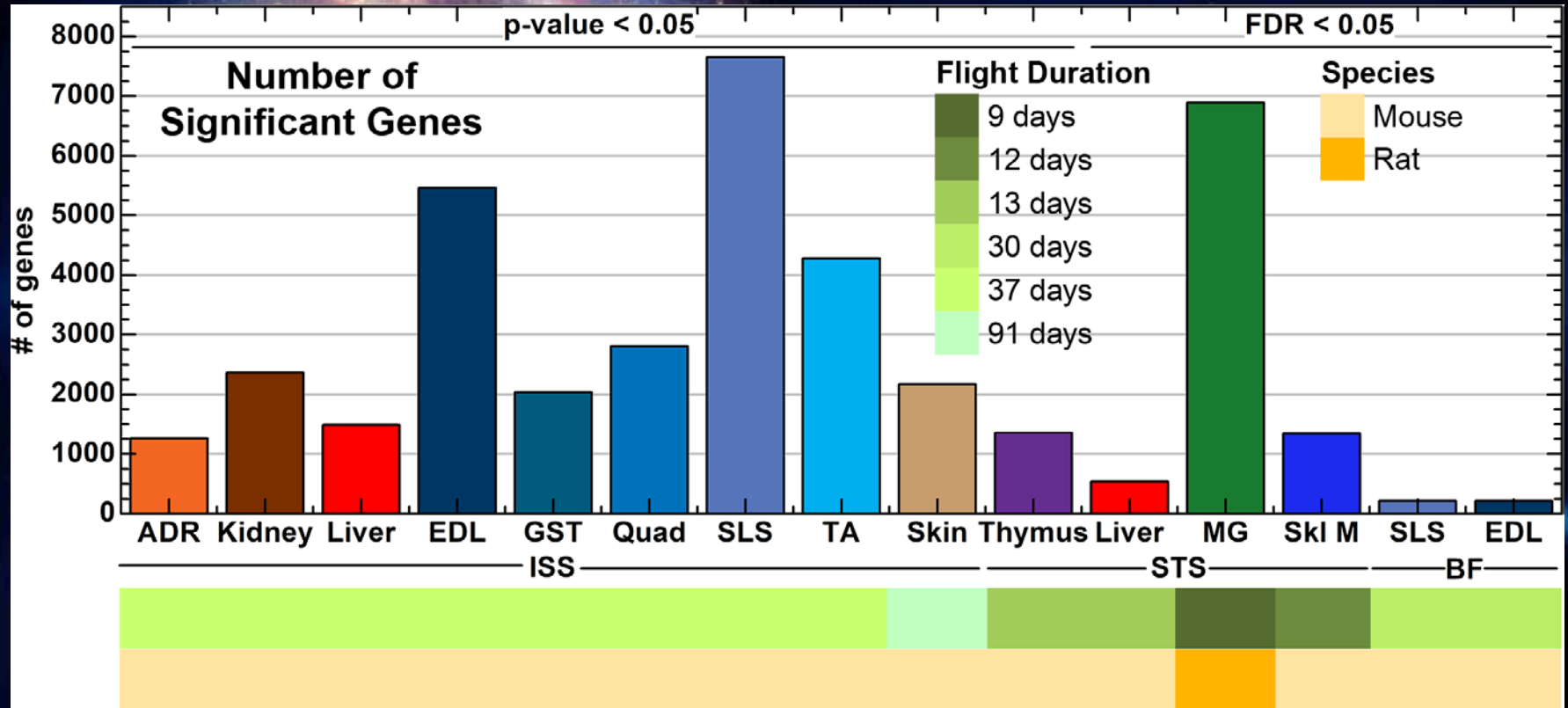
# GeneLab Data Used to Generate Results



- Extensor Digitorum Longus Muscle
- Soleus Muscle
- Gastrocnemius Muscle
- Quadriceps
- Tibialis Anterior Muscle
- Adrenal Glands
- Kidney
- Liver



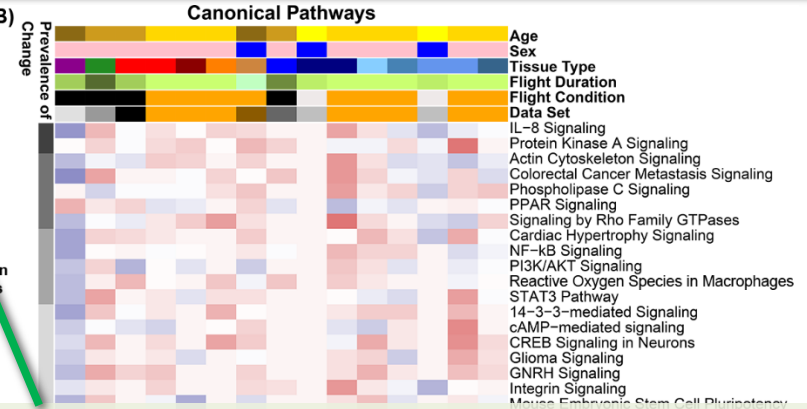
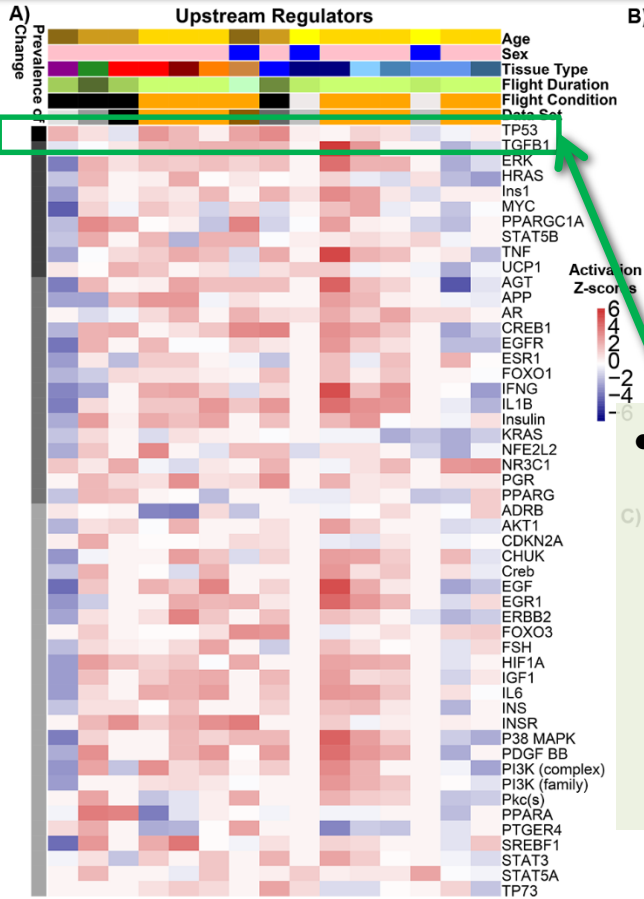
# Number of Significant Genes from Each Dataset



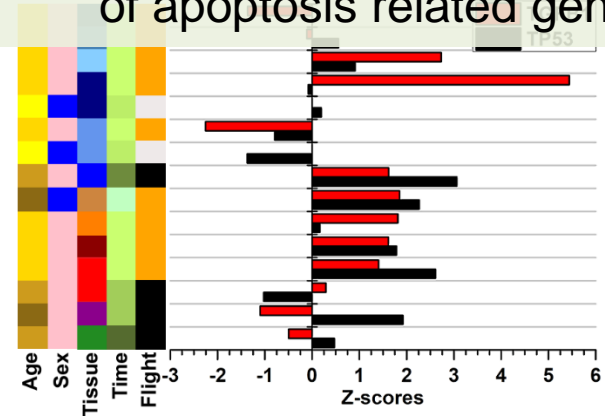
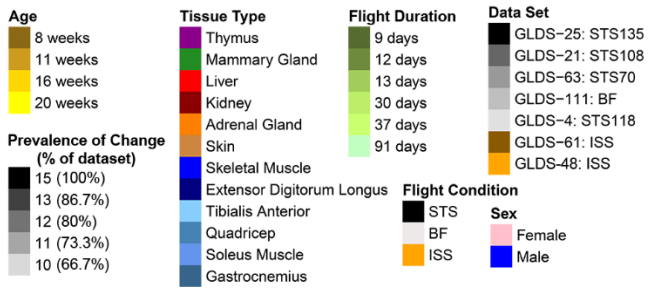
Fold-Change  $\geq$   
| 1.2 |

Pathway/Functional Predictions:  
Ingenuity Pathway Analysis (IPA)  
Gene Set Enrichment Analysis (GSEA)





- **p53 found in all tissues**
  - p53 is a transcription factor and in response to genotoxic stress, DNA damage, oncogene activation, and hypoxia, it is recruited to sites in chromatin, thus promoting transcription of apoptosis related genes

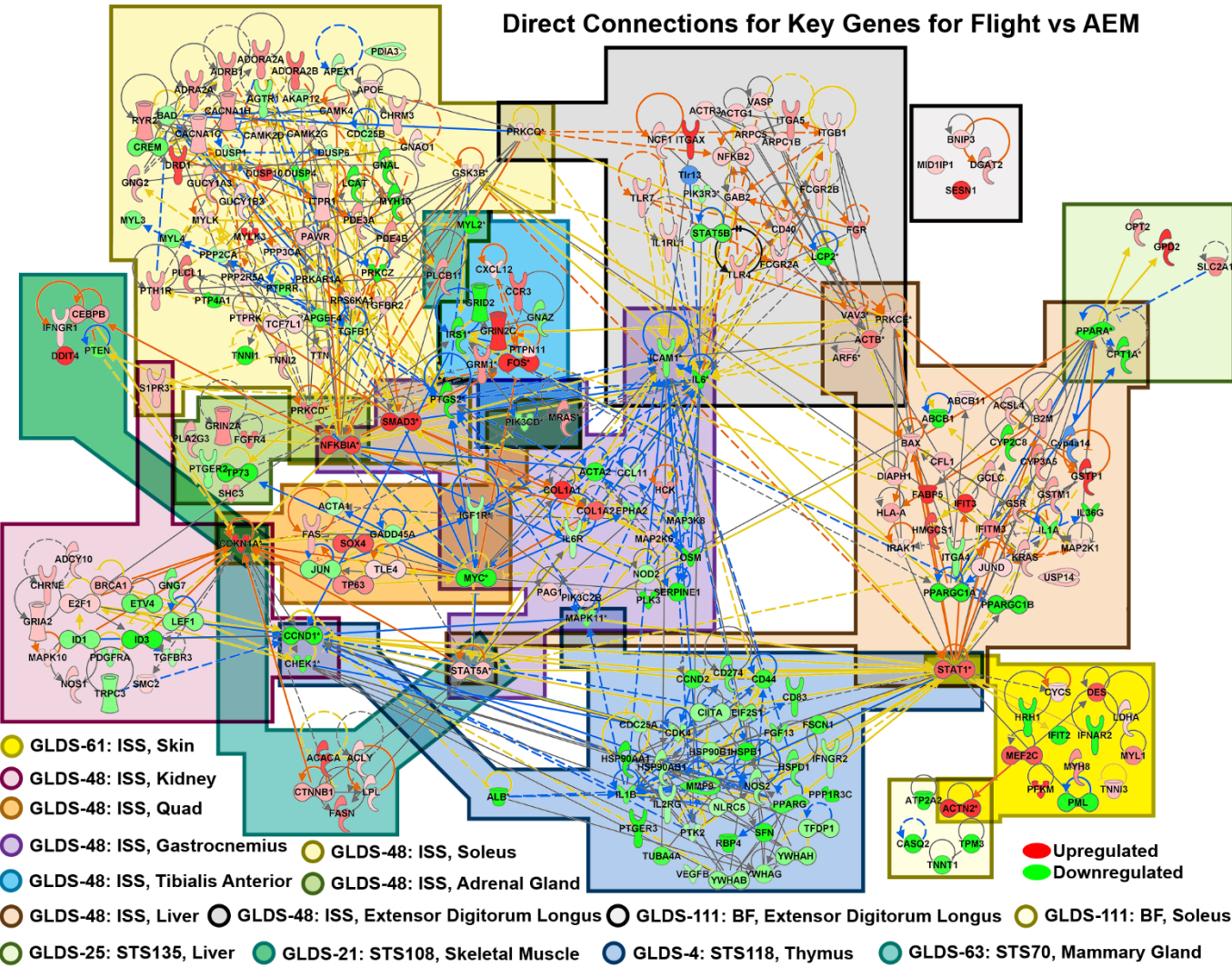


Beheshti, et al.,  
PLOS One, in  
press

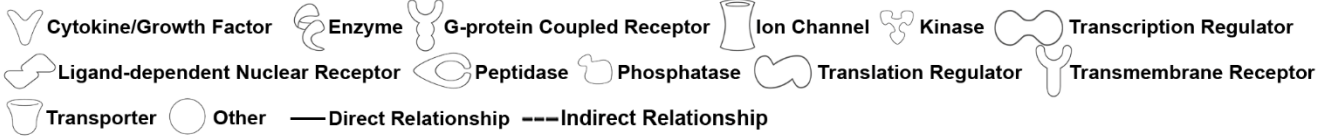
**A) Direct Connections for Key Genes for Flight vs AEM**

- **TGFβ1 found to be critical for maintaining tissue differentiation, cell homeostasis and previous studies to diminish TGFβ1 in unit gravity.**
- **TGFβ is known to sustain tissue differentiation, cell homeostasis and previous studies to diminish TGFβ1 in unit gravity.**
- **In another study, growth using identified in mod and late apoptosis endothelin-1 and**

**Direct Connections for Key Genes for Flight vs AEM**

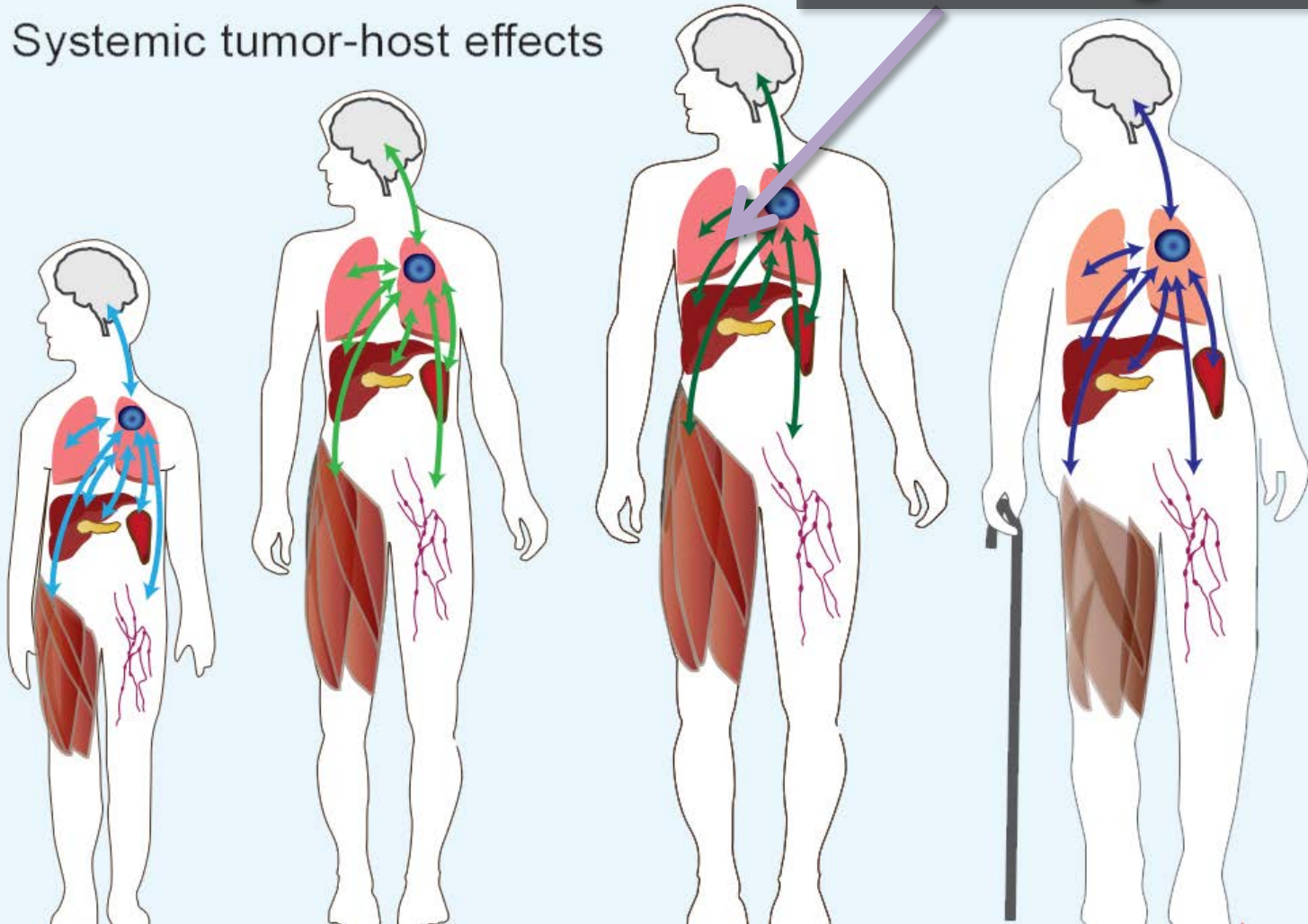


- GLDS-48: ISS, Quad
- GLDS-61: ISS, Skin
- GLDS-48: ISS, Tibialis Anterior
- GLDS-48: ISS, Liver
- GLDS-25: STS135, Liver
- GLDS-61: ISS, Skin
- GLDS-48: ISS, Kidney
- GLDS-48: ISS, Quad
- GLDS-48: ISS, Gastrocnemius
- GLDS-48: ISS, Soleus
- GLDS-48: ISS, Tibialis Anterior
- GLDS-48: ISS, Adrenal Gland
- GLDS-48: ISS, Liver
- GLDS-48: ISS, Extensor Digitorum Longus
- GLDS-111: BF, Extensor Digitorum Longus
- GLDS-111: BF, Soleus
- GLDS-25: STS135, Liver
- GLDS-21: STS108, Skeletal Muscle
- GLDS-4: STS118, Thymus
- GLDS-63: STS70, Mammary Gland

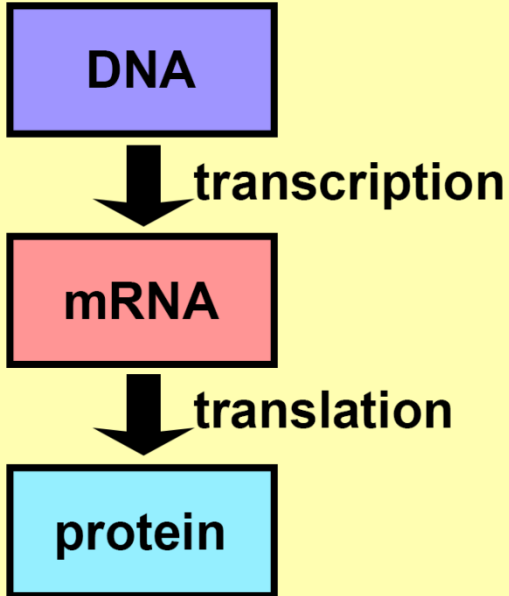


## Circulating miRNAs

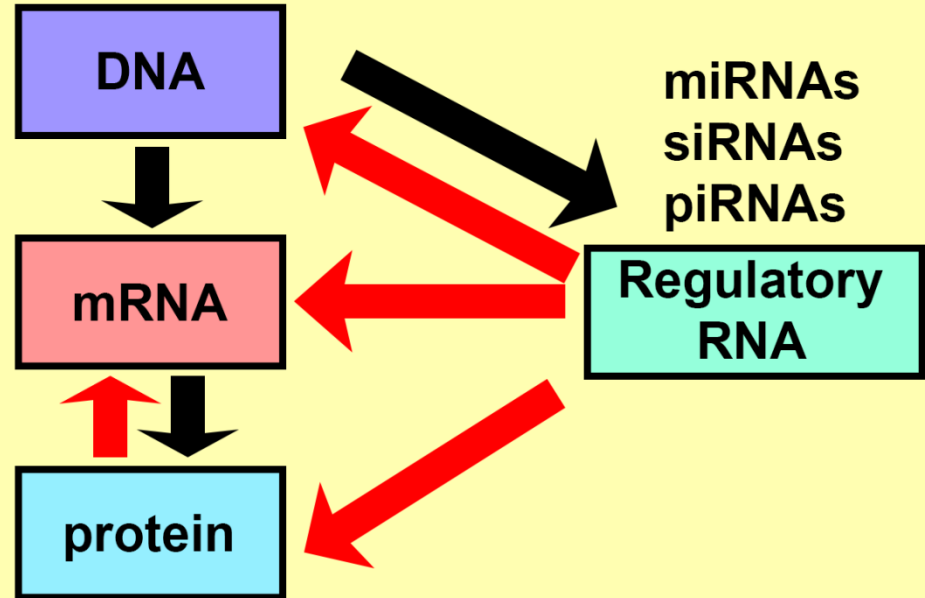
Systemic tumor-host effects



### Classical View of Molecular Biology

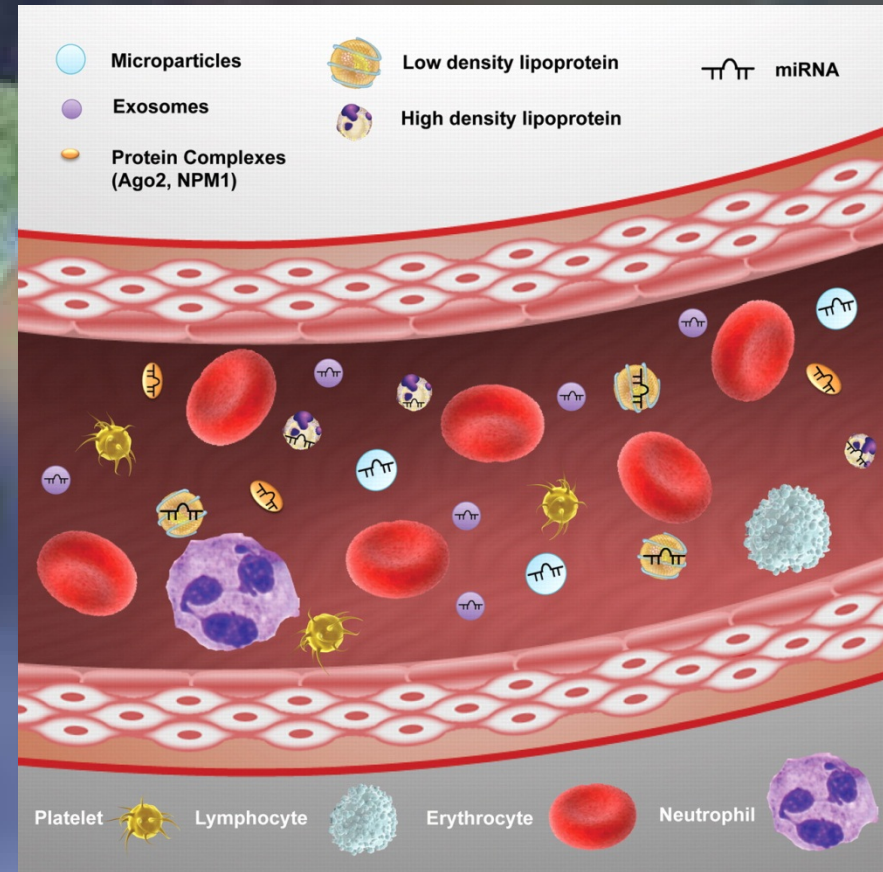


### New Understanding of Molecular Biology



- A single miRNA has been estimated to regulate up to 500 mRNAs
- miRNAs are single-stranded RNA sequences, of about 22 nucleotides in length, processed from longer transcripts.
- miRNAs are important regulators that repress the translation of mRNA transcripts

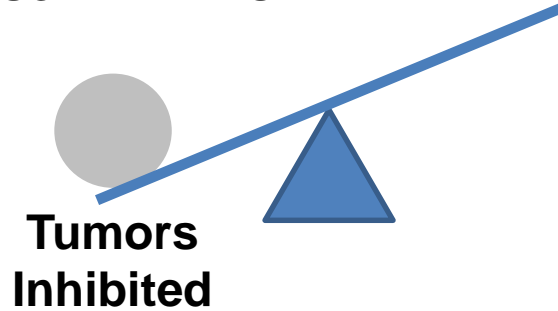
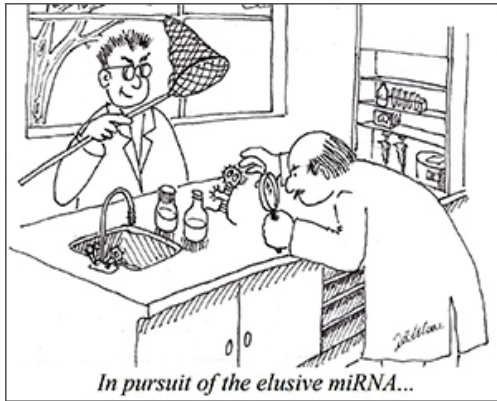
- Circulating miRNAs can carry signals from organs to other various parts of the body through the blood stream.
- The miRNAs can be transported in Exosomes, microparticles, lipoproteins, and outside any type of packaging.
- Our preliminary data shows that a miRNA signature is carried over from the spleen to the tumor with age.
  - Beheshti, et al. *PLoS ONE* 2017



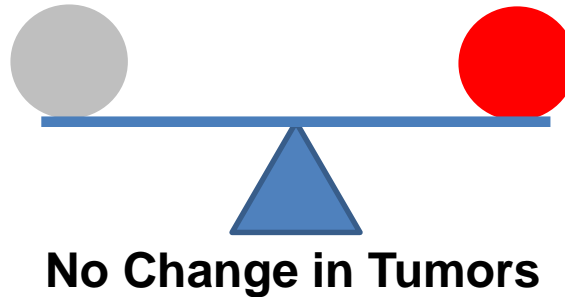
Profiling of circulating microRNAs: from single biomarkers to re-wired networks Anna Zampetaki, Peter Willeit, Ignat Drozdov, Stefan Kiechl, Manuel Mayr. *Cardiovascular Research*, 2011.

● Tumor Suppressor miRNAs

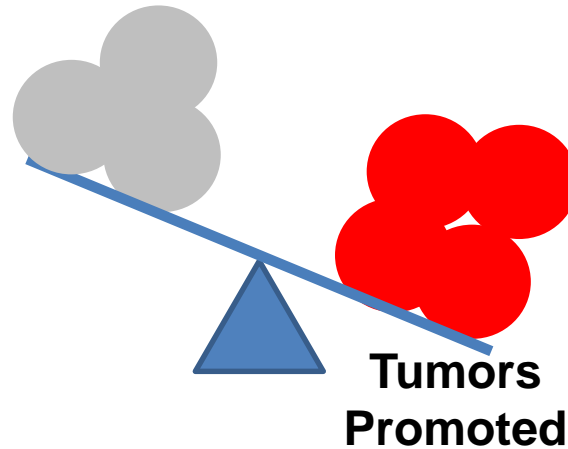
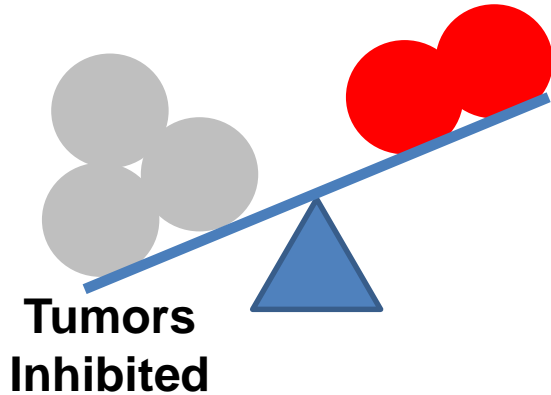
● OncomiRNAs



Only looking at a single miRNA



looking at a pair of miRNAs

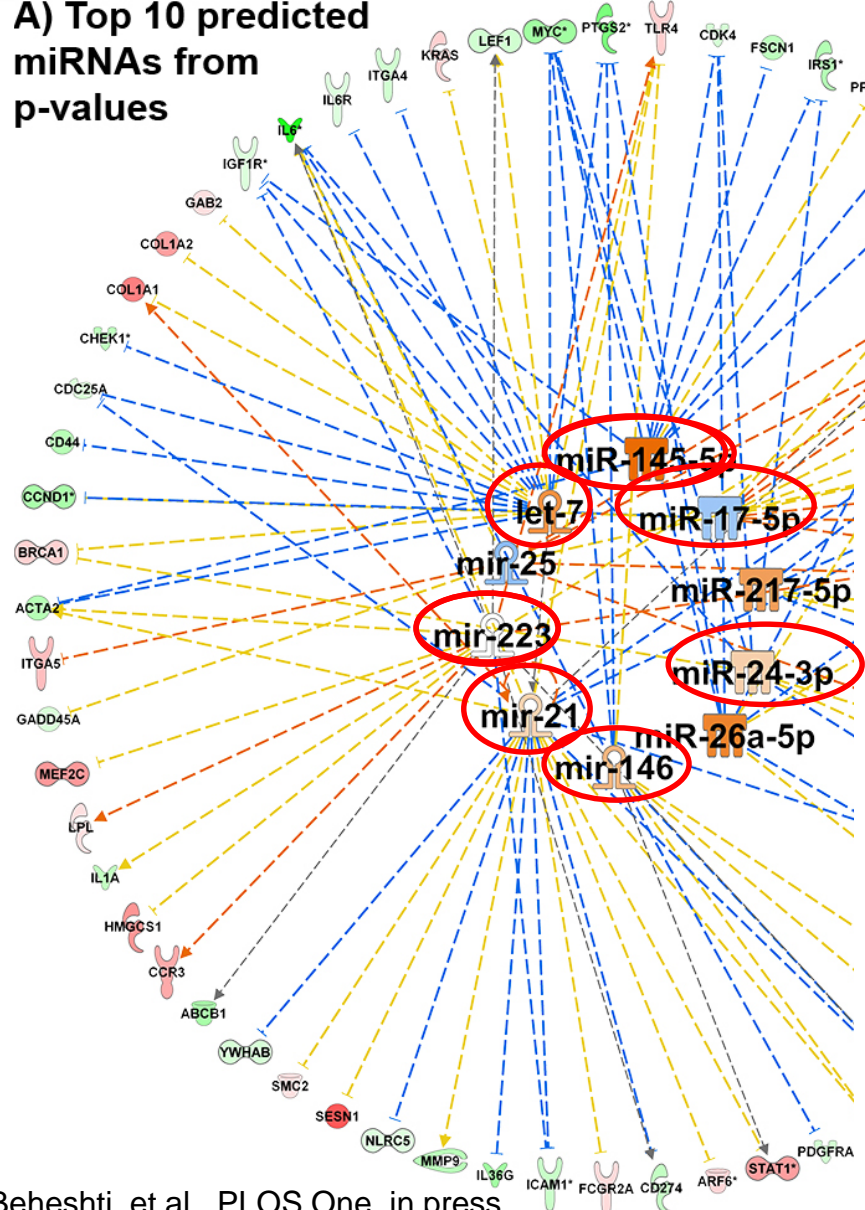


Systems Biology Approach: Looking at how the entire system impacts the most important miRNAs

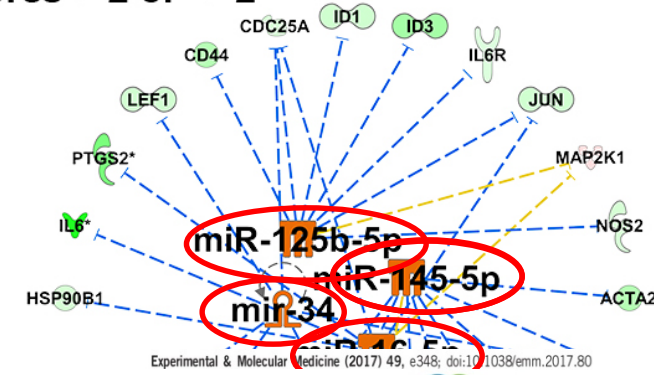
# Predicted miRNAs Involved with Microgravity Effects



A) Top 10 predicted miRNAs from p-values



B) All miRNAs with Z-scores > 2 or < -2



Hindawi Publishing Corporation  
BioMed Research International  
Volume 2014, Article ID 296747, 16 pages  
<http://dx.doi.org/10.1155/2014/296747>

Experimental & Molecular Medicine (2017) 49, e348; doi:10.1038/emm.2017.80  
Hindawi PLoS one

Research Article  
**Integration Analysis of MicroRNA and mRNA Expression Profiles in Human Peripheral Blood Lymphocytes Cultured in Modeled Microgravity**  
Lucia Celotti, Lucia Mognato

C. Girardi,<sup>1</sup> C. De Pittà,<sup>1</sup> S. Casara,<sup>1</sup> E. Calura,<sup>1</sup> C. Romualdi,<sup>1</sup> L. Celotti,<sup>1,2</sup> and M. Mognato<sup>1</sup>

<sup>1</sup> Dipartimento di Biologia, Università degli Studi di Padova, Via U. Bassi 58/B, 35131 Padova, Italy  
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We analyzed miRNA and mRNA expression profiles in human peripheral blood lymphocytes (PBLs) incubated in microgravity condition, simulated by a ground-based rotating wall vessel (RWV) bioreactor. Our results show that 42 miRNAs were differentially expressed in MMG-incubated PBLs compared with 1 g incubated ones. Among these, miR-9-5p, miR-9-3p, miR-155-5p, miR-150-3p, and miR-378-3p were the most dysregulated. To improve the detection of functional miRNA-mRNA pairs, we performed gene expression profiles on the same samples assayed for miRNA profiling and we integrated miRNA and mRNA expression data. The functional classification of miRNA-correlated genes evidenced significant enrichment in the biological processes of immune/inflammatory response, signal transduction, regulation of response to stress, regulation of programmed cell death, and regulation of cell proliferation. We identified the correlation of miR-9-3p, miR-155-5p, miR-150-3p, and miR-378-3p expression with that of genes involved in immune/inflammatory response (e.g., IFNG and IL17F), apoptosis (e.g., PDCD4 and PTEN), and cell proliferation (e.g., NKX3-1 and GADD45A). Experimental assays of cell viability and apoptosis induction validated the results obtained by bioinformatics analyses demonstrating that in human PBLs the exposure to reduced gravitational force increases the frequency of apoptosis and decreases cell proliferation.

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# Predicted miRNAs Involved with Microgravity Effects

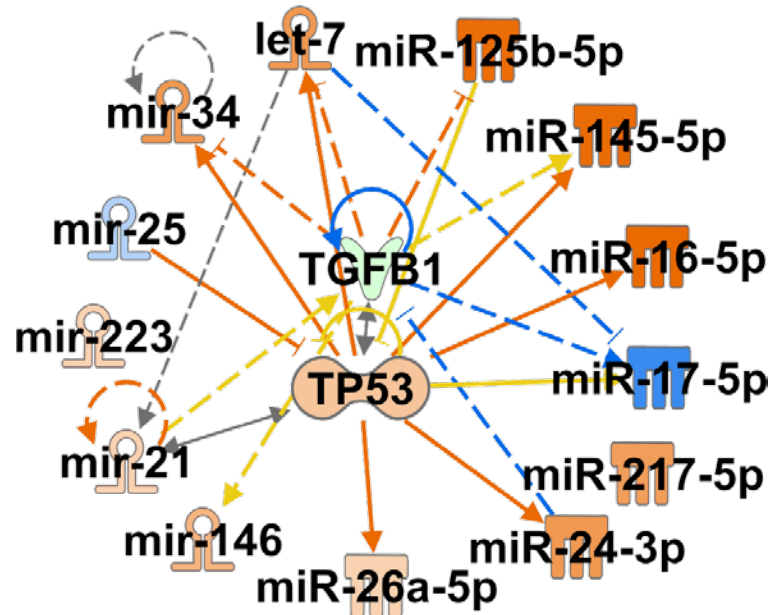


## Health Risk Due to miRNAs



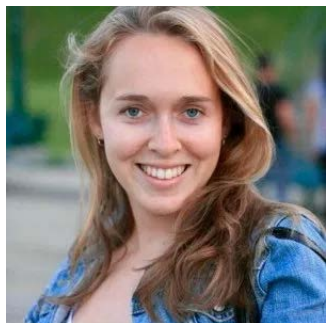
- A recent report showed that inactivation of p53 altered TGF- $\beta$  signaling, which ironically displayed both tumor-suppressive and pro-oncogenic functions. p53 functions to integrate crosstalk between Ras/MAPK and TGF- $\beta$  signaling via binding to Smad3, dislocating the Smad3/Smad4 complex formation and differentially regulating subsets of TGF- $\beta$  target genes

*Biological Health  
Risk Increased*





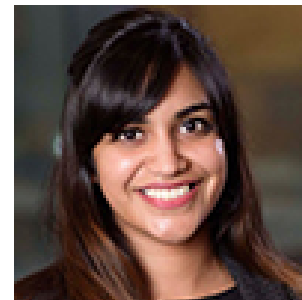
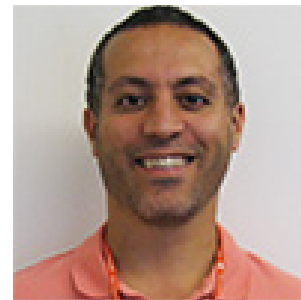
**Analysis Working Group (AWG) Member  
related work determines novel systemic  
biological factors causing damage due to  
spaceflight**



Kathleen Fisch Brin Rosenthal



UNIVERSITY of CALIFORNIA, SAN DIEGO  
SCHOOL OF MEDICINE



Deanne Taylor Hossein Fazelinia Komal Rathi



Helio Costa Kathryn Grabek



**STANFORD**  
UNIVERSITY



J. Tyson McDonald

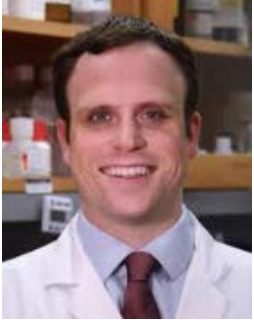


Gary Hardiman



Willian da Silveira





Chris Mason



Cem Meydan



Jonathan Foox



Flavia Rius



Cornell University



Yared Kidane



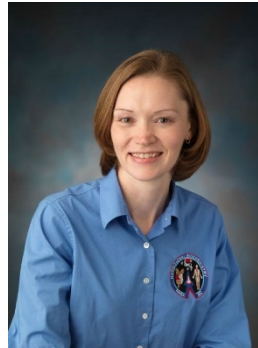
TEXAS  
SCOTTISH RITE HOSPITAL  
FOR CHILDREN



Susana Zanella



Scott Smith



Sara Zwart



Afshin Beheshti



Sylvain Costes





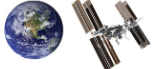
## FEMALE ASTRONAUT



Women suffer less from hearing loss with advancing age, and do not display a bias towards loss of hearing in the left ear



Women demonstrate a slight bias towards accuracy versus speed in response to an alertness test



Women mount more potent immune responses



Struvite kidney stones more common in women



Female astronauts, (to date) do not exhibit clinically significant visual impairment



Female astronauts are more susceptible to orthostatic intolerance



Urinary tract infections are more common in female astronauts



Large individual variability to muscle and bone loss in women

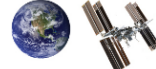


Health effect observed on Earth

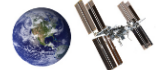
## MALE ASTRONAUT



Men suffer more from hearing loss with advancing age, and display a bias towards loss of hearing in the left ear



Men demonstrate a slight bias towards speed versus accuracy in response to an alertness test



Men mount less potent immune responses



Calcium oxalate kidney stones more common in men



Some male astronauts exhibit clinically significant visual impairment



Male astronauts less susceptible to orthostatic intolerance



Urinary tract infections less common in male astronauts

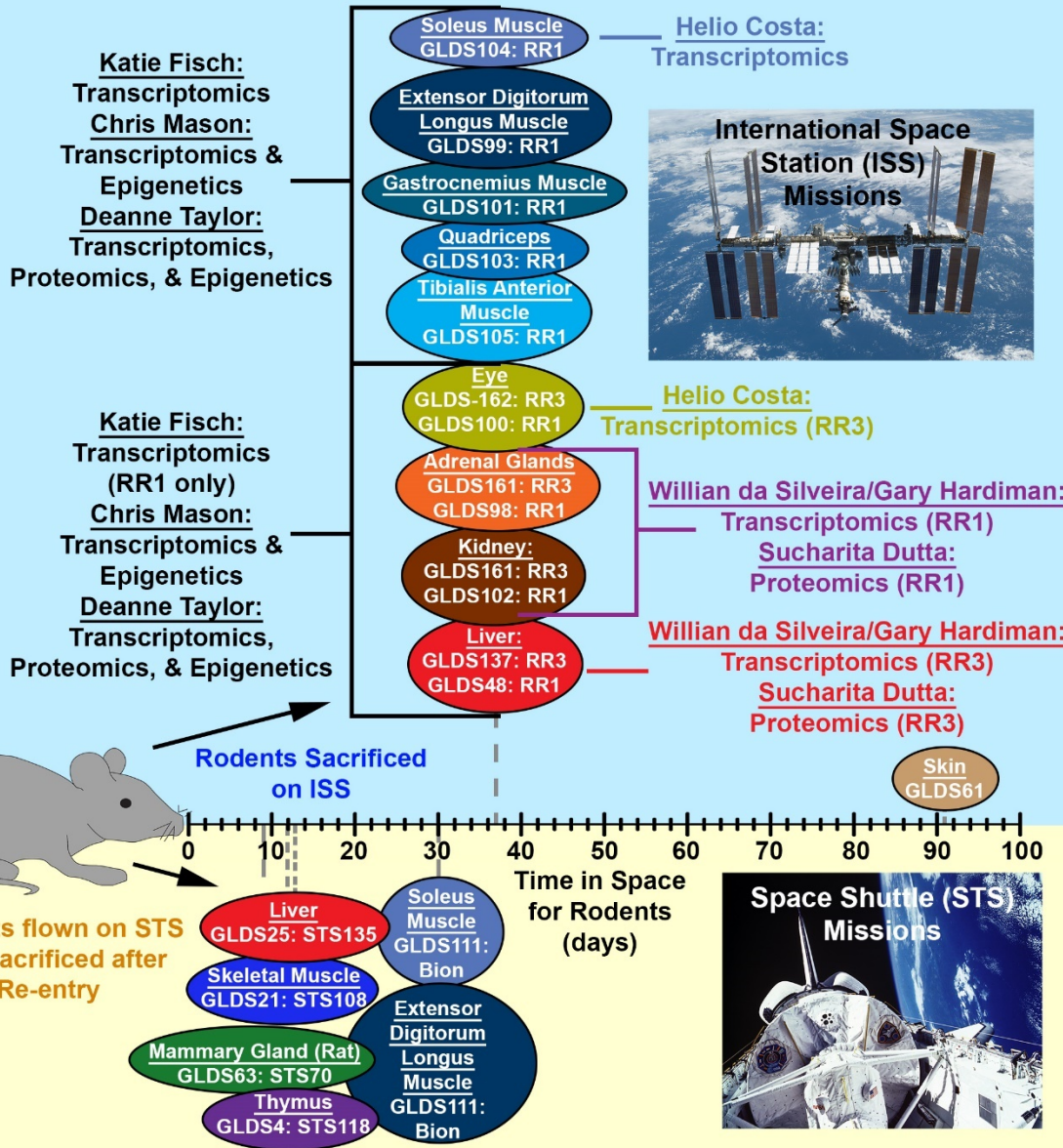


Large individual variability to muscle and bone loss in men



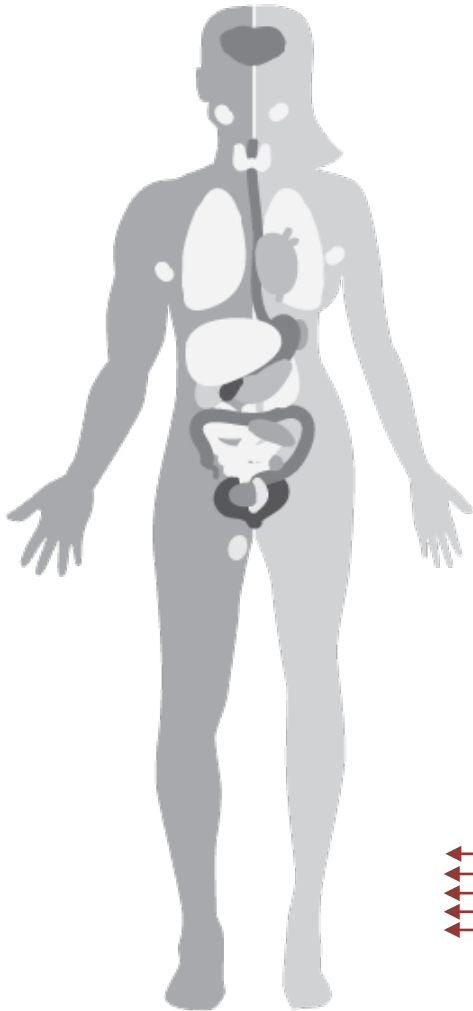
Health effect observed in space

# Specific Datasets and Tissues AWG Members Analyzed

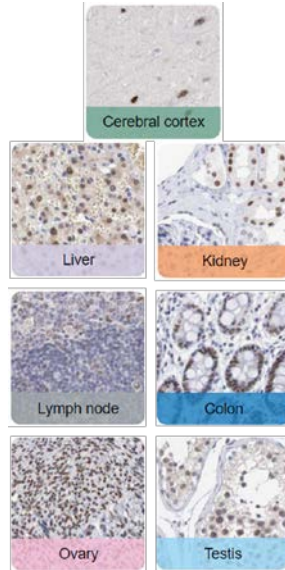


- Additional Datasets that are being analyzed:
  - Human datasets
    - GLDS-54, GLDS-174, GLDS-86, GLDS-118, GLDS-53, GLDS-54, GLDS-13. GLDS-52, or GLDS-114 (Tyson McDonald and Yared Kidane)

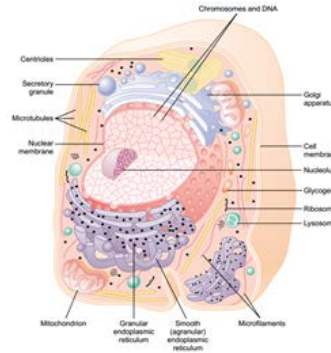
**Level 7: The Body**  
**Level 6: Organs**



**Level 5:  
Tissues**



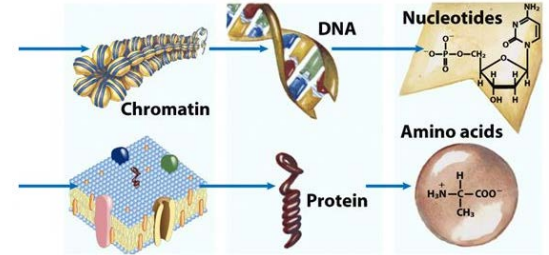
**Level 4:  
The Cell and its  
Organelles**



**Level 3:  
Supra  
molecular  
Complexes**

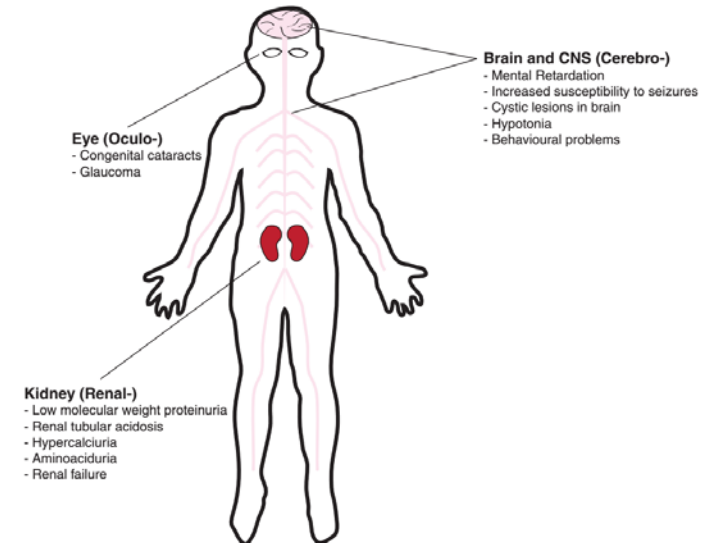
**Level 2:  
Macro  
molecules**

**Level 1:  
Monomeric  
Units**



- Spaceflight changes the physical properties of the cell components impacting from the molecular to the whole body level.
- The Mitochondria are the principal cellular component affect.
- The Liver is the principal organ affected in issues related to the metabolism.
- Possible disease that can be associated with liver damage and pathways is: Oculocerebrorenal Syndrome of Lowe
  - “Extensive research has demonstrated that OCRL-1 is involved in multiple intracellular processes involving endocytic trafficking and actin skeleton dynamics. This explains the multi-organ manifestations of the disease.”
  - “The classic form of the oculocerebrorenal syndrome of Lowe (OMIM #309000), first described by Lowe et al. in 1952 [1], is characterized by the triad of congenital cataracts, severe intellectual impairment, and renal tubular dysfunction with slowly progressive renal failure”
  - Patients with this disease manifest Cataract, Glaucoma and Muscle hypotonia.

Schematic diagram showing the organs affected in Lowe syndrome



<https://genelab.nasa.gov>

Participate in GeneLab  
Analysis Working Groups

**LATEST NEWS**  
NASA GeneLab Project: Bridging Space Radiation Omics with Ground Studies  
Accurate assessment of risks of long-term space missions is critical for human space exploration. It is essential to have a detailed understanding of the biological effects on humans living and working in deep space. Ionizing radiation from galactic cosmic rays (GCR) is a major health risk factor for astronauts on extended missions outside the protective effects of the Earth's magnetic field. Currently, there are gaps in our knowledge of the health risks associated with chronic low-dose, low-dose-rate ionizing radiation, specifically ions associated with high (H) atomic number (Z) and energy (E). The NASA GeneLab project aims to provide a detailed library of omics datasets associated with biological samples exposed to HZE... [Read more](#)

**Access GeneLab Omics Data**  
Home Repository Data Data Mining Tools Submit Data Help Workspace  
Search Data  
GeneLab NH GEO EB PRIDE ANL US-MSST

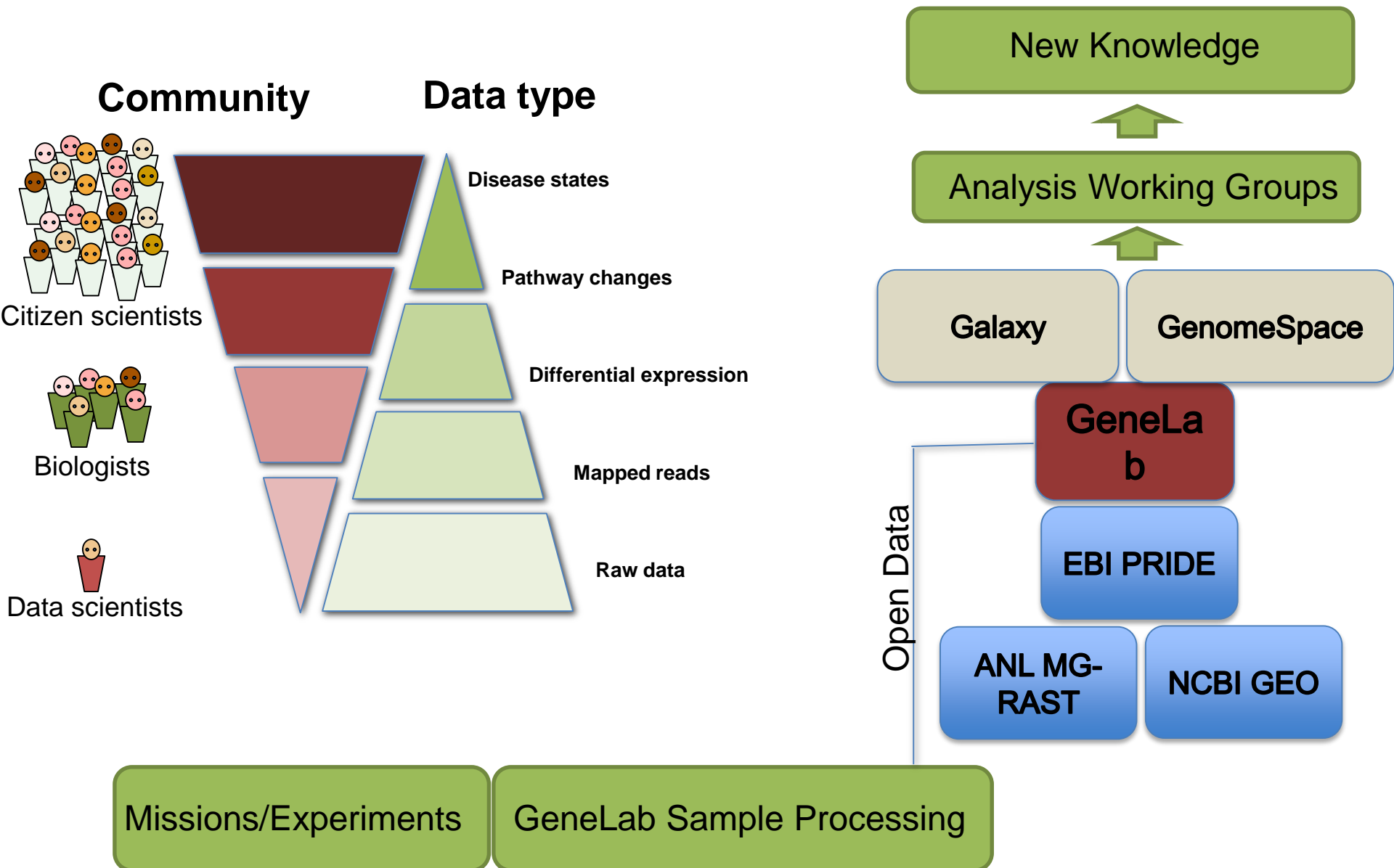
**SPOTLIGHT ON RADIATION**  
Radiation Dosimetry Measurements Added to Data Repository  
Low-Earth Orbit (LEO) International Space Station (ISS) Mission  
Commercial, Orbit 6000  
ISS & Station  
Typical Dosimetry  
10,000 Gy

**RESEARCH ANNOUNCEMENT**  
NASA Research Announcement: Topics in Human Health Countermeasures, Human Factors, and Behavioral Performance

LabRoots: A Conversation with Sigrid Reinsch – Public Access to Spaceflight Omics Data  
Marianne Sowa and Jack Miller Discuss Radiation Science Using GeneLab

- Social media :
  - @NASA Ames Facebook
  - Twitter #GeneLab
  - ResearchGate: <https://www.researchgate.net/project/Omics-for-Space-Biology-The-GeneLab-project>





Chris Barreras  
**Afshin Beheshti**  
**Dan Berrios**  
**Valery Boyko**  
Sonja Caldwell  
Jairon Camarillo  
Egle Cekanaviciute  
John Costa  
**Sylvain Costes (PM)**  
Marie Dinh  
Sandy Dueck  
**Homer Fogel**  
**Jon Galazaka (PS)**  
Samrawit Gebre  
Dennis Heher  
Lynn Hutchison  
Yared Kidane  
**San-Huei Lai Polo**  
Tristan Le  
Qiang Li  
Shu-Chun Lin  
Sneha Raghunandan  
Shayoni Ray  
**Sigrid Reinsch**  
David Smith  
Marla Smithwick  
Hao Thai  
Khai Peter Tran  
Andrew Williamson



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