

NASA Open Science Data Repository:

National Aeronautics and
Space Administration



Biomedical FAIR Data, Analysis Tools, User Communities, and Discoveries for Deep Space Missions

Ryan T. Scott



KBR | Science Lead

NASA Ames Life Sciences Data Archive

NASA Open Science Data Repository

Human Research Program Investigators' Workshop

February 13, 2024

ryan.t.scott@nasa.gov

Danielle Lopez (KBR)

Amanda Saravia-Butler (KBR)

Lauren Sanders (Blue Marble Space Institute of Science)

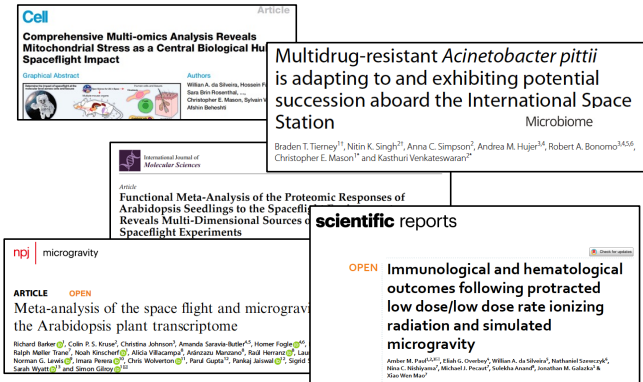
Sam Gebre (NASA Ames)

Sylvain Costes (NASA Ames)



Data: Maximally Open and Reusable for Life and Humans to Thrive in Deep Space

Knowledge Discovery

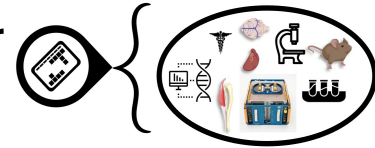


Enable Informatics, AI/ML, KG, DAG, AOP, Omic-Phenotypic Conclusions

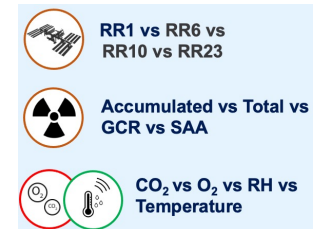
Model development
Active and adaptive learning
Causal and network inference
Explainable AI
Federated learning
Few- or one-shot learning
Generative learning (synthetic datasets)
Knowledge graphs
Lifelong learning (living lab)
Out-of-distribution learning
Transfer learning



Telemetry for Biomedical Context



Analysis Across Missions



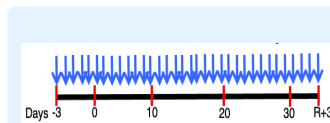
Across Hazards



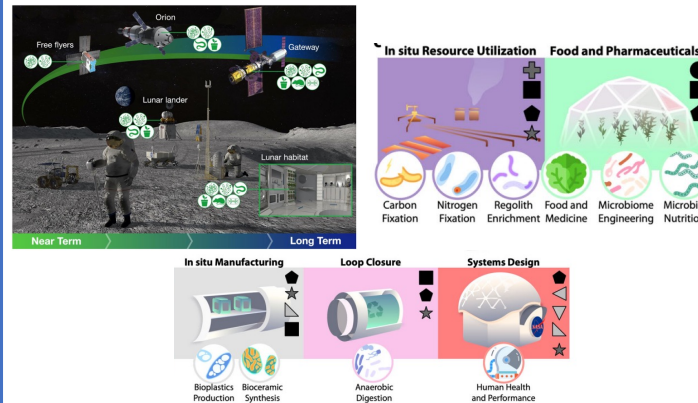
Across Species, Multimodal Data Types



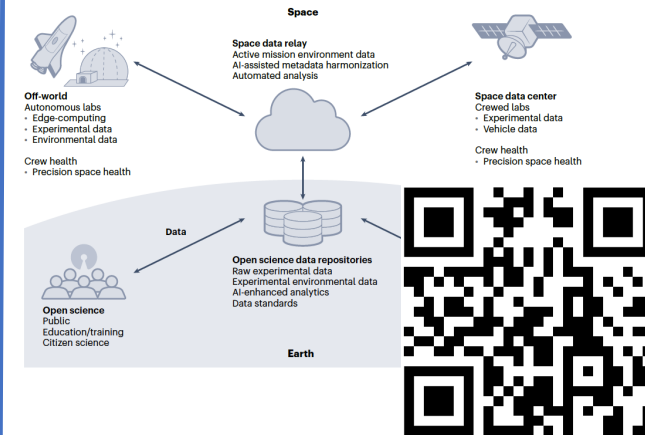
Longitudinal, Biomonitoring, & Experimental



Novel Ecosystem, Platform, Countermeasure Development, Health Risk Quantification



Involve the World in Spaceflight



(Scott et al., 2023 <https://rdcu.be/c8jSO>;
Sanders et al., 2023 <https://rdcu.be/c8jSS>)

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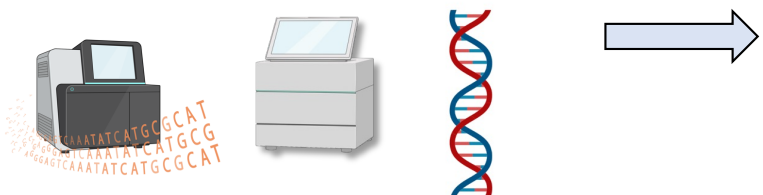
(Berliner et al., 2022 <https://doi.org/10.1038/s44172-022-00012-9>;
Everroad et al., 2021 <https://ntrs.nasa.gov/citations/20210023324>)

All Relevant Data for Biological, Biomedical, Health, Telemetry Analytics

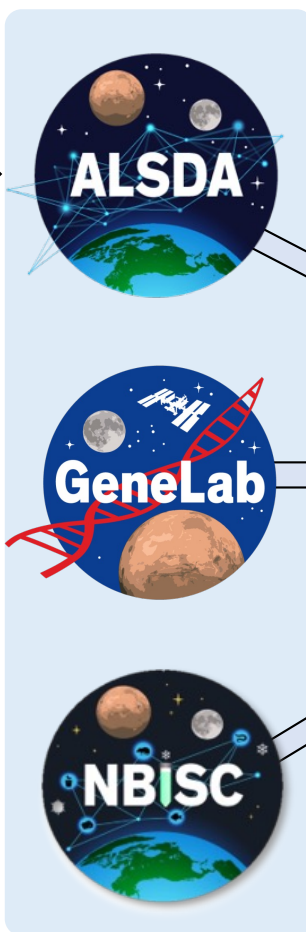
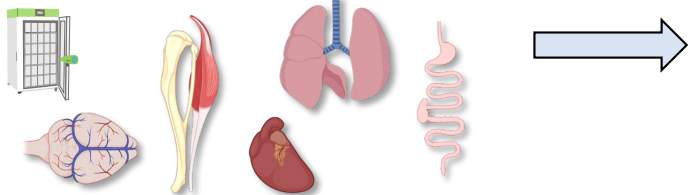
Physiological/Phenotypic/Imaging/ Environmental Telemetry Data



Molecular/Omics Data



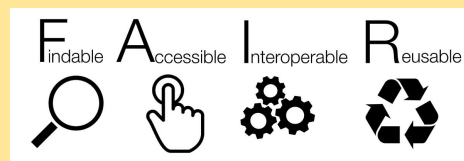
Biospecimens



NASA Open Science Data Repository (OSDR)

osdr.nasa.gov/bio

- Single Submission Portal
- User Web-Interface Tool for Research Data Submission Agreements
- Maximally Open Access
- Request Feature for Restricted Data
- Analytical Tools (Enables More Users)
- Data Maximally FAIR



453
Studies

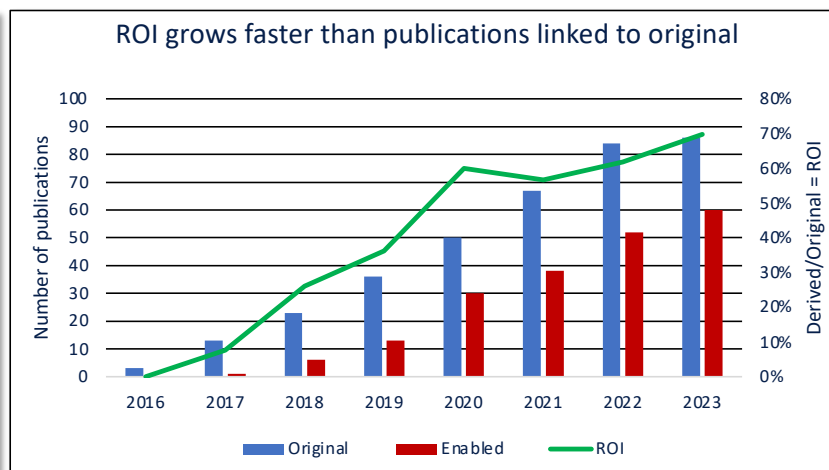
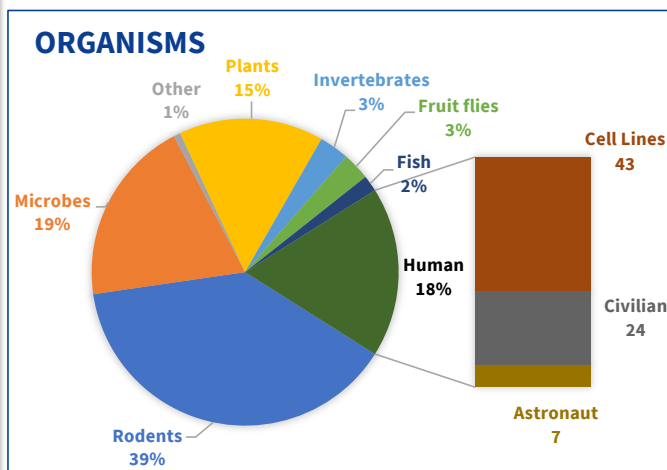
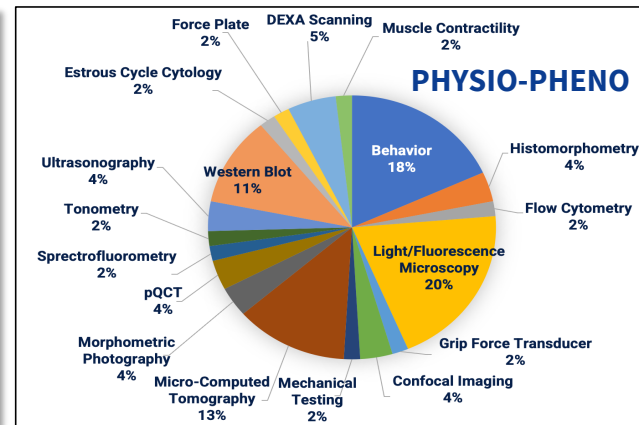
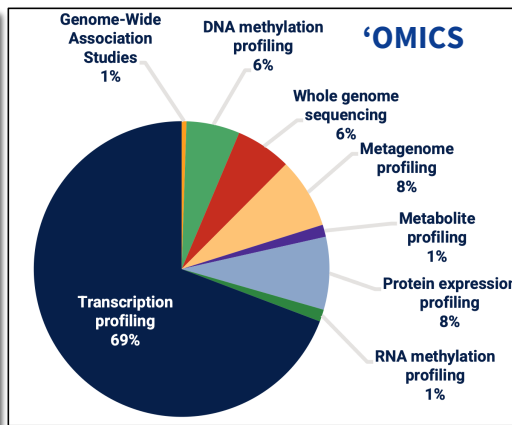
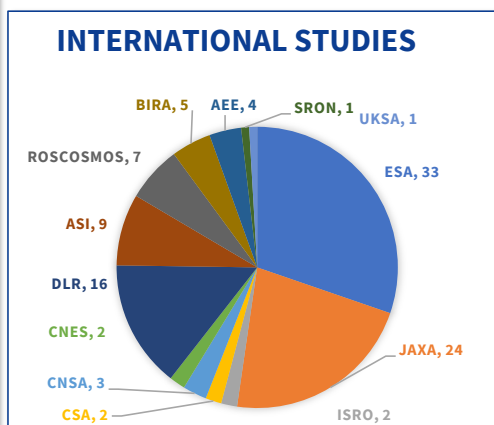
880
Datasets

45
Species

>55
Assays

>150TB
Data

NASA Open Science Data Repository



91
Original
Publications Have
Data Submitted
to OSDR

60
Publications
Enabled by OSDR
Data Mining

142+
Datasets Used in
Enabled
Publications

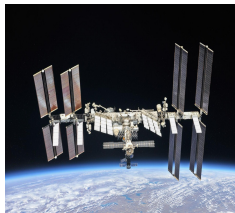
A Buffet of Data: From Raw Sequence Data to Imaging to Videos



Study
OSD-628

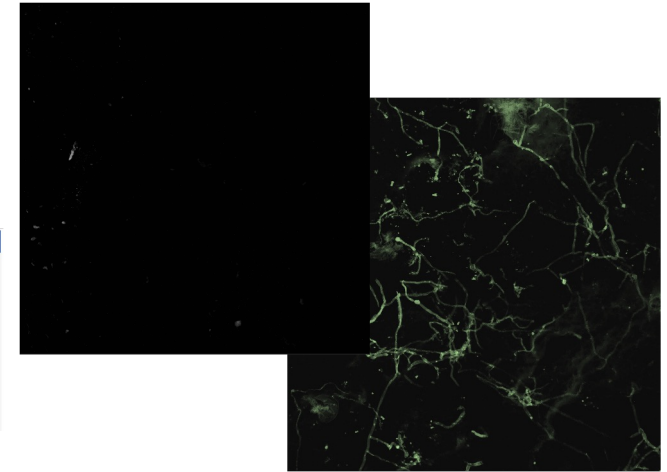
Characterization of Biofilm Formation, Growth, and Gene Expression on Different Materials and Environmental Conditions in Microgravity (Morphology of *Penicillium rubens* biofilms)

Organisms	Factors	Assay Types	Release Date	Description
<i>Penicillium rubens</i>	Spaceflight Growth Environment Time	Molecular Cellular Imaging	12-Sep-2023	Microorganisms' natural ability to live as organized multicellular communities – also known as biofilms – provides them with unique survival advantages. For instance, biofilms are protected against en...



Protocols									
Samples									
Sample Name	Characteristics	Characteristics	Characteristics	Characteristics	Characteristics	Characteristics	Characteristics	Characteristics	Characteristics
A1	ATCC 26913	Wild Type	Cells	Space Flight	Carbon Fiber				
A2	ATCC 26913	Wild Type	Cells	Space Flight	Carbon Fiber				
A3	ATCC 26913	Wild Type	Cells	Space Flight	Quartz				
A4	ATCC 26913	Wild Type	Cells	Space Flight	55019				
A5	ATCC 26913	Wild Type	Cells	Space Flight	Quartz				
A6	ATCC 26913	Wild Type	Cells	Space Flight	SiC/SiC				

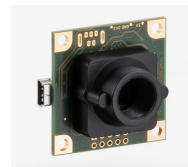
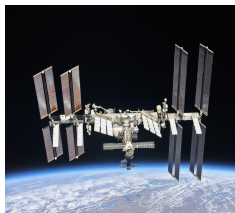
Assays									
Molecular Cellular Imaging - Confocal									
Sample Name	Protocol ID	Parameter Value	Parameter Value	Parameter Value	Parameter Value	Parameter Value	Parameter Value	Parameter Value	Parameter Value
A1	Image File Dimensions	575x573	35	1	2 comp 12bit	0.02 micron pixel	DAPI and TRITC		
A2	Image File Dimensions	575x573	35	1	2 comp 12bit	0.02 micron pixel	DAPI and TRITC		



Study
OSD-595

Artificial gravity partially protects space-induced neurological deficits in *Drosophila melanogaster*

Organisms	Factors	Assay Types	Release Date	Description
<i>Drosophila melanogaster</i>	Altered Gravity Spaceflight	Behavior	25-May-2023	Spaceflight poses risks to the central nervous system (CNS), and understanding neurological responses is important for future missions. We report CNS changes in <i>Drosophila</i> aboard the International Spa...



Protocols									
Samples									
Sample Name	Characteristics	Characteristics	Characteristics	Characteristics	Characteristics	Characteristics	Characteristics	Characteristics	Characteristics
Module 1	Module 1	<i>Drosophila melanogaster</i>	Bloomington Stock Center	W1118	Wild Type	Whole Organism	Space Flight		
Module 2	Module 2	<i>Drosophila melanogaster</i>	Bloomington Stock Center	W1118	Wild Type	Whole Organism	Space Flight		
Module 3	Module 3	<i>Drosophila melanogaster</i>	Bloomington Stock Center	W1118	Wild Type	Whole Organism	Space Flight		
Module 4	Module 4	<i>Drosophila melanogaster</i>	Bloomington Stock Center	W1118	Wild Type	Whole Organism	Space Flight		
Module 5	Module 5	<i>Drosophila melanogaster</i>	Bloomington Stock Center	W1118	Wild Type	Whole Organism	Space Flight		

Assays									
Behavior - Video Recording									
Sample Name	Protocol ID	Parameter Value	Parameter Value	Parameter Value	Parameter Value	Parameter Value	Parameter Value	Parameter Value	Parameter Value
Module 1	Behavior - Video Recording	10 min	10 min	10 min	10 min	10 min	10 min	10 min	10 min
Module 2	Behavior - Video Recording	10 min	10 min	10 min	10 min	10 min	10 min	10 min	10 min
Module 3	Behavior - Video Recording	10 min	10 min	10 min	10 min	10 min	10 min	10 min	10 min
Module 4	Behavior - Video Recording	10 min	10 min	10 min	10 min	10 min	10 min	10 min	10 min



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Open Science OSDR Analysis Working Group: ~600 Members Worldwide

ANIMAL

128 members



MULTI-OMICS

342 members



MICROBIAL

130 members



PLANTS

121 members



AI/ML

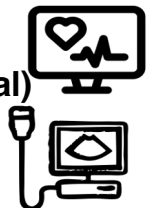
138 members



ALSDA

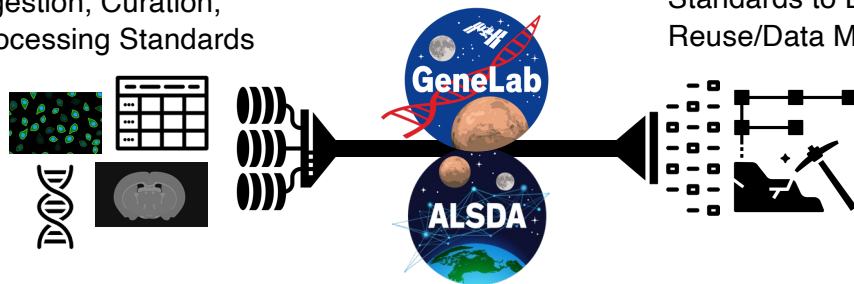
(Physiological/BioMedical)

249 members



Feedback on Ingress/Egress Standards

Ingestion, Curation,
Processing Standards



Standards to Enable
Reuse/Data Mining

Collaborate on Data Mining/Publications

<https://www.cell.com/c/the-biology-of-spaceflight>

<https://osdr.nasa.gov/bio/data/publications.html>

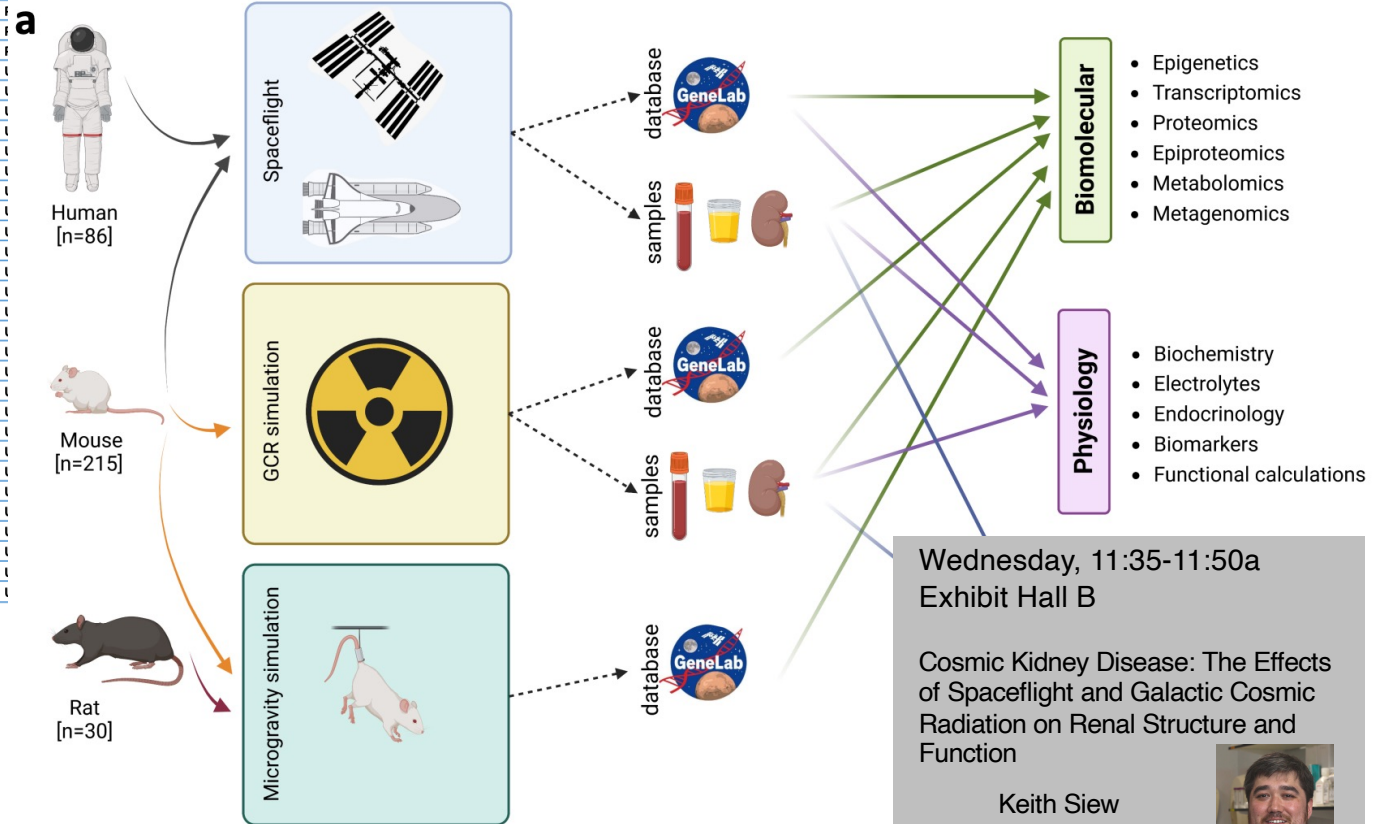


We invite you to join the over 600 AWG members -
<https://osdr.nasa.gov/bio/awg/join.html>

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Example of Open Science AWG Collaboration and Publication

Mission	Experimental Condition	Species	Sex	Background	GCR (mG)	Mission Duration (d)	Sample Collection	n	Control	Data Source	Tissue	DNA Meth	RNA	Protein	PTMs	Metab	Clin Chem	Morpho	Microbes
Inspiration4	Spaceflight	Human	Mix	USA	Unknown	3	R+0	4											
JAXA	Spaceflight	Human	♂	Japan	Unknown	120	L+120	6											
NASA	Spaceflight	Human	Mix	USA	Unknown	180	L+120	66											
Roscosmos	Spaceflight	Human	♂	Russia	Unknown	199	R+1	10											
BNL-1	simGCRsim	Mouse	♀	C57BL/6	500.0	~1.5yr sim	PE+1	10											
	MGsim				N/A	14	PE+1	10											
	simGCRsim + Mgsim				500.0	~1.5yr sim	PE+1	10											
BNL-2	simGCRsim	Mouse	♀	C57BL/6	500.0	~1.5yr sim	PE+1	10											
	MGsim				N/A	14	PE+1	10											
	simGCRsim + Mgsim				500.0	~1.5yr sim	PE+1	10											
BNL-3	simGCRsim	Mouse	♀	C57BL/6	500.0	~1.5yr sim	PE+1	10											
	MGsim				N/A	14	PE+1	10											
	simGCRsim + Mgsim				500.0	~1.5yr sim	PE+1	10											
NSRL-22A	GC	Mouse	♀	C57BL/6	500.0	~1.5yr sim	PE+1	10											
STS-135	Sp:	Human	Mix	USA	Unknown	28	R+0	7											
RR-1	Sp:	Human	Mix	USA	Unknown	28	L+38	6											
RR-3	Sp:	Human	Mix	USA	Unknown	28	L+41	6											
RR-6	Sp:	Human	Mix	USA	Unknown	28	R+4	9											
							L+75	9											
							L+25	5											
RR-7	Sp:	Human	Mix	USA	Unknown	28	L+75	5											
							L+25	5											
							R+1	5											
RR-9	Sp:	Human	Mix	USA	Unknown	28	L+28	10											
RR-10	Sp:	Human	Mix	USA	Unknown	28	R+0	8											
RR-19	Sp:	Human	Mix	USA	Unknown	28	R+1	9											
RR-23	Sp:	Human	Mix	USA	Unknown	28	R+2	6											
MHU-1	Sp:	Human	Mix	USA	Unknown	28	R+0	6											
MHU-3	Sp:	Human	Mix	USA	Unknown	28	R+0	6											
CNSA	MC	Human	Mix	USA	Unknown	28	R+0	30											



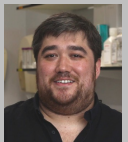
- Renal/Kidney Research
 - 53 datasets
 - 5 continents of collaborators
 - 20 spaceflight missions & ground simulations

(Credit: Keith Siew, Stephen Walsh, et al., 2024)

Wednesday, 11:35-11:50a
Exhibit Hall B

Cosmic Kidney Disease: The Effects of Spaceflight and Galactic Cosmic Radiation on Renal Structure and Function

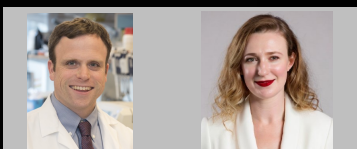
Keith Siew
Univ College London
AWG Member



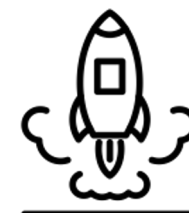
Engaging With Commercial Entities for Human Data into OSDR

INSPIRATION 4 N

- Upcoming Nature Portfolio 'I4/JAXA/SB Package'
- I4 Image Credit: Chris Mason's Lab; Overbey et al., 2024
- In Peer Review at *Nature*



Chris Mason Eliah Overbey
Weil Cornell Medicine

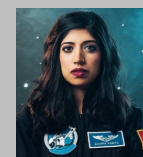


- Commercial Sub-Orbital
- Galactic-05 – Flew Nov. 2
 - Astroskin (ECG, systolic BP, heart rate (HR), breathing rate (BR), skin temperature, activity levels (provided by 3-axis accelerometer) and oxygen saturation in blood (SpO2)

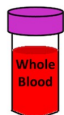
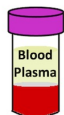
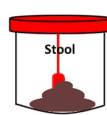
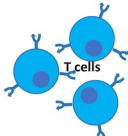
- Blood Glucose Monitoring Device

Soon!

- Credit: Dr. Shawna Pandya

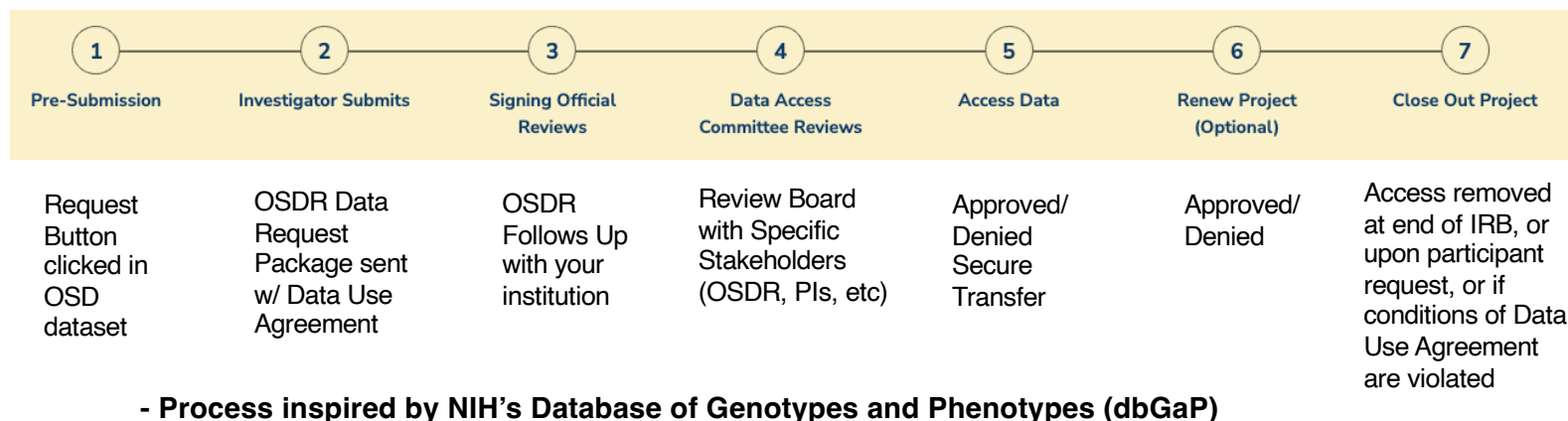
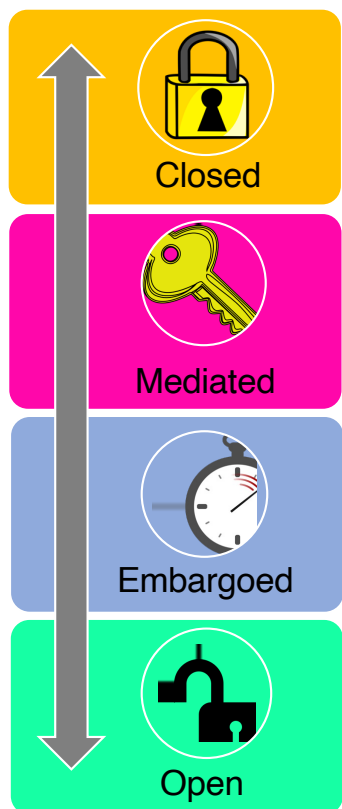


Shawna Pandya
IIAS Space Medicine

									
OSD-569	OSD-570	OSD-571	OSD-572	OSD-573	OSD-574	OSD-575	OSD-630	OSD-656	OSD-687
GLDS-561 • Nanopore Direct RNAseq • Epitranscriptomics • RNAseq (short-read) • Clonal Hematopoiesis • WGS	GLDS-562 • snRNAseq/snATACseq • scTCR-seq/scBCR-seq	GLDS-563 • Proteomics • Metabolomics • cDNAseq • cRNAseq	GLDS-564 • Metagenomics • Metatranscriptomics	GLDS-565 • Metagenomics • Metatranscriptomics	GLDS-566 • Spatial Transcriptomics • Metagenomics • Metatranscriptomics	GLDS-567 • Comprehensive Metabolic Panel • Cytokine Panel • Immune Panel	GLDS-599 • Metagenomics	GLDS-64 • Immune Panel	GLDS-618 • CUT&RUN ChIPseq
GLDS-7 • Complete Blood Count									

Maximally Open; Controlled Mgmt, Privacy Controls

The Continuum



Example of Mediated Dataset Request

Data should be as open as possible, as closed as necessary.

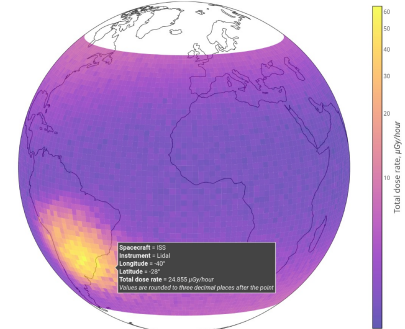
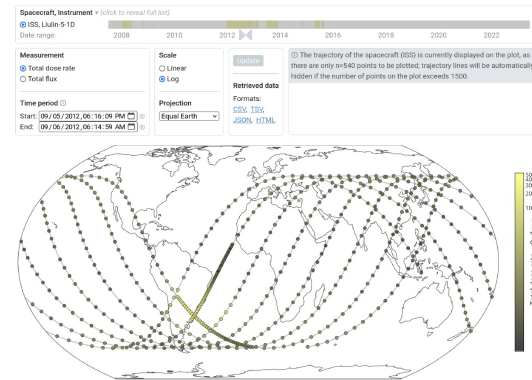
Metadata can *almost* always be open.



Environmental Data App and RadLab



<https://visualization.osdr.nasa.gov/eda>



<https://visualization.osdr.nasa.gov/radlab>

1 year update slide; multi-study, I4, eda/radlab, security

Mission Comparison

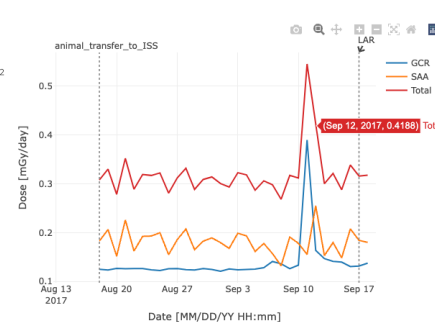
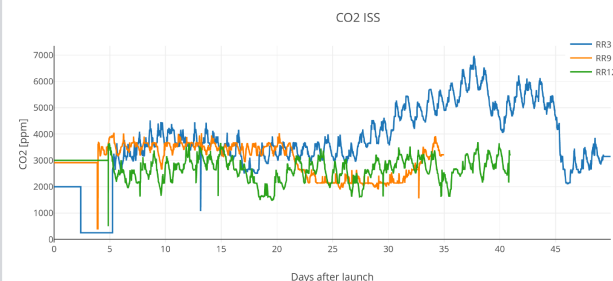
Select missions to compare

☐ RR1 ☒ RR3 ☐ RR4 ☐ RR5 ☐ RR6 ☐ RR8 ☒ RR9 ☒ RR12 ☐ RR17 ☐ RR18 ☐ RR19

Mission Comparison

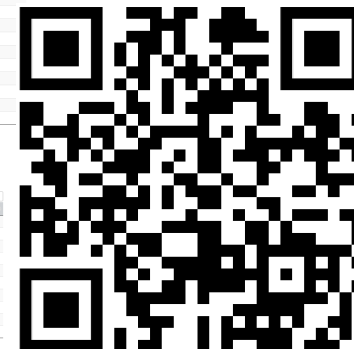
Temperature
Relative Humidity
CO2
ISS
Ground
Radiation

Data Tables

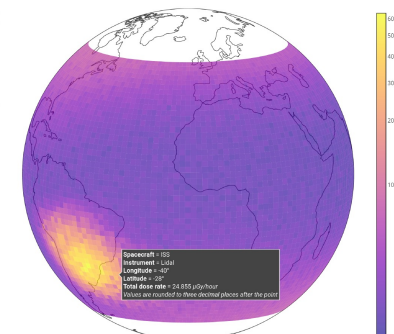
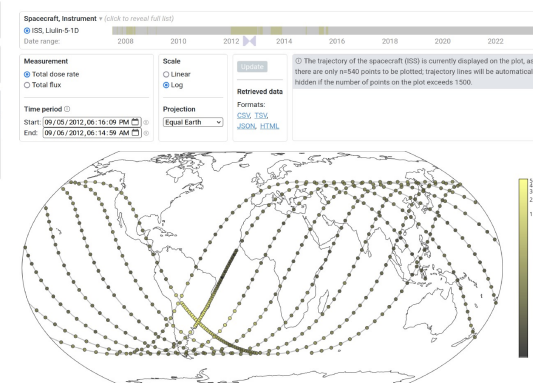


EIS - Summary table						
	Base	CRF	Safe	CRF	Safe	Median
CO2 GSD [gPM]	620.00	810.00	2000.00	458.00	1500.00	200.00
CO2 GSD [gPM]	450.00	450.00	3000.00	3000.00	3000.00	200.00
Relative humidity (rh) [%]	10.22	0.01	0.18	2.69	2.69	0.71
Relative DCF (rh) [%]	0.39	0.72	0.14	0.18	0.19	0.13
Relative DCF (rh) [%]	0.56	0.73	0.18	0.20	0.20	0.16
Relative DCF (rh) [%]	0.05	0.27	0.33	0.05	0.05	0.31
Relative humidity (rh) [%]	67.00	34.00	45.88	3.64	40.00	40.00
Relative humidity (rh) [%]	67.00	33.00	45.77	3.53	40.00	40.00
Temperature (GSD) [C]	30.00	21.00	20.00	23.55	23.55	23.55
Temperature (rh) [C]	20.00	21.00	20.00	23.55	23.55	23.55

BS-3 Telemetry data							
Time	Temp	Humid	CO2	PM2.5	PM10	PM1	Search
Generation_Temp_Offset	Temp_avg_Centroid	Temp_avg_HSS	Hum_percent_HSS	CO2_percent_HSS	PM10_percent_Ground	CO2_percent_Ground	
2019-06-10 00:00:00	24.00	24.00	0.00	0.00	0.00	262.00	
2019-06-10 00:10:00	24.00	24.00	0.00	0.00	0.00	262.00	
2019-06-10 00:20:00	24.00	24.00	0.00	0.00	0.00	262.00	
2019-06-10 00:30:00	24.00	24.00	0.00	0.00	0.00	262.00	
2019-06-10 00:40:00	24.00	24.00	0.00	0.00	0.00	262.00	
2019-06-10 00:50:00	24.00	24.00	0.00	0.00	0.00	262.00	
2019-06-10 01:00:00	24.00	24.00	0.00	0.00	0.00	262.00	
2019-06-10 01:10:00	24.00	24.00	0.00	0.00	0.00	262.00	
2019-06-10 01:20:00	24.00	24.00	0.00	0.00	0.00	262.00	
2019-06-10 01:30:00	24.00	24.00	0.00	0.00	0.00	262.00	
2019-06-10 01:40:00	24.00	24.00	0.00	0.00	0.00	262.00	
2019-06-10 01:50:00	24.00	24.00	0.00	0.00	0.00	262.00	
2019-06-10 02:00:00	24.00	24.00	0.00	0.00	0.00	262.00	
2019-06-10 02:10:00	24.00	24.00	0.00	0.00	0.00	262.00	
2019-06-10 02:20:00	24.00	24.00	0.00	0.00	0.00	262.00	
2019-06-10 02:30:00	24.00	24.00	0.00	0.00	0.00	262.00	
2019-06-10 02:40:00	24.00	24.00	0.00	0.00	0.00	262.00	
2019-06-10 02:50:00	24.00	24.00	0.00	0.00	0.00	262.00	
2019-06-10 03:00:00	24.00	24.00	0.00	0.00	0.00	262.00	
2019-06-10 03:10:00	24.00	24.00	0.00	0.00	0.00	262.00	
2019-06-10 03:20:00	24.00	24.00	0.00	0.00	0.00	262.00	
2019-06-10 03:30:00	24.00	24.00	0.00	0.00	0.00	262.00	
2019-06-10 03:40:00	24.00	24.00	0.00	0.00	0.00	262.00	
2019-06-10 03:50:00	24.00	24.00	0.00	0.00	0.00	262.00	
2019-06-10 04:00:00	24.00	24.00	0.00	0.00	0.00	262.00	
2019-06-10 04:10:00	24.00	24.00	0.00	0.00	0.00	262.00	
2019-06-10 04:20:00	24.00	24.00	0.00	0.00	0.00	262.00	
2019-06-10 04:30:00	24.00	24.00	0.00	0.00	0.00	262.00	
2019-06-10 04:40:00	24.00	24.00	0.00	0.00	0.00	262.00	
2019-06-10 04:50:00	24.00	24.00	0.00	0.00	0.00	262.00	
2019-06-10 05:00:00	24.00	24.00	0.00	0.00	0.00	262.00	
2019-06-10 05:10:00	24.00	24.00	0.00	0.00	0.00	262.00	
2019-06-10 05:20:00	24.00	24.00	0.00	0.00	0.00	262.00	
2019-06-10 05:30:00	24.00	24.00	0.00	0.00	0.00	262.00	
2019-06-10 05:40:00	24.00	24.00	0.00	0.00	0.00	262.00	
2019-06-10 05:50:00	24.00	24.00	0.00	0.00	0.00	262.00	
2019-06-10 06:00:00	24.00	24.00	0.00	0.00	0.00	262.00	
2019-06-10 06:10:00	24.00	24.00	0.00	0.00	0.00	262.00	
2019-06-10 06:20:00	24.00	24.00	0.00	0.00	0.00	262.00	



<https://visualization.osdr.nasa.gov/eda>



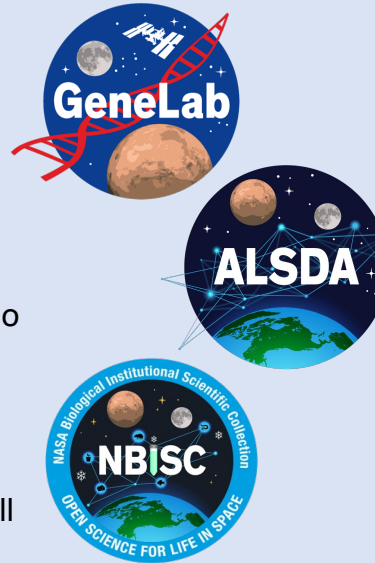
<https://visualization.osdr.nasa.gov/radlab>

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Stakeholders-Management

NASA Space Biology Program

NASA Biological and Physical Sciences

NASA Science Mission Directorate

NASA Human Research Program

Tuesday, 3:45-5p
Grand Ballroom A

Biological Research and Space
Health Enabled by Machine Learning
to Support Deep Space Missions

Sylvain
Costes



Tuesday, 4:30-6p
Exhibit Hall A

Enabling Model Organism and
Commercial Astronaut Data Access
through OSDR

Amanda
Saravia-
Butler



Wednesday, 2:45-4:15p
Exhibit Hall A

RadLab: Graphical and
Programming Interfaces for
Interrogation of Space Telemetry

Kirill
Grigorev



Wednesday, 2:45-4:15p
Exhibit Hall A

NASA Biological Institutional Scientific
Collection (NBISC): Tissue and
Biospecimens to Advance Space
Research

Sigrid
Reinsch

