

NIH's interest in space biomedical research

Decadal Survey on Biological and Physical Sciences Research in Space
May 4th 2022

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National Center for Advancing Translational Sciences

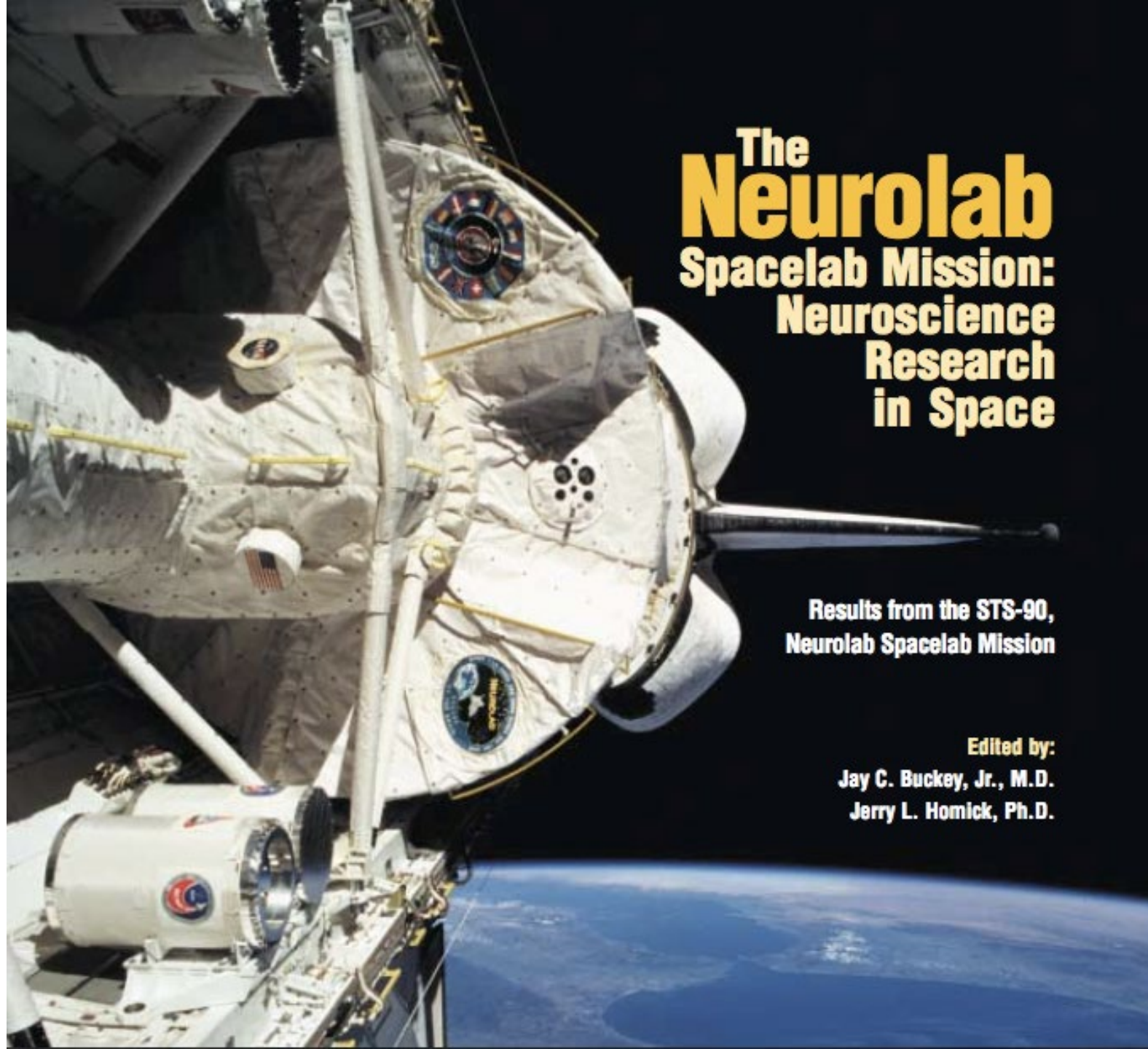




NCI	NEI	NHLBI
NHGRI	NIA	NIAAA
NIAID	NIAMS	NIBIB
NICHD	NIDCD	NIDCR
NIDDK	NIDA	NIEHS
NIGMS	NIMH	NIMHD
NINDS	NINR	NLM
CC	CIT	CSR
FIC	NCATS	NCCIH



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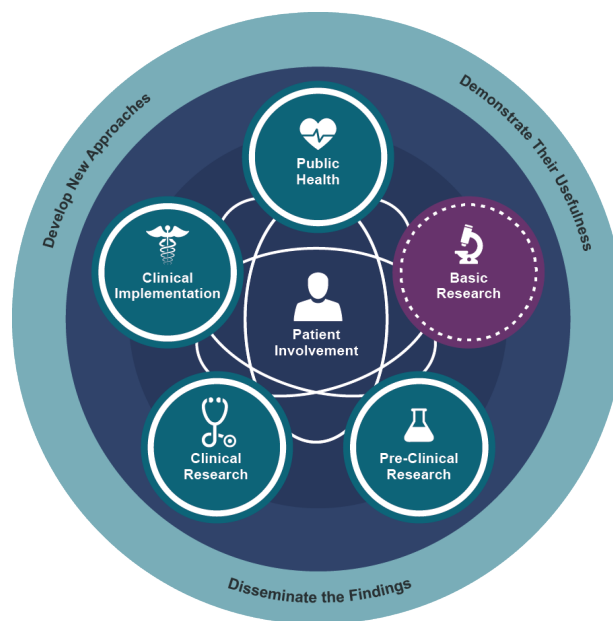




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NCATS' Mission

“To catalyze the generation of **innovative methods and technologies** that will enhance the development, testing and implementation of diagnostics and therapeutics across a wide range of human diseases and conditions.”



**DEVELOP
DEMONSTRATE
DISSEMINATE**



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Why is NIH interested in space-related biomedicine?

- NIH focuses on human health and disease
 - Humans in space are subject to unique physiological challenges which can inform the understanding of health and disease on Earth

Why would NIH partner with spaceflight organizations?

- Complementary strengths offer opportunities to benefit all parties' missions and leverage resources e.g.
 - Understanding loss of bone density in osteoporosis and exposure to microgravity
 - Studying behavior, mental health, telemedicine, in remote/isolated places
 - Gaining insight into physiology in extreme environments such as hypo/hypergravity
- Unique environment of space, plus access to ground-based facilities, offers opportunities for NIH-funded researchers e.g.
 - NCI radiation research at Brookhaven National Lab/NASA Space Radiation Laboratory
 - NCATS Chips in Space program onboard ISS



NONREIMBURSABLE UMBRELLA INTERAGENCY AGREEMENT

between the

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES

and the

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FOR

COOPERATION IN RESEARCH, TECHNOLOGY, AND DEVELOPMENT
ACTIVITIES

RELATED TO HUMAN HEALTH AND PUBLIC HEALTH



HHS and NASA Team Up to Explore Health on Earth and in Outer Space

December 6, 2018 | By: [Eric D. Hargan](#), Deputy Secretary of the Department of Health and Human Services

Summary: The collaboration between NASA and HHS has so many exciting possibilities for understanding health issues on Earth.

HHS-NASA Interagency Agreement



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Recent NIH-funded spaceflight missions

- T-Cell Activation in Aging – CRS-3
 - PI: Paola Divieti Pajevic, sponsored by NIA
- Osteocytes and Mechanotransduction (Osteo-4) – CRS-6
 - PI: Millie Fulford-Hughes, sponsored by NIAMS
- OsteoOmics – CRS-9
 - PI: Bruce Hammer, sponsored by NIBIB
- Crystallization of RAS in Space – CRS-16
 - PI: Dhirendra Simanshu, sponsored by NCI, partnership with ISSNL
- NCATS' Tissue Chips in Space program – CRS-16, 17, 20, 21, 22, 24, 25, 26
 - 9 projects, 2 flights each; partnership with ISSNL, NASA and NIBIB

From 2014 onwards



Article | OPEN | Published: 21 December 2017

Nanopore DNA Sequencing and Genome Assembly on the International Space Station

Castro-Wallace et al, Sci Rep 7:18022 (2017)

STEM CELL REPORTS

Volume 13, Issue 6, 10 December 2019, Pages 960-969



Report

Effects of Spaceflight on Human Induced Pluripotent Stem Cell-Derived Cardiomyocyte Structure and Function

Wnorowski et al, 2019



Photos: NASA

Protein crystal growth

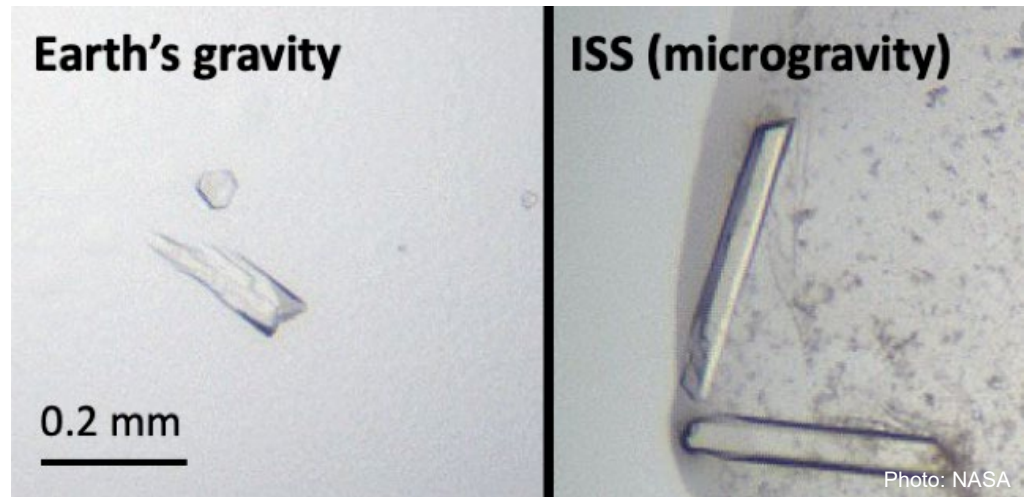


Photo: NASA



Ground-based collaborations

- NCI/NASA Collaboration at NASA Space Radiation Laboratory (NSRL), Brookhaven
 - Investigating radiation toxicity as a result of cancer chemotherapy; 'radioresistant' cancers; targeted radiation-based immunotherapies
- NEI/NASA work on early cataract detection
 - Laser light technique, dynamic light scattering (DLS), used for monitoring growth of protein crystals in microgravity
 - NEI-NASA clinical trial reported amount of alpha-crystallin in optic lenses for early cataract detection



NIH-NASA Scientific Potential/Actual Collaborative Efforts Group

- NIH-led group of scientific staff, with representation from 20 Institutes and Centers at NIH
- NASA co-chair; members from multiple centers



Aim: To build and grow ongoing relationships



NIH-NASA Scientific Potential/Actual Collaborative Efforts Group

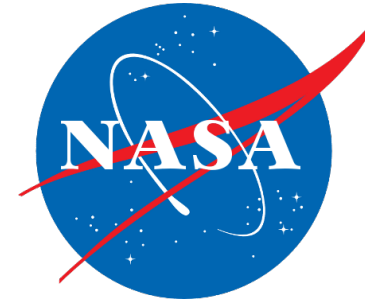
➤ Goals:

- *Explore areas of potential synergy for biomedical scientific research that fulfils the mandates of both NIH and NASA.*
- *Facilitate communications between researchers to instigate and support collaborative efforts.*
- *Explore possibilities for joint efforts between NIH and NASA to support research into synergistic biomedical interest areas, and implement appropriate joint exercises.*



SPACE group and joint agency activities

- Presentations from non-NIH stakeholders
- Joint exercises
 - Workshops
 - Seminar series
 - Presentations from academia and industry
- Joint publications
- Joint funding opportunities



CASIS™



BLUE ORIGIN



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Sex Differences in Radiation Research Workshop

(April 26-27, 2022)

Goals of this workshop:

- Examine sex differences within radiation animal models and understand how these may affect radiation medical countermeasure (MCM) development
- Explore sex differences in biodosimetry and/or biomarkers used to assess acute radiation syndrome (ARS), delayed effects of acute radiation exposure (DEARE), and/or predict major organ morbidities
- Learn about the challenges in medical research lacking representation from both sexes
- Discuss regulatory policies that influence inclusion of women in research, the gaps that exist in these practices, and emphasize the importance of this topic in drug development and device clearance
- Explore real-world sex differences in human health scenarios
- Generate a workshop report to be published in a peer-reviewed journal

Radiation and Nuclear Countermeasures program, with FDA and BARDA
Invited speakers from NASA

Tissue Chips in Space: an NIH and ISS-NL Joint program (2016-2022)



Immunosenescence



PI: Sonja Schrepfer

Post-traumatic osteoarthritis



PI: AI Grodzinsky

Drugs across blood-brain barrier

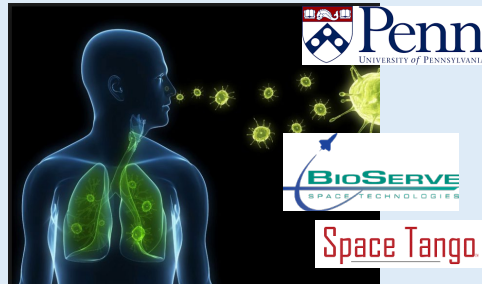
emulate



Space Tango

PI: Christopher Hinojosa

Lung infection



PI: Scott Worthen

Proteinuria and kidney stones formation



PI: Jonathan Himmelfarb

Gut inflammation

emulate



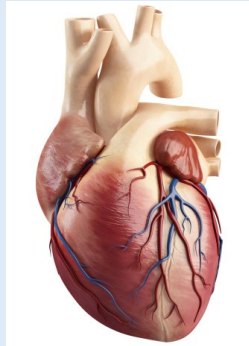
Space Tango

PI: Christopher Hinojosa

Cardiac dysfunction & engineered heart tissues

W
UNIVERSITY of
WASHINGTON

O
THE OHIO STATE
UNIVERSITY



S
Stanford
University

UCSB



PI: Joseph Wu

PI: Deok-Ho Kim

Muscle wasting (sarcopenia)



PI: Siobhan Malany

Aim: study human biology and disease that otherwise would be difficult or take longer on Earth



- SpaceX 16: December 5, 2018
 - Immunosenescence
- SpaceX 17: May 4, 2019
 - Lung infection/bone marrow; kidney stone formation; osteoarthritis; blood-brain barrier
- SpaceX 20: March 6, 2020
 - Cardiomyopathy; gut
- SpaceX 21: Dec 5, 2020
 - Cardiomyopathy; osteoarthritis; sarcopenia
- SpaceX 22: June 3, 2021
 - Kidney stones
- SpaceX 24: Dec 21, 2021
 - Blood-brain barrier

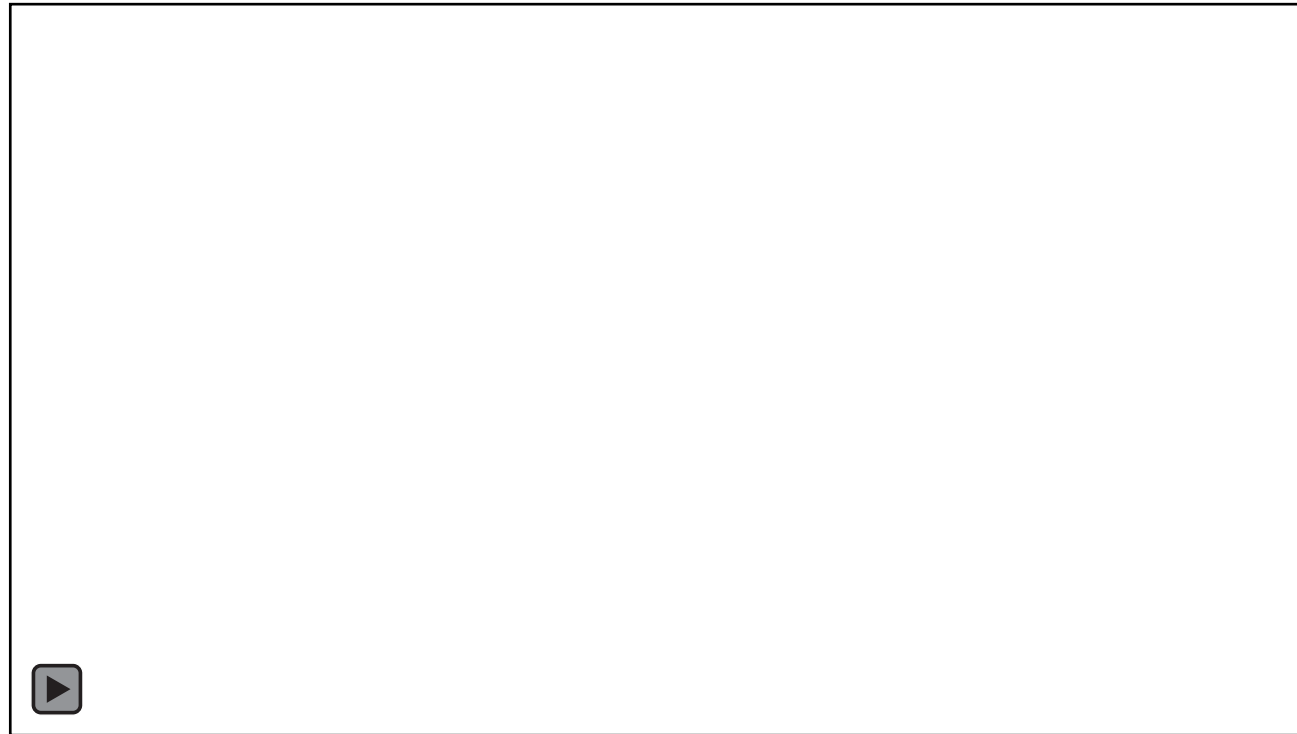


Next launches: SpaceX 25 and 26 in 2022
Sarcopenia, cardiomyopathy

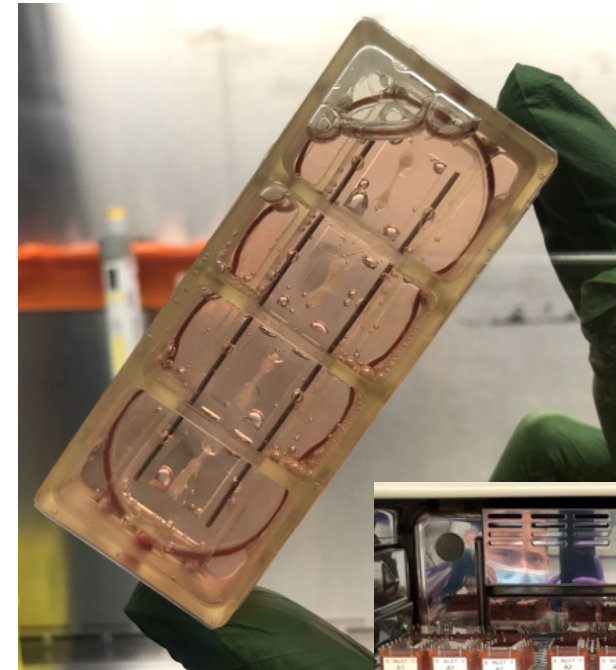
Drug responses in microgravity using engineered heart tissues



PIs: Joseph Wu
& Beth Pruitt

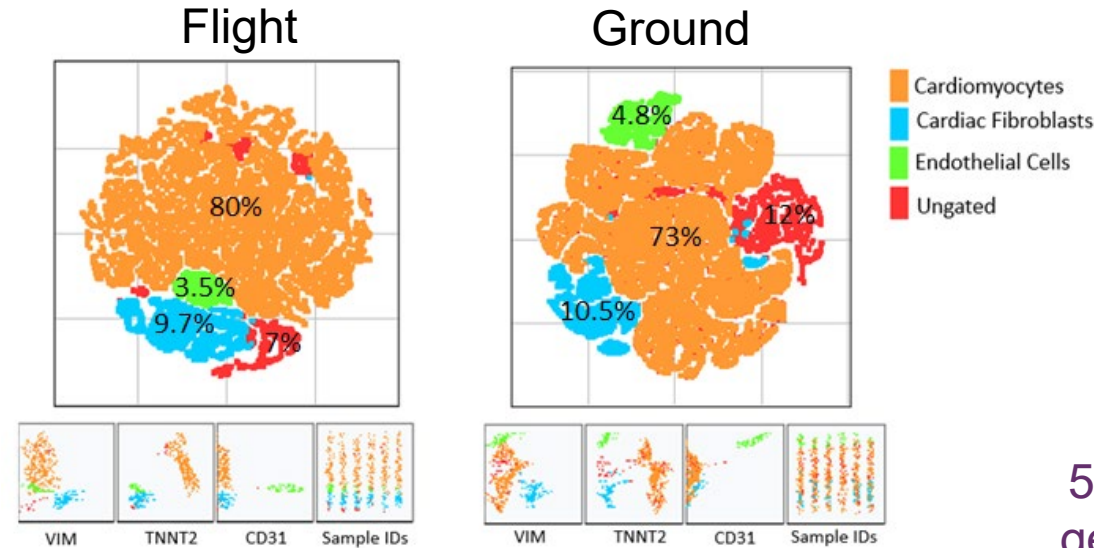
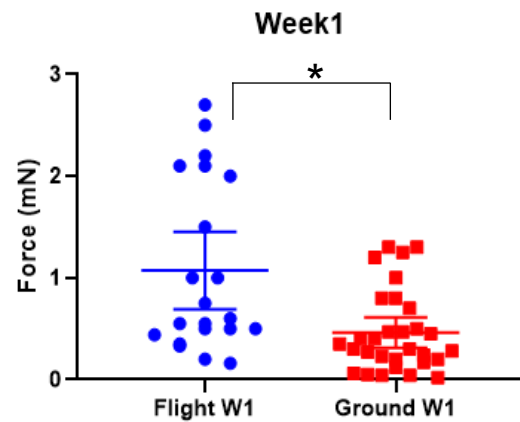


Cardiac cells grow between 2 posts and
spontaneously contract

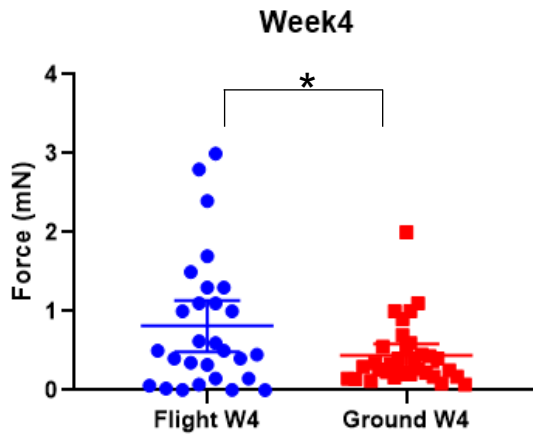


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Courtesy of Dilip Thomas, Stanford

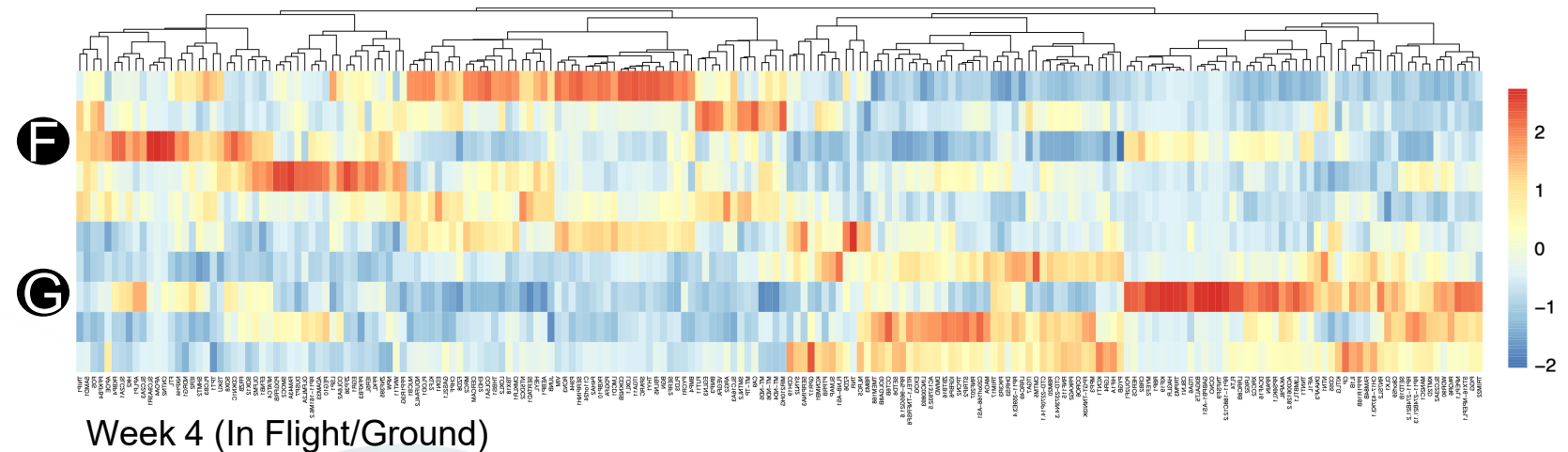


Cell populations shift after flight

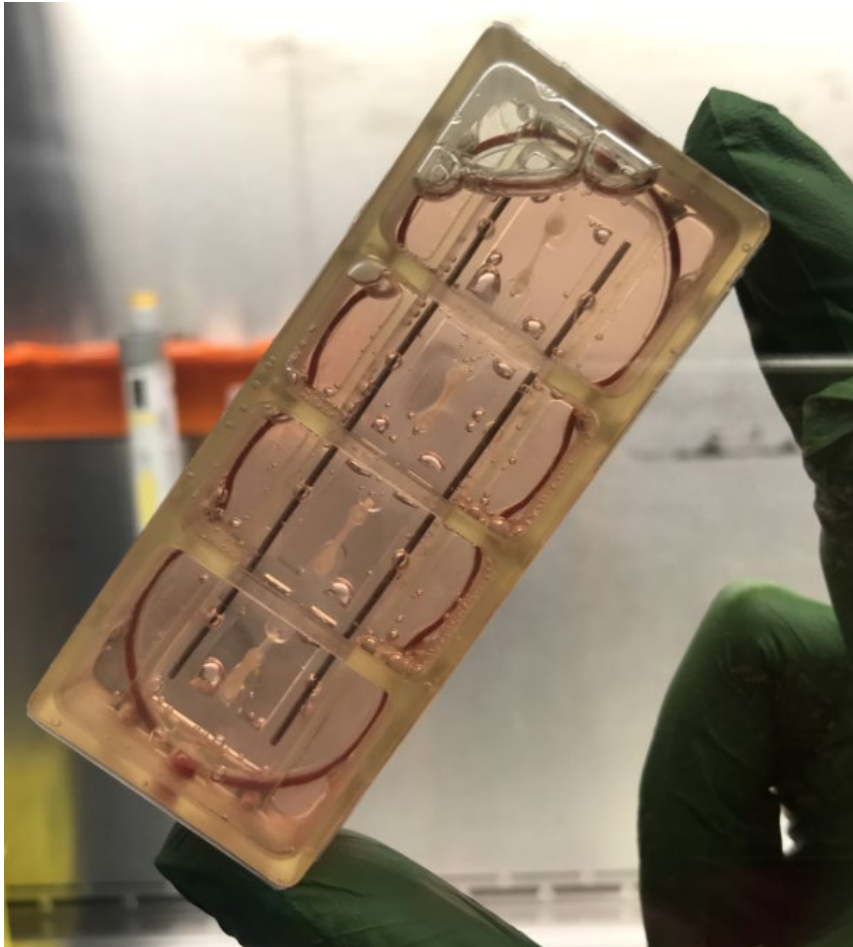


EHT twitch force strength is higher in microgravity

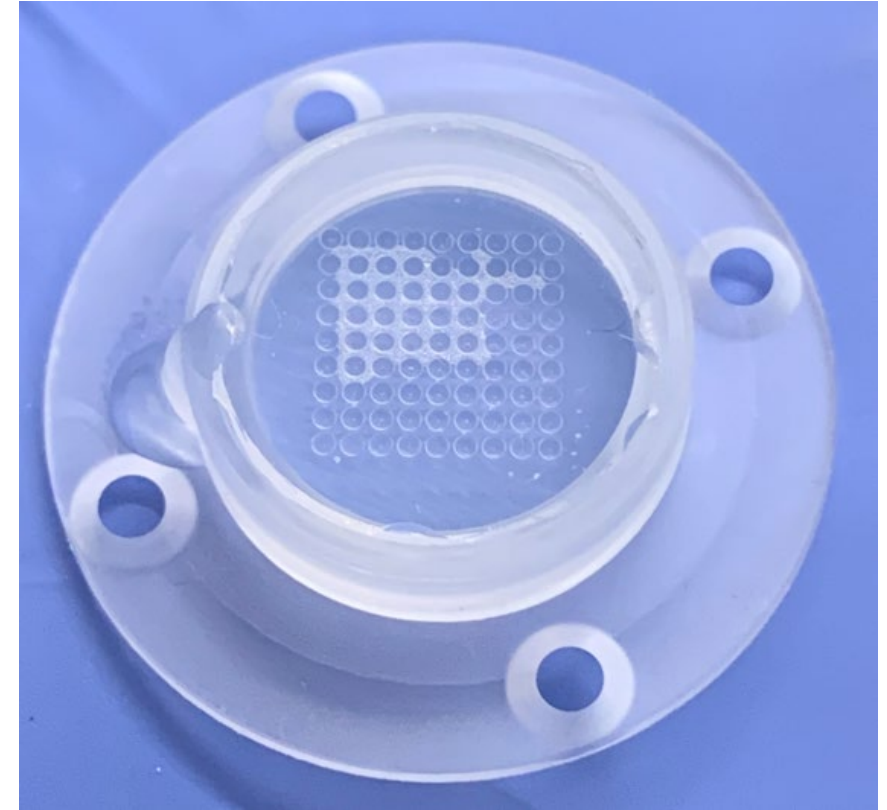
521 genes **upregulated** and 167 genes **downregulated** in Flight at week 4 $p(\text{adj}) < 0.05$



First flight



Second flight



Use of cardiac organoids will hugely increase throughput for next flight (scheduled for Oct 2022) and enable study of drugs and drug-drug interactions (chosen based on results from first flight)

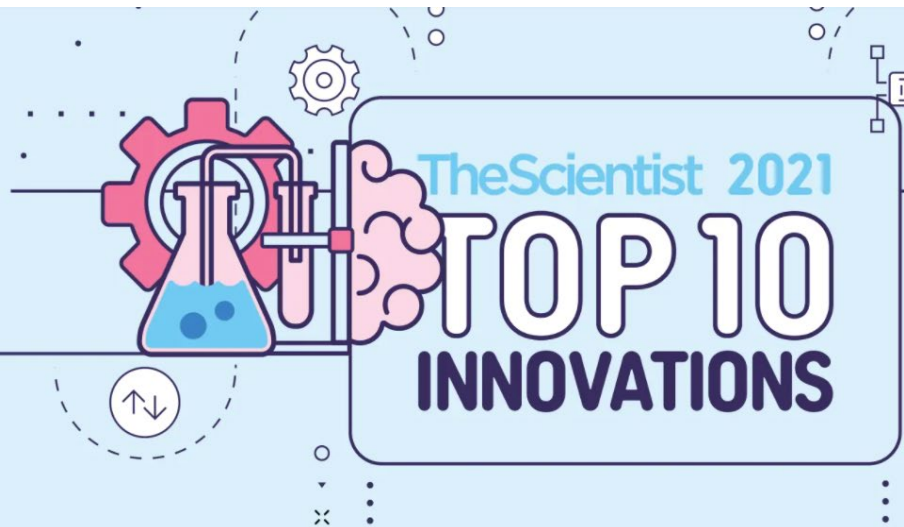
Article | [Open Access](#) | [Published: 08 October 2021](#)

Modeling alpha-synuclein pathology in a human brain-chip to assess blood-brain barrier disruption

[Iosif Padiaditakis](#) , [Konstantia R. Kodella](#), [Dimitris V. Manatakis](#), [Christopher Y. Le, C](#), [William Tien-Street](#), [Elias S. Manolagos](#), [Kostas Vekrellis](#), [Geraldine A. Hamilton](#), [Lorn](#), [Rubin](#) & [Katia Karalis](#) 

[Nature Communications](#) **12**, Article number: 5907 (2021) | [Cite this article](#)

5745 Accesses | 24 Altmetric | [Metrics](#)

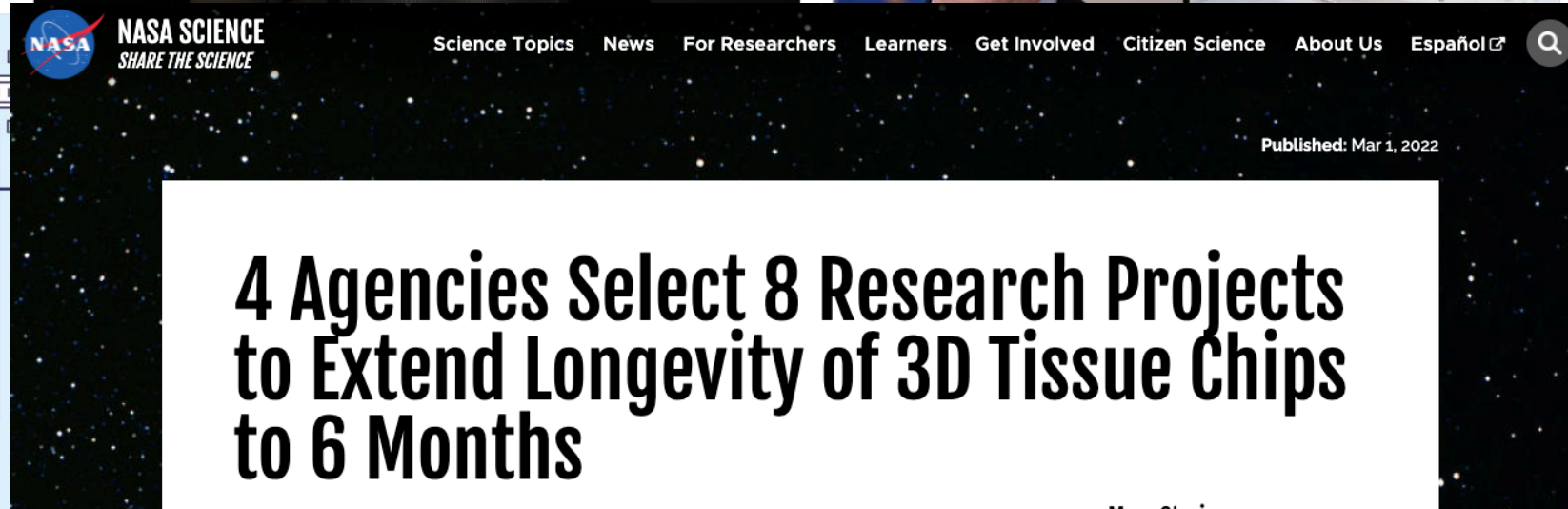


Crew-1 is going to be busy working on Tissue Chips research on the [@Space_Station!](#) [#LaunchAmerica](#) Dr. Lucie Low from the [@NIH](#) explains how these thumb drive-sized devices are helping us research the human body in space. Learn more: [nasa.gov/tissue-chips/](#)



Looking forward to chatting with [@Astro_Kate7](#) on Tuesday, 8/3!

ISS National Lab  [@ISS_CASIS](#) · Jul 20
The countdown to the International Space Station Research & Development Conference continues. Join us Day 1 for a conversation w/ [@NIH](#) Director Dr. Francis Collins & [@NASA](#) astronaut Dr. Kate Rubins as they talk [#tissuechips](#) & other exciting space science: [cvent.me/ovEGKz?RefId=N9](#)



Additional program highlights



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Published: Mar 1, 2022

4 Agencies Select 8 Research Projects to Extend Longevity of 3D Tissue Chips to 6 Months



NASA, the National Institutes of Health (NIH), Department of Health and Human Services Biomedical Advanced Research and Development Authority (BARDA), and the Food and Drug Administration (FDA) announce the award of 8 contracts in a multi-agency collaboration that will extend tissue viability and physiological function to a minimum of 6 months using automated engineering capabilities for real-time online readouts in complex human *in vitro* models, such as tissue chips or microphysiological systems.

The scientific objectives are to better understand 1) disease models, 2) drug development, 3) clinical trial design, 4) chemical and environmental exposures and countermeasures, and 5) physiological changes due to the spaceflight environment. In-depth characterization is a critical next step in the evolution of these technologies is,

More Stories

- 1** [Paving the Way to Thriving in Space](#)
- 2** [A New Home for NASA's Biological and Physical Sciences Research](#)
- 3** [Members of NASA GeneLab's Analysis Working Group Initiate International COVID-19 Data Analysis Effort](#)
- 4** [NASA Program Expands Research Participation to Scientists Across the U.S.](#)



FY22 Trans-Agency Research Program

Extended Longevity of 3D Tissues and Microphysiological Systems for Modeling of Acute and Chronic Exposures to Stressors

- Funding opportunity published by NASA
- Large number of highly competitive applications received
- Contracts, \$500K/year up to 4 years
- Development/validation of tissue chips able to function successfully for 6 months or more in an automated fashion, for modeling of acute and/or chronic exposures (e.g., to drugs and other compounds, radiation, environmental hazards, infection, microgravity exposure).



Slide courtesy of Carmen Rios (NIAID/NIH)

Final 9 projects

- **Elizabeth Blaber, Rensselaer Polytechnic Institute** *Understanding the Brain-Liver-Gut Axis during Spaceflight and Aging*
- **Joel Blanchard, ICAHN School of Medicine at Mount Sinai**, *Identification of Biomarkers and Pathological Mechanisms via Longitudinal Analysis of Neurological and Cerebrovascular Responses to Neurotoxic Stress Using a Multi-cellular Integrated Model of the Human Brain*
- **Guohao Dai, Northeastern University**, *Bioengineer Long-lasting 3D Neurovascular Microphysiological System to Model Chronic Inflammation-mediated Neurodegeneration*
- **Abhishek Jain, Texas A&M**, *Long-term Patient iPSC Vessel Chip Model to Assess Stressors of Atherosclerosis and mRNA Therapeutics*
- **Christopher Porada, Wake Forest University**, *Long-lived Single- and Multi-organ Tissue Equivalent (OTE) Platforms to Model the Response of Human Tissues to Various Stressors*
- **Gordana Vunjak-Novakovic, Columbia University**, *MORPH: Multi-Organ Repair Post Hypoxia*
- **Joseph Wu, Stanford University**, *Assessing Long-Term Effects of Radiation Exposure in Engineered Heart & Vascular Tissues*
- **Catherine Yeung, University of Washington**, *Extended Culture of Kidney MPS and Organoids to Model Acute and Chronic Exposure to Drugs and Environmental Toxins*
- **Guillermo Garcia-Cardena, Brigham and Women's Hospital**, *Modeling Anthracycline-triggered Vascular Dysfunction*



Comments on collaborations

- NIH's mission is to focus on improving human health and disease
- NIH does not have a policy on use of low Earth orbit or deep space for space-based biomedical research...
-but that doesn't mean we're not interested in using those environments for research that advances NIH's mission
- Collaborative efforts with other agencies/partners are likely necessary
- NIH houses a wealth of expertise and resources for partnership opportunities



Areas of potential joint interest

- Physiological changes occurring in microgravity that model disease/aging characteristics
- Mechanistic insight into basic human molecular/cellular processes using gravity vector as a variable
 - e.g. stem cell research
- Radiation effects
- Wearable devices/remote sensors as indicators of human health
- Ultrasound-based imaging/therapies
- Precision medicine/Big Data from small samples (e.g. $n=1$)
- No-touch/remote monitoring of physical and mental/social health, remote minimally invasive robotic procedures/surgery

A non-exhaustive list



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NCATS Collaborate – Innovate - Accelerate

Thank you

www.ncats.nih.gov/research/nasa

<https://sites.google.com/ncats.nih.gov/nihNASA/home>



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