Human Research Program-Funded Science: Highlights of Articles Published

From October 1, 2023 to October 1, 2024

HUMAN RESEARCH PROGRAM-FUNDED SCIENCE:

HIGHLIGHTS of ARTICLES PUBLISHED from

October 1, 2024 to October 1, 2025

Product of the Human Research Program's Science Integration Office

This report was developed by NASA's Human Research Program Science Integration Office.

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Cover image provided by Lauren Ring of Ames Research Center.

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Word cloud of countries which have cited published HRP-funded scientific manuscripts from 2000.

INTRODUCTION

NASA's Human Research Program (HRP) plays a vital role in supporting human spaceflight endeavors by conducting research and developing technologies to safeguard astronauts' health and safety during space missions. The program primarily focuses on understanding the physical, psychological, and behavioral challenges associated with long-duration space travel—insights that are essential for both NASA missions and the growing commercial space sector.

The research the HRP supports provides valuable information on how the spaceflight environment, which includes exposure to conditions such as microgravity and radiation, impacts the human body. Disorders such as loss of bone density, muscle atrophy, and the effects of exposure to space radiation are examined. The HRP also develops strategies to mitigate the effects of spaceflight on astronauts—strategies that include exercise programs, medications, and protective technologies. Additionally, the HRP develops training programs to ensure that astronauts remain healthy and perform optimally during missions. The HRP's findings and innovations play a crucial role in ensuring the safety and success of current spaceflight missions and will safeguard astronauts during future long-duration missions beyond low Earth orbit.

The HRP's Science Integration Office (SIO) has identified more than 5,000 publications describing HRP-funded research that were published from 2006 to October 1, 2024. These reports represent the work of more than 10,000 researchers and have been cited by more than 100,000 articles.

In an effort to share the results of the groundbreaking research funded by the HRP, the HRP's SIO has commissioned an annual report to highlight some of the recent scientific accomplishments. The more than 200 articles published during fiscal year 2024 represent the research of more than 500 scientists from 18 different countries. All the fiscal year 2024 publications are listed beginning on page 20 of this report. Implications of the results of these studies reach beyond the field of human research into multiple areas of science.

MEASURING HUMAN RESEARCH PROGRAM IMPACTS

Studies that determine how spaceflight affects humans are challenging and expensive, therefore, it is important to thoroughly determine the implications of the data derived from the HRP-funded science. The HRP SIO uses several methods to accomplish this. The relative importance of HRP findings published in peer-reviewed scientific journals is evaluated using the journal impact factor, which indicates the relative importance of a journal within its field and gives a measure of the frequency an average article in a journal is cited. Bibliometric analyses measure the impact of the HRP research by quantifying and visualizing networks of journals, citations, subject areas, and collaboration between authors, countries, or organizations. Bibliometric methods estimate how much influence or impact the research article has on future research, which can help guide management of future research.

KEYWORD TERM MAP

The SIO team uses the VOSviewer software tool to scan the content of all HRP-funded research articles and extract keywords based on the frequency of their appearance. The Keyword Term Map shown in Figure 1 represents a collection of words (items) that recurred throughout the articles. The software automatically grouped the results into 5 main categories or clusters based on the similarity of the areas of research. Each cluster (colored distinctly) represents a major area of scientific research.

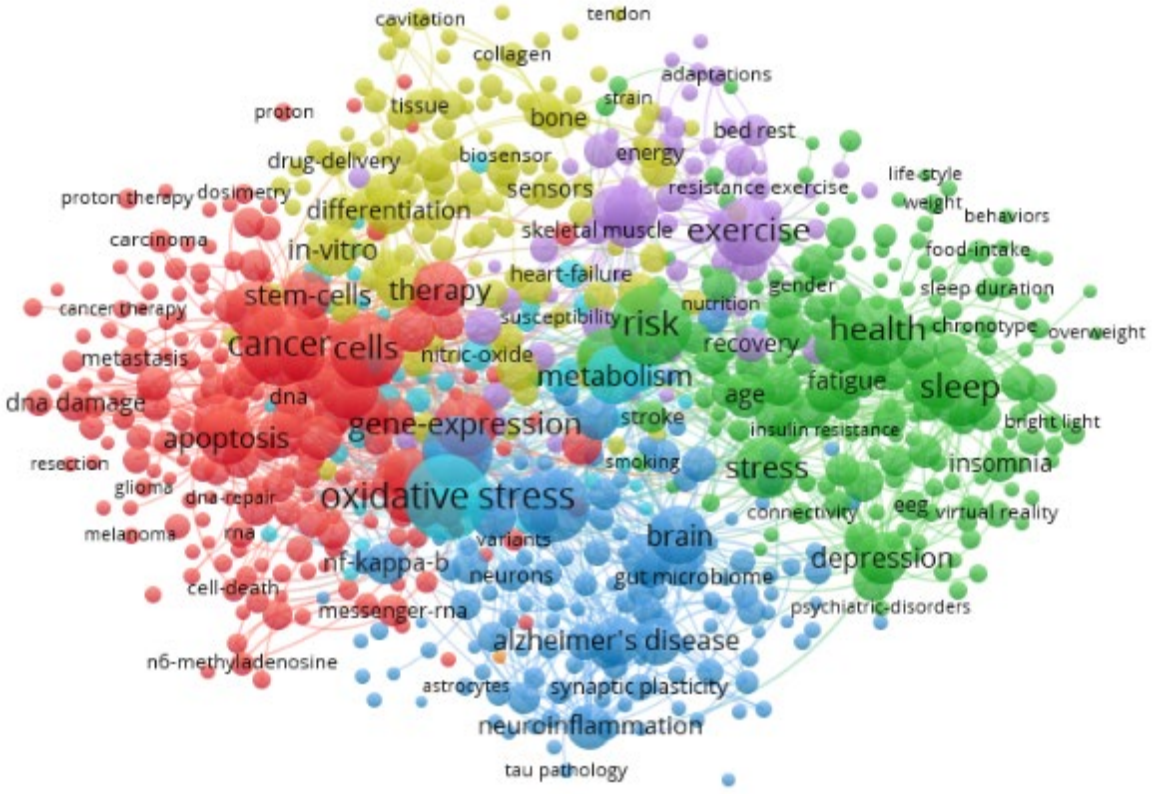


Figure 1. Keyword term map of articles that have cited HRP-funded articles.

EIGENFACTOR

The SIO uses Clarivate Analytics®, a global database that collects information regarding journal scores and metrics, to identify the top science produced by HRP researchers. One parameter, the journal's Eigenfactor score identifies the importance of each journal based on readership and influence, considering the different citation standards of each scientific discipline. Because different scientific disciplines have different standards for citation and different time spans across which citations occur, the Eigenfactor relies on an algorithm that uses the entire Web of Science citation network from Clarivate Analytics®. The Eigenfactor score includes citations in both science and social sciences journals, eliminates self-citations of journals, and is intended to reflect the amount of time researchers spend reading the journal. The Eigenfactor scores indicated that 43 of the HRP articles that were published from October 1, 2023 to October 1, 2024 were published in the top 100 journals, and 33 of those HRP publications were in the top 20 journals as reported by Clarivate Analytics®.

HRP Publications in the Top 100 Sources	Clarivate Analytics® (Eigenfactor Rank)	Source (#HRP Funded Publications)
	1	Nature Communications (15)
	2	Nature (5)
	3	Scientific Reports (3)
	5	Proceedings of the National Academy of Sciences (3)
	6	PLoS ONE (2)
	10	International Journal of Molecular Sciences (5)
	32	Cell Reports (1)
	48	Frontiers in Psychology (3)
	60	Applied Sciences (2)
	80	Advanced Science (1)
	94	Frontiers in Plant Science (1)
	95	Nature Materials (2)

The Moon's shadow, or umbra, is pictured covering portions of the Canadian provinces of Quebec and New Brunswick and the American state of Maine in this photograph from the International Space Station as it soared into the solar eclipse from 261 miles above (ISS071E002836).

Publication Highlights: Exploration Mission Capability (ExMC)

The mission of the HRP's ExMC Element is to advance medical system design and risk-informed decision making for exploration beyond low Earth orbit, to promote human health and performance during spaceflight.

Scientists reviewed medical devices and technologies that have been considered for inclusion within future spaceflight medical systems. Future space missions to the Moon and Mars will present significant challenges for maintaining the health of astronauts. Unlike missions to the International Space Station (ISS), where quick medical assistance from Earth is possible, these exploration missions will involve long distances, making immediate support and evacuation nearly impossible. This means that astronauts must rely on a well-designed medical system on board the spacecraft.

To effectively care for astronauts during exploration missions, new medical systems must incorporate a variety of components, including medical devices that can monitor health, diagnose medical conditions, and treat injuries. These systems must be lightweight, compact, and energy-efficient due to the strict limits on mass and volume for exploration spacecraft. NASA is looking into both commercial medical devices and those specifically modified for use in space to meet these needs.

The advanced technologies that are being developed to deliver effective care during long-duration exploration spaceflight include medical systems with imaging devices to diagnose injuries, systems for administering fluids and medications, and technologies for analyzing biological samples on board. Emphasis is on *ensuring that all equipment can function properly in microgravity because many devices designed for use on Earth must be modified before they can work effectively during spaceflight.*

Astronaut T.J. Creamer, is pictured near the Microgravity Science Glovebox located in the Columbus laboratory of the International Space Station (ISS023E033107).

In conclusion, this paper provides details regarding NASA's approach to mitigating risk from medical conditions that must be managed in space, and the challenges of developing an effective medical system for exploration missions. These advancements in medical technology are essential for ensuring that astronauts remain healthy and perform well during future exploration missions. With the right medical capabilities, astronauts will be better equipped to address health issues that arise during their journeys through space.

Lewandowski BE, Schkurko CM, Miller RS, et al. Technology modification, development, and demonstrations for future spaceflight medical systems at NASA. *Frontiers in Space Technology. 2024; 5.* doi: *10.3389/frspt.2024.1384457*.

Astronaut Jessica Meir conducts cardiac research in the Life Sciences Glovebox located in the Japanese Kibo laboratory module (ISS062E115369).

PUBLICATION HIGHLIGHTS: HUMAN FACTORS AND BEHAVIORAL PERFORMANCE (HFBP)

The mission of the HFBP Element is to develop a scientifically based, integrated approach to understanding and mitigating the behavioral health and operational performance risks associated with human spaceflight, and the human factors risk associated with the design and operations of spacecraft.

Researchers discuss development of a new survey designed to measure group living skills (GLS), which are essential skills for individuals who live and work together, particularly in extreme environments such as a spacecraft. The researchers recognized that embracing positive group living behaviors, such as being considerate of others and maintaining a tidy living space, has significant positive effects on team dynamics and can increase mission success.

To create the survey, the authors gathered input from experts who have conducted spaceflight research. These experts highlighted the importance of GLS during long-duration missions, especially when the duration increases and isolation becomes a factor. The resulting GLS survey was tested on 83 individuals from 24 different teams who participated in spaceflight missions or analogs of spaceflight missions that lasted 45–240 days.

The study confirmed that the GLS survey is both reliable and valid. The survey revealed the importance of 2 key aspects of GLS and showed how these skills can help improve team cohesion, performance, and well-being. The survey also identifies individuals best suited for these high-stress situations, and could inform training practices that promote healthy team dynamics. The authors emphasize the need for such a measure because no validated tool had existed previously for tracking these specific skills in operational settings. The authors suggest that the GLS survey could be useful not only for space missions but also for other extreme environments where teams live and work closely, such as military deployments, research stations in Antarctica, oil rigs, and emergency response teams.

Bottom row, from left NASA astronaut Frank Rubio and Roscosmos cosmonauts Sergey Prokopyev and Dmitri Petelin. Top row, from left are, Roscosmos cosmonauts Nikolai Chub and Konstantin Borisov; European Space Agency astronaut Andreas Mogensen; Roscosmos cosmonaut Oleg Kononenko; NASA astronauts Jasmin Moghbeli and Loral O'Hara; and Japan Aerospace Exploration Agency astronaut Satoshi Furukawa (ISS069E092197).

Landon LB, Miller JCW, Bell ST, Roma PG. When people start getting real: The group living skills survey for extreme work environments. *Frontiers in Psychology*. *2024;15:1348119. doi: 10.3389/fpsyg.2024.1348119*

European Space Agency astronaut Samantha Cristoforetti wears a microphone on her right shoulder for the Acoustic Diagnostics study (ISS067E183734)

PUBLICATION HIGHLIGHTS: HUMAN HEALTH COUNTERMEASURES (HHC)

The HHC Element is responsible for determining the normal physiologic effects of spaceflight and developing countermeasures to those with detrimental effects on human health and performance. The HHC Element provides the biomedical expertise for developing and assessing medical standards, vehicle and spacesuit requirements, and countermeasures that ensure crewmembers remain healthy during spaceflight.

This case study reports on the eye health of 2 astronauts during 6-month missions on the ISS. Both of these astronauts underwent vision correction surgeries in the past: one had photorefractive keratectomy (PRK) and one had laser-assisted in situ keratomileusis (LASIK).

Image of NASA astronaut Christina Koch testing her vision on board the space station.

The astronauts' vision was thoroughly examined before, during, and after their missions to determine if these vision correction procedures are stable in the spaceflight environment, which can affect the eyes. The astronauts' visual acuity (clarity of vision), corneal health, and other eye parameters were measured about 3 months before launch, during their spaceflight, and 5 days after returning to Earth.

Throughout their missions, the astronauts reported no vision problems. Their eyesight remained stable, allowing them to see clearly during transit to the ISS and when living there.

Various tests showed that their distance and near visual acuity were unchanged during the mission. Additionally, after their return, all eye examinations indicated that their eyes were in good condition, with no significant changes in factors such as corneal thickness or curvature.

The use of PRK and LASIK is beneficial as a method of correcting astronauts' vision because glasses can be difficult to position correctly in microgravity and are prone to fogging and displacement during extravehicular activities. Whereas, storage, cleaning, insertion, and the potential for ulcerative keratitis complicate the use of contact lenses. The findings suggest that astronauts can successfully maintain clear vision while performing their duties in space, enhancing their experience and safety during long missions.

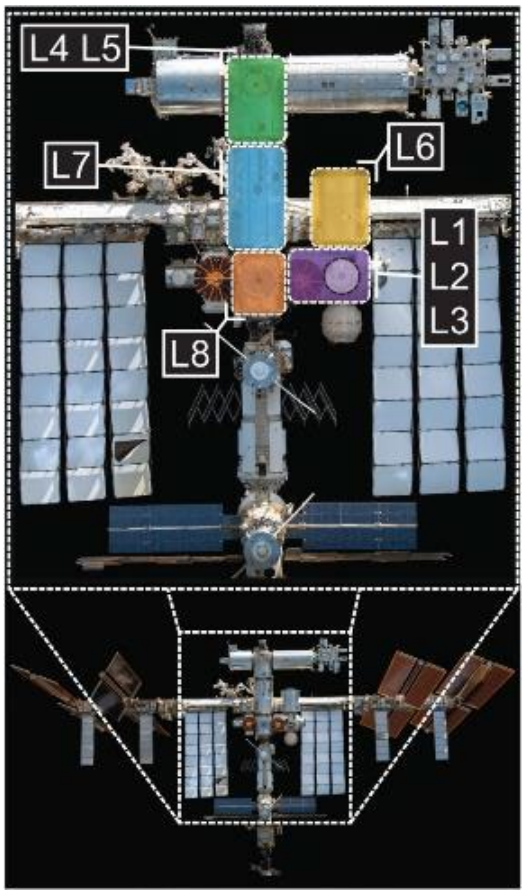
Gibson CR, Mader TH, Lipsky W, et al. Photorefractive keratectomy and laser-assisted in situ Keratomileusis on 6-month space missions. *Aerospace Medicine and Human Performance*. 2024;95(5):278-281. doi:10.3357/AMHP.6368.2024

This study explored how bacteriophages contribute to the adaptation of bacteria in the ISS environment. Previous research indicated that the microbes on the ISS predominantly derive from the crewmembers' microbiome, and they possess enhanced abilities related to metal ion tolerance, antibiotic resistance, and survival in dormant states. Microbes adapt to new environments using a process called genome plasticity, which allows the bacteria to acquire new genetic material from various sources. During this process bacteria can acquire virulent factors and antibiotic resistance genes that affect the behavior and characteristics of the bacteria.

Bacteriophages can enable genomic plasticity when they enter a bacterial cell through a process called lysogeny, during which their genetic material integrates into the host genome and remains dormant as a prophage. This dormant state can transition to an active phase in response to certain stressors, leading to the reproduction of new phages, the potential destruction of the host bacterium, and the opportunity for the phages to infect other bacteria.

Researchers conducted a comprehensive analysis of 245 bacterial genomes collected from the ISS, identified the presence of prophages and their functions, and compared them to similar terrestrial strains. The researchers identified 283 complete prophages among the 245 ISS-derived bacterial genomes, 21% of which were novel, meaning they had not been previously documented in other bacteria. The presence of unique prophages suggests that microbial populations are evolving differently in space than on Earth. When they compared ISS bacterial genomes to terrestrial counterparts, the researchers observed significant genetic differences, particularly in phage-associated genes. The novel prophage regions in the ISS bacteria are associated with increased persistence in extreme environments, such as spaceflight, and include antimicrobial resistance and virulence, DNA damage repair, and dormancy.

The results of this study indicate that microbes adapt during spaceflight to bacteriophage-encoded functions that may impact human



health, which emphasizes the need for ongoing surveillance of microbial populations in spacecrafts and understanding the mechanisms of their adaptation. Because the crewmembers' microbiomes may influence the microorganisms found on the ISS, this study highlights the importance of maintaining crew health and hygiene protocols to mitigate potential risks.

Irby I, Broddrick JT. Microbial adaptation to spaceflight is correlated with bacteriophage-encoded functions. *Nature Communications*. 2024;15(1):3474. doi:10.1038/s41467-023-42104-w.

Astronaut Suni Williams displays the Space Tissue Equivalent Dosimeter (SpaceTED) hardware inside the International Space Station's Kibo laboratory module (ISS072E143491).

PUBLICATION HIGHLIGHTS: SPACE RADIATION (SR)

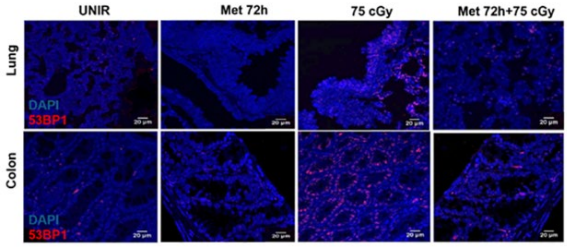
The Space Radiation Element characterizes and manages the human health outcomes associated with exposure to space radiation to protect astronaut health and well-being, and to enable human space exploration.

Metformin is a widely used medication that helps lower blood sugar levels in people with type 2 diabetes. However, researchers have discovered that metformin has other beneficial effects on cells, particularly its potential role in protecting against damage from ionizing radiation. During future missions to Mars, astronauts will be exposed to levels of radiation that are much higher than the exposure they incur in low Earth orbit, and this exposure to radiation in deep space may exceed the safe limits established by NASA.

When cells are exposed to ionizing radiation, it can cause significant damage to DNA, lipids, and proteins within those cells. This damage can lead to issues such as cancer, cell death, or mutations. Radiation can create harmful byproducts called reactive oxygen species, which further exacerbate cellular damage. Therefore, finding ways to protect cells from this damage is crucial.

Metformin activates a protein called AMP-activated protein kinase, which plays a role in regulating cellular energy and metabolism. This activation leads to the expression of radioprotective genes. Researchers conducted several experiments using human fibroblast cells and mouse models to assess the effects of metformin when administered before exposure to radiation.

The authors determined that metformin shows promise as a protective agent against radiation-induced damage. The insights gained from this study may lead to crucial developments in protective therapies for individuals who are exposed to radiation, for example, first responders to nuclear accidents, astronauts on long-duration space missions, and patients receiving radiation therapy.

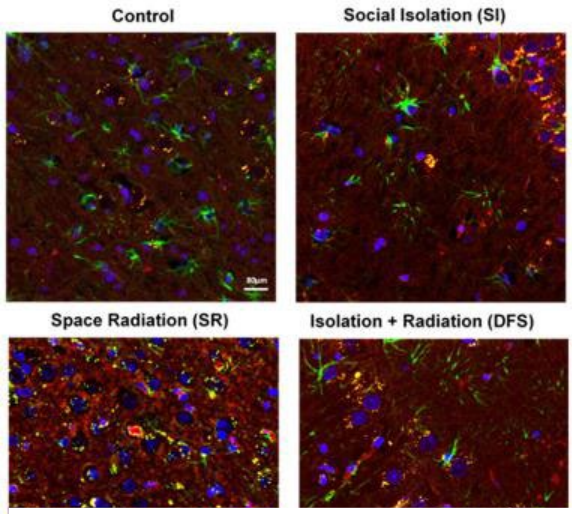


Pre-administration of metformin significantly reduces the number of micronuclei in bone marrow cells and mitigates DNA damage in colon and lung tissues, after exposure to the 75 cGy 33-beam GCRsim irradiated mice. Image courtesy of PLoS One.

Siteni S, Barron S, Luitel K, Shay JW. Radioprotective effect of the anti-diabetic drug metformin. Li H, ed. *PLoS ONE*. 2024;19(7):e0307598. doi:10.1371/journal.pone.0307598

Future space missions, especially those to Mars, will require astronauts to spend extended periods away from Earth, which will increase exposure to space radiation from cosmic sources. These conditions can alter astronauts' health, affecting their cognitive functions and their overall physical performance.

The blood-brain barrier (BBB) is a crucial structure that protects the brain from harmful substances. It regulates molecule and ion movement between the blood and the brain, thereby maintaining a stable environment. Damage to this barrier can lead to problems such as neuroinflammation, cognitive deficits, and psychological issues.



SR-induced BBB damage and astrocyte death was ameliorated by SI. Images of representative tissue slices within the limbic area of the brain showing quadruple-label immunofluorescence stained with GFAP (green), fibrinogen (yellow), Glut-1 (red), and DAPI (blue) displaying differences in vascular permeability in each treatment group. All images are at 40× magnification. Scale bar = 80 µm. Image courtesy of Life (Basel).

Researchers assessed the integrity of the BBB and the morphology of male rats' brains after they were exposed to social isolation, simulated space radiation, or a combination of both. Their findings suggest that exposure to space radiation significantly harms the BBB, potentially leading to cognitive issues. Although social isolation alone didn't seem to damage the BBB directly, it can still affect overall brain function. Many deficits observed in the radiation-exposed animals were lessened slightly by exposure to radiation and social isolation, indicating that combined spaceflight stressors interact to modulate the immune system and the BBB.

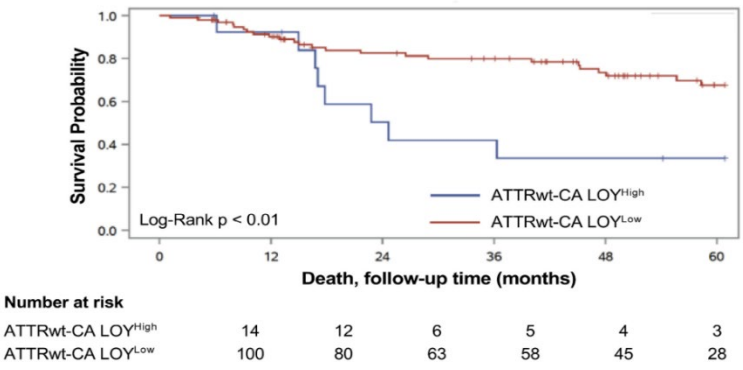
their exposure to various stressors. Two significant stressors are social isolation and

This study emphasizes the need to determine how the combination of different spaceflight stressors interact to modulate the immune system and the BBB. This will be crucial to fully understand the multiple pathways that could impact astronaut performance and health. Overall, this research sheds light on the challenges posed by space travel and the physiological adaptations that must be mitigated to keep crewmembers safe during long-duration space missions.

Adkins AM, Luyo ZNM, Gibbs AJ, et al. Alterations in blood–brain barrier integrity and lateral ventricle differ in rats exposed to space Radiation and Social Isolation. *Life*. 2024;14(5):636. doi:10.3390/life14050636

This study explored 2 conditions: one known as wild-type transthyretin cardiac amyloidosis (ATTRwt-CA), which ultimately causes heart failure; and a genetic phenomenon called the loss of the Y chromosome (LOY) whereby men lose their Y chromosome in a portion of blood cells, which has recently been associated with an increased risk of heart failure mortality. The researchers found that men with ATTRwt-CA had a significantly higher prevalence of LOY than those with heart failure from other causes. Specifically, nearly 58 percent of the ATTRwt-CA patients exhibited LOY, whereas only 29 percent of the control group exhibited LOY. Although the study did not delve deeply into the mechanisms of how LOY affects heart conditions, it speculated that LOY could influence immune responses or the activation of heart tissue cells in a way that contributes to disease progression. The study highlights that LOY is not only prevalent among men with ATTRwt-CA but also serves as a potential prognostic marker for worse outcomes This research provides valuable insights into the relationship between aging, genetics, and heart disease in men. Identifying LOY as a predictor of poor outcomes in patients with ATTRwt-CA opens up new avenues for understanding the complexities of heart failure and the potential for targeted genetic screening in at-risk populations.

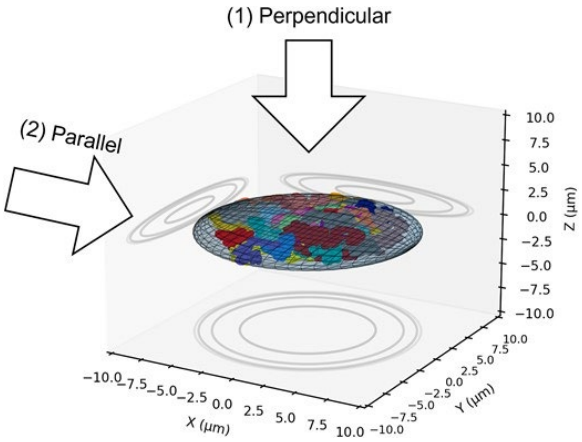
Thel MC, Cochran JD, Teruya S, et al. Mosaic loss of the Y chromosome is enriched in patients with wild-type transthyretin cardiac amyloidosis and associated with increased mortality. *Circulation: Heart Failure*. 2024;17(8). doi:10.1161/CIRCHEARTFAILURE.124.011681



Five-year all-cause mortality for patients with ATTRwt-CA based on elevated LOY allele fraction status using an optimized threshold of21.6% allele fraction. Statistical significance was determined by log-rank test (n=100 patients with ATTRwt-CA low LOY [LOYlow] and 14 patients with ATTRwt-CA high LOY [LOYhigh]). Image courtesy of Circulation: Heart Failure.

Cosmic radiation is a type of high-energy radiation that originates from outer space. It contains particles with high charges and energy levels at a broad range of linear energy transfer (LET) values, which is the amount of energy that an ionizing particle transfers to the material traversed per unit distance. When these particles collide with living tissues, they can cause damage to cellular structures, particularly DNA. DNA damage can lead to cell death or to mutations that can sometimes evolve into cancer.

This study uses a computational model to analyze how cells respond to exposure to cosmic radiation, and outputs from the model were combined with experimental data derived from 4 types of irradiated human cell lines. The researchers wanted to understand how the damage clusters within the DNA affect cell survival after exposure to ions with a broad range of LET. Their outputs from their model, which considered the impact of cell shape and nuclei size, matched the experimental data for cell survival. The researchers alleged that geometric characteristics of cells could be a significant factor in predicting radiation-induced biological effects.



Schematic view of simulation geometry and the two beam configurations for the irradiation of ellipsoidal nuclei. The two large arrows represention irradiation orientation. Cell nuclei (ellipsoid) are embedded in water. The chromosome distribution is shown, with each color representing a different chromosome. Image courtesy of Integrative Biology.

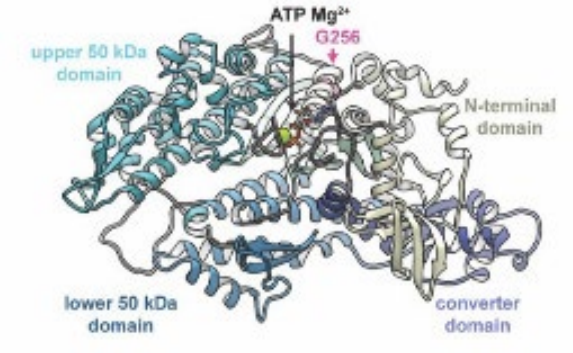
This study sheds light on the complex relationship between cosmic radiation and cellular response. By exploring how DNA damage occurs, how it clusters, and understanding various influencing factors, researchers can develop better models for predicting cellular outcomes after radiation exposure. This knowledge may contribute to enhancing safety measures for astronauts and potentially developing protective strategies against radiation-induced damage.

Poignant F, Pariset E, Plante I, et al. DNA break clustering as a predictor of cell death across various radiation qualities: influence of cell size, cell asymmetry, and beam orientation. *Integrative Biology*. 2024;16:zyae015. doi:10.1093/intbio/zyae015

Publication Highlights: Translational Research Institute for Space Health (TRISH)

TRISH works cooperatively with NASA's Human Research Program to develop and manage the implementation of a relevant research and technology portfolio of single- and multi-disciplinary teams that will lead to the identification and translation of novel knowledge and methods (across all biomedical, human performance, and associated technological disciplines) directly applicable to reducing the human health and performance risk for long-duration human space exploration missions.

This study investigated a specific genetic mutation associated with hypertrophic cardiomyopathy (HCM), a heart condition characterized by thickened heart muscles that can lead to serious complications. The particular mutation the researchers studied is the G256E mutation in the MYH7 gene, which encodes a protein known as β-myosin heavy chain. This protein is critical for heart muscle contraction.



The starting structure used for the WT myosin+ATP.Mg2+ simulations is shown and the four major structural domains of the protein have unique colors. The ATP molecule is shown in stick representation, the Mg2+. is shown in a green space-filling representation, and the atoms for G256 are shown in a pink space-filling representation.

HCM is one of the most common genetic heart diseases, affecting about 1 in 200 individuals globally. It can result in various symptoms, such as chest pain, shortness of breath, and even sudden cardiac death. The condition shows variability in how it affects individuals—some may experience severe symptoms, whereas others may remain asymptomatic. This variability often relates to specific mutations in the MYH7 gene, with over 200 known mutations leading to HCM. Among these, some mutations are termed "incomplete penetrant", meaning that not everyone who carries the mutation shows symptoms or develops the disease.

In summary, the research into the MYH7 G256E mutation sheds light on how specific genetic changes can lead to functional alterations in heart muscle, ultimately resulting in HCM. The study not only enhances understanding of this particular mutation's pathogenicity, it also demonstrates the value of a collaborative and comprehensive approach to studying complex genetic diseases. The insights gained from this study could lead to improved diagnosis, monitoring, and treatment strategies for patients affected by HCM and similar genetic heart conditions.

This combined effort to explore the relationship between genetics and heart function highlights the interconnectedness of molecular biology and clinical outcomes, paving the way for advancements in personalized medicine in cardiology.

Lee S, Vander Roest AS, Blair CA, et al. Incomplete-penetrant hypertrophic cardiomyopathy MYH7 G256E mutation causes hypercontractility and elevated mitochondrial respiration. *Proceedings of the National Academy of Sciences. 2024;121(19):e2318413121. doi:10.1073/pnas.2318413121*

In mammals, energy expenditure refers to the amount of energy used by the body at rest, which is often linked to metabolic rates. When exposed to cold temperatures, the body typically responds by increasing energy expenditure through shivering, which generates heat. However, this compensatory mechanism can lead to increased caloric needs and may not always be sustainable. This study suggests that lowering energy expenditure during cold exposure might provide benefits in certain scenarios, such as space missions or medical settings, when it is critical to conserve resources.

The primary objective of this research was to assess whether single oral doses of dexmedetomidine (1 µg/kg sublingual or 4 µg/kg swallowed) or tizanidine (8 mg or 16 mg) could effectively reduce energy expenditure and core body temperature during exposure to surface cooling in a controlled laboratory setting. The results indicated that oral dexmedetomidine significantly reduced energy expenditure 13–19% from baseline measurements. Both medications resulted in a decrease in core body temperature: dexmedetomidine decreased core body temperature by about 0.5–0.6°C, and tizanidine by approximately 0.5–0.7°C.

These temperature reductions typically occurred after the peak decreases in energy expenditure. Increases in plasma levels of dexmedetomidine correlated with changes in mean temperature, whereas this was not the case with tizanidine. The changes in metabolic rates were accompanied by notable declines in heart rate, blood pressure, and respiratory rates, suggesting an overall reduction in physiological activity.

NASA astronaut Tracy "TC" Dyson wearing her liquid cooling and ventilation garment with her donned leg section to the Extravehicular 1 (EV1) red stripped Extravehicular Mobility Unit (EMU) while still wearing a breathing apparatus inside the Quest Joint Airlock preparing for the Extravehicular Activity (EVA) during Expedition 71. NASA astronaut Michael Barratt is inside the Airlock assisting Dyson with Donning the rest of her EMU (ISS071E183377).

The demonstrated efficacy of oral doses opens up new avenues for research and application in both clinical and non-clinical settings, further expanding the potential uses of these medications beyond their traditional applications.

Callaway CW, Flickinger KL, Weissman A, et al. Alpha-2-adrenergic agonists reduce resting energy expenditure in humans during external cooling. *Temperature. 2024;11(3):280-298. doi:10.1080/23328940.2024.2339781*

This review manuscript describes current analytical platforms used to characterize human forebrain cortical organoids. Brain organoids are 3-dimensional structures that mimic some features of the human brain. They are created from human pluripotent stem cells, which can differentiate into any cell type. They can resemble the brain's development both structurally and functionally, providing insights into various neurological conditions. Researchers use brain organoids to study brain development, understand diseases affecting the brain, and test new treatments. Since their introduction, brain organoids have been valuable for studying normal brain development and various neurological disorders such as autism, Down syndrome, Rett syndrome, and fragile X syndrome.

ISS071e019814 Photo of NASA astronaut Michael Barratt utilizing the Life Science Glovebox (LSG) in the Japanese Experiment Module (JEM) for the Human Brain Organoid Models for Neurodegenerative Disease & Drug Discovery (HBOND) experiment.

The number of research publications on this topic has grown rapidly, reflecting ongoing interest and discoveries.
The paper highlights the challenges of using brain organoids and proposes recommendations for future studies to achieve greater precision and uniformity across laboratories. The success of brain organoid research depends on these principles. Inconsistent results can arise from variations in how organoids are created and studied, leading to confusion in scientific understanding and the potential for misapplying findings in medicine.

By adopting these recommended practices, the scientific community can strengthen the field of brain organoid research, making it a more robust platform for understanding human brain development and the basis of neurological disorders. The authors call for a collective effort to address variability and improve rigor, ultimately aiming for more reliable and valid scientific outcomes.

In summary, the authors stress the critical need for rigorous and reproducible methods to unlock the full potential of brain organoid research for understanding the human brain and improving health outcomes.

Sandoval SO, Cappuccio G, Kruth K, et al. Rigor and reproducibility in human brain organoid research: Where we are and where we need to go. *Stem Cell Reports. 2024;19(6):796-816. doi:10.1016/j.stemcr.2024.04.008*

Word cloud of journal titles that published HRP-funded research from October 1, 2023–October 1, 2024.

HRP FUNDED RESULTS PUBLICATIONS

OCTOBER 1, 2023 – OCTOBER 1, 2024

Adkins AM, Colby EM, Boden AF, et al. Effects of social isolation and galactic cosmic radiation on fine motor skills and behavioral performance. *Life Sciences in Space Research*. 2024;41:74-79. doi:10.1016/j.lssr.2024.01.005.

Adkins AM, Luyo ZNM, Gibbs AJ, et al. Alterations in blood–brain barrier integrity and lateral ventricle differ in rats exposed to space radiation and social isolation. *Life*. 2024;14(5):636. doi:10.3390/life14050636,.

Afshari N, Koturbash I, Boerma M, et al. A Review of numerical models of radiation injury and repair considering subcellular targets and the extracellular Microenvironment. *International Journal of Molecular Sciences*. 2024;25(2):1015. doi:10.3390/ijms25021015.

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