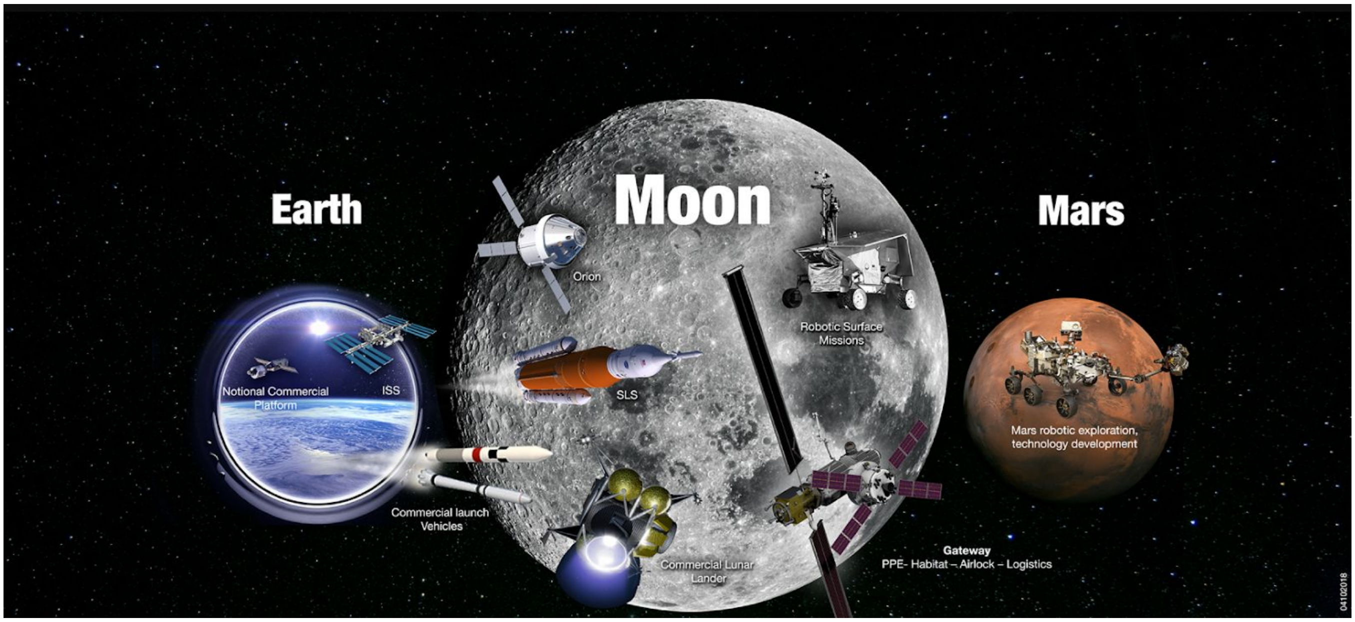
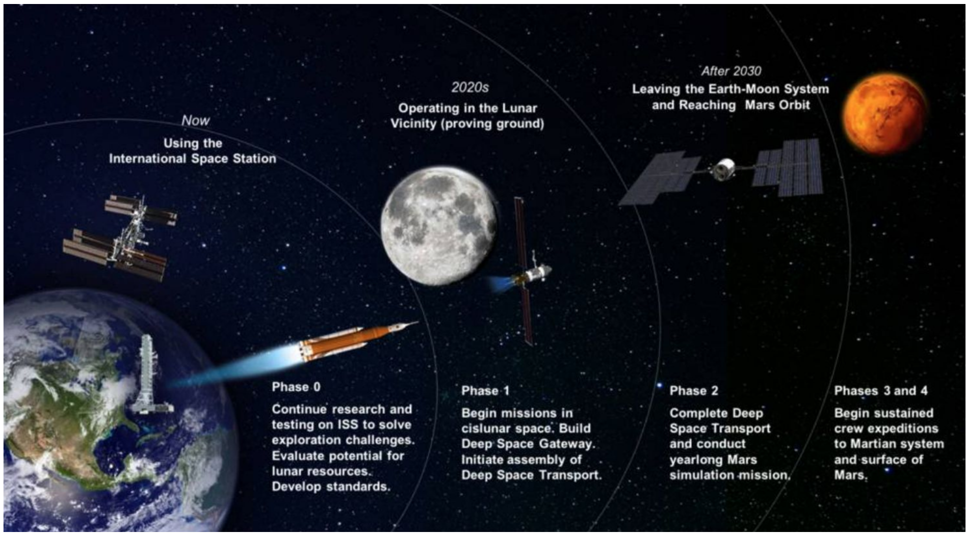


How AI Can Help Astronauts Stay Healthy on Long Duration Space Missions

As a result of microgravity astronauts can lose as much as 50% of their muscle mass in less than 6 months in space.

Humans have evolved over millions of years to live on Earth. Now humans are planning long duration space missions that will require them to live in space for extended periods of time. NASA's Journey to Mars, the longest manned space mission ever, will require humans to live in space for over three years. Since long duration space travel necessitates that humans live in environments that we have not evolved to live in, scientists are developing ways to keep humans healthy in space.

Scientists at the AI Precision Health Institute (AI-PHI) at the University of Hawai'i Cancer Center are developing AI powered technology that astronauts can use to monitor their health in space. This new technology will enable astronauts to precisely modify their nutrition and adjust their fitness training to minimize muscle loss in space. One of the most exciting aspects of this research is that some of the technologies that are being developed to keep astronauts healthy in space can also be used to keep humans healthy here on Earth.



Space is a Hostile Environment for the Human Body

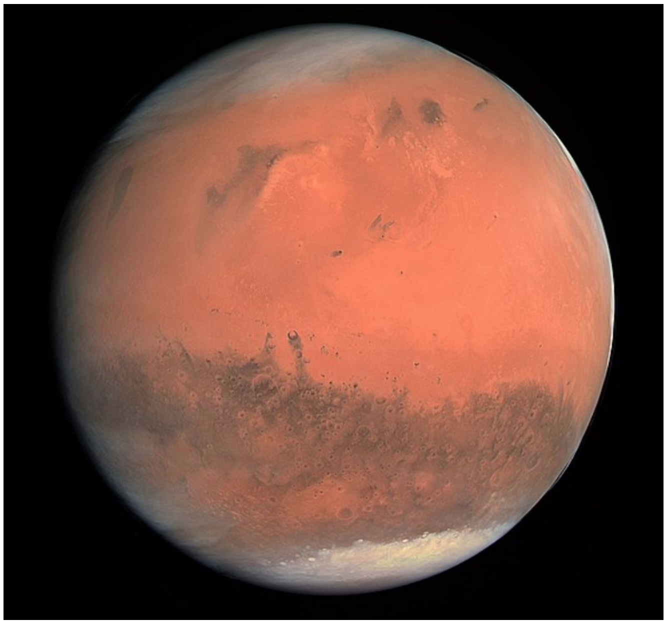
Although astronauts can acclimate to space, long duration space travel affects all organs and systems in the human body. The combination of gravity fields, radiation, a restricted diet, lack of exercise, lack of sunlight, lack of fresh air, isolation, and confinement all stress the body. In space, astronauts even sleep less and their sleep is more shallow than on earth. Space affects the human cardiovascular, excretory, immune, musculoskeletal, and nervous systems, and long-duration space missions magnify these challenges. Astronauts returning from months in space experience changes in vision, balance, coordination, and blood pressure. They often lose the ability to walk and the ability to stand up straight.

NASA has learned that without gravity human bone density drops at over 1% per month. By comparison, the rate of bone loss for the elderly on Earth is between 1% - 1.5% per year.

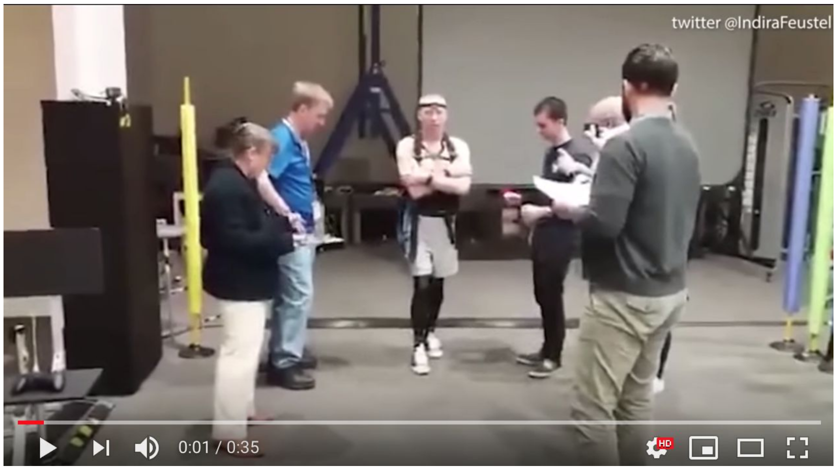
Gravity Fields

Gravity fields are considered one of the top hazards for astronauts. During long duration missions like NASA's Journey to Mars, astronauts must adapt to different gravity fields.

- During the six-month trip from Earth to Mars astronauts will be weightless.
- On the surface of Mars astronauts will live in 1/3 of Earth's gravity.
- When they return to Earth, they will need to readjust to Earth's gravity.



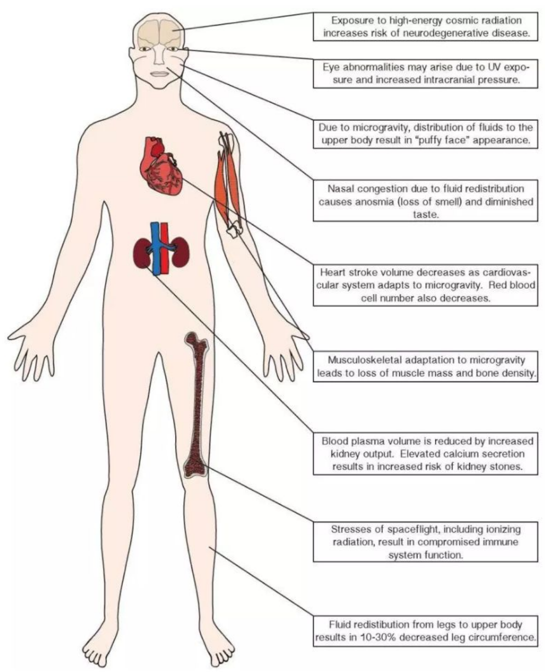
Transitioning from one gravity field to another is stressful on the human body. On earth, more than half of the muscles of the human body resist gravity, whereas in space, without gravity, muscles atrophy and astronauts lose muscle mass. Furthermore, in space, minerals like Calcium are excreted from the body at higher levels than on Earth, causing the femur, tibia, pelvic girdle, and spine to lose bone density. Astronauts are at risk of developing osteoporosis resulting in vertebral or hip fractures and hyperkyphosis. This frailty puts them at a 40% higher risk of falls, 25% high risk of hip fracture, and 82% higher risk of death.



This is a video of NASA astronaut Drew Feustel walking on Earth after spending 197 days in space on the International Space Station.

Bench-to-Spaceflight Model

NASA is using information gathered on the International Space Station to monitor the effects of space on the human body and to understand what types of equipment will be required for long duration space missions. NASA is working with Translational Research Institute for Space Health (TRISH) to develop innovative approaches to mitigate risks to humans. TRISH is a consortium led by Baylor College of Medicine that includes CalTech and MIT. The consortium is using cutting edge biomedical research and implementing a bench-to-spaceflight model, moving methods from laboratories and clinical trials to astronauts in space. TRISH supports both high-risk early-stage research as well as pre-seed and seed-stage health technologies that can be modified for use by astronauts on the way to Mars.



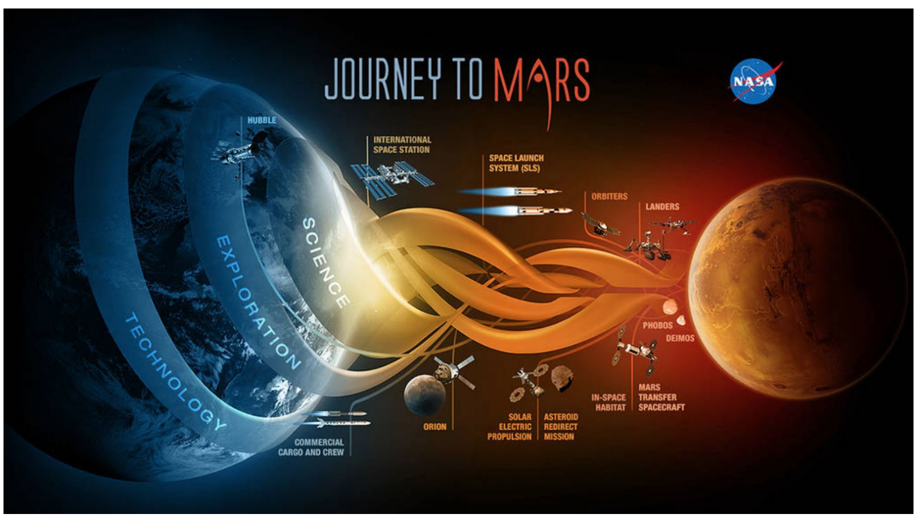
The ASTRO3DO Study

Recently TRISH awarded a grant to John Shepherd PhD, founder and director of the [AI Precision Health Institute] (AI-PHI) at the University of Hawaii Cancer Center, to study ways to keep astronauts healthy on long-duration space flights. The study is called the *Space-Feasibility Body Composition and Body Shape Analysis for Long Duration Missions (ASTRO3DO).* The AI-PHI in collaboration with researchers at NASA and UCSF will design special 3D optical scanners and use advanced statistical modeling to monitor astronauts' bone and body composition in space.

Astronauts on long-duration space flights need direct feedback on the quality of their muscles and bones. The AI-PHI is developing AI powered technology for astronauts to use to monitor their health, modify their nutrition, and adjust training to minimize muscle loss while on long-duration missions such as the mission to Mars.

John Shepherd, PhD, Director, AI-PHI

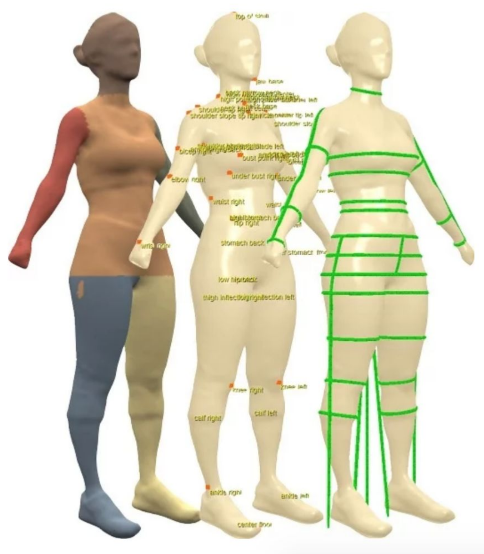
The most intuitive warning sign of functional decline is change in body shape. Body shape is the product of all omic processes. The AI-PHI is conducting the most advanced researchin the world analyzing body shape using AI. Researchers at the AI-PHI are studying how body shape information is related to health markers like strength, body composition, and blood biomarkers. Body shape is measured using 3D optical whole body scanners and advanced statistical modeling. 3D optical models can accurately estimate bone and body composition and be used to monitor frailty risk.



The aim of the *ASTRO3DO* study is to determine the optimal performance and space feasibility of 3D optical cameras to collect views of the body, and explore and identify the accuracy and precision of 3D optical derived total body composition. Dr. Shepherd plans to take what he has learned using 3D optical scanners in the NIH-supported *Shape Up! Study*and apply it to astronauts. Shepherd and his team aim to install several small cameras inside the space capsule to collect data. The astronauts will spin while they are floating in space, so their entire body can be captured.

The Shape Up! Study funded by the NIH aims to develop tools and techniques to derive clinical health information from 3D optical body scanners. Monitoring body shape using 3D scanners provides much more valuable feedback about changes in human health than monitoring changes in weight on a scale and 3D scanners are safe, inexpensive and accessible. Participants are analyzed using:

- Full-body high resolution 3D scans
- Dual-energy X-ray absorptiometry scans for body composition
- Blood test for metabolic markers
- Strength assessments
- Questions regarding lifestyles and eating habits



With this data researchers can do amazing things including modeling body shape changes due to gain or lose of muscle and fat. The findings from these studies will empower people to measure and monitor their body shape and health.

The *ASTRO3DO* research team will develop breakthrough approaches that reduce risks to human health and performance, and efficient ways for astronauts to monitor and measure bone and muscle mass to help them prepare for even longer exploration missions. Of all warning signs of functional decline, the most intuitive are physical changes in appearance and body shape. Astronauts returning from long-duration flights share frailty characteristics of sarcopenia and cachexia and may even develop osteoporosis while on Mars resulting in vertebral or hip fractures and hyperkyphosis.

The ASTRO3DO Research Team

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The ASTRO3DO study will monitor frailty risk using 3D optical scans with adjustment for fluid redistribution. Current 3DO models accurately estimate bone and body composition but lack space acclimation experience. To simulate space, Shepherd's team will perform studies to select hardware, algorithms, and augment models with microgravity analogs, and will build a space-feasible prototype for microgravity testing during parabolic flights. The long-term goal of ASTRO3DO is to create a space-feasible device and method to quantify astronaut fragility and risk of fractures from falls. The central hypothesis is that current 3DO models of body composition can be adapted to space feasible hardware and challenges associated with acclimation to space. The specific aims of the study are:

- To determine the optimal performance and space feasibility of 3D optical cameras to collect views of the body by characterizing the resolution, framing rate, precision of acquisition, and contrast detail characteristics using anthropomorphic phantoms.

- Explore and identify the accuracy and precision of 3DO derived total body composition (lean, fat, percent fat, BMD), special regions (visceral fat, subcutaneous fat, lumbar spine BMD) and automated anthropometry using pose varied, limited view scanning, analyzed with pose removed, compared to criterion methods (DXA and high resolution 3DO).

- To identify accuracy and precision limitations of 3DO body composition and automated anthropometry due to the effects of space acclimation using surrogate conditions (poses, postures, inverted gravity (inversion boots), buoyancy (underwater) and microgravity (trampoline apex).

- Construct and describe the performance of a space-feasible prototype under microgravity conditions during parabolic flights.

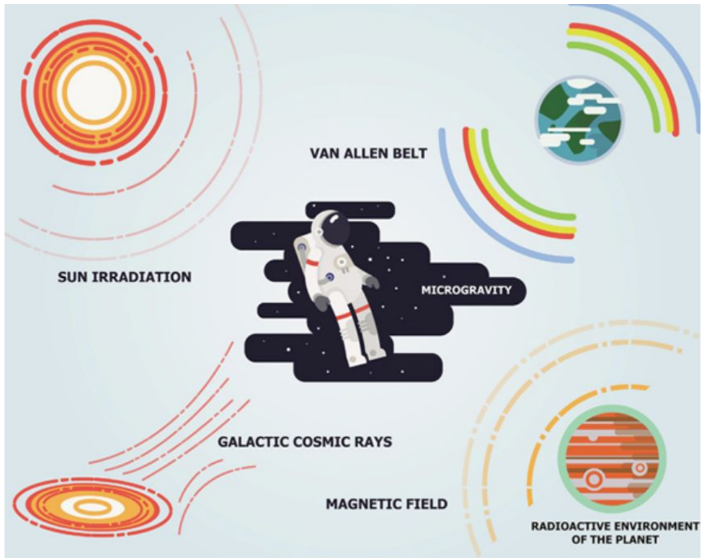
This research is incredibly novel as it will lead to the development of new methods for measuring body composition for astronauts in space who are prone to muscle and bone loss. It also has direct applications to cancer patients who may suffer from a similar condition called cancer cachexia.

Randall Holcombe, Director of The University of Hawai‘i Cancer Center and Advisor at the AI-PHI

Measurement of body composition is a relatively new area for cancer research that has direct implications for understanding how obesity and body shape contribute to the development of, and outcomes from, cancer. The results of the *ASTRO3DO* study on muscle loss and loss of function will be directly applicable to cancer cachexia research. Findings from *ASTRO3DO* research will be utilized to better understand and prevent cancer-related muscle wasting and improve the quality of life for cancer patients on Earth. Dr. Shepherd plans to conduct follow up studies with cachexia patients at the University of Hawai‘i Cancer Center.

Human Research Roadmaps

NASA has created a [Human Research Roadmap] detailing the high-priority risks for human health during space missions and listing the top dangers crews will face during such missions. NASA is conducting ground research in laboratories that mimic different parts of the space environment and also conducting research in the International Space Station.



One of the most interesting areas of space research focuses on how to protect astronauts' immune systems in deep space. This type of research is also relevant for the health and longevity of humans on Earth. If scientists discover practical ways to protect astronauts from radiation and other hazardous effects of space travel, the same technologies could be used to protect humans from existential threats here on Earth such as the nuclear disasters at Fukushima Daiichi and Chernobyl. This type of research could lead to ways to dramatically improve the human immune system.

As a result of this type of research, one day we may be able to repair damage in the human body associated with the biological aging process, and restore immune system performance to older adults. This could extend healthy longevity in a very practical way for humans on Earth. Last year our colleagues and collaborators at Deep Knowledge Ventures published a paper to lay the foundations for a roadmap toward enhancing human radioresistance in deep space. The paper entitled Vive la radiorésistance! outlined future research directions to enhance human radioresistance.

Scientists around the world are researching the health threats that humans face in space and developing methods to address these threats to keep astronauts healthy. They are using the most advanced technologies including AI and developing new methods in collaboration with NASA. One of the most exciting yet sometimes overlooked aspects of space research is that the same technologies that we develop to keep hundreds of astronauts healthy in space, will also be used to help keep billions of humans healthy right here on Earth.

This article was written by Margaretta Colangelo and Dmitry Kaminskiy.

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Dmitry Kaminskiy is General Partner of Deep Knowledge Ventures and Founding Partner at Longevity Capital. He is Founder of Aging Analytics Agency, Founder of Deep Knowledge Analytics, and Founder of Longevity.Capital. Dmitry is the Head of International Development of the Secretariat for the UK All-Party Parliamentary Group for Longevity and Managing Trustee of the Biogerontology Research Foundation. Dmitry is based in London.

Deep Knowledge Ventures is a leading investment fund focused on the synergetic convergence of DeepTech, frontier technologies and technological megatrends, renowned for its use of sophisticated analytical system for investment target identification and due-diligence. Major investment sectors include AI, Precision Medicine, Longevity, Blockchain and InvestTech. @DeepTech_VC

References

Dr. John Shepherd is known worldwide for his expertise in quantitative imaging using AI. He has over 200 peer reviewed papers and has been cited in other publications over 10,000 times. The AI-PHI located at the University of Hawai'i Cancer Center in Honolulu is the world's first AI Precision Health Institute using advanced technology including AI, machine learning, and deep learning to assess human health and predict risk of disease. For more information see AI-PHI website

For information about Translational Research Institute for Space Health see TRISH website

For information about the converging research in radiobiology and biogerontology to protect human immune systems in deep space see Vive la radiorésistance!

For information about NASA"s Journey to Mars see NASA website

For information about acclimation during space flight and effects on human physiology including how humans can loose as much as 50% of muscle mass in 6 months in space see Williams D, Kuipers A, Mukai C, Thirsk R (2009). CMAJ 180(11): 1317-1323

For information on top hazards of human space flight see NASA website

Illustration of the human body in space by Mark Springel, edited by Hannah Somhegyi.

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