The Kelly Story - One Year in Space

“We changed our badges - he is the one from space” Scott Kelly (Missions: STS-103, STS-118, Soyuz TMA-01M/Expedition 25/26, Soyuz TMA-16M/Soyuz TMA-18M/Expedition 43/44/45/46) said pointing at his twin brother and former NASA astronaut Mark Kelly (Space Shuttle missions: STS-108, STS-121, STS-124, STS-134) at NASA’s Johnson Space Center on Friday, March 4, 2016 at a press conference. The pair participated in parallel in a twin study experiment on the International Space Station (ISS) and Earth to help scientists compare the effects on the body and mind in space. Scott Kelly and his Russian cosmonaut experiment-partner Mikhail Kornienko (Missions: Soyuz TMA-18/Expedition 23/24, Soyuz TMA-16M/Soyuz TMA-18M/Expedition 43/44/45/46) spent 340 days together aboard the International Space Station (ISS) to perform this unique study.

The practical joke –demonstrating Scott Kelly’s good humor, he was sporting throughout his flight – also shows a significant preliminary result of this unique experiment on the ISS: the twins still can’t be told apart. Despite Einstein’s “twin paradox”, a thought experiment in which one twin rockets to the stars at high speed while the other stays home, the traveling twin should return younger than his brother.

NASA and the Russian Federal Space Agency (Roscosmos) announced in early 2013 an agreement to send one crew member each to the ISS on a dedicated one year mission. The other partners in the ISS Program also agreed to ensure and support the success of this mission. The unique and unprecedented scientific data collected during the flight will help send humans to new destinations like Mars, supporting the next generation of space exploration. [1]

NASA selected Scott Kelly and Roscosmos chose Mikhail Kornienko to perform identical tests and measurements of their bodily functions and determine the influence of the yearlong flight on their mental constitution.

Kelly together with Kornienko launched aboard a Russian Soyuz spacecraft from the Baikonur Cosmodrome in Kazakhstan on March 27, 2015 for their one-year stay on the ISS, the longest space mission ever assigned to a NASA astronaut.

“This [study] will build on the rich experience of long-duration flights, including four flights of a year or more conducted by our Russian colleagues on the Mir station,” says Dr. Michael Barratt, program manager for NASA's Human Research Program (HRP) at the agency's Johnson Space Center in Houston. “We have progressed considerably in our understanding of the human physiology in space and in countermeasures to preserve bone, muscle and fitness since then. The space station program provides us a robust framework for international collaboration that enables us to realize tremendous returns from such an experience.

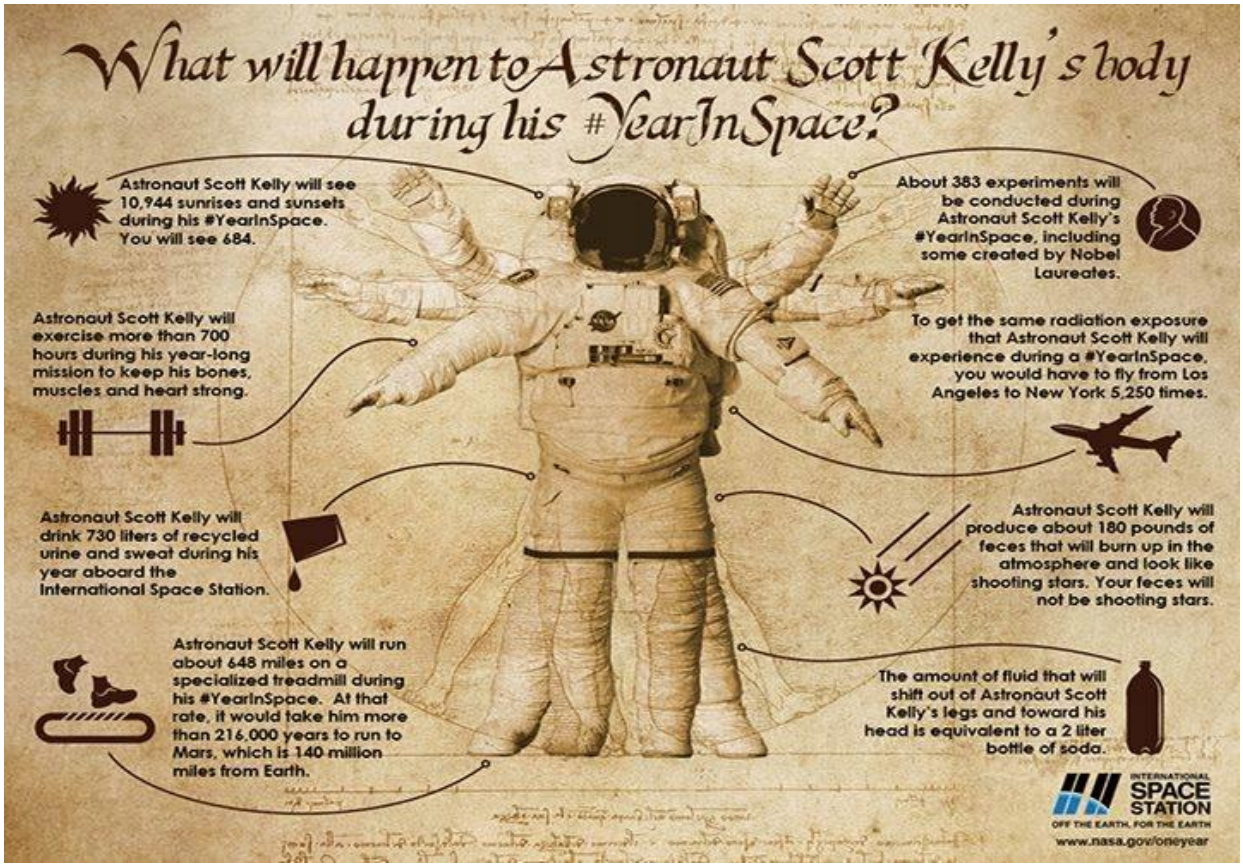
Specifically, this joint expedition will provide important insights into operational and scientific areas in human research in space and on Earth. Integrated scientific investigations between NASA and Roscosmos will combine resources to improve data sharing among space medical and human research communities,

as well as help inform current assessments of crew performance and health and better determine and validate countermeasures to reduce the risks associated with future exploration as NASA plans for missions around the moon, to an asteroid and eventually to Mars."

"Scientists have acquired enough data to begin to characterize the effects of six-month sojourns in weightlessness on astronauts' bodies, and some of those effects appear not to have reached a new adapted state," said John Charles, chief of the Human Research Program's new International Science Office. "This one-year mission opportunity will show if the trends continue as before or if we are approaching any 'cliffs' that will require new treatments while providing new insights."[1]

Enhanced by a spark of astronaut, and possibly familial, curiosity, twin NASA astronauts Scott and Mark Kelly initiated an unprecedented research request to study the human effects of spaceflight using their identical twin genetic makeup. NASA's (HRP) realized that another opportunity to study astronaut twins would be rare, and took the brothers up on their offer of genetic comparison in the name of human space exploration.

"This is a once-in-a-space-program opportunity," admits John Charles, Ph.D., chief of the HRP's International Science Office before the experiment list was finalized. "The mission of the HRP is to reduce the risk to astronauts during long-duration space flight. In typical investigations, we usually have a specific outcome in mind and are goal-oriented. In this case, the slate is essentially blank. I am anxious to see what proposals we will receive. Since Mark will not be a typical research control subject, meaning his environment and living habits will not mimic those of Scott's on the space station, the research is considered observational in nature. There are no defined outcomes for the investigations; instead, this is a chance to compare data collected from genetically similar astronauts to observe the human effects of spaceflight." [2]



Nasa finally selected 10 of the most interesting experiments for the one-year flight study in March 2014. Only one set of twins has ever been into space, and now those twins are providing an unprecedented opportunity for scientists to understand better the effects of microgravity on the human body.

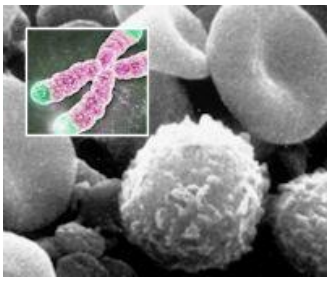
NASA's Human Research Program (HRP) funds the ten first-of-its-kind investigations into the molecular, physiological and psychological effects of spaceflight in a continuous effort to reduce the health impacts of human space exploration. The National Space Biomedical Research Institute is partnering with HRP to provide genetic counseling and assisting in the management of the research.

The study will focus in part on the comparison of blood samples collected from Scott, Mark and Kornienko at regular intervals before, during and after the one-year mission. Physiological and psychological testing also will be conducted on the brothers and Kornienko before, during and after the mission.

Scientific and technical experts from academia and government reviewed 40 proposals submitted in response to the research announcement "Human Exploration Research Opportunities - Differential Effects on Homozygous Twin Astronauts Associated with Differences in Exposure to Spaceflight Factors." The following ten selected proposals, which are from 10 institutions in seven states, will receive a combined $1.5 million during the three-year study period:

- **Emmanuel Mignot,** Stanford University School of Medicine, HERO Twin Astronaut Study Consortium (TASC): Immunome Changes in Space
- **Michael Snyder,** Stanford University, HERO Twin Astronaut Study Consortium (TASC) Project: Longitudinal integrated multi-omics analysis of the biomolecular effects of space travel
- **Michael Stenger**, Wyle Science, **Brinda Rana,** University of California**,** Proteomic Assessment of Fluid Shifts and Association with Visual Impairment and Intracranial Pressure in Twin Astronauts
- **Susan Bailey,** Colorado State University, Differential effects on telomeres and telomerase in twin astronauts associated with spaceflight
- **Fred Turek,** Northwestern University, HERO Twin Astronaut Study Consortium (TASC) Project: Metagenomic Sequencing of the Bacteriome in GI Tract of Twin Astronauts
- **Andrew Feinberg,** Johns Hopkins University School of Medicine, Comprehensive whole genome analysis of differential epigenetic effects of space travel on monozygotic twins
- **Christopher Mason,** Weill Medical College of Cornell University, The Landscape of DNA and RNA Methylation Before, During, and After Human Space Travel
- **Mathias Basner,** University of Pennsylvania School of Medicine, HERO Twin Astronaut Study Consortium (TASC) Project: Cognition on Monozygotic Twin on Earth
- **Stuart Lee,** Wyle Laboratories, Metabolomic And Genomic Markers Of Atherosclerosis As Related To Oxidative Stress, Inflammation, And Vascular Function In Twin Astronauts
- **Scott Smith,** NASA Johnson Space Center, Biochemical Profile: Homozygous Twin control for a 12 month Space Flight Exposure

HRP regularly assessed crew health and performance during spaceflight to evaluate associated risks. From these assessments, HRP developed strategies to monitor and mitigate these risks. These studies often have the considerable added benefit of advancing health care for people on Earth.[3]
Craig Kundrot of NASA's Human Research Program at the Johnson Space Center tries to illustrate some of the above experiments. "For the first time, we'll be able to study two individuals who are genetically identical. We will be taking samples and making measurements of the twins before, during, and after the one-year mission", he explains.



"Each proposal is fascinating and could be a feature-length story of its own, here are a few examples to give the flavor of the research: We already know that the human immune system changes in space. It's not as strong as it is on the ground," explains Kundrot. "In one of the experiments, Mark and Scott will be given identical flu vaccines, and we will study how their immune systems react." (see **Emanuel Mignot**, Immunome Changes in Space, experiment list above).

“Another experiment will look at telomeres--little molecular "caps" on the ends of human DNA. Here on Earth, the loss of telomeres has been linked to aging. In space, telomere loss could be accelerated by the action of cosmic rays. Comparing the twins' telomeres could tell researchers if space radiation is prematurely aging space travelers.” (**Susan Bailey**, Colorado State University)

“Meanwhile in the gut,” says Kundrot, "there is a whole microbiome essential to human digestion. One of the experiments will study what space travel does to [inner bacteria] which, by the way, outnumber human cells by 10-to-1."(**Fred Turek**, Northwestern University).

“Other proposals are equally fascinating. One seeks to discover why astronaut vision changes in space. Sometimes, their old glasses from Earth don't work," (**Michael Stenger**, Fluid Shifts experiment) notes Kundrot

"These will not be 10 individual studies," says Kundrot. "The real power comes in combining them to form an integrated picture of all levels from biomolecular to psychological. We'll be studying the entire astronaut." [4]
The very significance of this long term study experiment is the international cooperation and data exchange of the very sensible astronaut and cosmonaut data between the involved scientists as can be illustrated by looking for example at the “Fluid Shifts Before, During and After Prolonged Space Flight and their association with intercranial pressure and visual impairment” experiment.
Principal Investigators Michael B. Stenger (PhD), Scott A. Dulchavsky (M.D., PhD) and Alan R. Hargens (PhD) USA and 21 Co-Investigators from from Universities and other research institutions in the USA, Philippe Arabella Univerity Tours, France, Hanns Christian Gunga, Universitätsmedizin Berlin, Denmark, Valery V. Bogomolov, Institute for Biomedical Problems, Moscow Russia, Eugenia N. Yarmanova, Institute of Biomedical Problems, Moscow, Russia and Irina V. Alferova, Institute for Biomedical Problems, Moscow Russia.

More details about the “Fluid Shift” experiment and the other nine experiments can be found on the excellent public NASA page “Space Science is for everyone” [5] using the provided search engine on the home page. Another announced important feature of those experiment descriptions is, that they will gradually be filled in with the results as they are released.

Scott Kelly Mikhail Kornienko. landed in Kazakhstan on March 1, 2016 completing their 340-day experiment on the ISS.

Administrator Charles Bolden in a statement today. “All of us in the NASA family — and indeed in the broader scientific community — are grateful that he [Scott] was willing to sacrifice time with his loved ones, meals that don’t come in a bag, a cold beer, hot showers, cool autumn breezes, the sounds of birds chirping, the ability to lay his head on an actual pillow, and so much more of the pleasures of life during his year of research and experimentation the Intern**at**ional Space Station," said Bolden.

Watch the excellent summary of the one-year in space mission on the NASA video (youTube)

Scott Kelly has spent a total of 520 days in space.
Mark Kelly has spent a total of 54 days in space during his previous STS flights.
Mikhail Korienko has spent a total of 516 days in space including his previous Soyuz missions.

Remains to be said Scott Kelly retired from the space agency on April 1st, 2016 — less than a month after he returned from his one-year trip to the ISS. NASA said Kelly will continue to participate in follow-up tests for the mission and periodically contribute fluid samples for research, but he won't fly into space for NASA again.
Just because Kelly is retiring from NASA doesn't mean he's done with spaceflight though. Kelly told press after returning to Earth that he may consider flying to space with a private spaceflight company in the future. "Maybe in the next 20 years, you can buy a cheap ticket and go for a little visit," he said. [6]

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