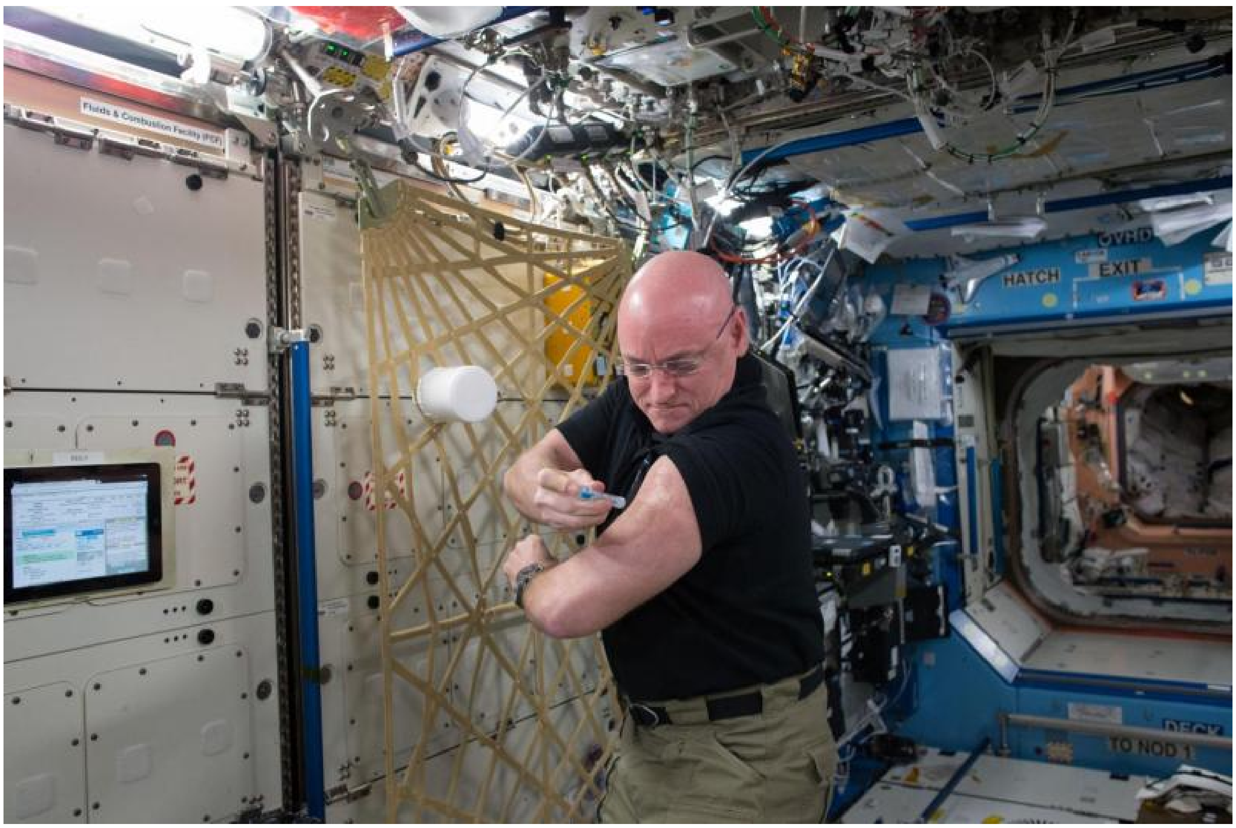
Precision immunization: NASA studies immune response to flu vaccine in space and on Earth

December 23 2015, by Amy Blanchett



NASA astronaut Scott Kelly gives himself a flu shot for an ongoing study on the human immune system. The vaccination is part of NASA's Twins Study, a compilation of multiple investigations that take advantage of a unique opportunity to study identical twin astronauts Scott and Mark Kelly, while Scott spends a year aboard the International Space Station and Mark remains on Earth. Credit: NASA

Every year, as influenza season - and flu shot season—rolls around, medical experts weigh in on just how effective it will be against that year's particular strain. What if that equation could take into account a person's own immune response? Emmanuel Mignot, M.D., Ph.D., known for discovering that narcolepsy is related to the immune system, is taking advantage of a unique opportunity to investigate how the immune systems of twin astronauts Scott and Mark Kelly respond to the seasonal flu vaccine.

Mignot is conducting his research as an investigator for NASA's Twin Study. NASA's Human Research Program is studying many aspects of Scott Kelly's health during his one-year space flight mission, with the unique advantage of also studying his identical twin brother, Mark, on Earth. It will help determine how the immune system changes during space flight, and how to possibly counterbalance the changes for a journey to Mars, perhaps through the use of vaccinations.

On the International Space Station, Scott is exposed to fewer and different pathogens than Mark over the course of the year. Exposure to bugs, bacteria and viruses on Earth causes the body to produce more T-cells, which protect us from infection. These immune cells patrol blood and tissues in the body looking for invaders, and due to previous exposures, are prepared to attack. This process strengthens the immune system.

"Each T-cell has a slightly different gene that allows them to react to specific bacteria or viruses and there are billions of different receptors in these T-cells to study," said Mignot, also professor of Psychiatry and Behavioral Sciences at Stanford University, and director of the Stanford Center for Sleep Sciences and Medicine. "Vaccinations only protect against one agent, in this case the flu. So we can look at the specific T-cells that are recruited by the body to fight against the flu and see how the immune system responds."

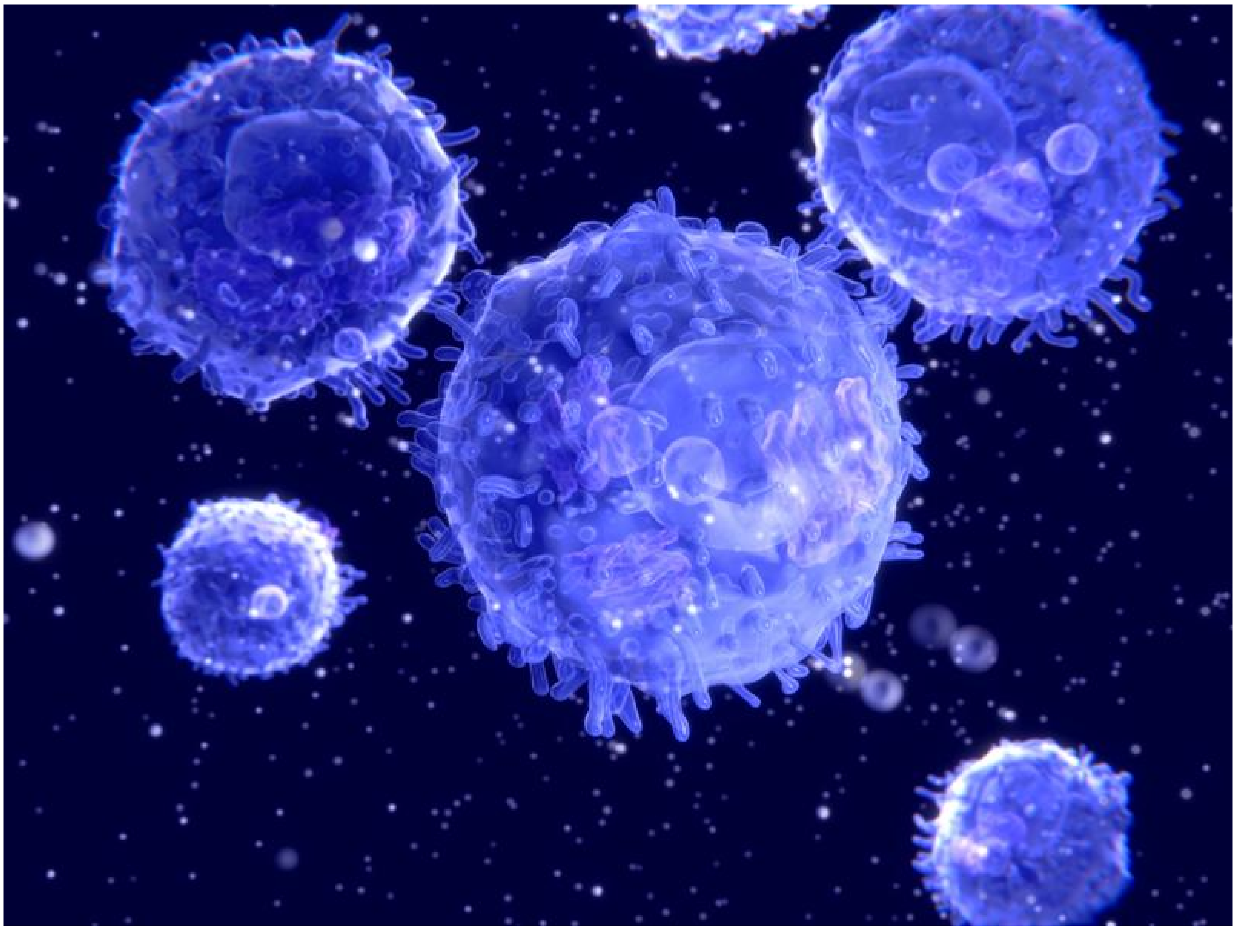
Mignot and his team are curious to know whether after a year in an isolated environment like the space station, if Scott's immune system will be less responsive or more active due to other stressful exposures such as isolation and being in an environment far from home and family, work stress, radiation, microgravity and altered sleep cycles. It is crucial to understand this, because stress and immune changes could lead to reactivation of latent infections.

To evaluate his immune system on a molecular level, Scott and Mark received commercially available flu vaccines at the same time. Flu shots were administered and blood samples were taken before flight and six months into the year-long mission. Six months after Scott returns to Earth, the final flu shots will be administered and blood samples taken. Samples are taken one week after each flu vaccination because that is the time when the T-cell immune response is most prominent.

Former astronaut Mark Kelly takes his flu shot during his lab testing in support of the NASA Twins Study with his brother Scott Kelly. Credit: NASA

The immune system is very complex. Our bodies are continually fighting against a variety of bugs. Flu vaccines help because they stimulate the immune system by pre-activating T-cells in the body causing them to react faster to block development of disease. Then, when we are exposed to the flu, the T-cells are already geared up to protect us from invaders.

Everyone's immune system is different because of their genes and where they live and work, and individuals are exposed to different microbes, bacteria, pathogens and viruses throughout their lifetime. It is beneficial for researchers such as Mignot to use the latest technology in gene sequencing, such as the integrative personalized omics profiling (iPOP), to study the immune system. Omics measures the diversity of genetic material in our bodies, the totality of all cells such as molecular interactions, pathways, genes, microbiome, hormones, antibodies, metabolites, and proteins to name a few.



An image of lymphocytes or T-cells. Credit: NASA

It will be interesting to compare Scott and Mark's T-cells because it is not known which T-cells will be recruited to respond to the flu vaccine. It is hoped, by examining twins who are genetically similar but are in different environments, that more information can be acquired about T-cells. This information combined with pre- and post-vaccination data on 210 twins, ages 8-82 years, from the National Institutes of Health, may help protect future astronauts on long-duration space missions, possibly through personalized vaccines. Using Omics, researchers can see more molecular reactions than ever before and learn more about immune responses.

"We will be able to determine what portion and pathways of the immune system are most challenged by space flight," said Mignot. "We'll calibrate the amount of immune changes present and offer ideas on how to counterbalance it, for example using higher doses of vaccination for key viruses to avoid reactivation."

Mignot plans to study as many T-cells as possible and envisions a day when a flu vaccine will be tailored to a person's genetic and "bug" makeup by removing the components of the vaccine which cause side effects and reactions of those who may be genetically predisposed.

Provided by NASA