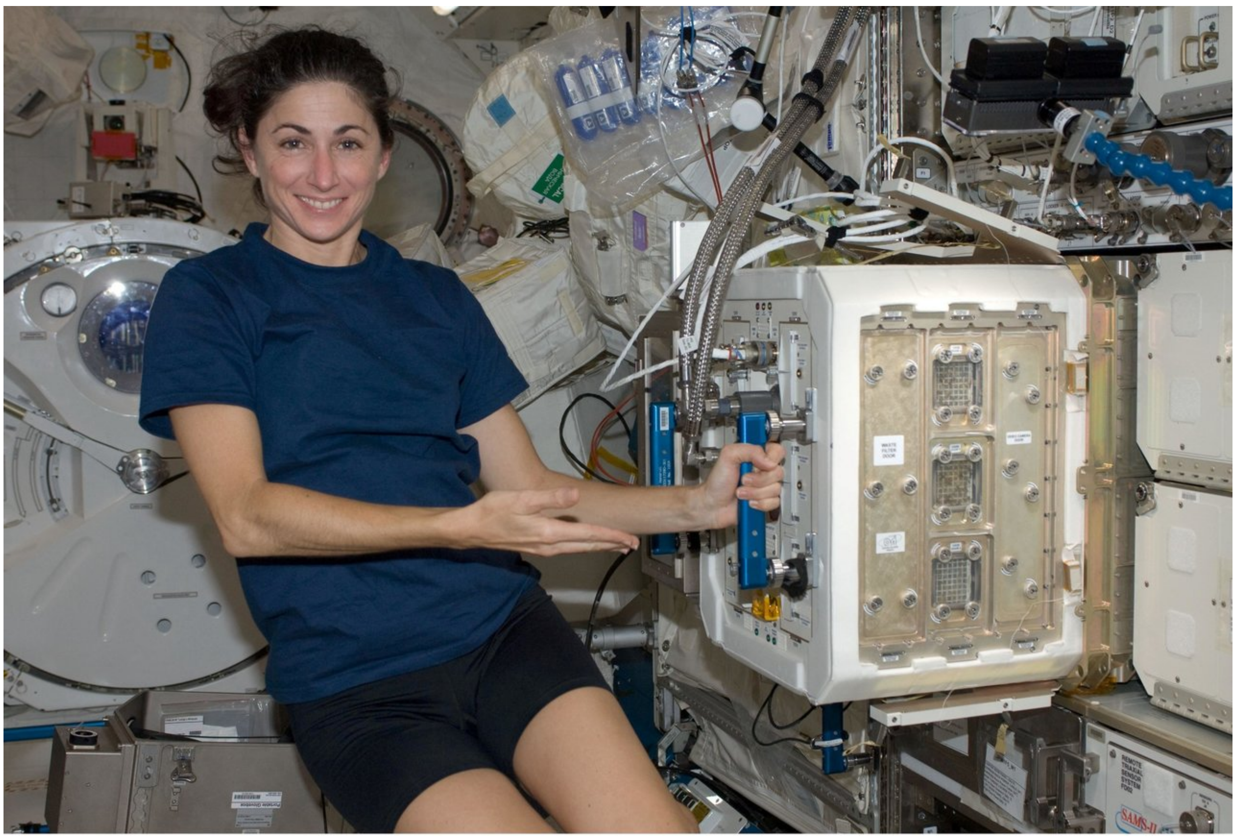
To avoid vision problems in space, astronauts will need some kind of artificial gravity

September 19 2018, by Matt Williams



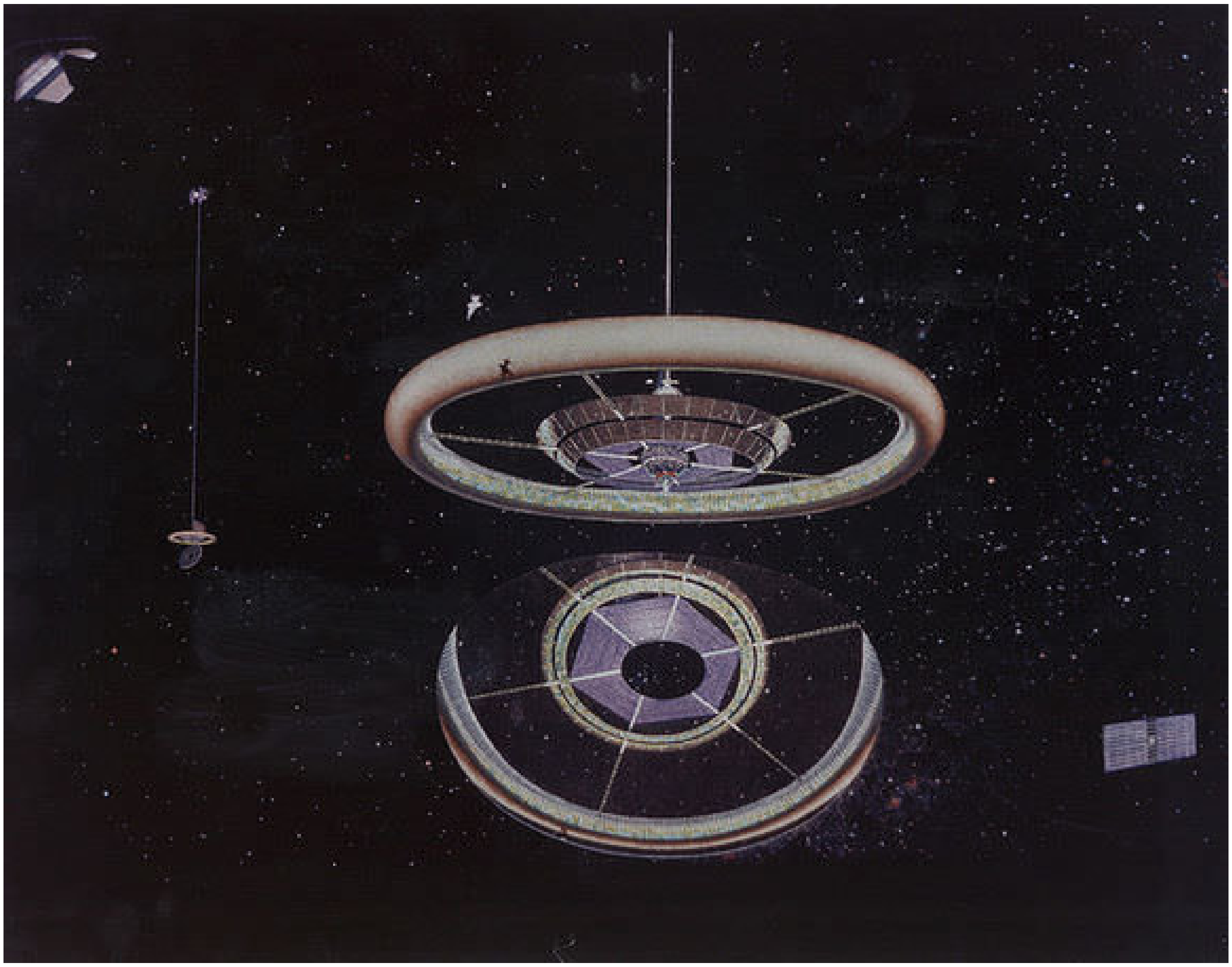
NASA astronaut Nicole Stott, Expedition 20/21 flight engineer, is pictured near the Mice Drawer System (MDS) in the Kibo laboratory of the International Space Station. Credit: NASA

Ever since astronauts began going to space for extended periods of time, it has been known that long-term exposure to zero-gravity or microgravity comes with its share of health effects. These include muscle atrophy and loss of bone density, but also extend to other areas of the body leading to diminished organ function, circulation, and even genetic changes.

For this reason, numerous studies have been conducted aboard the International Space Station (ISS) to determine the extent of these effects, and what strategies can be used to mitigate them. According to a new study which recently appeared in the *International Journal of Molecular Sciences*, a team of NASA and JAXA-funded researchers showed how artificial gravity should be a key component of any future long-term plans in space.

As noted, a considerable amount of research has been conducted to identify and quantify the effects microgravity has on the human body. A good example of this is the Twins Study conducted by NASA's Human Research Program (HRP), which researched the effects on astronaut Scott Kelly's body after he spent a year aboard the International Space Station – using his twin brother, Mark Kelly, as the control.

These and other studies have confirmed that exposure to microgravity can not only affect bone density and muscle mass, but also immune-function, blood oxygenation, cardiovascular health, and even possible genomic and cognitive changes. In addition, eyesight is also something that can be effected by time spent in space, which is the result of less circulation and oxygen making it to the ocular tissue.



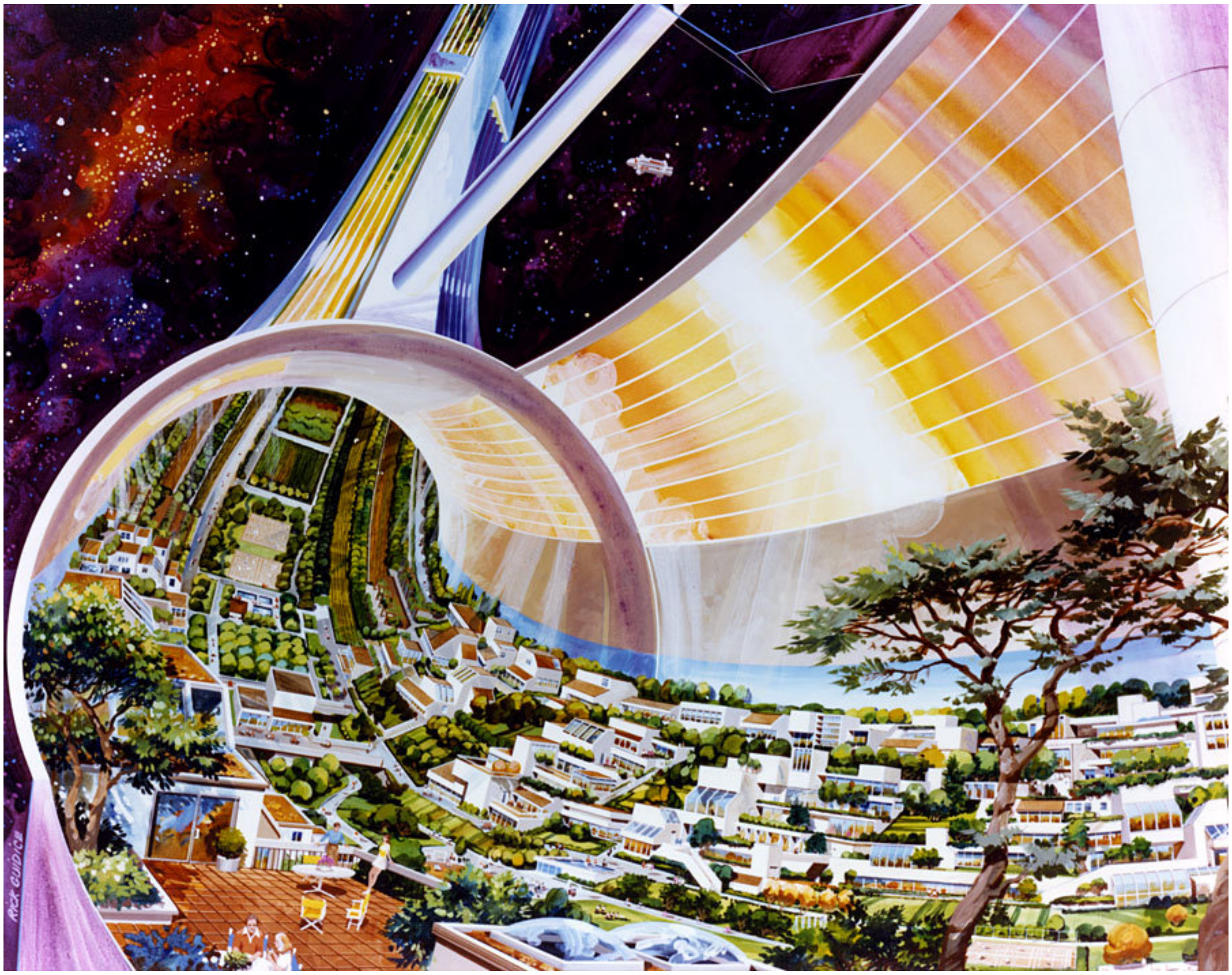
Exterior view of a Stanford torus. Bottom center is the non-rotating primary solar mirror, which reflects sunlight onto the angled ring of secondary mirrors around the hub. Credit: Painting by Donald E. Davis

In fact, about 30 percent of astronauts on short-term space shuttle flights (roughly two weeks) and 60 percent on long-duration missions to the ISS have reported some impairment to their vision. In response, Professor Michael Delp – the Dean of the College of Human Sciences at Florida State University (FSU) and a co-author on the paper – and his colleagues recommend that artificial gravity be incorporating into future missions.

For years, and with the support of NASA, Delps has been studying the affect microgravity has on astronaut eyesight. As he said in a recent FSU News release:

"The problem is the longer the astronauts are in space, the more likely they are to experience visual impairment. Some astronauts will recover from vision changes, but some don't. So this is a high priority for NASA and space agencies worldwide. With this application of artificial gravity, we found it didn't totally prevent changes to the eye, but we didn't see the worst outcomes."

To determine if artificial gravity would lessen these effects, Delp teamed up with researchers from the Japan Aerospace Exploration Agency (JAXA) in a first-ever collaboration. They were joined by Professor Xiao Wen Mao (the study's lead author) from Linda Loma University, as well as members from the University of Arkansas for Medical Sciences, the Arkansas Children's Research Institute, and the University of Tsukuba.



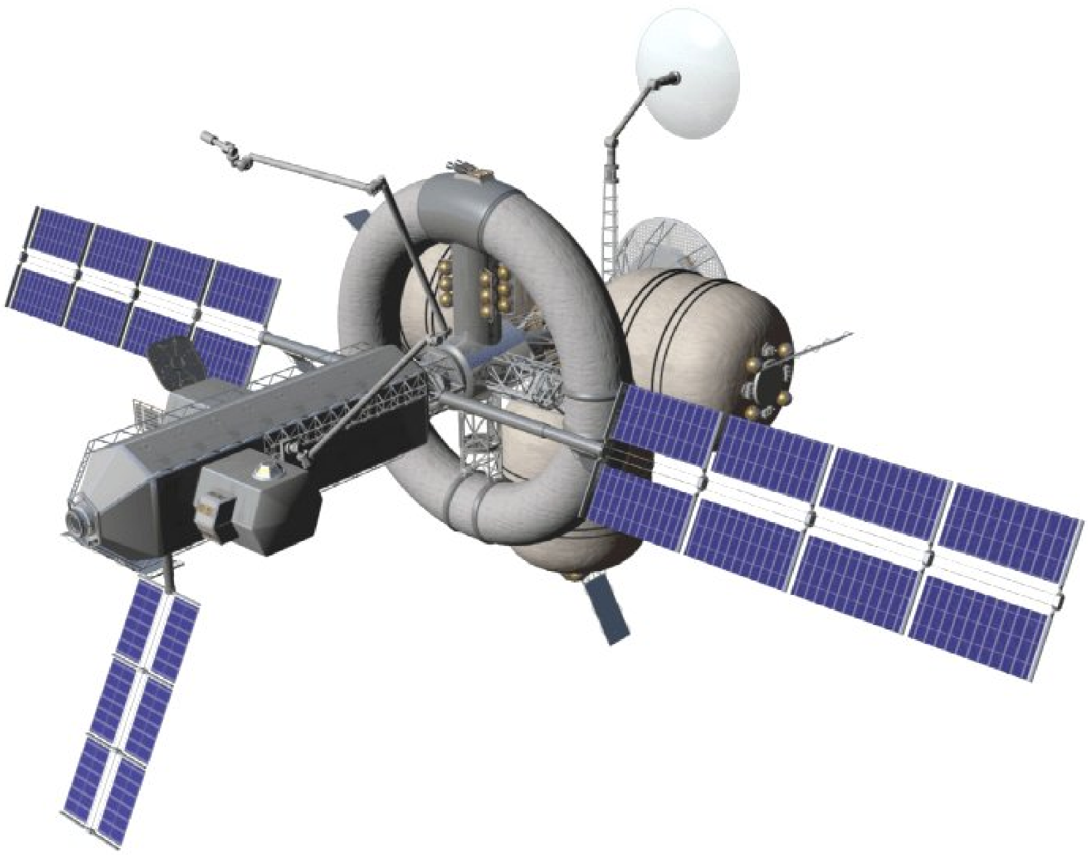
Stanford Torus cutaway view. The rotation of the torus provides Earth-normal gravity on the inside. Credit: Rick Guidice/NASA

The team then examined changes in the ocular tissues of mice after they spent 35 days aboard the ISS. The test subjects consisted of 12 nine-week-old male mice that were flown from the Kennedy Space Center and housed in the mouse Habitat Cage Unit (HCU) in the JAXA "Kibo" Laboratory on the ISS. Over the course of their stay, the mice were divided into two groups.

Whereas one group lived in ambient microgravity conditions, the other lived in a centrifugal habitat unit that produced 1 g of artificial gravity (the equivalent of Earth's gravity). From this, the research team found that the former group suffered damage to the blood vessels that are important for the regulation of fluid pressure within the eyes.

"When we're on Earth, gravity pulls fluid down toward our feet," said Phelps. "When you lose gravity, the fluid shifts toward the head. This fluid shift affects the vascular system throughout the body, and now we know it also affects the blood vessels in the eye."

In addition, the team noted that protein expression profiles had also changed in the mice's eyes as a result of microgravity. By comparison, the mice that spent their time in the centrifuge did not experience nearly as much damage to their ocular tissues. These results indicate that artificial gravity, likely in the form of rotating sections or centrifuges, will be a necessary component for long-duration space missions.



A global view of the Nautilus-X multi mission space exploration vehicle designed by NASA. Credit: Mark L Holderman – NASA Technology Applications Assessment Team

As concepts go, the use of artificial gravity in space is not something new. In addition to being a well-explored concept in science fiction, space agencies have looked into it as a possible way of establishing a permanent human presence in space. A shining example of this is the Stanford Torus Space Settlement, a principal design that was considered by the 1975 NASA Summer Study.

As a collaborative effort between NASA's Ames Research Center and

Stanford University, this ten-week program consisted of professors, technical directors and students coming together to construct a vision of how people might someday live in a large space colony. The result of this was a concept for a wheel-like space station that would rotate to provide the sensation of either Earth-normal or partial gravity.

In addition, rotating torus' have been considered for spacecraft to ensure that astronauts on long-duration missions could limit their time in microgravity. A good example of this is the Non-Atmospheric Universal Transport Intended for Lengthy United States Exploration (Nautilus-X), a multi-mission spacecraft concept that was developed in 2011 by engineers Mark Holderman and Edward Henderson of NASA's Technology Applications Assessment Team.

As with previous research, this study highlights the importance of maintaining astronaut health during long-term missions in space, as well as long-duration voyages. However, this study is distinguished in that it is the first in a series designed to better understand vision impairment among astronauts.

"We hope continued strong science collaboration will help us accumulate the experimental results needed to prepare for future manned deep-space exploration," said Dai Shiba, a senior researcher for JAXA and a co-author on the paper. Mao, the lead-author on the study, also indicated that she is hopeful that this research will go beyond space exploration and have applications here on Earth:

"We hope our findings not only characterize the impact of spaceflight environment on eyes but will contribute to new cures or treatments for spaceflight-induced vision problems as well as more Earthbound disorders, such as age-related macular degeneration and retinopathy."

There is no doubt that when it comes to the future of space exploration, there are many challenges lying ahead of us. Not only do we need to develop spacecraft that can combine fuel efficiency and power, we need to reduce the cost of individual launches and come up with ways to mitigate the health risks of long-term missions. Beyond the effects of microgravity, there is also the issue of prolonged exposure to solar and cosmic radiation.

And let's not forget that missions to the lunar surface and Mars will have to contend with long-term exposure to lower gravity, especially where outposts are concerned. As such, it would not be farfetched to imagine that tori and centrifuges could become a regular part of space exploration in the near future.

More information: Thomas Goodwin et al. Oxidative Stress and Space Biology: An Organ-Based Approach, *International Journal of Molecular Sciences* (2018). DOI: 10.3390/ijms19040959

Source Universe Today