Researchers launch heart tissue to the International Space Station to help cardiac patients on Earth

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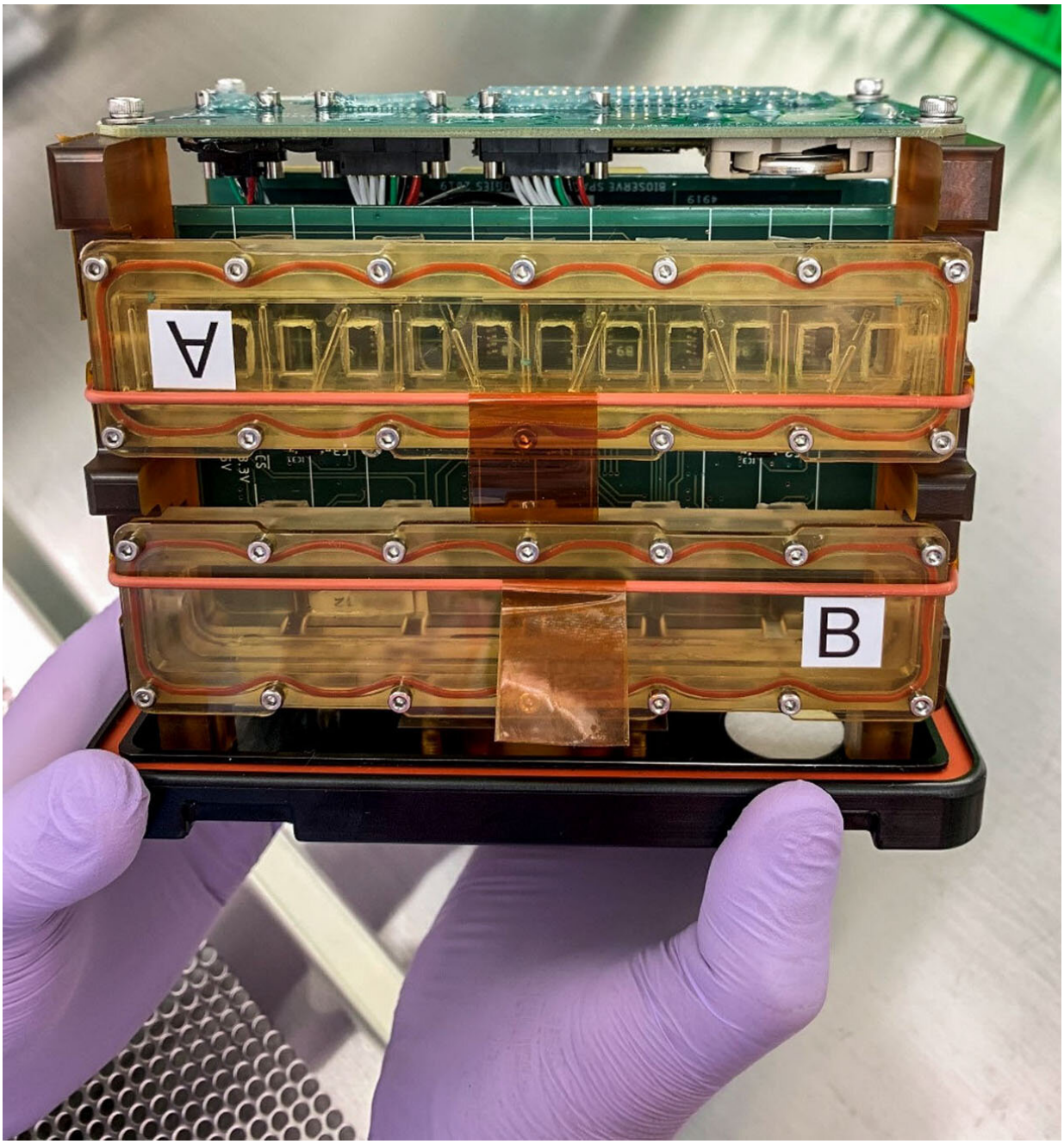

Tissue chambers loaded into a plate habitat designed for research aboard the ISS. Credit: Johns Hopkins Medicine

When Dr. Peter Lee leaves his Brown University lab and looks up into

the night sky, he can sometimes catch a glimpse of his own research project.

A practicing cardiothoracic surgeon and a Brown assistant professor of pathology and laboratory medicine (research), Lee is a member of a multi-institution team that has collaborated with the National Institutes of Health and NASA to send human heart "tissue-on-a-chip" specimens into space. The tissue samples were launched into the stratosphere aboard a Cargo Dragon spacecraft as part of SpaceX CRS-27, a resupply mission to the International Space Station that blasted off from NASA's Kennedy Space Center this spring.

The project, led by researchers at Johns Hopkins University, is designed to monitor the tissue for changes in the mitochondria of heart muscle cells, as well as their ability to contract in low-gravity conditions. Astronauts on board during the mission will also introduce three medicines to the samples in an effort to prevent heart cell changes known or suspected to occur in people undertaking long-duration space flights.

The low-gravity environment of the space station provides an ideal laboratory in which to study aging-like biological processes that otherwise take place over much longer periods of time on Earth, Lee explained.

"Researchers have found that the changes that happen to human tissues in space are similar to what happen during the course of normal aging—but over a few weeks or a month compared to many years," Lee said. "Our experiment is using the space microgravity environment as a model of accelerated aging so that we can observe cellular changes in heart muscle that would normally take a long time to happen, and quickly translate them into experiments here on Earth."

The results of the space experiments have far-reaching implications.

"What we learn from these experiments with heart tissue can inform how we treat age-related cardiac problems in patients," Lee said. "The study will not only improve understanding of how the heart cells respond to drugs in space, but could also lead to innovations in drug development to help patients on Earth."

A career that spans space and time

From a young age, Lee has always had stars in his eyes and a hunger for space exploration. As a student in the Program in Liberal Medical Education at Brown, Lee sought out Herman Vandenburgh, now a professor emeritus of pathology and laboratory medicine, who had flown experiments on the space shuttle, and spent the summer after his first year of medical school working in Vandenburgh's lab. Lee's student experiment from that time even flew on John Glenn's space shuttle flight in 1998.

Midway through his education in the M.D./Ph.D. program at Brown's Warren Alpert Medical School, Lee completed a one-year master of science in space studies at the International Space University in France. He planned to be a NASA flight surgeon, but changed course during his third-year surgical rotation to focus on cardiothoracic surgery. Yet he continued to pursue space medicine research. (As a dual citizen, Lee was a finalist for the Canadian astronaut program in 2016 and is involved in the leadership of national and international space biology and aerospace medical organizations.)

Before launching his own lab in 2013, Lee helped obtain two grants for International Space Station projects, researching how space flight affects fruit fly hearts and stem cell-derived heart cells. Three years ago, Lee participated in a study that sent bio-engineered heart tissue into space for

one month to study the effect of microgravity on the heart. NASA astronaut Jessica Meir, Lee's friend and fellow Brown graduate, was a collaborator on that project—she helped tend to the tissues on the International Space Station.

Tissue-on-a-chip on a spaceship

The project launched into space this spring is Lee's first interstellar effort since returning to Brown as a research faculty member in 2020. Like the previous experiment, the one launched on the SpaceX Dragon also involves engineered heart tissues made from cardiomyocytes, or heart muscle cells. The tissue-on-a-chip models are small, Lee said, but they are able to continuously contract in the same way that a human heart regularly beats. The researchers have designed a mechanism using magnets and sensors to calculate the force being generated on the tissues in real time.

This time, scientists will be focusing on proteins activated during tissue inflammation and mitochondrial dysfunction. The astronauts aboard the space station will also test whether any of three clinically approved medicines can mitigate the signs of the abnormal effects anticipated from the previous study.

When the samples return to Earth in late April, the scientists, including Lee, will perform additional tests to assess the condition of the tissues. In addition to the tissue chip research, the current mission is carrying more than 15 other ISS National Lab-sponsored projects, including advanced materials research, technology demonstrations and physical sciences studies.

Compared to lab work on Earth, conducting research on the ISS is very different, Lee said. The tissues were created weeks in advance, then tended by researchers until they could be carefully placed inside special

hardware and handed over to NASA just before the launch—a date that at times can be a moving target.

"You usually have the opportunity to repeat an experiment in the lab, but because of the complexities and cost of space flight experiments, we just have one shot to get it right," Lee said.

Provided by Brown University