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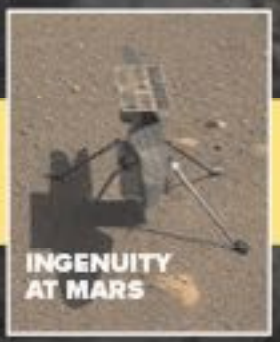
2021 Year in review

247 kilometers on one charge

and dozens of other breakthroughs



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3D-printed tissues, freeze-dried sperm and gene editing

BY JONATHAN METTS

The **Life Sciences and Systems Technical Committee** advances technologies required to keep people healthy and safe as they explore space.

Competing research teams from **Wake Forest University** in North Carolina claimed first place and second place in **NASA's Vascular Tissue Challenge** in June by **replicating liver function in a long-lasting artificial tissue**. Using different methods and materials, both teams 3D-printed scaffolds with vascular channels to mimic blood flow in human tissue. NASA is interested in the technology's potential to provide artificial tissue or even functional organs for transplant into astronauts who cannot quickly or safely return to Earth for emergency treatment.

Both teams created artificial tissues housing human liver cells that remained functional through at least 30 days, producing albumin and bilirubin. They 3D-printed the macroscale tissues with a volumetric envelope over 1 cubic centimeter. The challenge required that these tissues be maintained only by perfusion of blood (or other fluid) to provide nutrients and oxygen while disposing of waste products, without leakage into the surrounding tissue.

A spaceflight demonstration of Team Winston's winning technology is in development with the **International Space Station National Laboratory**, with the goals of enabling tissue research in space by modeling human biology under precisely controlled conditions, as well as studying the benefits and challenges of biomanufacturing such tissues in microgravity.

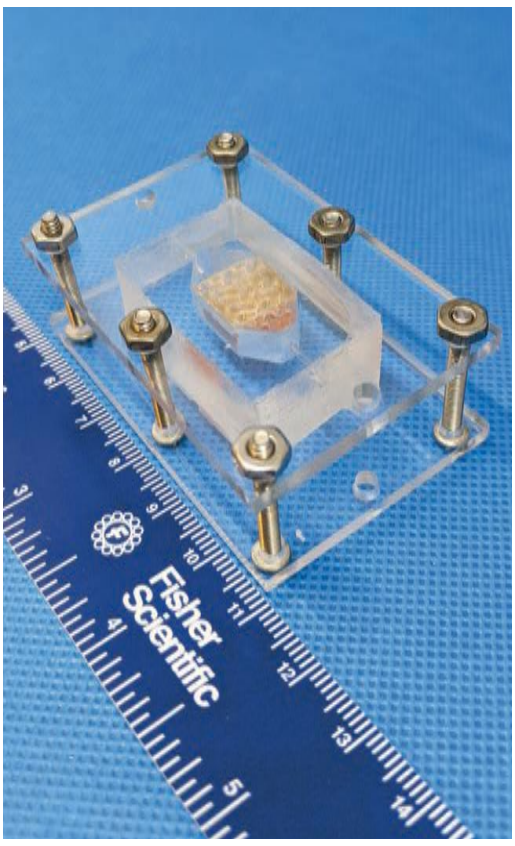
Freeze-dried mouse sperm first launched to orbit in 2013 were stored on the ISS in a long-term fertility study on space exposure, according to results from the **University of Yamanashi in Japan** that Science Advances published in June. The samples were returned to Earth after increasing intervals, up to nearly six years later. After landing and recovery, the sperm were rehydrated and used to fertilize mouse eggs that had not been flown to space. All mice born of the study, a total of 168 pups over the years, developed normally. Genetic analysis of the space-flown sperm and the resulting mice showed no defects. These results support the prospects for off-world storage and transport of mammalian genetic material.

The researchers also exposed nonflown sets of both fresh and freeze-dried mouse sperm to high doses of X-rays, finding the freeze-dried sperm to be equally fertile with no radiation and more tolerant than fresh sperm when exposed to radiation up to 10 Gray (1,000 rad) of an absorbed dose. Freeze-drying also allows for long-term storage at room temperature, which has operational benefits for in-space research and storage.

NASA has long understood that increased exposure to ionizing radiation in space, particularly beyond Earth's magnetosphere, such as during lunar exploration, can damage DNA and lead to health problems. In results published by PLOS One in June, **researchers demonstrated gene editing technology aboard the ISS for the first time**.

In the experiment, devised by a team of Minnesota high school students with support from researchers at the **Massachusetts Institute of Technology**, the team used the **CRISPR-Cas9 method** to sever both strands of the double helix in yeast DNA. They then allowed test samples to repair themselves, which can occur by two natural processes — one of which, nonhomologous end-joining, can result in an altered gene sequence with increased risk of mutation and cancer.

By preparing and testing the samples in space, this research shows that microgravity can be isolated as the only variable for such experiments, thus **introducing a new genetic research capability on the ISS**. Results also showed that the method of repair can be effectively determined using ground-based gene sequencing of lab results obtained on orbit. Future studies will investigate whether spaceflight affects either or both double-strand DNA repair processes. ★



▶ Artificial vascular tissue was 3D-printed into this chamber as a support structure for human liver cells by a team of researchers at Wake Forest University. NASA held a competition to develop technology to produce artificial tissues in space for astronauts who may not be able to return to Earth quickly.

Wake Forest Institute for Regenerative Medicine