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Astronauts demonstrate CRISPR/Cas9 genome editing in space

June 30 2021

NASA Astronaut Christina Kock performing the experimental procedure aboard the International Space Station. Credit: Sebastian Kraves

Researchers have developed and successfully demonstrated a novel method for studying how cells repair damaged DNA in space. Sarah Stahl-Rommel of Genes in Space and colleagues present the new technique in the open-access journal *PLOS ONE* on June 30, 2021.

Damage to an organism's DNA can occur during normal biological processes or as a result of environmental causes, such as UV light. In humans and other animals, damaged DNA can lead to cancer. Fortunately, cells have several different natural strategies by which damaged DNA can be repaired. Astronauts traveling outside of Earth's protective atmosphere face increased risk of DNA damage due to the ionizing radiation that permeates space. Therefore, which specific DNA-repair strategies are employed by the body in space may be particularly important. Previous work suggests that microgravity conditions may influence this choice, raising concerns that repair might not be adequate. However, technological and safety obstacles have so far limited investigation into the issue.

Now, Stahl-Rommel and colleagues have developed a new method for studying DNA repair in yeast cells that can be conducted entirely in space. The technique uses CRISPR/Cas9 genome editing technology to create precise damage to DNA strands so that DNA repair mechanisms can then be observed in better detail than would be possible with non-specific damage via radiation or other causes. The method focuses on a particularly harmful type of DNA damage known as a double-strand break.

The researchers successfully demonstrated the viability of the novel method in yeast cells aboard the International Space Station. They hope the technique will now enable extensive research into DNA repair in space. This study marks the first time that CRISPR/Cas9 genome editing has successfully been conducted in space, as well as the first time in space that live cells have undergone successful transformation—incorporation of genetic material originating from outside the organism.

Future research could refine the new method to better mimic the complex DNA damage caused by ionizing radiation. The technique could also serve as a foundation for investigations into numerous other molecular biology topics related to long-term space exposure and exploration.

"It's not just that the team successfully deployed novel technologies like CRISPR genome editing, PCR, and nanopore sequencing in an extreme environment, but also that we were able to integrate them into a functionally complete biotechnology workflow applicable to the study of DNA repair and other fundamental cellular processes in microgravity," said senior author Sebastian Kraves. "These developments fill this team with hope in humanity's renewed quest to explore and inhabit the vast expanse of space."

First author Sarah Stahl Rommel adds, "Being a part of Genes in Space-6 has been a highlight of my career. I saw firsthand just how much can be accomplished when the ideas of innovative students are supported by the best from academia, industry, and NASA. The expertise of the team resulted in the ability to perform high-quality, complex science beyond the bounds of Earth. I hope this impactful collaboration continues to show students and senior researchers alike what is possible onboard our laboratory in space."

Co-author Sarah Castro-Wallace says, "It was an honor to support Genes in Space-6. I am still blown away by the incredible sophistication of the science that was realized when an organism was transformed, its genome edited with CRISPR/Cas9 to cause breaks in the DNA, followed by its growth to allow for DNA repair, and, finally, its DNA sequenced, all in the spaceflight environment onboard the ISS. The ability to perform this all-encompassing, end-to-end investigation is a huge step forward for space biology. This caliber of work speaks to both the exceptional students and the Genes in Space Program."

More information: Stahl-Rommel S, Li D, Sung M, Li R, Vijayakumar A, Atabay KD, et al. (2021) A CRISPR-based assay for the study of eukaryotic DNA repair onboard the International Space Station. *PLoS ONE* 16(6): e0253403. doi.org/10.1371/journal.pone.0253403

Provided by Public Library of Science