NASA releases 'Microbiomics: The Living World In and On You' video

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NASA astronaut and molecular biologist Kate Rubins, Ph.D., will sequence DNA from a bacterium, virus and mouse in space for the first time, using a portable, nanopore sequencer, to confirm that the technology and technique work correctly in space. Credit: NASA

NASA's Human Research Program (HRP) is releasing a video titled

"Microbiomics: The Living World In and On You" to highlight microbial research on the International Space Station. HRP's Twins Study uses omics to study Scott and Mark Kelly's microbiome, which is the collection of each individual's microbes. Omics is an evolving field integrating collections of measurements, biomolecules and sub-disciplines to provide a more complete picture of health. It includes the studies of DNA, RNA, proteins, environment and metabolites, in addition to the microbiome. This video is the seventh in the eight omics video miniseries. It focuses on the importance of the microbiome and provides a broad overview of ongoing Twins Study research.

NASA Twins Study Principal Investigator Fred Turek, Ph.D., Northwestern University, Feinberg School of Medicine, Center for Sleep & Circadian Biology, and his team are studying the microbiomes of Mark and Scott Kelly. The investigation explores the identical twin brothers' dietary differences along with the space environment to determine how both affect the organisms in their guts.

"We asked Scott and Mark to keep a food diary for three days prior to sample collections. To date, three samples were taken preflight, five to six samples during flight and soon we will receive the post flight samples," Turek said. "In this research, we're sequencing bacteria for this study using two different methods to obtain the most accurate data."

Turek and his collaborators are using a strategy known as whole genome "shotgun sequencing" which is a large-scale, random sequence of all the DNA in a sample. DNA sequences are broken up randomly into smaller fragments and then reassembled by looking for regions of overlap. The separation process enables enzymes and nucleotides within a sequencer to copy and reconnect the bases, A, T, C, and G. Software identifies the bases during the reconnection process. Working with many overlapping copies of shorter strands of DNA creates a consensus and ensures more accuracy, fewer errors and higher integrity of genetic differences.

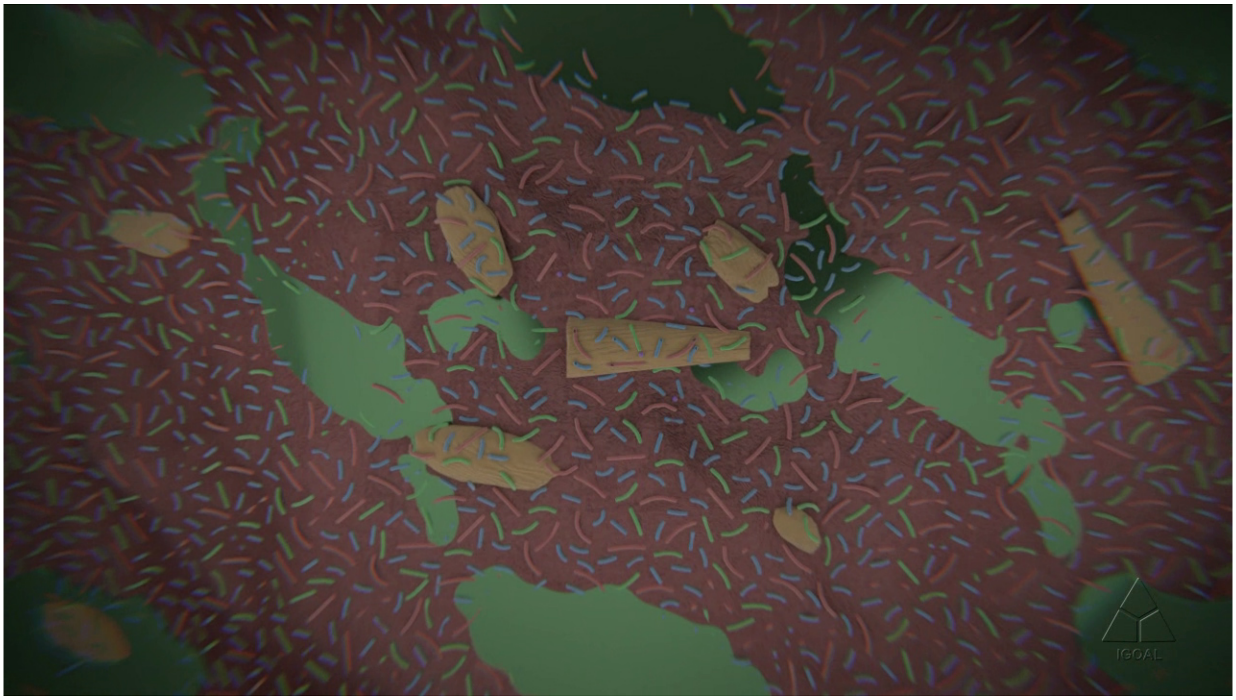

Illustration of microbes in a human which make up the microbiome. Credit: NASA

He also is using 16S ribosomal sequencing. This is a more targeted approach focused on the 16S ribosomal gene present in all bacteria. Some regions of the gene have changed very little over millions of years, while other regions have evolved as new species of bacteria have appeared. This sequencing leverages a stable region of the genome shared by all bacteria, flanked by a region that is unique to each bacterium. With this sequencing, researchers can quickly identify all the bacteria present in a sample.

Turek said, "Your microbiome is like the ecology in the rainforest where the species depend on each other. What happens when a species is removed? Does another out-compete and take over? We're really looking to see if different families, genes or species of bacteria have increased, decreased or even exploded or disappeared in Scott Kelly during his time on the space station."

"It's an exciting time in the microbiome research world," Turek said. "Advances in technology have opened up a whole new world for medical researchers. For example, prior to the availability of next-generation DNA sequencing technology, bacteria had to be cultured. Only the bacteria that could be grown in a culture could be identified. With new technology, culturing the organisms can be skipped and one can gain sequence information on all of the microbes present in a sample."

NASA microbiologist Sarah Wallace, Ph.D., explained that most mainstream sequencers determine order of fluorescently labeled bases during the sequencing reaction and are precise, very large and very vibration sensitive. NASA is testing a new, smaller, portable sequencer for spaceflight. This instrument generates a DNA sequence in a fundamentally different way from the larger sequencers. It detects bases as they pass through very small, nanometer-size, biological nanopore proteins. In nanopore-based sequencing, an ionic current passes through the nanopore proteins and when a DNA strand migrates through the pores it causes a disruption in the current. The change in current characterizes the sequence of migrating DNA.

Wallace said, "If an astronaut were to get an infection in deep space, the portable sequencer has the ability to help identify what exactly is causing the infection. In the past, tools on the space station required researchers to know specifically what to look for. The portable sequencer's identification of the infection is a significant advancement for spaceflight research."

NASA astronaut and molecular biologist Kate Rubins, Ph.D., will sequence DNA from a bacterium, virus and mouse in space for the first time, to confirm that the technique works correctly in space. In the future, she said, "We can extract DNA from the genome of a bacteria, sequence it and investigate the microbial world around us in space with less gravity, increased radiation and recycled air and water. The information we learn from these experiments using this technology can give us a better understanding of how it will work in remote research and medical environments, like the field laboratory where I used to work in Central Africa."

Brian D. Piening, Ph.D., who works in genetics at Stanford University School of Medicine and supports NASA's Twins Study, said, "Sequencing individual bacteria, fungi and viruses has been done as far back as the introduction of sequencing technologies. Somewhat newer is the sequencing of entire microbiomes from places and in people. As technologies improve, our ability to comprehensively characterize a diverse collection of microbes gets better and better."

Piening said, "We still need to ask the basic question of what happens to the human microbiome when placed in a unique environmental condition as space. The NASA Twins Study should provide insight into how it changes along with whether this affects millions of other parameters in the human body such as biomolecules in the blood, changes to cognition, sleep and other factors."

On Earth, researchers are finding novel connections between changes to people's microbiomes and a whole host of diseases. It has opened up new avenues for therapies. The video "Microbiomics: The Living World In and On You" explains the significance of studying the microbiome and provides a glimpse into the evolving field of omics and the exciting research NASA's Human Research Program is conducting via its Twins Study.