Microbiome Research Takes Flight
The International Space Station (ISS) is a unique microgravity research laboratory in low-Earth orbit. Astronauts working on ISS conduct experiments in biology, physics, astronomy, and other scientific areas. (Image courtesy of NASA.)
the surfaces and in the air of ISS over a one-year period. MT-2 goes further by studying microbial populations of the astronauts as well as those in the station environment. “We are conducting the first study that looks at the crew and environment together in a comprehensive and integrated way,” says Jaing. In addition, MT-1 cataloged only bacteria and fungi, whereas this study also considers viruses, which Jaing says “are somewhat under-studied” in space. “We can provide countermeasures once we know what astronauts are breathing in and breathing out,” adds JPL’s Kasthuri Venkateswaran. “Beyond the microbes affecting the crew, we need to know what microbes are in the environment and riding on the cargo.”

So far, four astronauts from three countries are participating in MT-2. As part of the project, each astronaut collects saliva, nasal, mouth, and skin samples several times before, during, and after their time on ISS. They also gather ISS surface and air samples from various locations. The astronauts’ missions to ISS overlap, enabling continuous monitoring of ISS over an 18-month period. Throughout that time, the researchers can explore the evolution of each astronaut’s microbiome and that of the station as a whole as well as how the two interact. For instance, do microbes living in the air of ISS eventually become part of the astronauts’ nasal microbiome? If so, do they then pose a health risk to crew members’ health by displacing existing beneficial nasal microbes?

As part of the analysis, the researchers will compare microbiome data (hygiene and health samples from the crew) with environmental data (temperature and humidity inside the station) to better understand why changes in the microbiome occur. The team suspects that individual samples from the astronauts will contain distinct collections of microbes that are likely to be affected by different environmental factors associated with space travel. Skin microbes are expected to be more susceptible to space radiation, for example, while microorganisms in the mouth may be influenced by changes in an astronaut’s diet. Data gathered from MT-2 will be shared with the scientific community through an open-access NASA database, called GeneLab, and will serve as a baseline for studies of the microbiome.

**Probing Pathogens**

Each of the institutions involved in MT-2 will analyze a portion of the samples. Researchers at Johnson Space Center are evaluating viruses and determining which viruses might be harmful to the crew. JPL scientists are performing microbiological analysis, using traditional culturing techniques and DNA sequencing to ascertain which bacteria and fungi are present and alive. However, less than 10 percent of microbes can be cultured. Therefore, Jaing, Be, and their Livermore colleagues are using complementary

![Graph showing abundance of different genera in ISS dust, ISS filter, and clean room samples.](image)

Researchers used DNA sequencing and the Livermore Metagenomic Analysis Toolkit to identify and determine the relative abundance of species found in samples from ISS and an Earth-based clean room. By performing this type of in-depth microbial analysis, researchers gain a better understanding of how microbial populations evolve in a spacecraft environment and how they may affect the crews’ health.
Having shown that their analysis techniques can achieve thorough results, the researchers have begun applying these methods to the MT-2 samples. This work will provide insight into how humans and microbes influence one another and are influenced by the crowded, complex, yet isolated spacecraft environment. NASA can also use MT-2 data to perform a risk assessment of potential pathogens, determine the level at which they could become a threat to the astronauts, and develop strategies for eliminating or treating the microbes. In the coming years, NASA and its research partners could develop capabilities that would enable crew members to perform microbial characterization while in space—for instance, on the way to Mars. All of these efforts serve the goal of ensuring that astronauts, together with a beneficial mix of microorganism populations, thrive as they continue to venture farther from home for longer periods than ever before.

—Rose Hansen

**Key Words:** bacteria, International Space Station (ISS), Lawrence Livermore Microbial Detection Array (LLMDA), Livermore Metagenomic Analysis Toolkit (LMAT), Microbial Tracking-2 (MT-2), microbiome, microgravity, NASA, pathogen.

For further information contact Crystal Jaing (925) 424-6574 (jaing2@llnl.gov).