Musing over Microbes in Microgravity

Microbial Physiology Flight Experiment

New York City, the most populated city in the United States, is home to over 8 million humans. This means over 26,000 people per square mile! Imagine, though, what the view would be if you peeked into the world of microscopic organisms. Scientists estimate that a gram of soil may contain up to 1 billion of these microbes, which is as much as the entire human population of China! Scientists also know that the world of microbes is incredibly diverse—possibly 10,000 different species in one gram of soil—more than all the different types of mammals in the world.

Microbes fill every niche in the world—from 20 miles below the Earth's surface to 20 miles above, and at temperatures from less than –20 °C to hotter than water's boiling point. These organisms are ubiquitous because they can adapt quickly to changing environments, an effective strategy for survival.

Although we may not realize it, microbes impact every aspect of our lives. Bacteria and fungi help us break down the food in our bodies, and they help clean the air and water around us. They can also cause the dark, filmy buildup on the shower curtain as well as, more seriously, illness and disease. Since humans and microbes share space on Earth, we can benefit tremendously from a better understanding of the workings and physiology of the microbes. This insight can help prevent any harmful effects on humans, on Earth and in space, as well as reap the benefits they provide.

Space flight is a unique environment to study how microbes adapt to changing environmental conditions. To advance ground-based research in the field of microbiology, this STS–107 experiment will investigate how microgravity affects bacteria and fungi. Of particular interest are the growth rates and how they respond to certain antimicrobial substances that will be tested; the same tests will be conducted on Earth at the same times. Comparing the results obtained in flight to those on Earth, we will be able to examine how microgravity induces physiological changes in the microbes.

The astronauts and cosmonauts of STS–105 and Expeditions Two and Three gather for one of their first joint meals on the *International Space Station*. A better understanding of microbial physiology will help prevent illness for humans in the remote environment of space.

Earth Benefits and Applications

Space-based research of microorganisms results in:

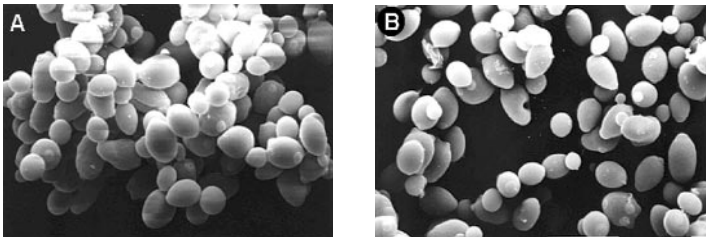
- Improved development of treatments for infectious diseases
- New knowledge on how microorganisms grow and develop with changing conditions.

Principal Investigator: Dr. Randolph Schweickart, ICOS Corp., Bothell, WA, and Dr. Michael McGinnis, University of Texas Medical Branch, Galveston, TX
Project Scientist: Dr. Jacob Bloomberg, Johnson Space Center, Houston, TX
Project Manager: Angie Lee, Johnson Space Center, Houston, TX

Background Information

Science

Microbiologists have long studied the physiology and metabolic pathways of microbes by manipulating environmental factors such as temperature, pH, and the content of the growth medium to see how their growth and function are affected. From this knowledge, we have developed antimicrobial agents and antibiotic treatments. This does not mean, however, that we have a complete knowledge of microbial physiology. Bacteria, for example, are constantly adapting and may develop resistance to antimicrobial agents. With the rise in the last few decades of antibiotic use and coincident resistance, the mechanisms for developing resistance are being studied intensely. We still have much to learn about microbial physiology and the genetic programming that allows for adaptation to changing conditions. Gravity plays a unique role in that it is one environmental condition in which all life forms have evolved. In these experiments, the absence of gravity will present the microbes with a challenge that they have not before encountered.



The scanning electron micrographs show *Saccharomyces cerevisiae* grown in microgravity (A) and gravity (B). In microgravity yeast cells grow in clusters. *S. cerevisiae* will be one of the fungal strains tested on STS-107 for changes in growth pattern and physiology.

The experiment consists of two separate microbial studies: one with bacteria (four species) and fungi (four species) as subjects, and the other with fungi alone (two species). Both studies follow the same procedures and use the same hardware. Their investigators are looking for the same data parameters — growth, use of components of the growth medium (different nitrogen and carbon sources), and reaction to antimicrobial agents — to show the effect of microgravity on the microorganisms. These studies will continue during a second phase in future flights to test the microbes against specific formulations of growth media and antimicrobials.

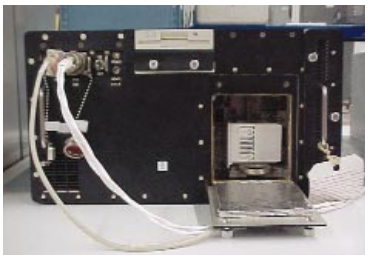
Hardware

These studies measure microbial growth during flight using a device called the automated microbial analysis system (AMS), a commercial instrument manufactured by bioMérieux Vitek, Inc., that has been adapted for space flight. Before flight, the bacterial and fungal strains to be tested are introduced, or inoculated, to cards containing the various growth media or antimicrobial agents being tested. These cards are refrigerated, sealed, and placed onto card trays to minimize the handling of the test cultures by crewmembers. This measure ensures the health of the crew was well as preserving the integrity of the experiment.

Once the cards containing the test strains have been loaded into the AMS, its heater and circulation fan maintain constant incubator temperatures for microbial growth. The optical array of the AMS measures the optical density of each microbial sample, indicating the population and growth over time. A laptop computer serves as the interface between crewmembers and the AMS and also saves the data for analysis after flight.

Operations

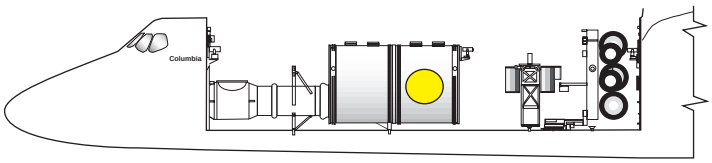
The experiment will begin on the first day of flight with the setup and activation of the AMS. The six card trays for bacterial and fungal testing will be loaded into the AMS and tested in 24-hour incubation cycles for days one through six on orbit. The card trays for fungal testing alone will be loaded and tested in 48-hour incubation cycles for days seven through ten. To produce control data, identical procedures will be performed simultaneously on the ground with the same card populations. By comparing the data obtained in flight with those on Earth, researchers will be able to home in on the physiological response to microgravity.



The cards containing the microbial test strains will be loaded into the AMS, shown above, during flight.

Earlier Results

Prior space flight research indicates that exposure to microgravity can lead to increased growth rates (Biosatellite in 1967) and increased resistance to antimicrobial agents (Salyut in 1982 and Spacelab D1 in 1985). However, there is limited data and conflicting results because experimental conditions are difficult to replicate. The STS–107 experiment uses a well-controlled methodology adapted for microbial research in flight to obtain conclusive results.



Approximate location of this payload aboard STS–107.