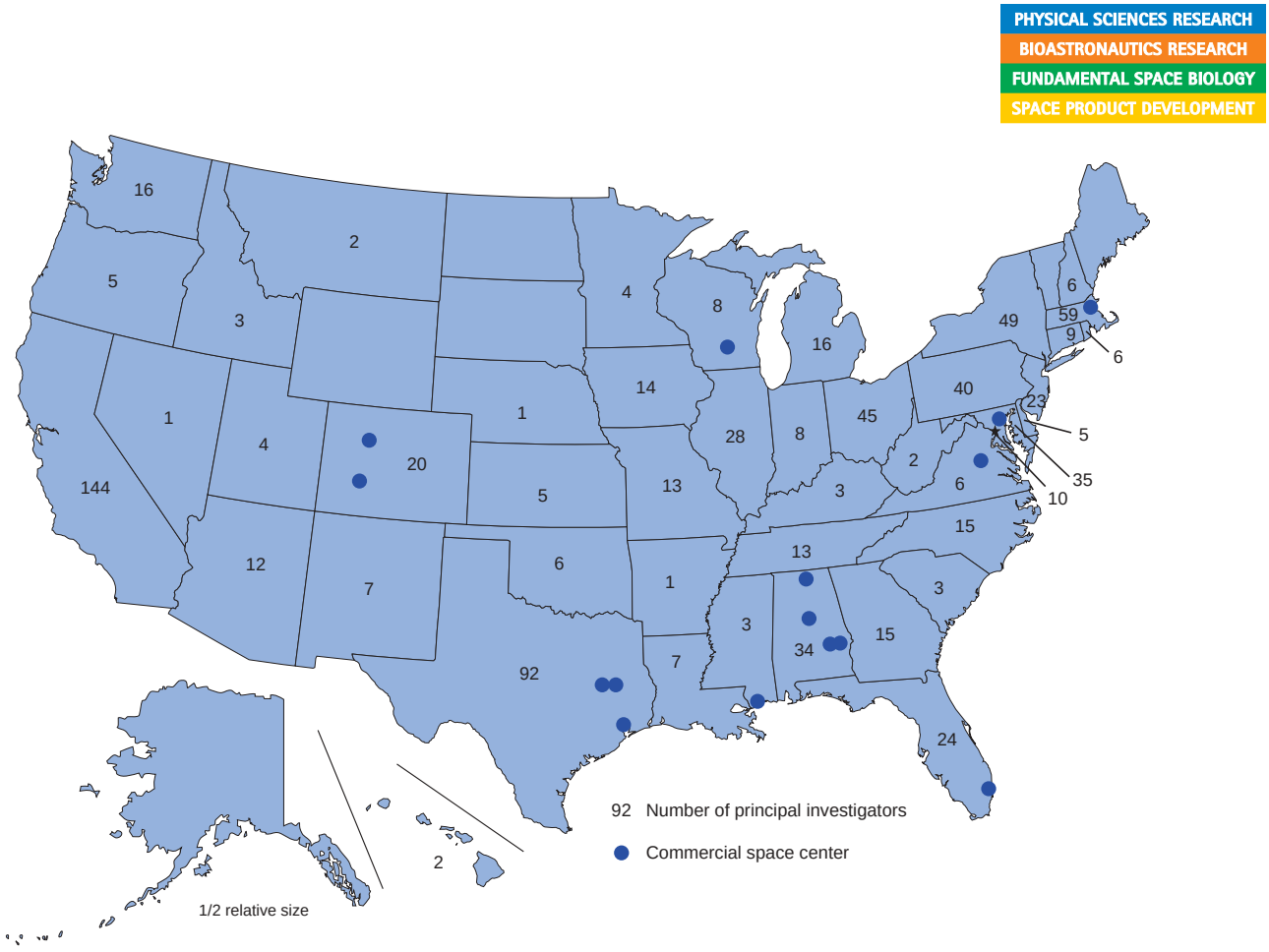
National Aeronautics and
Space Administration

Office of Biological and Physical Research

NATIONAL DISTRIBUTION OF NASA BIOLOGICAL AND PHYSICAL RESEARCH

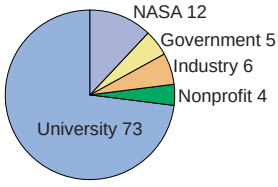


Principal Investigators

(For FY 2001: 830 investigators,
1,104 investigations in 44 States and DC)

Principal Investigators	830
Co-investigators	1,176
Postdoctoral students	534
Doctoral students	803
Graduate students	589
Undergraduate students	912
Corporate partners	197
Peer-reviewed articles	1,144
Awards	67
Books (or chapters)	82
Dissertations and theses	63
Patents	22

by institution (%)



8/02

Commercial Space Centers

BioServ Space Technologies, Boulder, CO
Center for Biophysical Sciences and Engineering, Birmingham, AL
Center for Commercial Applications of Combustion in Space, Golden, CO
Center for Microgravity Materials Processing, Boston, MA
Center for Satellite and Hybrid Communication Networks, College Park, MD
Center for Solidification Design, Auburn, AL
Center for Space Power, College Station, TX
Center for Space Power and Advanced Electronics, Auburn, AL
Commercial Space Center for Engineering, College Station, TX
Consortium for Materials Development in Space, Huntsville, AL
Medical Information and Technology Applications Center, Richmond, VA
ProVision Technologies, Stennis Space Center, MS
Space Communications Technology Center, Boca Raton, FL
Texas Center for Superconductivity at the University of Houston, Houston, TX
Wisconsin Center for Space Automation and Robotics, Madison, WI

EDUCATION AND OUTREACH

PHYSICAL SCIENCES RESEARCH
BIOASTRONAUTICS RESEARCH
FUNDAMENTAL SPACE BIOLOGY
SPACE PRODUCT DEVELOPMENT

Why is it important?

Communicating diverse research goals to a range of communities of varying levels of technical background is a challenging but essential task. OBPR is obligated and committed to describing to the public what comes from investments in space.

What is NASA doing?

In the past year, OBPR heightened the visibility of OBPR outreach by:

- expanding Microgravity News—now Space Research—to span all of OBPR's research disciplines;
- sponsoring activities related to STS-107 investigations, such as the "Space Research and You" in Rosslyn, VA, bioreactor and soil mechanics classroom activities, and a special CD for science museums;
- developing a new classroom drop tower using small TV transmitters and laptop computers to capture video;
- holding the second Dropping In a Microgravity Environment (DIME) competition to give Ohio-area high school teams the opportunity to use NASA Drop Tower facilities;
- exhibiting at conferences as diverse as the American Library Association, the National Medical Association, and the American Public Health Association;
- delivering a kid-scale mockup of the Microgravity Science Glovebox for use in museums; and
- signing a Memorandum of Understanding with Biotechnology Industry Organization for potential collaboration.

A youngster (above) finds that a simple child's puzzle is not so simple when special goggles give him a mirror image of the world. Below, a high school student prepares a basic fluids experiment for two seconds of freefall in the NASA Drop Tower. Both activities give students insight into the basics of space research.

What are the benefits?

Outreach and education activities explain to the taxpayer 1) what research is taking place, 2) why it is taking place, and 3) how it benefits the taxpayer.

What is next?

In addition to continuing activities initiated in 2002, OBPR in 2003 will

- pursue a joint venture with the American Library Association and local communities nationwide through a "NASA At Your Library" exhibit campaign (by 2005, it should reach 120 communities),
- participate in Centennial of Flight events in 2003, and
- work with professional organizations to build upon the positive reactions received during conferences in 2002.

NASA contact: John Emond (202-358-1686) or Bonnie McClain (202-358-2181)

National Aeronautics and
Space Administration

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SOLVING A HOT PARADOX

PHYSICAL SCIENCES RESEARCH
BIOASTRONAUTICS RESEARCH
FUNDAMENTAL SPACE BIOLOGY
SPACE PRODUCT DEVELOPMENT

Why is it important?

The last place you want to be in traffic is behind the bus or truck that is belching large clouds of soot onto your freshly washed car. The mechanisms of soot formation are among the most important unresolved problems of combustion science because soot affects contemporary life in so many ways.

Besides looking and smelling bad, soot is a health hazard. Soot also is wasted energy, and therein lies an interesting paradox: soot forms in a flame's hottest regions where you would expect complete combustion and no waste. Soot enhances the emissions of other pollutants and radiates unwanted heat to combustion chambers, among other effects.

What is NASA doing?

The Laminar Soot Processes (LSP-2) experiments use the microgravity environment of space to eliminate buoyancy effects and thus slow the reactions inside a flame so that they can be more readily studied. LSP-2 will expand on surprising results developed from its first two flights in 1997. The data suggest the existence of a universal relationship, the soot paradigm, that, if proven, will be used to model and control combustion systems on Earth.

What are the benefits?

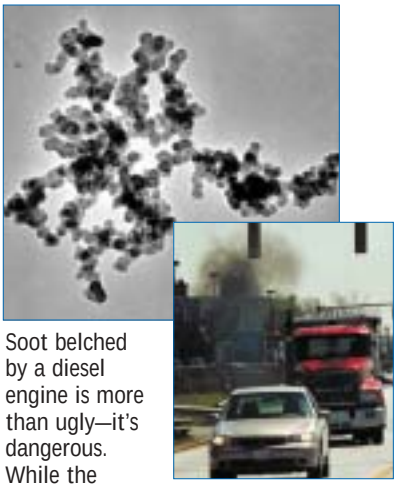
NASA anticipates that improved understanding of soot formation in combustion processes will have industrial and environmental benefits, including the following:

- controlling soot production in combustion processes,
- reducing radiative heat transfer that damages engines,
- improving electric power generation while maintaining complete soot burnout (no emissions),
- enhancing soot production in processes for carbon black used in tires and other applications, and
- enhancing combustion studies to design new systems and to retrofit existing systems.

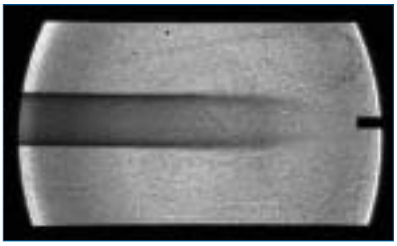
What is next?

LSP-2 will fly on the STS-107 Space Shuttle mission in 2003 to build on the results from its highly successful 1997 mission. NASA plans additional soot formation experiments using the International Space Station's Combustion Integrated Rack.

NASA contact: Dr. Merrill King (202-358-0817)



Soot belched by a diesel engine is more than ugly—it's dangerous. While the largest particles (like this one from LSP's 1997 flight experiment, shown 50,000 times its actual size) may wash out of the air when it rains, smaller particles linger and possibly endanger human health and the environment.



"Laminar" means a simple, smooth fuel jet burning in air, somewhat like a butane lighter. This classical flame (seen here in LSP's 1997 flight) is difficult to study on Earth with gravity making hot air rise and cold air flow in behind it.

BUBBLING UP TROUBLE

Why is it important?

Ninety percent of all the manufactured goods we use every day contain at least one cast metal part. These parts are vital to manufacturing, science, medicine, aerospace, and many other fields. However, millions of dollars' worth of castings become scrap every year because of defects such as voids that reduce the part's strength or cause it to fail prematurely.

Voids form when gases generate bubbles as the molten metal cools in its mold. On Earth, some of these bubbles rise to the top of the casting and pop; others are pushed toward the center of the casting and can cause detrimental voids in the center of the part.

What is NASA doing?

Scientists are using the microgravity environment on the International Space Station to study how these bubbles form, move, and interact. The Pore Formation and Mobility Investigation (PFMI) in the Microgravity Science Glovebox aboard the International Space Station uses a transparent material called succinonitrile that behaves like a metal to study this problem. Video images sent to the ground allow scientists to watch the behavior of the bubbles as they control the melting and freezing of the material. The bubbles do not float to the top of the material in microgravity, so the scientists can study their interactions.

What are the benefits?

The PFMI provides a unique opportunity to

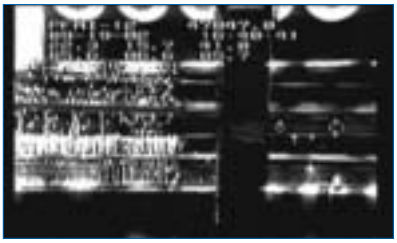
- observe how bubbles form and move as a material changes from liquid to solid without the buoyancy effects of gravity,
- understand pore formation in previous microgravity experiments,
- design better microgravity experiments for the future, and
- apply the knowledge gained to help reduce voids in castings produced on Earth.

What is next?

The PFMI is scheduled to process 12 to 15 samples with different compositions and under various processing conditions. Information from the first samples processed on the ISS show exciting results that will be incorporated into the next sample runs. The samples and recorded video will return to Earth for additional analysis.

NASA contacts: Dr. Michael Wargo (202-358-0822) and Linda Jeter (256-544-7392)

Pores and voids often form in metal castings on Earth (above), making them useless. A transparent material (in the glass ampoule, below) that behaves at a large scale in microgravity (bottom) the way that metals behave at the microscopic scale on Earth, will help show how voids form and help us learn how to prevent them.



National Aeronautics and
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HELPING ASTRONAUTS AND THE ELDERLY KEEP THEIR BALANCE

PHYSICAL SCIENCES RESEARCH
BIOASTRONAUTICS RESEARCH
FUNDAMENTAL SPACE BIOLOGY
SPACE PRODUCT DEVELOPMENT

Why is it important?

Being able to keeps one's balance is crucial to normal activity. Yet partial loss of this ability is a problem shared by astronauts and elderly people, as well as other people suffering from balance disorders. Research on astronauts in space is providing insight into this problem for people on Earth as well as travelers in space.

Our sense of up and down comes from the brain's interpretation of many signals from sensors in the inner ear and other parts of the body. In orbit, the signal pattern changes and may cause temporary disorientation and motion sickness in many astronauts until the brain adapts. On return to Earth, the brain must re-adapt, putting astronauts on the same footing as patients with posture problems.

What is NASA doing?

NASA researchers use a computerized dynamic posturography (CDP) system to assess how the brain handles input from the ear, eyes, and other sensors throughout the body, and how it commands muscles to stand upright. The astronaut stands on a tiltable posture platform and looks at an artificial horizon. Eye and muscle reflexes are measured as this mini-world changes. Astronauts are tested several times before and after a mission. NASA is collaborating with the National Institute on Aging on similar balance studies in the Baltimore Longitudinal Study on Aging.

What are the benefits?

Research with the CDP has accomplished the following:

- provided a means of evaluating when astronauts may return to duty after flight,
- shown that veteran astronauts re-adapt faster,
- provided a means to measure a patient's progress in therapy,
- assisted in diagnosing a fluid leak from the balance organs to the inner ear that causes balance problems (perilymphatic fistula or PLF).

What is next?

CDP shows promise as a technique for detecting whether a person is at risk for falling disorders. Because most falls are thought to arise directly or indirectly from balance organ abnormalities, preventing falls could significantly reduce fall-related deaths and injuries. Research will continue with astronauts before and after long missions aboard the International Space Station.

NASA contact: Dr. David Tomko (202-358-2211)

Computerized dynamic posturography tests how astronauts use cues we take for granted to maintain their balance before and after flight. The lessons are being applied on Earth for people with balance disabilities.

CHECKING HEARTS VIA THE INTERNET

PHYSICAL SCIENCES RESEARCH
BIOASTRONAUTICS RESEARCH
FUNDAMENTAL SPACE BIOLOGY
SPACE PRODUCT DEVELOPMENT

Why is it important?

One thing that astronauts share with explorers of past generations is their separation from hospitals and caregivers. The distance from the International Space Station to the nearest emergency room is measured not in its 220-mile altitude above Earth, but in the precious hours it would take to get to the hospital. On Earth, many people share this situation in remote villages or work sites. Modern communications, including the Internet, can close part of the distance by sending lifesaving information to physicians.

What is NASA doing?

NASA is developing techniques to improve the echocardiography available for diagnosing sick astronauts and to study the long-term effects of space travel on their health. Echocardiography uses ultrasound, generated in a sensor head placed against the patient's chest, to produce images of the structure of the heart walls and valves. However, ultrasonic imaging creates an enormous volume of data, up to 220 million bits per second. This volume can challenge ISS communications, as well as Earth-based providers.

Compressing data for rapid transmission back to Earth can degrade the quality of the images. Researchers at the Cleveland Clinic Foundation are working with NASA to develop compression techniques that meet imaging standards now used on the Internet and by the medical community, and that ensure that physicians receive quality diagnostic images.

What are the benefits?

The ability of physicians on Earth to view real-time echocardiograms of astronauts will improve the following:

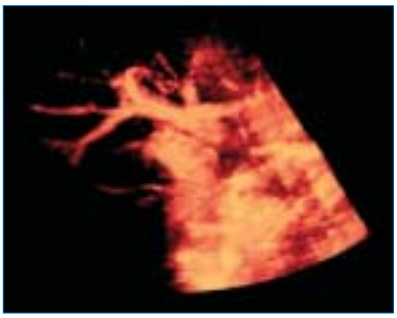
- diagnoses during medical emergencies in space,
- understanding of long-term space exposure effects on the heart, and
- opportunities for use in remote locations on Earth.

Digital echocardiography offers significant savings in storage space and physician review time and provides greater diagnostic accuracy compared with images stored on traditional analog videotape.

What is next?

This capability will be made available on the ISS and in other remote locations, where it might not be possible to have a physician available on site, thus reducing the need for costly and inconvenient travel by patients.

NASA contact: Dr. David Tomko (202-358-2211)



Echocardiographic images provide quick, safe images of the heart as it beats (above). Although a state-of-the-art echocardiograph unit is part of the Human Research Facility on the ISS (below), quick transmission of images and data to Earth is a challenge.

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GROWING PLANTS IN SPACE

PHYSICAL SCIENCES RESEARCH
BIOASTRONAUTICS RESEARCH
FUNDAMENTAL SPACE BIOLOGY
SPACE PRODUCT DEVELOPMENT

Why is it important?

Alternative agricultural systems that can efficiently produce greater quantities of high-quality crops in a small area are important for future space expeditions. Also, regenerative life-support systems that include plants will be an important component of long-term space missions. Data from the Biomass Production System (BPS) and the Photosynthesis Experiment and System Testing and Operations (PESTO) will advance controlled-environment agricultural systems and will help farmers produce better, healthier crops in a small area. This same knowledge is critical to closed-loop life support systems for spacecraft.

What is NASA doing?

The BPS comprises a miniature environmental control system for four plant growth chambers, all in the volume of two Space Shuttle lockers. The experience with the BPS on orbit is providing valuable design and operational lessons that will be incorporated into the Plant Growth Units.

The objective of PESTO was to flight-verify the BPS hardware and to determine how the microgravity environment affects the photosynthesis and metabolic function of Super Dwarf wheat and Brassica rapa (a member of the mustard family).

What are the benefits?

Analysis is underway on the first BPS specimens grown on orbit. Expected benefits include determining the effects of microgravity on wheat, including the following:

- carbon dioxide and light response curves;
- metabolism and electron transport processes associated with photosynthetic and respiratory gas exchange;
- carbohydrate partitioning; and
- gas exchange, including water, over range of atmospheric vapor pressure deficits.

What is next?

BPS has been returned to Earth for detailed study of its components and for analysis of its specimens. Continued research is planned using the Plant Research Unit when it is placed aboard the ISS.

NASA contact: Dr. David Liskowsky (202-358-1963)

Dwarf wheat (above) and Brassica rapa plants were photographed aboard the International Space Station in April 2002. Lessons from onorbit research on plants will have applications for terrestrial agriculture as well as long-term space missions.

National Aeronautics and
Space Administration

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"MODELED MICROGRAVITY" INCREASES BACTERIAL VIRULENCE

PHYSICAL SCIENCES RESEARCH
BIOASTRONAUTICS RESEARCH
FUNDAMENTAL SPACE BIOLOGY
SPACE PRODUCT DEVELOPMENT

Why is it important?

The potential for infectious disease among space crews is an important medical risk and is a relatively new and unexplored area of fundamental space biology research. An individual's vulnerability to infectious diseases can be increased by a weakened immune system and by the virulence of a microbe or other infectious agent. Space travel is known to affect the function of the human immune system. At the same time, evidence suggests that bacteria become more active in the low-g environment of space.

What is NASA doing?

Dr. Cheryl Nickerson of Tulane University is studying the effects of simulated low-g on a well-known pathogen, Salmonella typhimurium, a bacterium that causes two to four million cases of gastrointestinal illness in the United States each year. Thus, a simple case of food poisoning could disrupt a space mission.

Using the NASA rotating-wall bioreactor, Nickerson cultured S. typhimurium in modeled microgravity. Mice infected with the bacterium died an average of 3 days faster than the control mice, indicating that S. typhimurium's virulence was enhanced by the bioreactor. Earlier research showed that 3 percent of the genes were altered by exposure to the bioreactor.

Nickerson's work has earned her a 2001 Presidential Early Career Award for Scientists and Engineers.

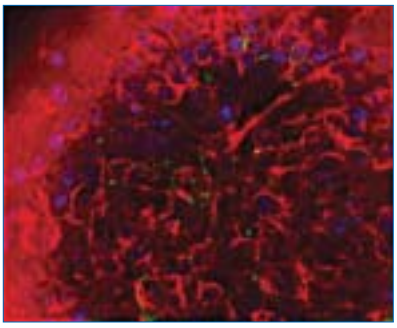
What are the benefits?

This research ultimately will provide significant insights into the molecular basis of salmonella virulence and may have the potential for vaccine development and other novel countermeasures for prevention and treatment of disease caused by salmonella.

What is next?

An experiment planned for the Space Shuttle, eight test tubes of salmonella will be carried in a containment module that isolates them from the crew. The bacteria will be cultured for two days on orbit, then fixed for postflight analysis of changes in the bacteria's genetic makeup.

NASA contact: Dr. David Liskowsky (202-358-1963)



Salmonella typhimurium (above) appears green in human intestinal tissue (stained red) cultured in a NASA rotating-wall bioreactor (below).

WORKING TO PLANT THE FUTURE

Why is it important?

Researchers face 1,000-to-1 odds in trying to transfer desirable genes for disease resistance and other improvements into important crops. Instead of older methods, researchers now use bacteria to transfer the gene carrying the desired traits to seedlings. These seedlings, in turn, allow subsequent generations of the crops to stably inherit the trait.

Previous commercial flight research has shown that microgravity can greatly improve the success rate of gene transfer. The increase is due in part to the fact that microbes thrive in microgravity. Learning how to control bacteria so they can develop without harming the seedlings requires further research.

What is NASA doing?

The Wisconsin Center for Space Automation and Robotics (WCSAR) at the University of Wisconsin-Madison, one of NASA's Commercial Space Centers, is a primary center for commercial agribusiness research in microgravity. It has developed the ASTROCULTURE™ commercial plant growth research hardware, a completely self-contained system for growing plants that includes lighting, temperature control, atmospheric control, nutrient delivery, and more.

What are the benefits?

Several enhancements have been observed in six Space Shuttle missions to date:

- enhanced seed production, such as reducing soybean growth cycle from an average of 110 days to an average of 62 days, a significant improvement, and
- increased shelf-life of perishable items by a week, providing a significant savings by reducing the amount of food or other materials that spoil.

What is next?

The STS-107 Space Shuttle mission in 2003 will carry an ASTROCULTURE™ plant growth unit and glovebox to validate microgravity's impact on soybean transformation. It is hoped that the results will provide benchmark information for the future development of a commercial space-based gene-transfer system. The Advanced ASTROCULTURE™ experiments aboard the ISS started in April 2001 and will continue through mid-2003. The plants on board the ISS also demonstrate multigenerational research that longer duration exposure in microgravity can provide.

Contact: Dr. Weija Zhou, Director of the Wisconsin Center for Space Automation and Robotics (608-262-5526)

The development of new crops is being enhanced through commercial microgravity research. Arabidopsis plants (below) were grown on the STS-104 mission.

National Aeronautics and
Space Administration

Office of Biological and Physical Research

ANNIHILATING ANTHRAX

PHYSICAL SCIENCES RESEARCH
BIOASTRONAUTICS RESEARCH
FUNDAMENTAL SPACE BIOLOGY
SPACE PRODUCT DEVELOPMENT

Why is it important?

Bioterrorism is a major threat facing modern society. As shown by the post-September-11 anthrax attacks, deadly bacteria are easy to introduce into a building and difficult to clean up. The challenge is to neutralize the bacteria spores, not just sequester them.

What is NASA doing?

A result of NASA- and industry-sponsored research to develop small greenhouses for space research is the unique AiroCide TiO2 system that kills anthrax spores. In the 1990s, University of Wisconsin professor Marc Anderson and colleagues from the Wisconsin Center for Space Automation and Robotics (WCSAR), a NASA Commercial Space Center, made a crucial discovery: ultrathin layers of titanium dioxide (TiO2) exposed to ultraviolet light efficiently eliminate ethylene, a gas that plants emit and that would build up in a closed greenhouse. Titanium dioxide, a harmless, nontoxic coloring agent, converts ethylene into water vapor and carbon dioxide.

Additional tests showed that airborne dust mites were killed as well. Ultraviolet light generates positive and negative charges on titanium dioxide surfaces. Those charges split nearby water molecules into hydrogen and the hydroxyl ion. Hydroxyl, in turn, disrupts organic molecules and kills dust mites, anthrax, and many other pathogens. The bright ultraviolet lamps also kill pathogens as they swirl through the maze of coated plastic tubes in the AiroCide TiO2 unit.

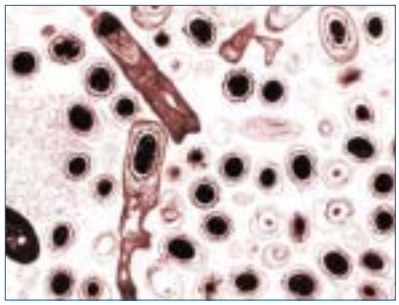
What are the benefits?

"Spores that pass through the box aren't filtered, they're fried," says Hayman. "That's appealing for people who don't want to change an anthrax-laden air filter." Tests show that as many as 93 percent of anthrax spores that enter AiroCide TiO2 are destroyed. Survivors circulate out of the chamber, where they are likely to be sucked back in again for another pass.

What is next?

Hospital operating rooms, emergency rooms, jails, and veterinary clinics are just a few of the current facilities utilizing the AiroCide TiO2 unit. Currently, other potential markets are being examined. Clearly, this capability to destroy harmful bacteria will aid future long-term human space missions involving closed environments.

Contact: Dr. Weija Zhou, Director of the Wisconsin Center for Space Automation and Robotics (608-262-5526)



Anthrax spores (above) are inactive forms of Bacillus anthracis. They can survive for decades inside a spore's tough protective coating; they become active when inhaled by humans. the AirTcide TiO2 air cleaner (below, being assembled and shown installed) is a compact air cleaning system that "fries" anthrax spores and other pathogens.