# INNOVATIONS FOR HEALTH IN SPACE AND ON EARTH

## Innovations for Health in Space and on Earth

Jeffrey P. Sutton, M.D., Ph.D.

The pathway to lunar habitation and human voyages onward to Mars will be challenging in many ways, and the challenges to the human body will be daunting. Prolonged weightlessness, reduced-gravity environments and radiation exposure will affect many of the body's systems.

Finding answers to these health concerns is the primary mission of the National Space Biomedical Research Institute's science, technology and education programs. In turn, the Institute is generating benefits to enhance life on Earth.

NSBRI investigators are among the brightest minds at America's universities, medical schools and research laboratories. Our programs harness this brainpower to address the health-related problems and the physical and psychological challenges men and women will face on long missions. The results of these efforts are innovations in health care and technology that benefit both space travelers and Earth-based medicine and research.

NSBRI is firmly committed to a strong education program that spans from the elementary grades to clinical research training in space medicine. Elementary and middle school efforts target improving science and math skills for all students. Our advanced programs, such as internships, graduate education and postdoctoral fellowships, inspire the next generation of scientists and engineers who will lead the exploration effort.

This NSBRI executive report highlights a few of the Institute's science, technology and education projects. We invite you to take a few minutes to review NSBRI's work to expand the frontiers of knowledge about our universe and ourselves.

**Join us as we explore, innovate and educate.**

Jeffrey P. Sutton

**Jeffrey P. Sutton, M.D., Ph.D.**

Director
National Space Biomedical Research Institute


EXPLORE
NATIONAL SPACE BIOMEDICAL RESEARCH INSTITUTE
NSBRI
INNOVATE
EDUCATE

## Exploring Space Health, Benefiting Earth

Exploration is a part of human nature. For centuries, men and women have adapted to difficult conditions to learn more about their surroundings.

The National Space Biomedical Research Institute (NSBRI) contributes substantially to NASA's exploration objectives, including completion and utilization of the International Space Station, a return to the moon and exploration of Mars.

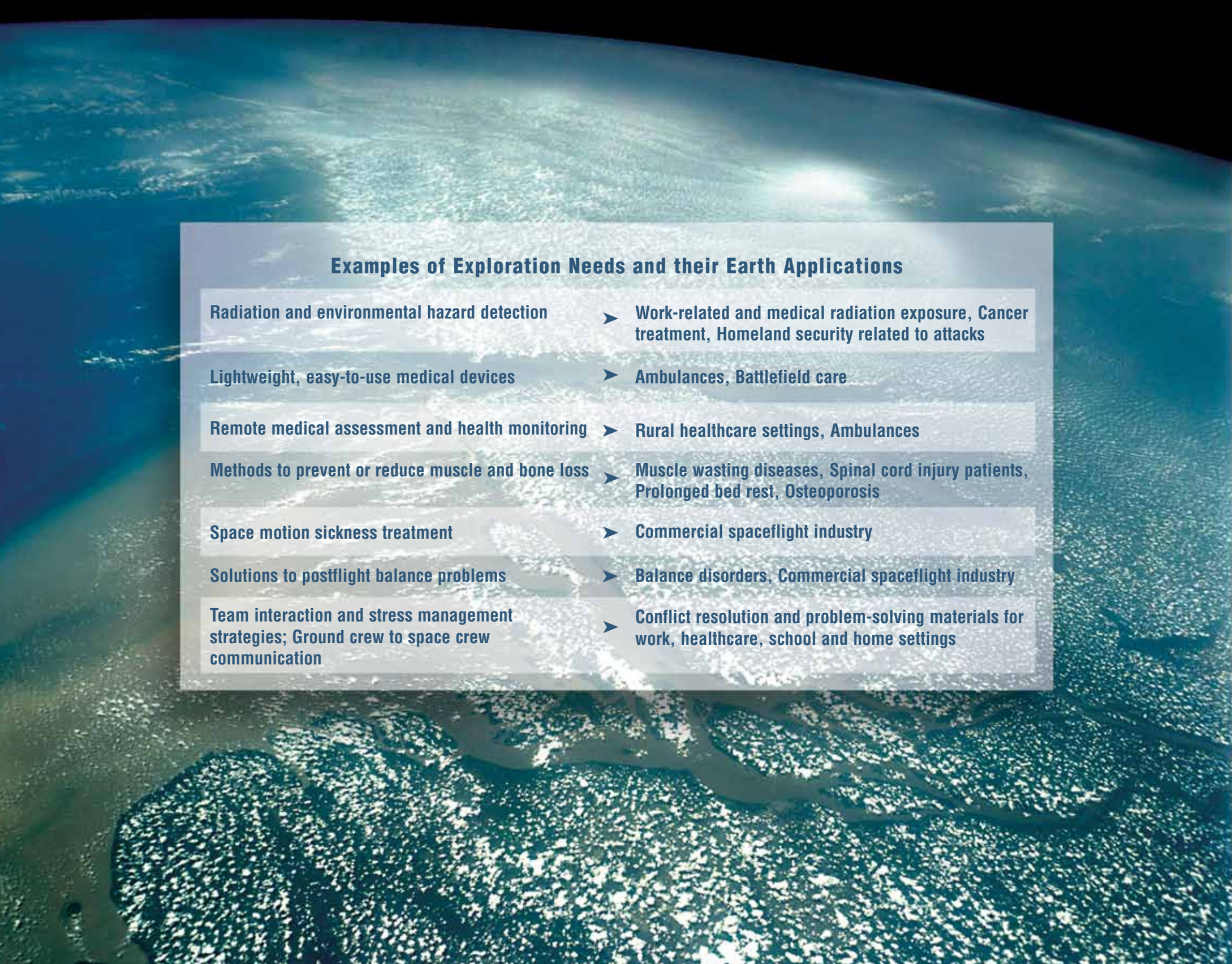
Founded in 1997 through a NASA competition, NSBRI is a non-profit organization dedicated to advancing biomedical research to ensure a safe and productive long-term human presence in space. By developing new approaches and countermeasures to prevent, minimize and reverse risks to health, the Institute is an essential partner with NASA.

During extended missions, weightlessness, reduced-gravity environments and radiation exposure will affect many of the body's systems. The human body, accustomed to living in Earth gravity, must adapt to these new environmental elements. The challenges to the body, if not diminished, could impact an astronaut's health and performance during lunar or Mars missions and upon return to Earth.

NSBRI's science, technology and education programs engage scientists, engineers and clinicians in goal-directed, peer-reviewed projects using a team approach. The nearly 60 projects in 24 states involve more than 180 investigators.

As NSBRI discovers solutions to space health concerns and develops advanced methods of remote medical care, the products have tremendous Earth applications ranging from patient care to homeland security. NSBRI technologies designed for remote medical monitoring, diagnosis and treatment can immediately aid battlefield medics, ambulance crews and rural healthcare providers.

Techniques addressing astronaut health risks on long missions will benefit patients suffering from similar conditions on Earth, such as bone loss, muscle wasting, shift-related sleep disturbances, balance disorders, and cardiovascular system problems.



## Examples of Exploration Needs and their Earth Applications

| | | |
|---|---|---|
| Radiation and environmental hazard detection | ➤ | Work-related and medical radiation exposure, Cancer treatment, Homeland security related to attacks |
| Lightweight, easy-to-use medical devices | ➤ | Ambulances, Battlefield care |
| Remote medical assessment and health monitoring | ➤ | Rural healthcare settings, Ambulances |
| Methods to prevent or reduce muscle and bone loss | ➤ | Muscle wasting diseases, Spinal cord injury patients, Prolonged bed rest, Osteoporosis |
| Space motion sickness treatment | ➤ | Commercial spaceflight industry |
| Solutions to postflight balance problems | ➤ | Balance disorders, Commercial spaceflight industry |
| Team interaction and stress management strategies; Ground crew to space crew communication | ➤ | Conflict resolution and problem-solving materials for work, healthcare, school and home settings |

**NSBRI Mission**

To lead a national effort to accomplish the integrated, critical path, biomedical research necessary to support long-term human presence, development and exploration of space.

To enhance life on Earth by applying the resulting advances in knowledge and technology.

## Accelerating Findings from Lab to Practical Use

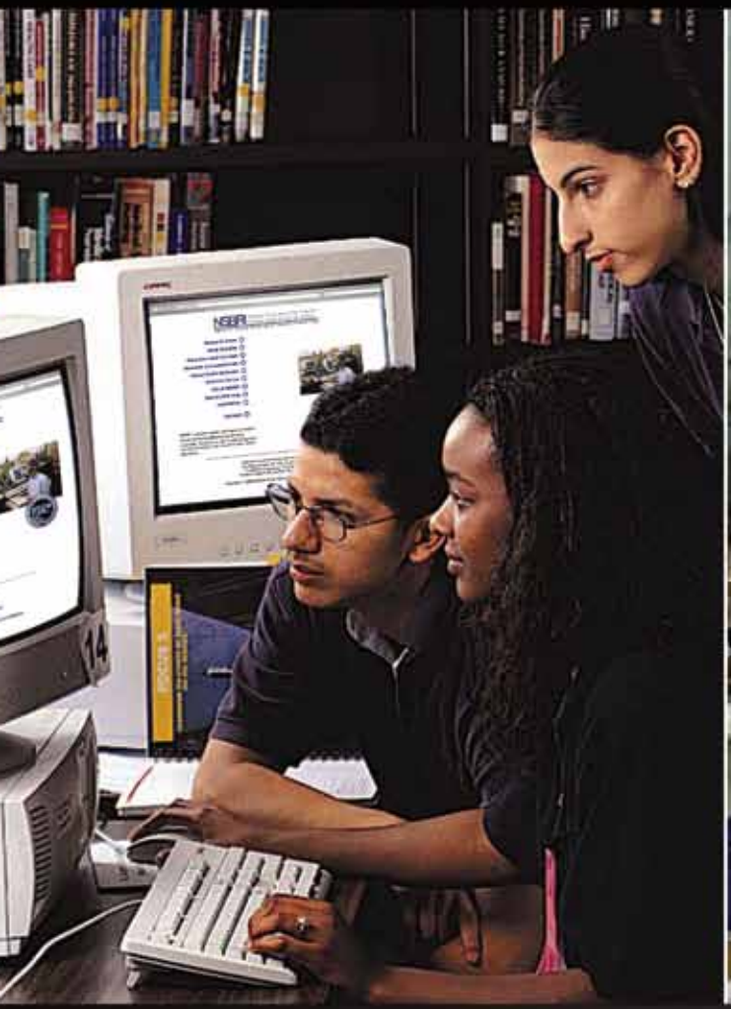
NSBRI's translational research program aids NASA by accelerating the transfer of findings from the laboratory to spaceflight and clinical applications. The product-oriented approach to research and development is leading to a number of operationally-relevant countermeasures and technologies ready for testing and evaluation aboard the International Space Station and in medical settings.

Projects are openly solicited, peer reviewed and competitively awarded with a focus on activities that show high promise for translating biomedical knowledge to needed countermeasures and useful healthcare tools. NSBRI's integrated team approach bridges multiple disciplines and unites the scientific and clinical expertise and resources of the biomedical community with the scientific, engineering and operational expertise of NASA.

Key working relationships are established with end users, including astronauts and flight surgeons, and with NASA scientists and engineers, other federal agencies, industry and international partners. This broad base of stakeholders ensures that the research program meets NASA's requirements and that the highest priorities of risk are addressed and reduced.

## Five-Year Review – Quality Products and Teams

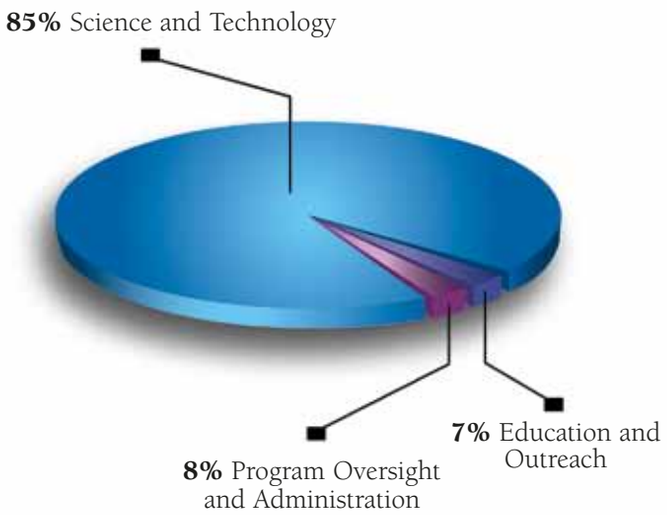
NSBRI's cooperative agreement with NASA calls for periodic, comprehensive reviews. During the last review, the external review panel was impressed with the overall quality of NSBRI's scientific, education and management components.



The report stated that, "It was agreed that the quality of NSBRI science products and teams was excellent, that NSBRI is attracting some of the best biomedical researchers in the United States and that the researcher teams had made fine progress towards performing projects that are focused on producing deliverable countermeasures to NASA."

In addition it was noted, "The Panel recognizes the potential 'spin-off' benefits of NSBRI research products in contributing to the development of novel therapies to treat medical problems of the every day American." The panel recommended that annual NASA funding for NSBRI be in the range of $50 million to $100 million.

## Operating Budget




## Leveraging Research Dollars

NSBRI is productive, cost-effective and scalable. The Institute provides NASA an opportunity to leverage its impact through access to outstanding academic research facilities that provide maximum return on valuable resources invested.

The operating plan assures that the greatest investment goes toward projects focused on the Institute's mission with approximately 85 percent going to science and technology, 7 percent to education and outreach, and 8 percent to program oversight and administration.

Through a collaborative environment with high-powered, top-tier academic research institutions and national laboratories, NSBRI gains access to unprecedented facilities and resources. Cost sharing, leveraging and alliances with industry allow NSBRI and its investigators to develop deliverables at an accelerated pace for spaceflight and for Earth applications.

## Strong Program Oversight and Management Rigor

The Institute's management plan is based on a hybrid of National Institutes of Health and Department of Defense management models. The senior management structure includes a Chairman of the Board, Director, Associate Director, Senior Scientists, Space Medicine Advisor, and International Liaison.

NSBRI is governed by a consortium of 12 institutions – Baylor College of Medicine, Brookhaven National Laboratory, Harvard Medical School, The Johns Hopkins University, Massachusetts Institute of Technology, Morehouse School of Medicine, Mount Sinai School of Medicine, Rice University, Texas A&M University, University of Arkansas for Medical Sciences, University of Pennsylvania Health System, and University of Washington. Consortium membership is not a requirement for participation in the science, technology or education programs.

The Board of Directors is comprised of two representatives from each consortium member, two industry representatives, two at-large community representatives and two senior medical statesmen.

A Board of Scientific Counselors is responsible for assuring excellence in the Institute's science, technology and education programs through independent, external peer review. An External Advisory Council provides advice to management concerning programmatic relevance and effectiveness.

NSBRI also maintains a User Panel of current and former astronauts and flight surgeons to help determine high-yield research areas which will lead to effective strategies that enhance mission success and maintain or improve crew health. The Panel focuses on significant hazards and threats to exploration missions and on operational approaches to solve problems and reduce risks.

**"The Panel recognizes the potential 'spin-off' benefits of NSBRI research products in contributing to the development of novel therapies to treat medical problems of the every day American."**

**Five-Year Review Panel**

Baylor College of Medicine

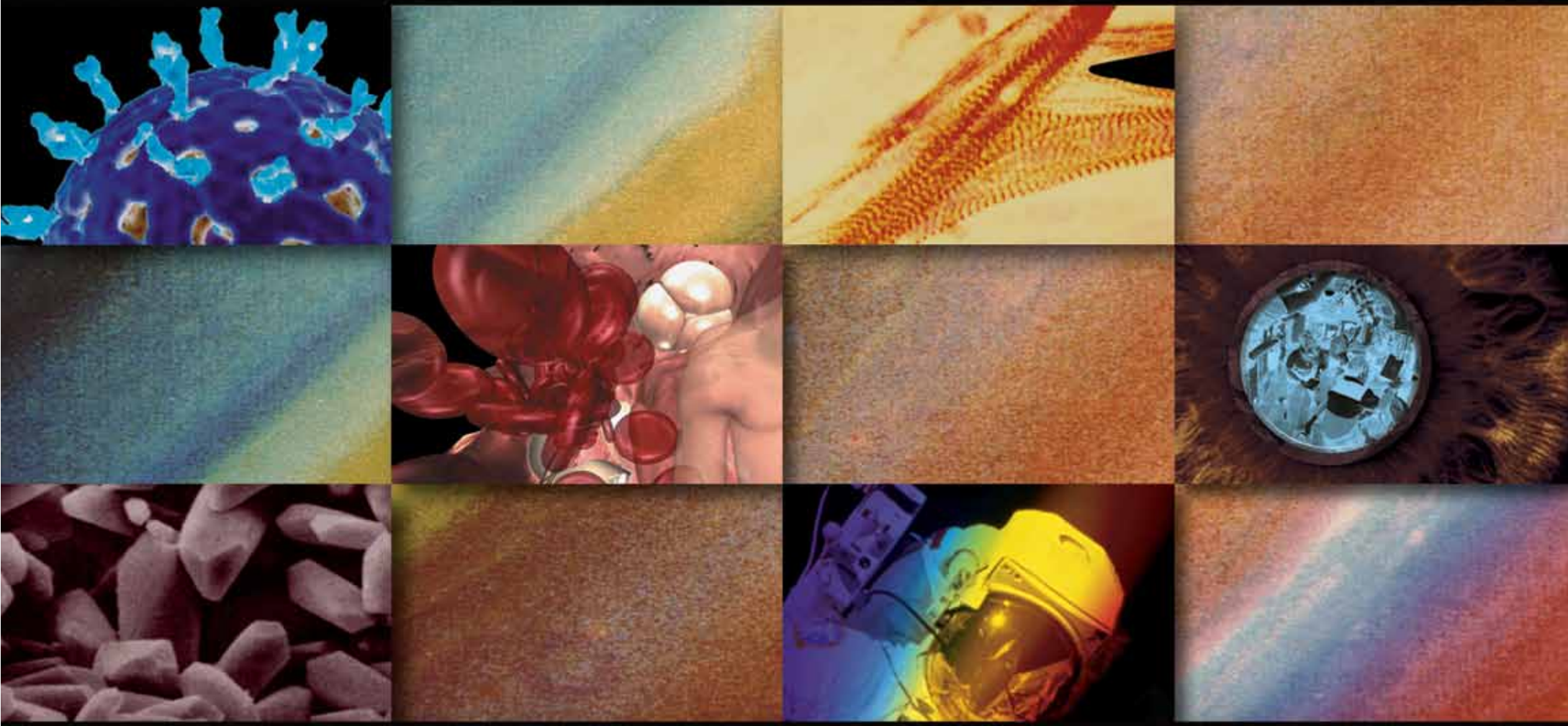
Brookhaven National Laboratory

Harvard Medical School

The Johns Hopkins University

Massachusetts Institute of Technology

Morehouse School of Medicine



Mount Sinai School of Medicine

Rice University

Texas A&M University

University of Washington

University of Arkansas for Medical Sciences

University of Pennsylvania Health System

## Solutions for Space and Earth Health

NSBRI's collaborations and revolutionary research advances are leading to substantial benefits for both the space program and the American people. Projects typically involve successful partnerships among academia, industry and government entities to achieve a deliverable for NASA and for commercial or medical use.

### Science/Technology Portfolio:

- Fifty-four projects
  - 21 focus on countermeasure development.
  - 23 focus on both countermeasure and technology development.
  - 10 focus on technology development.
- NSBRI Center of Acute Radiation Research – Awarded for a five-year period involving multiple projects to assess the acute effects of radiation exposure from solar events, better define the risks, and develop and test methods to protect astronauts.
- Peer-reviewed projects are distributed between consortium members and other institutions (41% consortium and 59% other institutions).
- More than 180 participating scientists, physicians and engineers from 60 institutions.
- Projects well distributed among NASA's Space Life Sciences divisions of Habitability and Environmental Factors, Human Adaptation and Countermeasures, and Space Medicine.
- New invention disclosures, patents and licensing agreements across multiple teams.

**"NSBRI is linking innovative science and technology projects to the operational activities of NASA."**

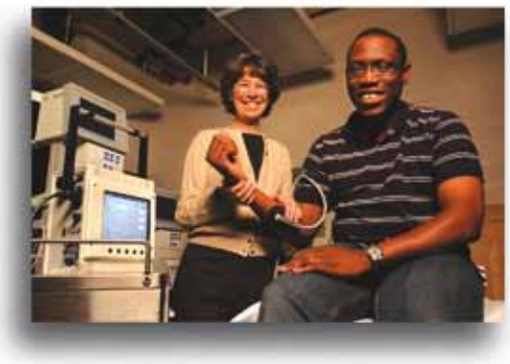
**Leroy Chiao, Ph.D.**
NASA Astronaut
Commander and Science Officer
International Space Station
Expedition 10
Chairman, NSBRI User Panel

### NSBRI Science and Technology Program

- Cardiovascular Alterations
- Human Factors and Performance
- Musculoskeletal Alterations
- Neurobehavioral and Psychosocial Factors
- Radiation Effects
- Sensorimotor Adaptation
- Smart Medical Systems and Technology

"The noninvasive monitor can help physicians identify and treat patients with shock caused by excessive bleeding or infection and help with pediatric patients, where it can be difficult to take multiple blood samples. We expect that the monitor will also be useful in helping train athletes for higher levels of performance."

**Babs R. Soller, Ph.D.**
University of Massachusetts Medical School, NSBRI Smart Medical Systems and Technology Team Leader



## Needle-free Measurements - Blood and Tissue Chemistry and Muscle Metabolism

Trauma and acute medical problems, along with loss of muscle strength and endurance, are serious risks facing astronauts on long missions. The team led by Babs R. Soller, Ph.D., at the University of Massachusetts Medical School (UMMS), continues development of a small, lightweight medical monitor to assess blood and tissue health and muscle metabolism without using needles.

Dr. Soller's team has developed a multi-parameter system which allows accurate, noninvasive blood and tissue measurements of muscle pH, muscle oxygen and red blood cell volume. These readings are used to provide an early indication of shock, assess its severity and help guide patient treatment. Dr. Soller and colleagues at UMMS patented the monitor's tissue oxygen measurement system as well as the pH and hematocrit measure technologies and have started a company to commercialize the monitor.

Measurements are made through a near infrared spectroscopic (NIRS) sensor placed directly on the skin. Most people encounter NIRS at the doctor's office when a small clip is placed on their finger to measure pulse rate and the level of oxygenated blood.

The research group expanded NIRS technology to include new measurement parameters and to provide accurate readings not impacted by body fat or skin color. As an extension of this work, Dr. Soller is testing the monitor's ability to assess muscle metabolism and muscle temperature during exercise.

Through readings taken during stationary cycling, treadmill walking and running at NASA Johnson Space Center, the device is being evaluated as a simple method to assess crew health and performance capabilities. Placement of the sensor in spacesuits would alert astronauts of their oxygen consumption during lunar excursions and spacewalks.

### Earth Applications

The "needle-free" monitor, evaluated in the UMMS emergency department and intensive care unit, can assist emergency and critical care physicians in the diagnosis and treatment of critically ill patients and holds promise for use in air and ground ambulances and on the battlefield. The device also has a general medical application for diagnosis of anemia and chronic heart problems.

The muscle metabolic measurements may one day assess physical therapy used in rehabilitating patients with muscle injury or atrophy. In addition, smaller versions of the monitor could find use in the training of elite and weekend athletes.

## Undersea and Arctic Missions: Evaluating Objective Self-Test for Fatigue

In isolated environments, astronauts, flight crews and military forces must maintain vigilance and teamwork to ensure safe and successful outcomes.

NSBRI uses analogs simulating space and lunar environments to test tools being developed to quickly assess stress, fatigue and cognitive fitness for performing critical mission tasks.

Several studies have used the National Oceanographic and Atmospheric Administration's Aquarius underwater habitat, located off the Florida Keys. Three NASA Extreme Environment Mission Operations crews (NEEMO 9, 12 and 13) participated in evaluations of a test that is sensitive to fatigue and factors impacting a person's ability to be attentive to a task and respond quickly and accurately. Additional testing occurred in the High Arctic at Devon Island, Canada, at the Haughton Mars Project Research Station.

Both settings are similar to lunar missions in key respects. With NEEMO, there is isolation, confinement to small habitats, work in an at-risk environment, and the need to perform optimally as an individual and a team. At Devon Island, there is a simulated lunar landscape, extravehicular activities, and no immediate rescue in an emergency situation.

David F. Dinges, Ph.D., of the University of Pennsylvania School of Medicine, used these analog environments to gather data using a test that objectively measures processes involving attention, vigilance and reaction time. Participants completed a 3-minute Psychomotor Vigilance Test (PVT) Self Test. The test was developed through Dr. Dinges' work with NSBRI, NASA, Department of Defense, National Institutes of Health, and Department of Homeland Security. The test requires the user to watch for a visual signal and respond quickly and accurately when it appears. During the NEEMO and Devon Island experiments, PVT was taken at least four times a day – on waking, before and after simulated lunar activities, and before bed.

Astronaut feedback was solicited during development of an interface component to the test that provides users with immediate feedback. PVT Self Test, renamed "Reaction Self Test," is a flight experiment on the International Space Station scheduled to begin in late 2009. The study will provide a validated measurement of in-flight cognitive performance and will help NASA characterize and quantify the risk of performance errors due to sleep loss, sleep schedule disruption, fatigue and work overload.

**"Improved technologies to assess team performance, interaction and alertness will be invaluable to any group working in an isolated, potentially high-stress environment."**

David F. Dinges, Ph.D.
University of Pennsylvania School of Medicine
NSBRI Neurobehavioral and Psychosocial Factors Team Leader

### Earth Applications

The project is refining real-time behavior-monitoring techniques and technologies to objectively and reliably predict how groups might perform in remote conditions. The technologies being developed, validated and tested for feasibility have applicability to a wide range of Earth-based conditions in which small groups of people must operate remotely and at high levels of alertness. Examples include flight crews, special military operations, submariners, police and firefighters.

## Real-time Radiation Risk Assessment

Radiation is one of the main concerns for crews on lunar and Mars missions. Travelers outside of Earth's orbit lose the protection provided by the planet's magnetic field, making it essential to monitor types and levels of radiation exposure.

A rugged, portable and lightweight radiation detection instrument is being developed in partnership with the faculty and midshipmen of the United States Naval Academy. The device will enable real-time measurement of radiation risk to astronauts.

The device measures the three forms of space radiation – solar particle events, trapped particle radiation and galactic cosmic rays. The instrument will use these measurements to estimate risk of damage to body tissue.

The device, called a microdosimeter or MIDN, is the project of Vincent L. Pisacane, Ph.D., of the Naval Academy. MIDN will also warn of the onset of enhanced radiation, so crews can seek safe shelter.

Radiation exposure can lead to many health problems including damage to blood cells, the immune system, skin, eyes, the gastrointestinal system, lungs, and the central nervous system. Exposure also increases cancer risk. In the spacecraft or habitat, radiation may cause reduced power generation, background noise in sensors and operational failure of electronic devices.

In addition to placement in spacecraft and lunar habitats, the portable device can be used on spacesuits, rovers and extravehicular tool boxes. MIDN will provide advance warning of impending exposure, allowing crews on the lunar surface or a space walk to take appropriate action.

A prototype MIDN flew on the Naval Academy's MidSTAR-1 satellite, launched on an Atlas V rocket as part of the U.S. Department of Defense Space Test Program.

**"The microdosimeter will give astronauts real-time radiation risk assessment. On Earth, it will be useful for nuclear material clean up or in the event of a homeland security incident. It can also act as a monitor during radiation treatment."**

**Vincent L. Pisacane, Ph.D.**
U.S. Naval Academy
NSBRI Radiation Effects Team

### Earth Applications

The ability to monitor radiation risk and estimate damage quickly is applicable to homeland security needs and work environments with high potential of radiation exposure. This technology is also important for quantifying radiation-induced cancers, a matter of significant concern with respect to radiation therapy (particularly for pediatric cancer patients) because of the well-documented probability of treatment-induced secondary cancers.

## Ultrasound Training Program Expands Medical Care

Diagnosis and management of health problems in space can be difficult due to limited medical training and experience. An ultrasound training program gives non-physician astronauts the tools to assess health using real-time remote assistance from medical experts.

Scott A. Dulchavsky, M.D., Ph.D., of Henry Ford Hospital, leads this project to increase the capabilities of ultrasound in space for assessing health situations that could impact a mission. In collaboration with NASA and Wyle Laboratories, Dr. Dulchavsky's team developed training methods and interactive CD ROM refresher modules that allow astronauts to perform complex ultrasound examinations alone or with guidance from an expert on the ground.

Ultrasound can be used to assess a number of medical conditions such as fractured bones, a collapsed lung, kidney stones or organ damage. This imaging technique can also provide information about the musculoskeletal system, including muscle or tendon injury or bone atrophy.

International Space Station crews have completed more than 80 hours of ultrasound examinations in space. These examinations demonstrated that non-physician astronauts can perform diagnostic quality ultrasounds in space, and team with ground-based experts to provide information on physiological adaptation to the space environment. These techniques have expanded diagnostic capabilities in the space program and can be extended to exploration missions.

Dr. Dulchavsky's team is currently enhancing the training through an intuitive ultrasound image cataloging system that will allow non-expert operators to perform and interpret ultrasound, extending health care capabilities in space and on Earth.

### Earth Applications

Dr. Dulchavsky's group has modified these space-relevant technologies for Earth-based medical care through the use of video streaming technology. This extends ultrasound use to ambulances, accident scenes and remote areas, including military locations and third-world nations. Professional sports teams (hockey, baseball, football and basketball) have adopted these novel diagnostic tools to rapidly assess the extent of injuries during a game. The techniques were employed by athletic trainers during the 2006 Winter and 2008 Summer Olympic Games. Dr. Dulchavsky recently partnered with the United Nations Millennium Project to use ultrasound to improve maternal mortality.

The training methods have been adopted by the American College of Surgeons for training physicians to perform point-of-care ultrasound and are used by Wayne State University School of Medicine for medical student training.

**"With remote guidance, we couple a modestly trained operator with an experienced medical expert, essentially making the non-physician the hands of the expert. There is tremendous potential for space medicine and benefits for Earth."**

**Scott A. Dulchavsky, M.D., Ph.D.**
**Henry Ford Hospital, NSBRI Smart Medical Systems and Technology Team**

**"The training and refresher course is excellent and should be expanded on future flights. This method could be used in medical emergencies on the Space Station to guide crew members."**

**Mike Fincke, NASA Astronaut**
**Science Officer and Flight Engineer, International Space Station Expedition 9**
**Commander, International Space Station Expedition 18**

## Lunar Dust – Reducing Risk to Lungs

Lunar dust will be more than a housekeeping issue for astronauts; their health will depend on the amount of exposure they have to the tiny particles.

To prepare for a return to the moon, G. Kim Prisk, Ph.D., D.Sc., of University of California, San Diego, is evaluating how and where simulated lunar dust deposits in the lungs. This information will help scientists assess the health risk of long-term exposure and will influence the design of lunar bases.

During Apollo missions, the clingy particles were easily transported via spacesuits into the lunar lander. Although there were no illnesses due to exposure, lunar dust remains a concern because it has properties comparable to fresh-fractured quartz, a highly toxic substance.

Future lunar missions will be longer duration with increased chance of exposure. Dr. Prisk is examining how the reduced gravity on the moon, combined with the dust particle size, impacts the lungs' ability to remove unwanted matter. The moon's gravity is relatively weak – one-sixth of Earth's gravity.

To study how the dust behaves, Dr. Prisk's group uses NASA's Reduced Gravity Aircraft. The plane provides short periods of lunar gravity during a series of steep climbs and descents. During lunar-gravity segments, simulated dust particles are injected into a mouthpiece worn by study participants. Subjects breathe in and out, and the team measures how the particles move and how many end up inside the lung.

They have learned that tiny particles, which are the most significant in terms of damage, are greatly affected by alterations in gravity. The team is continuing to investigate both the severity of the risks and methods to limit exposure.

**"If we learn how to target drugs to specific areas inside the lung, it will be possible to achieve optimal results with small quantities of drugs delivered to exactly the right place in the lung, minimizing side effects."**

**G. Kim Prisk, Ph.D., D.Sc.**
University of California, San Diego
NSBRI Human Factors and Performance Team

### Earth Applications

This research will give scientists a better understanding of how the lungs work, improving the understanding of how particles distribute within the lungs. This information will lead to development of better models to assess risk related to environmental exposure to particulate matter pollution – a concern for healthy individuals, but particularly troublesome for people with asthma and chronic obstructive pulmonary disease.

In addition, drugs delivered by aerosol spray can be better targeted to the right place in the lung, leading to more effective medications, minimized side effects and smaller amounts of drug necessary per dose.

## Maximizing America's Potential

The Institute's education and outreach programs support national priorities for improving science and technology education and the nation's global economic competitiveness. NSBRI is supporting the development of future space life scientists, engineers and technicians, while at the same time improving science teaching and learning for all students. Current activities align with NASA's *Education Strategic Coordination Framework*. NSBRI educational activities focus on developing curricular materials; deploying Web-based resources for teachers and faculty; implementing workshop-based teacher professional development programs; and supporting summer internship, graduate and postdoctoral programs. The program received a Stellar Award from the Rotary National Award for Space Achievement Foundation recognizing "performance as a nationally recognized, top-tier program that is pioneering new models for exemplary teaching, training and public outreach in support of space exploration."

### Education/Outreach Portfolio:

- **Pre-college Projects**
  - More than 1,000 teachers participate annually in NSBRI-sponsored professional development activities, impacting thousands of students with NSBRI science education materials.
  - Thousands of teachers access Web-based resources and online professional development.
  - Partnerships with Challenger Learning Centers and other museums across the United States impact large numbers of students and families in informal science settings.
- **Undergraduate and Graduate Student Project**
  - Summer Internship Program receives more than 150 applications annually with 10-15 students selected for 3-month placements with space life sciences projects at NASA Centers.
- **Graduate Education and Postdoctoral Projects**
  - Eleven students are enrolled in the Graduate Education Program in Space Life Sciences.
  - Postdoctoral Fellowship Program enrolls four Fellows per year.
- **Space Medicine Grand Rounds and Aerospace Medicine Board Meetings at NASA Johnson Space Center reach more than 250 participants each year.**

## Graduate Education Program – Specialized Training in Space Life Sciences

NSBRI funds an innovative Graduate Education Program in Space Life Sciences conducted jointly at Texas A&M University and Massachusetts Institute of Technology (MIT) through the Harvard-MIT Division of Health Sciences and Technology. The program is developing modules to strengthen current graduate curricula at these two institutions enabling students to experience advanced courses in biomedical science and engineering, specifically as these fields relate to the space program. Once fully developed, it is anticipated that the educational modules will be applicable to accredited doctoral programs across the nation.

Each year, the NSBRI-sponsored Graduate Fellows participate in a seven-week summer enrichment program in Houston. The program includes a week of space life sciences lectures followed by a six-week assignment in a NASA Johnson Space Center laboratory.

**"Even though the research done at NASA is related to space, the products and discoveries that follow have an even larger contribution for life on Earth. The project I worked on may show potential to not only counter bone loss in space but also bone loss on Earth."**

**Huda Abdul-Razzak**
Student, University of Texas at Austin
NSBRI Summer Intern

## Postdoctoral Fellowship Program Expands

NSBRI's Postdoctoral Fellowship Program addresses the nation's need for scientists who will conduct research to mitigate the risks associated with human space exploration. The two-year fellowships, expanded to accept four Fellows each year, allow young scientists the opportunity to conduct independent, space-related research projects, while still continuing to learn from an experienced research faculty mentor.

Fellows become part of an established NSBRI research team, participating in the team's teleconferences and meetings, and attending annual investigator retreats. They also attend a one-week summer institute at NSBRI and NASA Johnson Space Center. Through these activities, they gain professional relationships with leading scientists across the country.

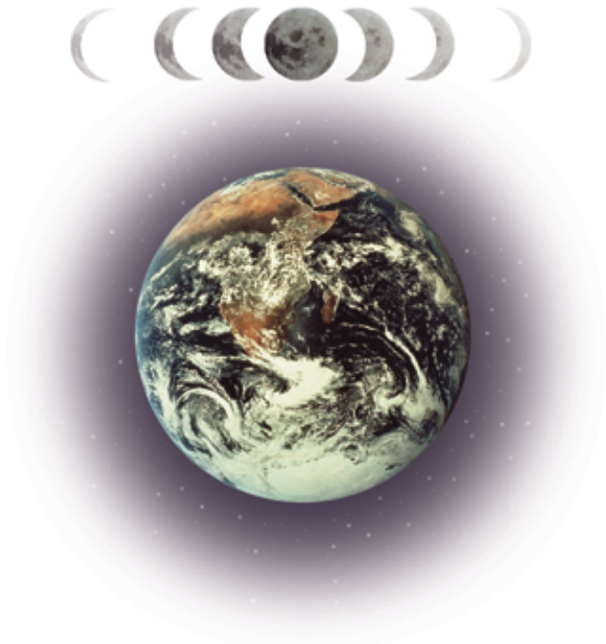
Since the program's inception in 2004, 17 Fellows have been selected – 7 women and 10 men – representing universities in 8 states and the District of Columbia. Fellows who have completed the program continue to compete successfully for faculty positions at universities and research institutes.

Fellows are selected through an open, national solicitation for research proposals. All proposals undergo peer review for scientific merit and relevancy to NSBRI's mission.

## Strengthening Middle and High School Teachers' Science Knowledge

Each year, more than 1,000 teachers – representing more than 24,000 students – participate in NSBRI-sponsored professional development activities in person and via the BioEd Online Web site. The goal of these efforts is to strengthen middle and high school teachers' science knowledge and abilities to incorporate space life sciences content into their classroom instruction. Examples of teacher professional development programs and materials developed by NSBRI's pre-college to undergraduate continuum include:

- Teacher Activity Guides: *Food and Fitness, Muscles and Bones, Sleep and Daily Rhythms,* and *Heart and Circulation*
- Training sessions at national conferences of science teacher organizations
- *Podcasts Plus Lessons*: pairing NSBRI science podcasts with related supplementary standards-based educational activities
- Workshops for teachers in schools that enroll large numbers of disadvantaged students, conducted in partnership with school districts, such as Houston Independent School District and Atlanta Public Schools
- Intensive teacher professional development workshops conducted by Morehouse School of Medicine in partnership with Morgan State University
- BioEd Online and K8 Science Web sites that have served more than 11,000 and 1,300 sessions, respectively, on Internet slide talks and presentations from NSBRI's *Food and Fitness* guide.



## Spiders and Butterflies Experiment on Space Station

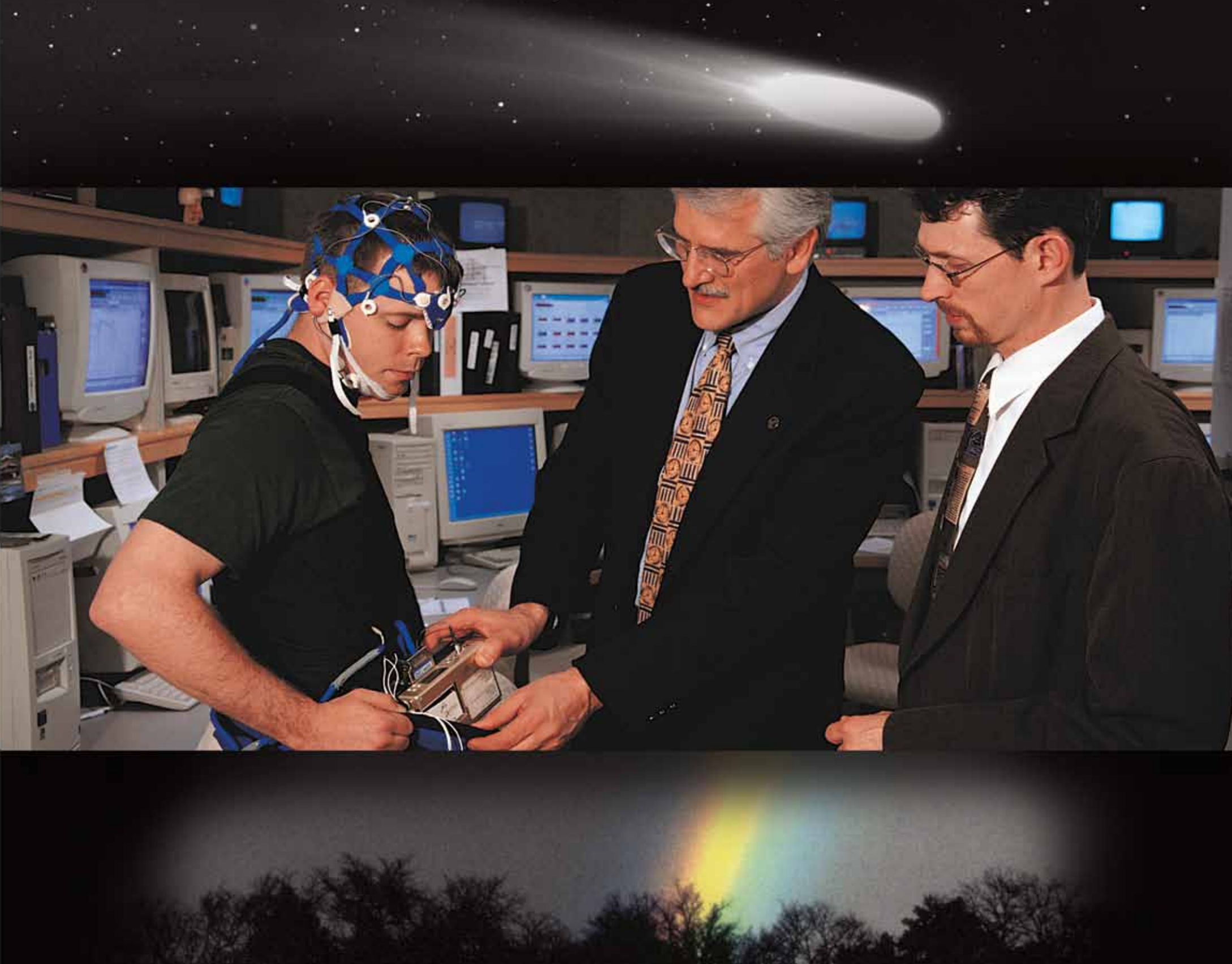
Space Shuttle Endeavour delivered orb spiders and *Vanessa cardui* (painted lady butterfly) larvae to the International Space Station. This unusual cargo was part of an NSBRI-funded education project designed to excite students and engage them in science through space-based flight experiments suitable for classroom replication and student research.

Schools in Colorado and Texas participated in a pilot study, replicating the experiments on Earth with spiders and butterfly larvae in their classrooms. Using video and photos taken aboard the Space Station, students were able to compare the life cycles and behaviors of the "space" spiders and butterflies to those of the spiders and butterflies living in habitats in their classrooms. Program results and observations from pilot teachers were gathered, and the educational materials will be revised for future Space Station-based projects.

The project was a partnership between Baylor College of Medicine and BioServe Space Technologies at the University of Colorado. It will result in an educator's guide that will allow future classes to replicate the space experiment and compare their classroom results with the data and photos transmitted from space.

**"NSBRI cared so much about our future success that they organized a job interview workshop for us. It was just in time for my actual interviews. The fellowship gave me independence in conducting my research and enabled me to have an easier transition from being a postdoc to being an assistant professor."**

**Vesna Zderic, Ph.D.**
Assistant Professor, George Washington University
Former NSBRI Postdoctoral Fellow



## Future Directions

NSBRI continues to mature as an innovative and successful institute for conducting translational biomedical research and development on a national scale. Together with our NASA partner, NSBRI is implementing recommendations from the positive Five-Year Review to further strengthen its programs and ensure that NASA and the American people receive the maximum return on the investment made in NSBRI. The Institute is committed to continued excellence in science, technology and education, and in achieving its noble mission.

Going forward, NSBRI will maintain its leadership role in engaging the academic biomedical community with NASA scientists, engineers, astronauts and flight surgeons. There is increased focus on moving promising countermeasures toward operations, with testing and evaluation on Earth in analog environments and on the International Space Station. These efforts ensure high-quality deliverables for use in space exploration. NSBRI will continue to solicit and support innovative and highly meritorious science and technology proposals, while utilizing its User Panel and NASA expertise to guide projects toward useful products and procedures that address high-priority needs.

There is synergy among projects in the science and technology portfolio, increased alliances with industry, and integration with the education and outreach programs. The Institute plans to foster these trends as it strengthens productivity and commercialization efforts, and helps inspire and prepare the next generation of scientists and engineers. A pipeline of NSBRI educational opportunities from elementary school through independent investigator has been established, and the Institute is uniquely positioned to effectively implement education programs as an important component of its strategic plan.

As interdisciplinary teams work to generate countermeasures and mitigate risks, NSBRI will continue to provide an invaluable resource to NASA as the International Space Station nears completion, its utilization capabilities increase, and the emphasis strengthens for lunar habitation and exploration of the moon and Mars. NSBRI is proud to be part of the country's strength in biomedical research and education. It is our privilege to work with NASA and the international community, and to build upon our nation's legacy in spaceflight that expands the frontiers of human knowledge and experience.

## Consortium Members




HARVARD
MEDICAL SCHOOL





MOUNT SINAI
SCHOOL OF
MEDICINE




## Become an NSBRI Supporter

For information on how to become an NSBRI supporter, please contact us:

**Julie Do**
Chief Financial Officer
National Space Biomedical Research Institute
BioScience Research Collaborative
6500 Main Street, Suite 910
Houston, TX 77030-1402
713-798-7412 phone
713-798-7413 fax
**www.nsbri.org**

**Image Credits:**

Martin Bost – 22

Tom Callins – 20 (bottom)

John Glowczwski – 6 (left), 20 (center), 25

L. Barry Hetherington – 13

NASA – 4-6 (middle), 10-12, 14 (left), 15, 17-19

NSBRI/Haughton Mars Project / Marcelo Vazquez – 14 (right)

Kris Snibbe/Harvard News Office – 6 (right)

James T. VanRensselaer – 16

**Design:** Piland Design, Inc.


National Space Biomedical Research Institute
BioScience Research Collaborative
6500 Main Street, Suite 910
Houston, TX 77030-1402
Phone: 713.798.7412
Fax: 713.798.7413
www.nsbri.org