



National Space Biomedical Research Institute

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**Biotechnology Utilization Planning for the
International Space Station National Laboratory**



Overview

- **NSBRI selected in 1997 through an open competition**
- **Institute partnership with NASA managed through Cooperative Agreement NCC 9-58 with Johnson Space Center**
- **NSBRI is a non-profit organization competitively engaging ~70 U.S. universities in 26 states to work on space biomedical projects**
 - **51 science and technology projects**
 - **11 education and outreach projects**
 - **~250 investigators**
 - **International participation**
 - **Flight experience**



Mission

- **To lead a national effort for accomplishing the integrated biomedical research necessary to support long-term human presence and exploration of space**
- **To enhance life on Earth by applying the resultant advances in human knowledge and technology**



NSBRI and ISS National Laboratory

- **Excellent opportunity to capitalize on NASA's investment in NSBRI science, technology and education portfolio and programs to enhance ISS utilization**



INNOVATIONS FOR HEALTH IN SPACE AND ON EARTH

EXPLORE



INNOVATE

EDUCATE



Value

- **Intellectual and institutional resources, leveraging the nation's investment in biomedical research and development, are brought to bear on solving problems for NASA**
 - **High caliber and productivity of investigators**
 - **Strength of the consortium and non-consortium institutions**

Consortium Members

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
University of Washington

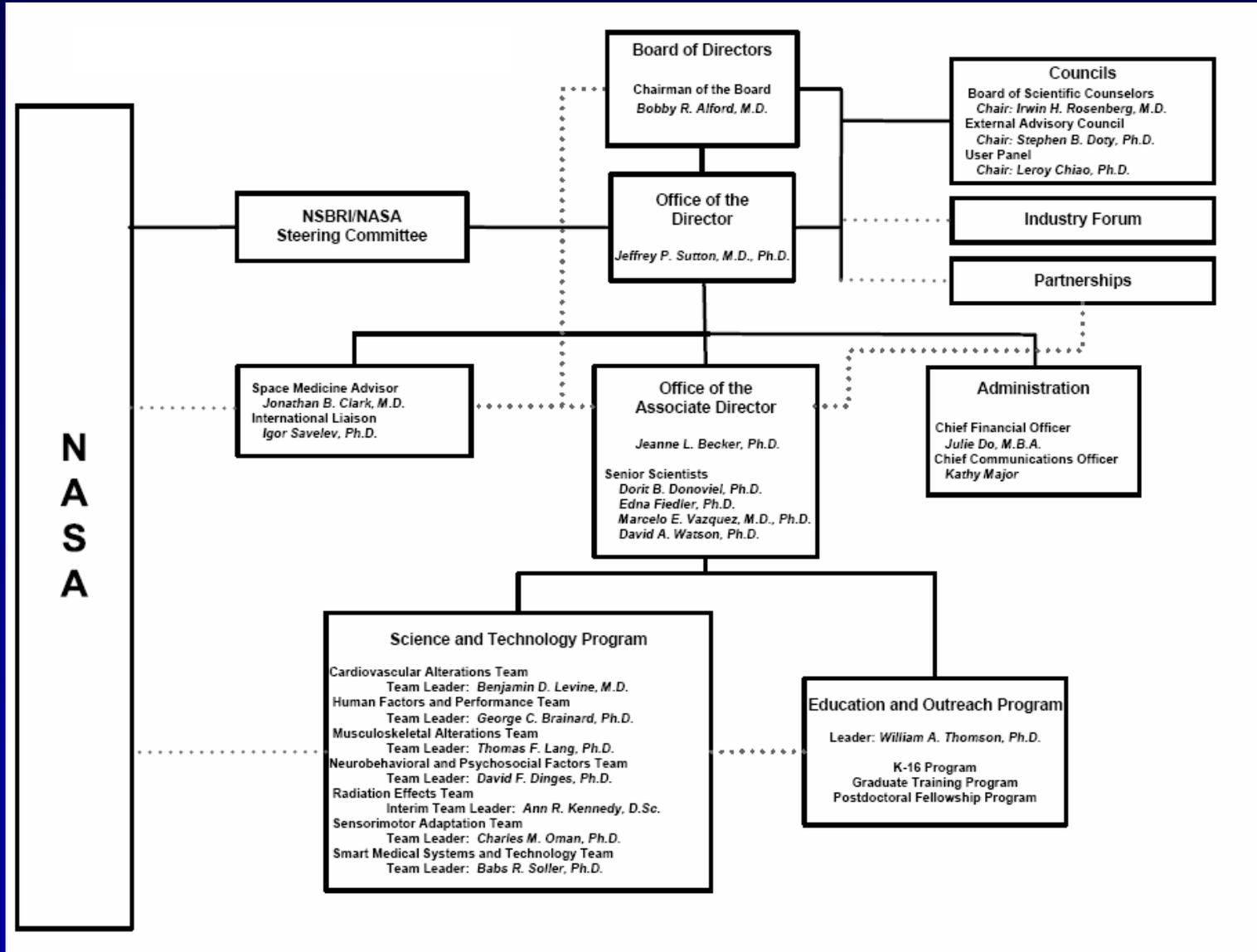


Value

- **Unique, national translational research and development program**
 - Model for a virtual academic institute partnered with government
 - Focus on deliverables
 - Multidisciplinary teams
 - One third of projects have ties to industry + NSBRI Industry Forum
 - Active User Panel to help ensure operational relevance of portfolio
 - Opportunities for high risk/long lead time, high payoff projects
 - Peer review and ongoing assessments of progress (ESMC, pipeline)
 - Cost effective
- **Extensive education and outreach program**
 - Continuum of opportunities in education, training, outreach
 - Opportunities aligned with STEM
 - Each S&T project has ~ 3 trainees



Organizational Structure





Sample NSBRI Achievements

- **1,000+ peer-reviewed publications, including the first publication from space [with NASA, *Radiology* 2005;234(2):319-322] and associated spin-offs**
- **Completed a clinical study in space analog showing effectiveness of zoledronate to reduce bone loss**
- **Integrated projects using blue light to enhance human performance with applications to crew exploration vehicle design**
- **Developed and tested a non-invasive blood and tissue monitoring device for space medicine**
- **Delivered a miniaturized time-of-flight mass spectrometer for environmental monitoring and medical assessment**
- **Received a 2007 Stellar Award for “*performance as a nationally recognized, top-tier program that is pioneering new models for exemplary teaching, training and public outreach*”**



Non-invasive Blood and Tissue Monitoring
Smart Medical Systems and Technology Team



Science and Technology Program

- **Research, Development, Testing, Evaluation, Operational Implementation**
- **Balance portfolio**
 - **Distribution among high priority areas**
 - **Ladder projects among countermeasure and technology readiness levels**
 - **Driven by science and by user needs (requirements) and feasibility**
- **Focus is on deliverables**



Science and Technology Program

- **Open solicitations**
- **Peer review**
- **Variety of project types (R01-like, P01-like, directed)**
 - **Center for Acute Radiation Research**
 - **International 105-day Isolation Study (to commence in 2009)**
- **Portfolio aligned with most recent iteration of the NASA Integrated Research Plan**
- **Strong educational component**



Science and Technology Teams

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



Mapping to NASA Human Research Program Elements

<i>Element</i>	<i>Number of Projects</i>
Human Health and Countermeasures	15
Behavioral Health Performance	12
Exploration Medical Capabilities	8
Space Human Factors and Habitability	7
Space Radiation	9
	<hr/>
	51



Countermeasure Readiness Levels

COUNTERMEASURE OPERATIONS

9. Countermeasure fully flight tested and ready for operational implementation.

COUNTERMEASURE EVALUATION & VALIDATION

8. Validation with human subjects in actual operational space flight to demonstrate efficacy and operational feasibility.

7. Evaluation with human subjects in controlled laboratory conditions simulating operational space flight environment.

6. Laboratory/clinical testing of potential countermeasure in human subjects to demonstrate efficacy of concept.

5. Proof of concept testing and initial demonstration of feasibility and efficacy.

COUNTERMEASURE DEVELOPMENT

4. Formulation of countermeasures concept based on understanding of phenomenon.

RESEARCH TO PROVE FEASIBILITY

3. Validated hypothesis. Understanding of scientific processes underlying problem.

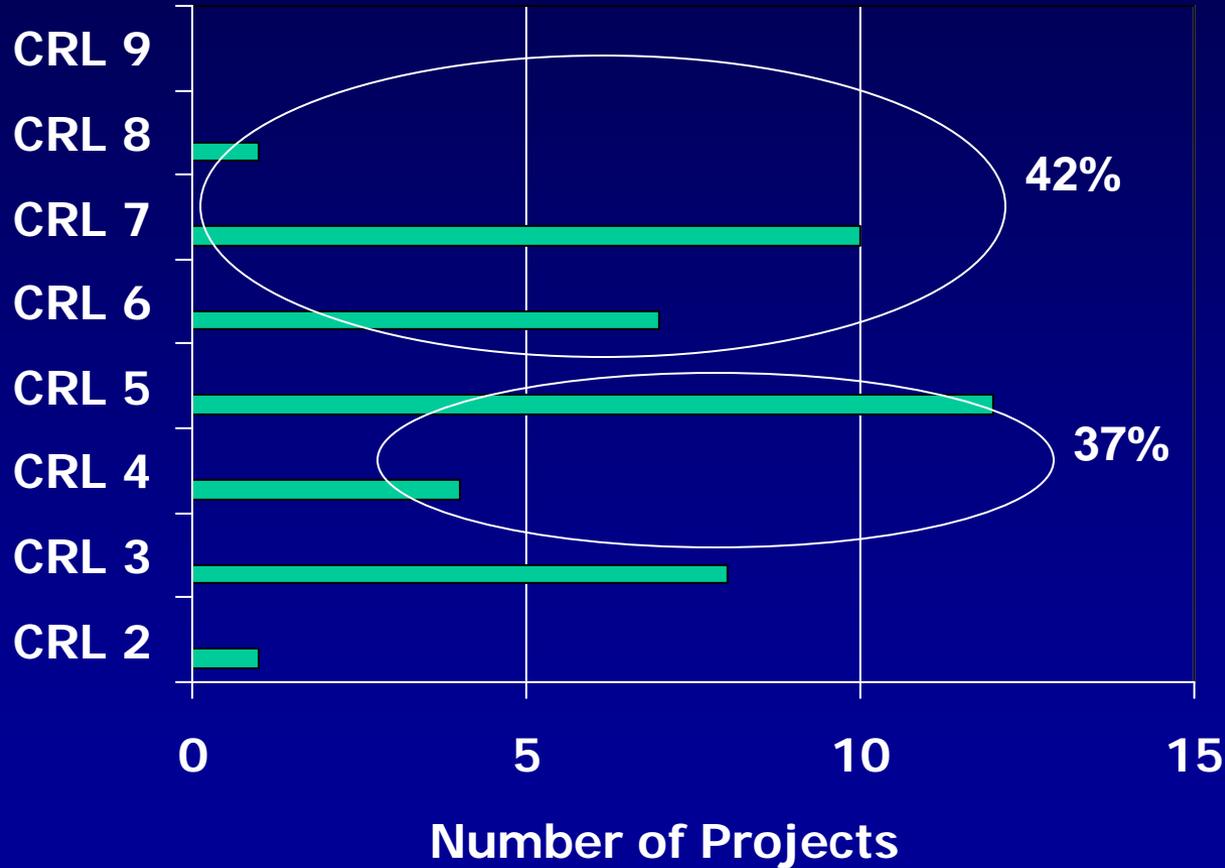
BASIC RESEARCH

2. Hypothesis formed, preliminary studies to define parameters. Demonstrate feasibility.

1. Phenomenon observed and reported. Problem defined.

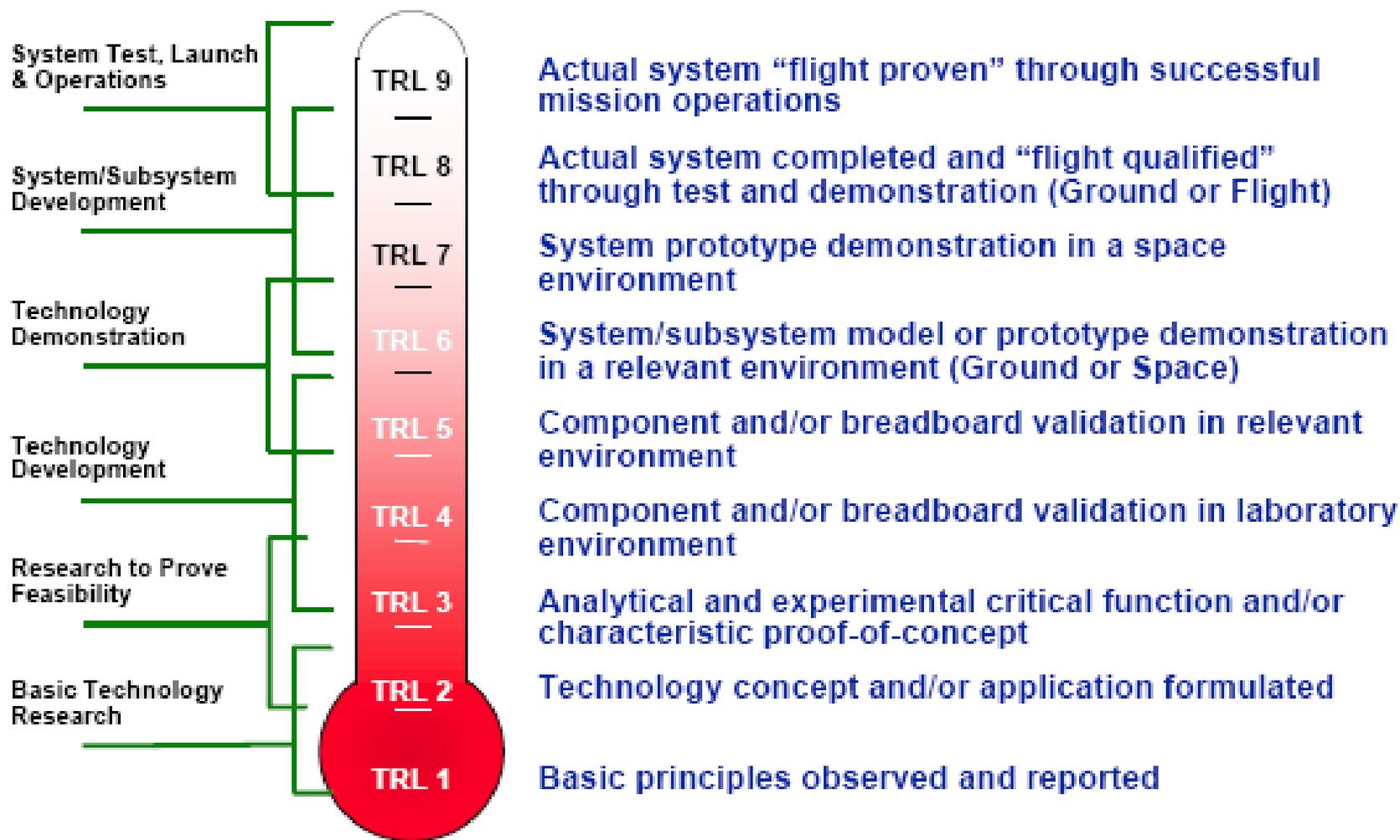


NSBRI Science & Technology Portfolio: Countermeasure Projects – Current



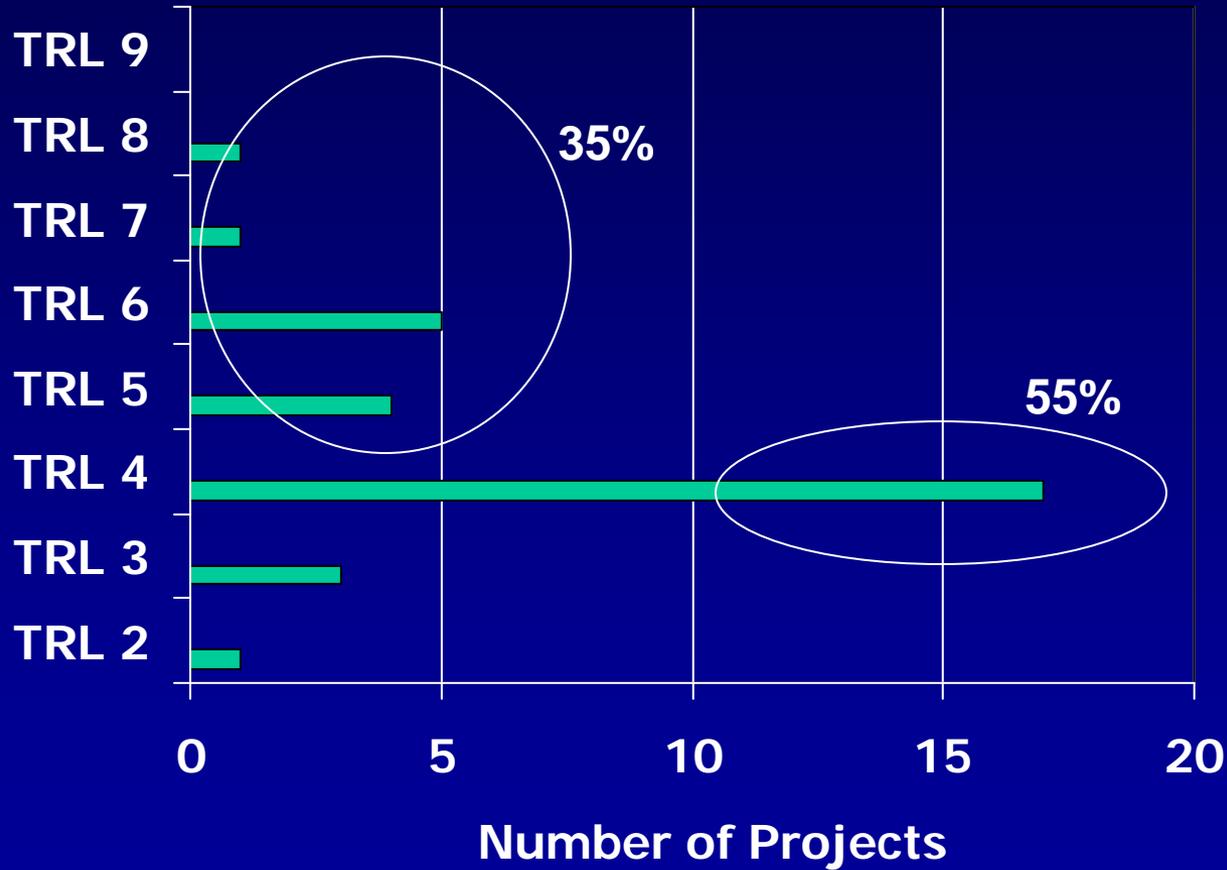


Technology Readiness Levels





NSBRI Science & Technology Portfolio: Technology Projects – Current



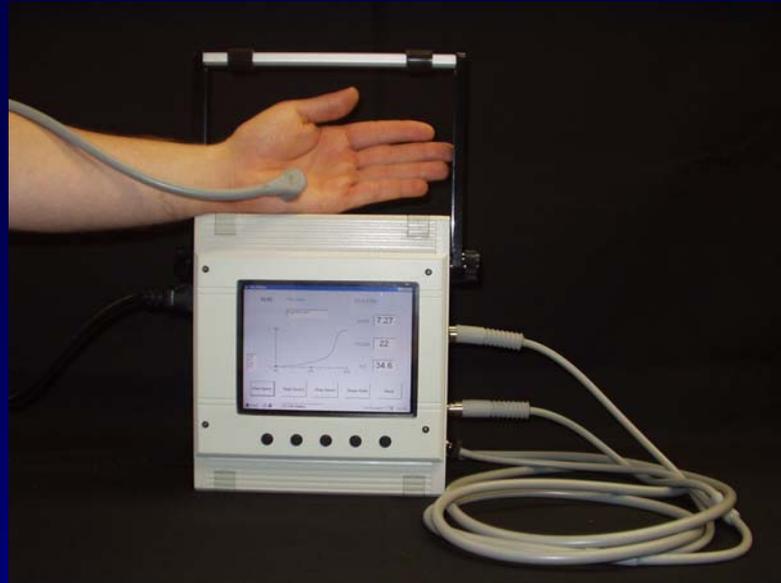


Infrared Spectrometry Monitoring of Physiologic Parameters

- **Needle-free blood and tissue measurements**

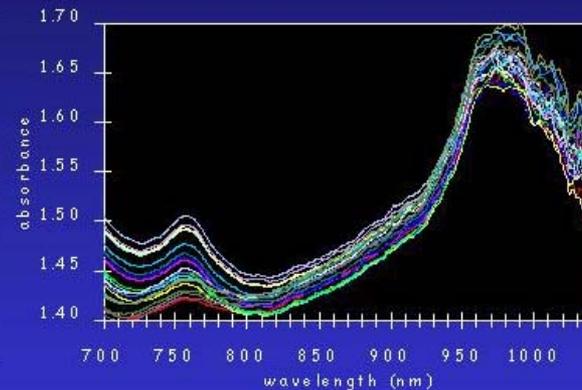
**Tissue oxygen measurement system:
US Patent No. 6,766,188**





Spectroscopic Measurement of Tissue pH

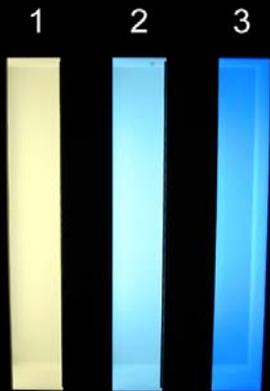
Tissue spectra will change as a function of pH and statistical methods can be used to relate these spectral changes to tissue pH.





Helping to Ensure Operational Success

- **Blue Light: Progress to optimize the light spectrum, particularly for 420-460 nm, to enhance human performance and mitigate sleep disruption**



Lamp output shown at left is generated by:

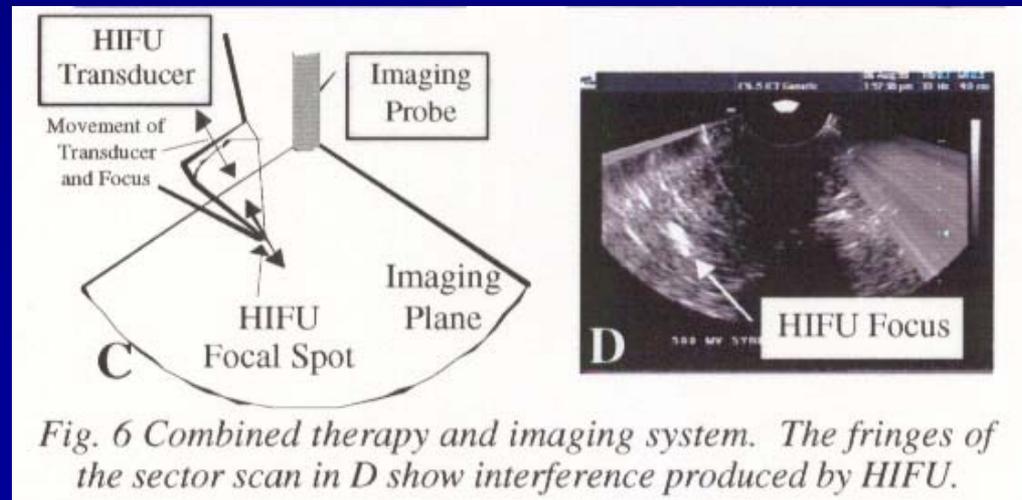
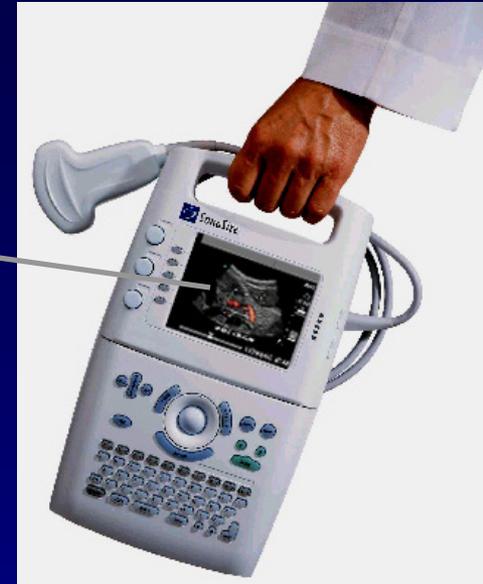
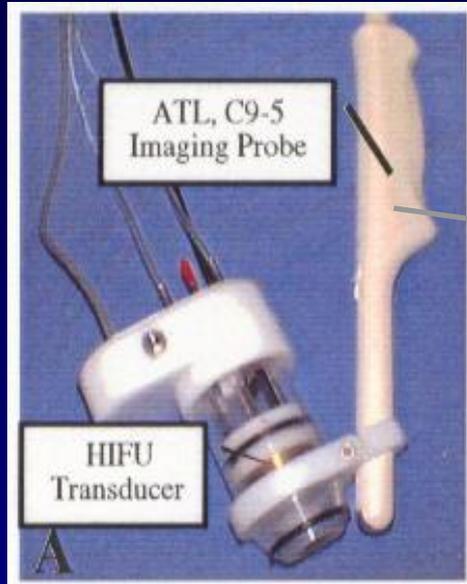
- 1) A commercially available white fluorescent lamp.
- 2) A blue-enriched lamp predicted to have twice the circadian potency.
- 3) A further blue-enriched lamp predicted to have four times the circadian potency.

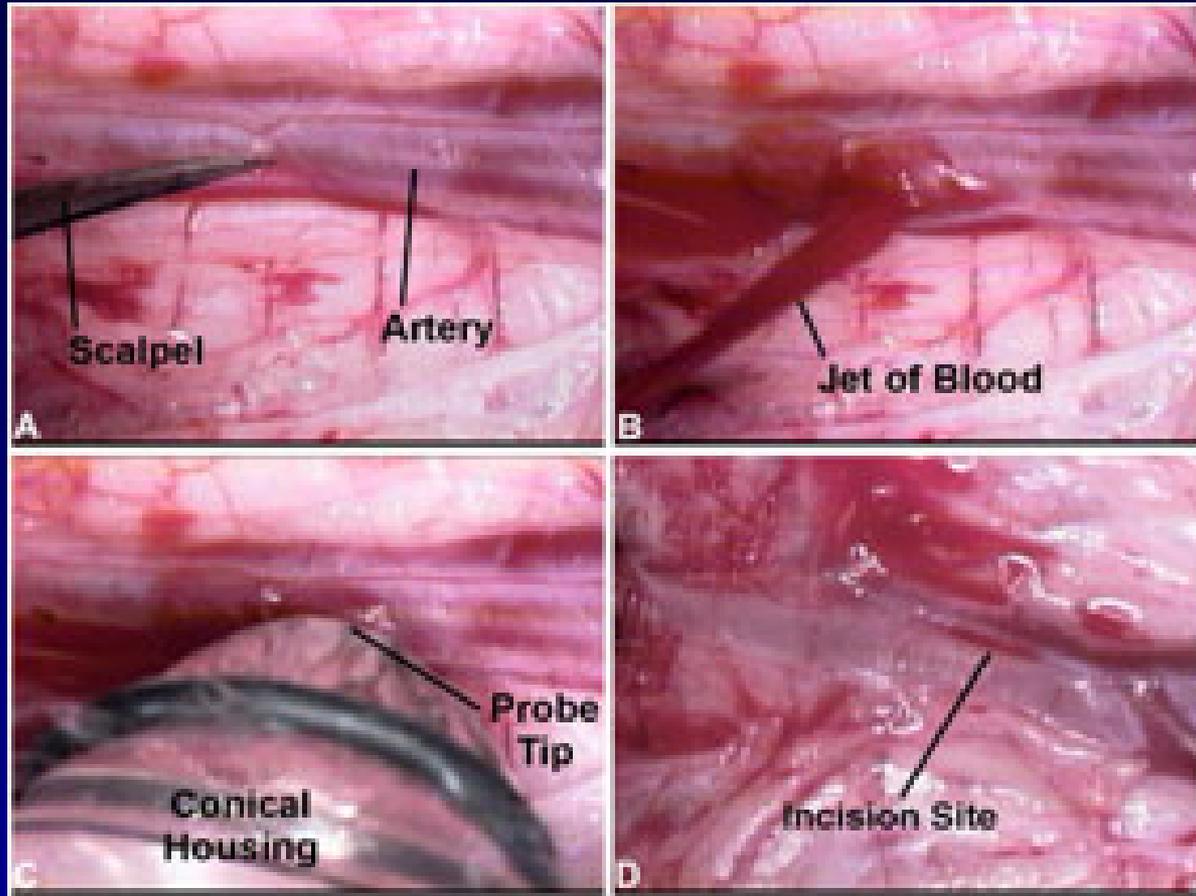


Ultrasound in Space and on Earth



A screenshot of a software interface titled 'PRINCIPLES OF ULTRASOUND'. The interface is divided into several sections. On the left is a 'MAIN MENU' with a list of topics: INTRODUCTION, EXPERIMENT OVERVIEW, BRAIN GYM, HARDWARE SETUP, ANATOMY, PRINCIPLES OF ULTRASOUND, SAFETY, ULTRASOUND CONCEPTS, PRINCIPLES OF REMOTE GUIDANCE, DATA ACQUISITION, EXERCISES, BLOOPERS, and CONCLUSIONS. The main area shows a 2D ultrasound image of a brain scan. To the right of the image is a text box titled 'ULTRASOUND CONCEPTS' with the text: 'ULTRASOUND IMAGES ARE ACOUSTIC REFLECTIONS OF ORGANS AND STRUCTURES IN THE BODY. THESE IMAGES ARE IN 2D PLANES.' Below the text is a 3D anatomical diagram of a human torso showing internal organs, with a yellow probe icon pointing to the liver area. At the bottom of the interface are navigation buttons: 'PREVIOUS SECTION', 'NEXT SECTION', 'VOLUME: 87%', 'VIEW REMOTE GUIDANCE CARD', 'Quit', 'Switch User', 'BACK', 'SPACE', 'NEXT', and 'SPACE'. The page number 'Page 2 of 7' is visible in the top right corner.





Countermeasures

- Use of ultrasound for diagnosis and treatment of injury using image guided non-invasive surgery



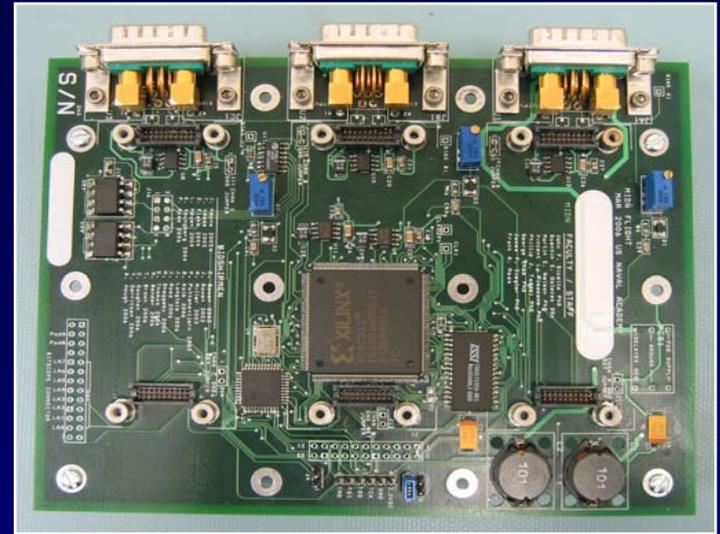
Integrated Experiments: Analog Environments

NASA Extreme Environmental Mission Operations (NEEMO) habitat
Antarctica
Mt. Everest
Haughton-Mars Project in high Canadian arctic



Atlas 5 (AV-013) Launch Carrying United States Naval Academy Microdosimetry Payload Developed by National Space Biomedical Research Institute

March 8, 2007





Education as a Lifelong Process

**Elementary,
Middle, High
School**

Undergraduate

Graduate

Post-Graduate

Investigator •••

**University
science and
engineering
courses**

**University
science and
engineering
courses**

**Research
through
Mentor's
grants**

**Research
Grants**

**Teacher
training**

**Workshops
Conferences**

**Student
curriculum**

**Summer
internship
with NASA**

**Research
Program for
curriculum
development
and research
Ph.D.**

**Post-doctoral
Fellowship
Program**

**Continuing
Medical
Education**

**Mentoring
of students**

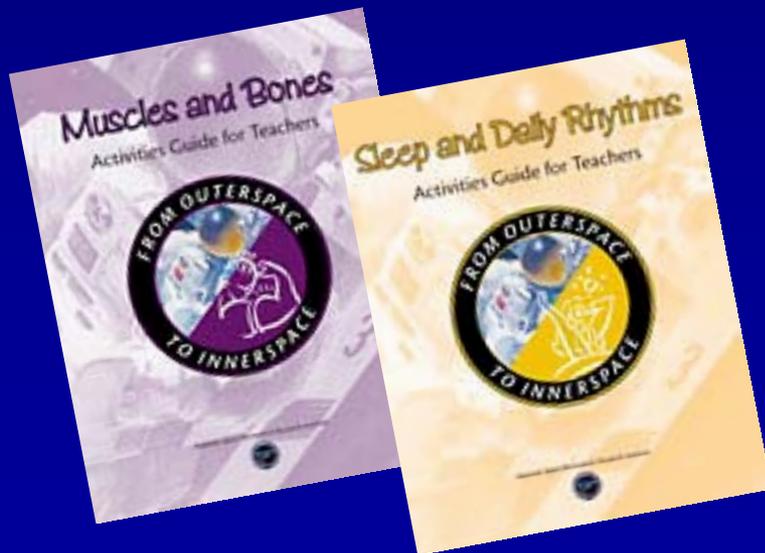
**Summer
Internship
with NASA**

**Public
Outreach**



Elementary, Middle, High School

- > 1,000 teachers have participated in NSBRI-sponsored professional development activities
- > 45,000 students impacted by NSBRI science education materials and laboratory activities
- Thousands of teachers reached through dissemination of Web-based resources





Butterfly and Spider Educational Payload Aboard STS-126 to ISS

Objectives

- Study one full life cycle (larvae to winged adult) for Painted Lady butterfly in microgravity, as compared earth-based controls
- Compare the ability of the orb-weaving spider to spin webs in microgravity, as compared to webs spun on earth
- Video and still images downlinked during the study for classroom use
- Targets K-12 to inspire interest in science, technology, engineering and math

Partnerships

BioServe (University of Colorado – Boulder)

Denver Museum of Nature and Science

Butterfly Pavilion at Westminster, CO

Baylor College of Medicine Center for Education & Outreach



Undergraduate Education

- University courses (~50 universities) and summer internships (100+ applicants)



Graduate Education

- 2006 – Commenced innovative graduate education program in space life sciences awarded to Texas A&M, MIT and Baylor College of Medicine
- Facilitates development of modules of course content to supplement existing accredited programs leading to Ph.D.



Post-Doctoral Fellowship Program

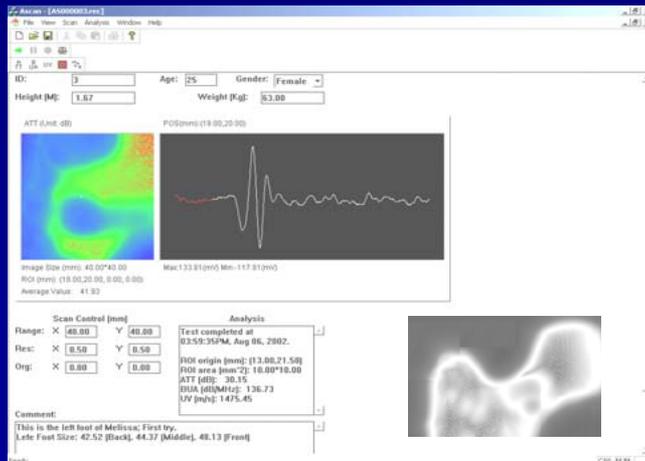
- Fifth year of operation
- Annual solicitations – each fellowship lasts two years
- Popular program, excellent for career development, cost effective





Continuing Medical Education

- Productive exchange of knowledge (last year: 24 activities, 441 participants)
- Important for maintaining M.D. certification for flight surgeons and for investigators to obtain insight and feedback into operational aspects of countermeasure development



Photos courtesy of Yi-Xian Qin, Ph.D.



Public Outreach

- **NSBRI HQ has Communications and Public Outreach group**
- **Active Web site (~70,000 hits/month), news releases, newsletter**
- **Investigator community regularly featured in press, including television education programs**
- **Podcasts**





Strategy Going Forward

- **Lead a national biomedical research effort to support human space exploration**
- **Enhance life on Earth through advances made in space biomedical science and technology**
- **Provide a comprehensive education program in space biomedical science and technology**
- **Expand partnerships in space biomedical science, technology and education**
- **Broaden capabilities as a national science and education resource**

CENTER FOR SPACE MEDICINE

Faculty, Staff and Students
Research and Development
Education and Outreach
Portal for Medical Care

**New Opportunities
and Partnerships**



NSBRI Consolidated Facility
Science and Technology
Project Maturation
Education and Outreach
Administration