

National Space Biomedical Research Institute

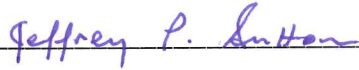


Strategic Plan

2010

National Space Biomedical Research Institute

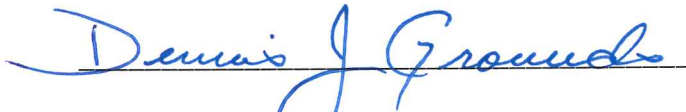
Strategic Plan



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Acronyms

BCM	Baylor College of Medicine
BSC	Board of Scientific Counselors
CARR	Center of Acute Radiation Research
CRF	Consolidated Research Facility
EAC	External Advisory Council
ESMC	Executive Science and Medicine Council
HRP	Human Research Program
IF	Industry Forum
IRP	Integrated Research Plan
ISS	International Space Station
HRR	Human Research Roadmap
JSC	Johnson Space Center
MIT	Massachusetts Institute of Technology
NASA	National Aeronautics and Space Administration
NIH	National Institutes of Health
NSBRI	National Space Biomedical Research Institute
STEM	Science, Technology, Engineering and Mathematics
TL	Team Leader

Executive Summary

The National Space Biomedical Research Institute (NSBRI) is the premier scientific institute in the United States that conducts integrated biomedical research to support the long-term human presence, development and exploration of space. NSBRI works in partnership with the National Aeronautics and Space Administration (NASA) and implements bold, focused and coordinated programs involving academia, industry and government. The emphasis is on developing countermeasures, technologies and other deliverables to reduce or mitigate risks inherent in human space exploration. NSBRI achievements and products advance its mission for space exploration and enhance life on Earth. The education and outreach efforts of the Institute are broad and inspire the next generation of scientists, engineers and space explorers. NSBRI is proud to have a unique enabling role in NASA's space exploration objectives and to serve as a valuable national resource in science, technology and education. The Institute supports approximately 60 projects involving more than 180 investigators at 70 institutions in 25 states.

This strategic plan sets forth goals for NSBRI over the next five years. Inevitably, there will be new opportunities and challenges as the United States moves forward with its next generation of vehicles, as other nations increase their prominence in human space exploration, and as new advances are made in science, technology and medicine. NSBRI has a strong track record of adapting to change and in leading new initiatives in high-priority areas.

The five strategic goals for 2010 through 2014 are to:

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

NSBRI is committed to achieving these goals and to furthering the Institute on behalf of NASA and all stakeholders. It will continue to work in innovative and collaborative ways, and build upon a legacy of excellence, discovery and leadership. The Institute accepts and will meet its responsibilities and is honored to help the nation sustain and enhance its prominence in biomedical research and human space exploration for many years to come.

Mission and Vision

The National Space Biomedical Research Institute is a unique, non-profit science institute established in 1997 by NASA through an open competition. It provides unprecedented capabilities and focused, outcome-driven research leading to the development of effective countermeasures to mitigate risks and help ensure safe, long-duration human exploration of space.

As a nationally and internationally acclaimed institute, NSBRI has been at the forefront of innovation in science, technology and education. NSBRI adds unique intellectual and institutional resources to NASA programs, including the agency's Human Research Program (HRP). The strong and productive partnership with NASA is managed through Cooperative Agreement NCC 9-58, awarded in four successive five-year increments based on performance. Both the Cooperative Agreement and associated Cooperative Agreement Management Plan are administered by Johnson Space Center (JSC).

Advances in science and technology made by NSBRI to support human space exploration have important applications to improve life on Earth. Additionally, the Institute prides itself in having robust education and outreach programs that inspire and train the next generation of scientists, engineers and space explorers. NSBRI's integrated and coordinated activities engage academic, government and industry sectors, and emphasize achievement through excellence. The Institute's operations are overseen by a consortium of academic institutions, led by Baylor College of Medicine (BCM) as the sole member of the 501(c)(3) corporation acting on behalf of the consortium.

NSBRI Consortium 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
University of Washington

NSBRI's Mission

To lead a national effort to conduct the integrated, critical path, biomedical research necessary to support long-term human presence, development and exploration of space, and to enhance life on Earth by applying the resulting advances in human knowledge and technology.

Vision for NSBRI

NSBRI will continue to be a world leader in translational space biomedical research, and is committed to achieving its mission using innovative science, technology, education and management strategies having high impact for all stakeholders. The Institute will remain focused on developing safe and effective countermeasures and technologies that substantially reduce significant biomedical risks associated with human space travel. These discoveries not only ensure crew health, but they also improve life on Earth.

By engaging a diverse, open community of outstanding scientists, engineers, clinicians and educators to work on peer-reviewed projects in integrated teams, and by using the resources available through leading institutions, NSBRI achieves its mission while inspiring the next generation of space life scientists. The Institute strives to be the focal point of, and a major resource for, NASA-sponsored space biomedical research and education in the United States. Through international cooperation and collaboration, NSBRI also aims to serve as a leading space biomedical institute among space-faring nations.

Going forward, the Institute will continue to embrace core values that have guided its maturation from inception. These values are:

- Achievement through excellence
- Teamwork and collaboration
- Integrity
- Leadership
- Service

Strategic Goals

Over the next five years, from 2010 through 2014, NSBRI will focus on five Strategic Goals.

NSBRI's Strategic Goals	
Strategic Goal 1	Lead a national biomedical research effort to support human space exploration.
Strategic Goal 2	Enhance life on Earth through advances made in space biomedical science and technology.
Strategic Goal 3	Provide a comprehensive education program in space biomedical science and technology.
Strategic Goal 4	Expand partnerships in space biomedical science, technology and education.
Strategic Goal 5	Broaden capabilities as a national science and education resource.

Strategic Goal 1

Lead a national biomedical research effort to support human space exploration

Since inception, NSBRI has cultivated its leadership role in biomedical research to support human space exploration. In 2005, the Institute underwent a comprehensive five-year review, chaired by the Deputy Assistant Secretary of Health, U.S. Department of Health and Human Services. The *2005 Review for the NASA Chief Scientist of NSBRI Progress, Status and Plans* concluded “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.”

Furthermore, “the Review Panel complimented NSBRI’s understanding of NASA’s shifting goals and objectives, and notes that they were responsive and supportive of the new United States *Vision for Space Exploration*.” The Review Panel also “thought that NSBRI team research support was a more flexible and effective funding mechanism, and that it effectively complemented other mechanisms used by NASA.”

Over the next five years, NSBRI will work with NASA and other stakeholders to secure and sustain an appropriate budget to support an integrated program of outstanding academic, government and private-sector investigators and resources in order to reduce health risks associated with long-duration human space missions. The Institute will maintain and refine its productive team approach to science and technology, and it will continue to emphasize deliverables, add value to NASA capabilities, and leverage the nation’s investment in biomedical research to advance human space exploration.

The sub-goals are to:

Sub-goal 1A – Sustain a national science and technology program aligned with NASA priorities.

Sub-goal 1B – Advance scientific knowledge and develop, test and evaluate countermeasures and technologies to mitigate high-priority biomedical risks associated with long-duration human space missions.

Sub-goal 1C – Enhance assessment of programmatic performance and foster successful outcomes.

Sub-goal 1D – Promote excellence in leadership across the Institute.

Sub-goal 1A – Sustain a national science and technology program aligned with NASA priorities

As an integral constituent of the nation's human space program, NSBRI will maintain close working relationships with NASA's HRP, Space Life Sciences Directorate, Exploration Systems Mission Directorate and other pertinent entities, to achieve the Institute's mission. NSBRI will continue to assist NASA in assessing and updating evidence associated with biomedical risks related to human space missions, including those aboard the International Space Station (ISS) and those pertaining to exploration. The Institute will also continue to support the development, revision and implementation of NASA requirements and the HRP Integrated Research Plan (IRP) and Human Research Roadmap (HRR), which delineate and track biomedical risks and gaps.

NSBRI and NASA will retain and enhance coordination of complementary programs through multiple forums, including the joint NSBRI/NASA Steering Committee, which meets regularly and consists of senior management, co-chaired by the NSBRI Director. Throughout NSBRI, scientists, engineers, clinicians and managers will coordinate their efforts with NASA counterparts. The offices of the NSBRI Director and NSBRI Associate Director will maintain their critical roles at the NSBRI/NASA interface, to ensure that the Institute's science and technology portfolio is appropriately diversified and aligned with NASA's IRP and HRR. NSBRI and NASA will continue to collaborate on ground-based opportunities, use of analog environments and essential, albeit limited, flight opportunities.

In 2007, NSBRI revised its *Policy on Team Leadership*, and emphasized the important responsibility of Team Leaders (TLs) in interacting with NASA science leadership in their corresponding disciplines. The Institute will expand and support team leadership in their work to promote productive scientific exchanges, project and team alignment, and favorable outcomes.

A cornerstone of NSBRI's science and technology program, and its accompanying national stature, will continue to be openly solicited, peer-reviewed research that attracts outstanding investigators who compete for NSBRI awards. Opportunities to participate in NSBRI programs will remain open to all eligible U.S. academic institutions, including consortium and non-consortium institutions, as well as government laboratories and commercial entities.

Over the next five years, the Institute will build on its solid foundation of conducting top-tier, peer-reviewed, translational biomedical research for space using a model that integrates aspects of the extramural research programs at the National Institutes of Health (NIH) and the Department of Defense. NSBRI will continue to emphasize investigator-initiated projects, with mechanisms to support program projects, individual multi-year grants and small, directed awards.

In developing and implementing targeted research solicitations, NSBRI will work closely with NASA, as well as with the NSBRI External Advisory Council (EAC) and NSBRI User Panel. The EAC is comprised of leading scientists who advise the Institute on strategic and tactical matters, and make specific recommendations regarding programmatic content. The User Panel,

consisting primarily of current and former astronauts and flight surgeons, provides advice on the operational needs and feasibility of emerging countermeasures and technologies.

NSBRI will maintain scientific rigor and integrity in peer review of proposals received by the Institute. The process will be facilitated by an independent NSBRI Board of Scientific Counselors (BSC) and by a third-party expert contractor in national peer-review services. Selection of proposals, following peer review, will be coordinated with the HRP Manager. Once awarded, NSBRI projects will be assigned to a science and technology team. Progress, challenges and opportunities will be carefully monitored to foster successful outcomes. The ongoing status of the science and technology program, and other programs, will be reported to the NSBRI Board of Directors and to NASA, in accord with requirements of the Cooperative Agreement and good oversight practices.

Between 2010 and 2012, NSBRI will:

- Increase coordination in implementing recommendations from the EAC and User Panel, and foster interactions between these two groups and the TLs.
- Rotate membership on the BSC and recruit new members who have scientific stature comparable to NIH peer-review panel chairs.

Between 2010 and 2014, NSBRI will:

- Release an annual solicitation for proposals targeting high-priority areas of research in space biomedical science and technology. Solicitations will be done jointly with NASA, whenever possible, and proposals selected for funding will typically be funded for three-to-four years.
- Maintain a balanced portfolio of projects with ongoing assessment of progress and performance.
- Continue to emphasize merit, programmatic relevance and cost in filling gaps in the science and technology portfolio to the benefit of the U.S. human space program.

Sub-goal 1B – Advance scientific knowledge and develop, test and evaluate countermeasures and technologies to mitigate high-priority biomedical risks associated with long-duration human space missions

NSBRI supports approximately 60 projects involving more than 180 investigators at 70 institutions in 25 states. Approximately 55 of these projects are in the science and technology program and are assigned to one of seven integrated teams addressing high-priority risk areas. Each science and technology team carries out a focused research program that coordinates individual projects tied closely together by a team strategic plan. Team members, including TLs, are geographically dispersed at their own and other institutions, and utilize the diverse resources that those institutions offer. Additionally, team members have access to resources afforded by NSBRI and NASA to advance their projects and to engage in collaborations within and between teams, and with NASA end users, such as engineers, flight surgeons and astronauts.

NSBRI's science and technology program is organized into the following seven integrated 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

Over the next five years, projects on the teams will contribute important scientific knowledge and be part of a product pipeline of countermeasures and enabling technologies that spans research, development, testing, evaluation and operational integration. NSBRI will serve as a focus of space biomedical research that leverages the infrastructure of U.S. academic institutions and laboratories. Furthermore, it will foster a pathway for science and technology utilization of the unique and important capabilities of the ISS.

An established goal is that each team will deliver, by 2014, at least three countermeasures, technologies or information related to flight rules for human space exploration aligned with NASA's IRP and HRR for the HRP. In accord with recommendations from the *2005 Review for the NASA Chief Scientist of NSBRI Progress, Status and Plans*, NSBRI will continue to:

- Work with NASA to more effectively utilize the scientific expertise present across NSBRI teams and in other parts of the scientific community.
- Encourage and facilitate the addition of applied experts to its teams to maximize the ability to transfer research findings to the operational world.
- Engage with NASA and other entities to attain access to ground-based analogs and flight opportunities in order to enable the development and testing of countermeasures:
 - Analogs include bed rest, the NASA Extreme Environment Mission Operations habitat, the Haughton-Mars Project Research Station, the Desert Research and

Technology Studies environment, the isolation habitat at the Institute for Biomedical Problems, Antarctica and parabolic flights;

- Flight opportunities include the shuttle, ISS, Department of Defense flights, free flyers and commercial flights.
- Work with NASA to support ground-based and flight opportunities for animal, cell and tissue models related to developing and testing new countermeasures.

Moreover, the Institute will add value to its science and technology program by integrating projects, working with TLs, the EAC, the User Panel, NASA, strategic partners and others to refine team efforts and enhance success toward deliverables. An important facet is to maintain a diversified portfolio of projects, with respect to the risk areas addressed, team composition and the laddering of projects at various levels of countermeasure and technology readiness. A summary of team strategic plans follows.

Cardiovascular Alterations Team

The Cardiovascular Alterations Team determines the effects of long-duration spaceflight on the heart and blood vessels and designs novel therapies to combat prolonged deconditioning. For 2010-2014, the team plans to:

- Determine whether long-duration spaceflight leads to clinically and physiologically significant changes in cardiac and vascular structure and function.
- Determine whether long-duration spaceflight causes a documented risk for developing cardiac arrhythmias.
- Establish effective countermeasures to cardiovascular deconditioning in order to maintain cardiac structure and function, and to allow preservation of thermoregulatory capacity sufficient to meet mission work demands.
- Determine, using animal models, whether the radiation exposure during long-duration spaceflight will injure coronary endothelium and accelerate atherosclerosis.
- Determine the optimal strategy of cardiovascular screening and training to reduce the risk of flying astronauts with pre-existing, but subclinical, cardiovascular diseases that could become manifest during a prolonged exploration-class mission.

Human Factors and Performance Team

The Human Factors and Performance Team improves daily living and keeps crew members healthy, nourished, productive and safe. This is achieved by supporting standards to prevent risks to performance and health, and by developing countermeasures to reduce performance errors and mitigate habitability, environmental and other behavioral factors that pose significant risks to mission success. Over the period 2010-2014, the team will:

- Reduce the risks associated with sub-optimal, human-centered design and integration, including issues of habitability, information presentation and task design.
- Reduce the risks associated with sleep loss, circadian desynchronization, fatigue and workload by characterizing, quantifying and modeling the effects of spaceflight and other mission schedules on sleep and circadian rhythms of both ground and space/lunar crews.

- Reduce the risk of inadequate nutrition and inefficiencies in the food system.
- Measure, assess and monitor alterations in, and reduce the risks to, health and performance associated with behavioral and environmental factors.
- Support development of the NASA Space Flight Health Standards for Human Performance.
- Participate in isolation studies and other analog or operational environments to simulate long-duration space missions.

Musculoskeletal Alterations Team

The Musculoskeletal Alterations Team addresses bone loss and the inherent fracture risks, as well as loss of skeletal muscle mass, strength and endurance during spaceflight. The overarching team goals are to better understand the effects of microgravity and partial gravity on the physiology of musculoskeletal tissues and to develop exercise-based and pharmacologic countermeasures to reduce the risk of musculoskeletal injury through mitigating bone and muscle loss. Over the next five years, the team will:

- Perform mechanistic studies in animal models to determine the effect of simulated lunar gravity and microgravity on musculoskeletal tissue physiology, including the inter-related processes of bone loss, muscle atrophy, radiation effects, drug effects and healing of bone fractures.
- Perform integrated human studies addressing bone, muscle and associated system effects of prolonged exposure to reduced gravity, changes in gravity, and the requirements for countermeasures.
- Develop hardware to monitor the loads applied to bone during missions, and improve the efficiency and efficacy of exercise countermeasures by integrating multiple exercise modalities into a unified compact exercise machine or platform.
- Develop pharmaceutical countermeasures to mitigate the negative effects of microgravity and/or space radiation on the musculoskeletal system.

Neurobehavioral and Psychosocial Factors Team

The Neurobehavioral and Psychosocial Factors Team investigates methods and tools that can be used to enable crews to cope with stress, isolation and crew performance in space. During the period 2010-2014, the team will:

- Identify and mitigate risks of stress, anxiety and depression in spaceflight through new tools to monitor mood and predict the risk for, and management of, behavioral and psychiatric conditions prior, during and following spaceflight.
- Mitigate risks of interpersonal conflict, ineffective communication and poor group cohesion through the development of tools, training and methods to maintain performance and mission success.
- Mitigate risks of cognitive performance deficits in space by development of techniques to prevent, detect and counter deficits due to radiation and fatigue in space.

- Perform research necessary to enable development and validation of Fitness for Duty Behavioral Health and Cognition standards.
- Participate in isolation analog studies that address crew, mission control and time delay factors associated with long-duration exploration missions.

Radiation Effects Team

The Radiation Effects Team determines the risks and deleterious effects of simulated space radiation on biological systems. The emphasis is on acute effects and mitigation strategies through countermeasure development. In 2008, NSBRI openly competed, awarded and established a Center of Acute Radiation Research (CARR) to address these priorities and provide a national center of excellence in space radiation research and countermeasures. The CARR complements other NASA and NSBRI scientific investigations in radiation, including the development of real-time, portable dosimetry for human space exploration. Over the next five years, the team will:

- Contribute to an understanding of the mechanisms and pathways of space radiation effects on cells, tissues and complex biological systems.
- Define health risks from acute radiation exposures such as solar particle events.
- Develop technologies for characterizing and monitoring the radiation environment and exposure.
- Develop, test and evaluate radiation dosimeters that provide real-time assessment of risk, and are small enough to fit in a spacesuit, toolbox or lunar extravehicular activity backpack.
- Investigate medical countermeasures, such as dietary supplements and drugs, to combat acute radiation syndromes that may be associated with space exploration beyond low-Earth orbit.

Sensorimotor Adaptation Team

The Sensorimotor Adaptation Team addresses the role of sensorimotor disturbances that occur during and after spaceflight on vehicle control and other operational task performance issues. The team also develops pre- and in-flight training countermeasures to help astronauts adjust more rapidly to microgravity and other gravitational environments, while motivating new technologies to improve display and control during vehicle and extravehicular activity operations. During 2010-2014, the team will:

- Assess how changes in manual and visual function impact the ability to control vehicles.
- Develop sensorimotor training programs to facilitate adaptation to changes in gravitational environments and examine retention properties of the training.
- Develop methods for simulating landing disorientation, and train crews to fly through them.
- Understand how sensorimotor alterations contribute to impaired crew exploration vehicle functional egress on land or water rafts after long-duration spaceflight.

- Develop improved field tests to assess early alterations in gaze, posture and locomotor performance that predict decrement in functional performance related to current and future operational activities and technologies.

Smart Medical Systems and Technology Team

The Smart Medical Systems and Technology Team designs new methods of remote medical monitoring, diagnosis and treatment. The team also develops small, low-power and noninvasive instrumentation for medical care during human space exploration. Throughout 2010-2014, the team will:

- Develop sensors and data systems for in-flight health monitoring and early detection of medical problems during space travel, extravehicular activities and planetary surface operations.
- Develop, test and evaluate integrated medical care systems for diagnosis and treatment of illness and trauma in the space environment.
- Provide novel training tools and onboard intelligence systems to help crews address medical issues when contact with the Earth is limited or delayed.
- Utilize analogs, ISS and other resources, to build upon and apply rapid advances in biomedical research on Earth, in order to advance medical capabilities for space exploration.

Sub-goal 1C – Enhance assessment of programmatic performance and foster successful outcomes

The NSBRI Executive Science and Medicine Council (ESMC) oversees the Institute's science, technology and education portfolios. ESMC works with investigators, TLs and NASA to coordinate and integrate programs, increase efficiency and productivity, and add strength to the Institute's partnership and end-user relationship with NASA. The Council is primarily composed of personnel from the offices of the NSBRI Director and NSBRI Associate Director.

The Council maintains an up-to-date and integrated matrix of all NSBRI projects and programs. The matrix tracks standard information concerning cost, schedule and performance, as well as mappings for each project to NSBRI team(s), HRP element(s), risk area(s), deliverables, spin-offs and other pertinent data related to progress and integration with the IRP and HRR. Each project is assessed regarding its maturation using agreed upon NASA/NSBRI countermeasure and technology readiness metrics. Operational need and feasibility also are evaluated, along with scientific productivity (e.g., peer-reviewed publications in leading scholarly journals), advanced technology demonstrations, invention disclosures, patents, commercial partnering, leveraging and other measures.

Going forward, NSBRI will maintain and build upon its processes to review and provide formal feedback on project and team reports submitted by principal investigators and TLs, respectively. The reports, as well as critical assessments by NSBRI management and advisory groups, NASA and other entities will aim at fostering successful outcomes from the NSBRI portfolio of projects.

Throughout 2010-2014, NSBRI will:

- Work with NASA to better communicate progress and ensure delivery of high-quality products that meet NASA's needs and timeline.
- Collaborate with NASA HRP to:
 - Update the knowledge base relevant to biomedical responses of humans in space;
 - Understand and quantify risk levels associated with this knowledge base;
 - Recommend acceptable risk levels for long-duration missions;
 - Increase data sharing; and,
 - Transition promising countermeasures and technologies from bench to analog to flight.
- Support NASA HRP in keeping the IRP and HRR current, given that the IRP and HRR adjust in response to progress made in reducing biomedical risks.
- Promote data sharing of evidence-based space medicine, the operations environment, engineering and human factors requirements, training, clinical care and the effectiveness of countermeasures.

In early fiscal year 2011, an external comprehensive review of NSBRI progress, status and plans will be conducted for the NASA Chief Scientist (or other authority). This review is a requirement of NCC 9-58 and will assist NASA in determining whether or not NSBRI will receive a fourth five-year increment of support under its Cooperative Agreement for the period 2013-2017.

Sub-goal 1D – Promote excellence in leadership across the Institute

NSBRI recognizes and values the importance of leadership, diversity and integrity at all levels of the Institute. Over the next five years, NSBRI will maintain its emphasis on strong, visionary and diverse leadership. NSBRI will manage the Institute using a corporate model with strong scientific and medical representation in key leadership positions. It will balance continuity of membership, and the need to rotate individuals to gain new perspectives, on its distinguished Board of Directors, BSC, EAC, User Panel and other groups and committees.

The Institute will also maintain efforts and resources to support strong leadership of its teams. In 2011-2012, all team leadership positions will be re-competed through an open solicitation. This process occurs every four years, with the last team leadership re-competition occurring in 2007-2008.

Within its management and staff, NSBRI will build upon currently supported opportunities for professional development to ensure that employees stay at the forefront of their fields of expertise.

Strategic Goal 2

Enhance life on Earth through advances made in space biomedical science and technology

An important component of NSBRI's mission is to improve life on Earth by transferring the knowledge gained, and the discoveries and technologies developed, to reduce risks inherent in human space exploration. As a translational research institute, NSBRI projects focus on deliverables for the space program that may also have commercial, military, medical or homeland security use. The NSBRI investigator cohort includes leading scientists, physicians and engineers whose research extends beyond spaceflight into many areas of medicine and biomedical science. The Institute is therefore well positioned to foster applications to improve health on Earth, through advances made by its science and technology teams, as well as translate discoveries for commercialization.

The sub-goals are:

Sub-goal 2A - Improve health on Earth.

Sub-goal 2B - Translate discoveries for commercialization.

Sub-goal 2A - Improve health on Earth

Over the next five years, each of the science and technology teams will perform research, development, testing and evaluation of countermeasures and technologies for human space exploration. Advances will be made that also have applications to address or solve problems on Earth. A goal is to deliver, by 2014, at least two significant new applications to improve health on Earth on each of the seven NSBRI science and technology teams.

Cardiovascular Alterations Team

Terrestrial applications will include enhanced understanding of cardiac risks, development of new tests for heart-rhythm disturbances, cardiac conditioning programs for patients affected by long periods of bed rest or physical inactivity, and measures to prevent or reduce cardiovascular damage from terrestrial radiation sources.

Human Factors and Performance Team

Earth-based benefits will consist of new monitoring, testing and treatment methods for people affected by sleep disorders and circadian rhythm disruptions. Studies of lighting for the next generation of space vehicles and habitats will translate into better options for people who are chronically exposed to poor artificial lighting. Nutrition and physical fitness countermeasures will potentially benefit burn victims, elderly and bedridden individuals, and cancer patients. Research on environmental exposure to particulate matter in space environments will have relevance to those exposed to terrestrial contaminants. Mathematical modeling of circadian rhythms, sleep, performance and alertness will allow the design of work schedules and countermeasures for times when work must occur despite adverse circadian phase and extended work durations. This research is relevant for individuals who work rotating, shift or extended schedules, such as those in security, transportation, military, industrial and healthcare occupations.

Musculoskeletal Alterations Team

Benefits to life on Earth will include the development of exercise equipment and other approaches that reduce the risk of bone fractures in the elderly and other individuals. This will be achieved by reducing bone loss, improving bone strength, reducing fall risk, preserving mobility and improving muscle strength and neuromuscular performance. Other investigations will include characterization of novel pharmacologic treatments that could potentially combat bone atrophy and muscle wasting associated with aging, cancer, HIV and other debilitating and chronic illnesses.

Neurobehavioral and Psychosocial Factors Team

Applications on Earth will include development of technologies that can unobtrusively detect cognitive performance deficits, stress, fatigue and mood shifts, and can be deployed in adverse conditions and high-risk situations. Individualized, computer-based detection and treatments for stress, anxiety, depression and conflict resolution will also have potential for use in remote or

isolated environments. The advances will provide cost-effective access to behavioral management to millions of people who cannot otherwise afford treatment.

Radiation Effects Team

By improving scientific understanding of the mechanisms involved in the acute effects of radiation exposure, and by investigating pharmacological and other countermeasures to mitigate risks, NSBRI studies will potentially benefit cancer patients subjected to radiation therapy and persons exposed to occupational hazards. Other relevant groups will include those exposed to higher-than-normal radiation levels. Advances in radiation dosimetry for space will have applications for medicine, environmental monitoring, the military and homeland security.

Sensorimotor Adaptation Team

Dizziness and balance problems affect 90 million Americans, particularly the elderly. Training and sensory-feedback systems developed by NSBRI will have potential benefits to this population and to rehabilitation regimens.

Smart Medical Systems and Technology Team

Benefits in medical care on Earth will include enhanced technologies for noninvasive, portable monitoring of blood and tissue chemistry, metabolic assessment and integrated sensor-effector devices using ultrasound. These applications will have relevance to trauma management and disorders affecting the cardiovascular, bone, renal and other systems. Medical devices, therapies and training techniques for telemedicine in space will be relevant to trauma in the field, emergency care in major centers, remote populations and the battlefield.

Sub-goal 2B - Translate discoveries for commercialization

NSBRI recognizes the importance of working with NASA and other federal entities, academic institutions and industry to advance NSBRI-sponsored research and development products toward commercialization and public use. The Institute encourages investigators and TLs to apply discoveries and enhance life on Earth. NSBRI has an Industry Forum (IF; see Sub-goal 4B) as a resource to support the translation of scientific and technological advances.

When a company is the sole recipient of an NSBRI award, the associated intellectual property resides within the commercial sector from the start. More frequently, awards are made to academic institutions, which license the intellectual property, arising from university-based NSBRI research, to industry. In some instances, complex arrangements exist when awards are made to recipients with more than one academic, commercial or government component.

Over the next five years, NSBRI will:

- Increase efforts to address opportunities and challenges in commercializing NSBRI-sponsored discoveries through workshops and a Small Business Development Program.
- Expand the NSBRI IF as a resource to the NSBRI community.
- Seek matching funds from industry to accelerate promising discoveries toward maturation and commercialization.

Strategic Goal 3

Provide a comprehensive education program in space biomedical science and technology

Training students and teachers in space biomedical science and technology supports the nation's education efforts and legislation aimed at ensuring America's competitiveness in science, technology, engineering and mathematics (STEM). NSBRI develops and implements successful programs that meet national standards, attract and retain students in STEM disciplines, and contribute to the STEM workforce. The Institute also enhances its public outreach activities to educate and engage the community in NSBRI's mission.

Over the next five years, NSBRI will expand the breadth of its programs to provide a continuum of educational opportunities spanning elementary, middle and high school, undergraduate and graduate education, summer internships, postdoctoral fellowships, career development awards, continuing medical education, and other activities, such as conferences and workshops. The Institute will also offer multiple pathways for training. For instance, a postdoctoral fellow in a STEM discipline may be supported as part of an NSBRI science and technology project, or may receive a separate NSBRI postdoctoral fellowship.

NSBRI's strong and diverse academic constituency functions as the cornerstone of its unparalleled education and outreach programs in space biomedical science and technology. NSBRI will continue to assist NASA in its educational objectives and maintain its emphasis on metrics and outcomes to assess the impact of its programs. Programmatic excellence, innovation and seamless coordination among all education and outreach components remain key principles, as NSBRI builds on its education and outreach efforts, which were recognized by a 2007 Stellar Award from the Rotary National Award for Space Achievement Foundation. The citation acknowledged NSBRI's "performance as a nationally recognized, top-tier program that is pioneering new models for exemplary teaching, training and public outreach in support of the Vision for Space Exploration."

The sub-goals are:

Sub-goal 3A – Educate the next generation of space biomedical scientists, engineers and physicians.

Sub-goal 3B – Translate and transfer knowledge about space biomedical research to the scientific community, general public and other stakeholders.

Sub-goal 3A – Educate the next generation of space biomedical scientists, engineers and physicians

Elementary and Secondary School (K-12) Education

In accord with the U.S. Department of Education, NASA, the National Science Foundation and other agencies that offer STEM-related programs, NSBRI recognizes the importance of addressing the needs of K-12 students and teachers. NSBRI promotes educational access, curricula and career awareness in space life sciences among the K-12 population. There is a commitment to ensure access across varied communities, so that all children can be inspired by journeys into space and learn about human space exploration.

The Institute will further its work to strengthen middle and high school teachers' knowledge base and skills to incorporate space life sciences content into their classroom instruction. Resources will include hardcopy and Web-based curricular materials developed and disseminated by the Institute. Hundreds of teachers each year will participate in focused professional development experiences delivered by NSBRI. These workshops will reach diverse participants across educational levels and provide opportunities for interactions with professionals in various fields.

Within the next two years, NSBRI plans the following initiatives for its K-12 Program:

- Generate and disseminate new classroom materials and resources.
- Produce and deploy Internet presentations through the BioEd Online website.
- Establish collaborative activities with Challenger Learning Centers and other national programs.
- Advance NSBRI's mission at national and international meetings.

Over the next five years, NSBRI will expand its K-12 efforts, including its partnerships with leading scientific and educational organizations, with the goal of coordinating national and international efforts and increasing the impact of space life sciences education. By 2014, NSBRI will achieve the following objectives:

- Develop and implement collaborative activities for students to participate in biomedical science experiments performed in space.
- Offer research experiences for teachers to translate in-depth science knowledge and transfer it to their classrooms.
- Enrich partnerships and solidify NSBRI's unique role in supporting STEM education nationally.

Undergraduate and Graduate Education

To spark student interest in STEM disciplines related to space biomedical science and engineering, and to provide educational opportunities and enhance university curricula, NSBRI coordinates a number of undergraduate and graduate programs. These include a Summer

Internship Program conducted annually in collaboration with NASA. Undergraduate and graduate students, as well as engineering and health professions students, compete for three-month placements at JSC. In 2009, NSBRI and NASA expanded this highly competitive program to include placements at multiple NASA Centers, thereby reflecting the true national scope of the program. The Institute will continue to support this popular program going forward.

NSBRI remains strongly committed to strengthening the pipeline for women and minority group students entering medicine and biomedical research careers. For the past decade, NSBRI has partnered with Morehouse School of Medicine to offer summer internships that further the interest among and preparation of science and medical students from underserved communities to pursue careers in space life sciences, and to deepen these students' research skills. This important summer research program for minority students will also continue.

In 2010, NSBRI will introduce a Space Biomedical Engineering Apprenticeship Program for promising engineering undergraduates. This program will place students in NSBRI IF companies for hands-on experiences in STEM disciplines. The program will have didactic and practical components and be supported by the IF.

NSBRI openly solicited a Graduate Education Program in Space Life Sciences and made a joint award in 2006 to Texas A&M University and the Harvard/MIT Division of Health Sciences and Technology at the Massachusetts Institute of Technology (MIT). This multi-faceted program includes the design and implementation of modules that expand graduate curricula at these two institutions. Students take advanced courses in biomedical science and engineering, specifically as these fields relate to human space exploration. Training also includes a summer enrichment program at BCM and JSC.

Within five years, the Graduate Education Program in Space Life Sciences will achieve the following milestones:

- Complete and integrate modules within existing accredited programs at Texas A&M University and MIT, leading to a doctorate degree in an established discipline, with approved sub-specialization in Space Life Sciences or equivalent designation.
- Make completed course modules and other resources readily adaptable to other institutions and available for wide dissemination.
- Encourage students from Texas A&M, MIT and other institutions to participate in the program.
- Support and foster appropriate faculty supervision to ensure program success, including student and faculty exchanges, student retention and completion of graduate education.

Postdoctoral Fellowship Program

Recognizing the importance of postdoctoral fellows in ensuring America's academic prominence, NSBRI supports an innovative and highly competitive Postdoctoral Fellowship Program. The two-year fellowships allow young scientists from across the nation to conduct mentored, peer-reviewed research projects related to space. Fellows become part of at least one

NSBRI science and technology team, participate in NSBRI meetings, and attend a special Summer Institute at NSBRI and JSC. Fellows who complete the program garner significant recognition and typically accept positions at prestigious universities or research institutes.

Commencing in 2010, the Postdoctoral Fellowship Program will:

- Provide an optional third year of support, based on performance and need.
- Create more opportunities for program graduates to maintain active involvement with NSBRI.

NSBRI will also leverage and pursue appropriate collaborations to expand the program with matching funds and new training experiences. A goal is to increase the number of fellowships by 50% by 2012.

Career Development Program

In 2008, NSBRI established a Career Development Program to foster the professional training of exceptional young scientists, engineers and physicians who have an advanced degree and are pursuing careers in space life sciences research or space medicine. The program provides research opportunities and seed funding at a critical stage of career development, typically following a postdoctoral fellowship and prior to receipt of a first major grant as an independent investigator. This program fills a strategic gap in NSBRI's comprehensive education portfolio.

From 2010 to 2014, NSBRI will:

- Continue to provide career development opportunities for promising young scientists, engineers and physicians who have completed their advanced degree(s) and are establishing themselves as young investigators.
- Support a Space Medicine Clinical Research Training Program, providing research training opportunities for aerospace medicine residents early in their careers. This will be done cooperatively with NASA and will augment current training of the next generation of flight surgeons, with the aim of maintaining U.S. prominence in clinical space medicine.

Sub-goal 3B – Translate and transfer knowledge about space biomedical research to the scientific community, general public and other stakeholders

NSBRI is committed to communicating information to further an understanding of NSBRI's programs, activities and plans to advance its mission. The Institute's Communication and Outreach group, and others throughout the Institute, inform key constituents, partners, stakeholders, the research community at large and the public about NSBRI progress, achievements, initiatives, programmatic changes and opportunities for funding. NSBRI also provides lectures on a broad range of scientific and technical topics related to human spaceflight. Furthermore, senior leadership gives testimony before Congress, as requested.

Going forward, increased use of targeted news distribution lists will allow NSBRI to tailor the recipients reached for each news release based on the release topic. The adoption of social media tools, such as Facebook, social bookmarking and podcasts, will allow NSBRI to reach a growing audience that is using these Internet and mobile-based tools for sharing and discussing information.

Commencing in 2010, NSBRI will expand its communication efforts through a revised website (www.nsbri.org). There will be references to publications and evidence-based information in space biomedical science and technology, as well as a portal to enhanced educational materials. Distinguished members of the NSBRI community will continue to deliver prominent academic lectures, which will be readily available by podcast and other means. NSBRI will enhance its presence on expert science, medical and education panels, and will increase its participation in scholarly activities that convey new knowledge about biomedical research and human exploration of space.

Through community and public outreach, the Institute will maintain, and strive to enhance, its strong position in advancing scientific literacy. NSBRI will seek to instill, within a broad audience, an appreciation for its science, technology and education programs, and the ways research conducted for human space exploration can help improve life on Earth. This will be accomplished through formal presentations, media relations, exhibits, direct mailings, the Internet, informal science activities and other information venues.

Strategic Goal 4

Expand partnerships in space biomedical science, technology and education

NSBRI maintains strategic relationships with a wide variety of academic, government, corporate and international organizations to add value and to magnify the scope and effectiveness of its contributions for NASA and other stakeholders. Over the next five years, the Institute will expand its network of strategic partners, increase utilization of its IF and create an NSBRI Consolidated Research Facility (CRF) with reconfigurable laboratories as a resource for the NSBRI community.

The sub-goals are:

Sub-goal 4A – Broaden the network of strategic relationships in space biomedicine within the U.S. and abroad.

Sub-goal 4B - Increase the scope and utilization of the Industry Forum.

Sub-goal 4C - Create a Consolidated Research Facility in partnership with BCM and other consortium institutions.

Sub-goal 4A – Broaden the network of strategic relationships in space biomedicine within the U.S. and abroad

In addition to its collaborative network among consortium and other institutions, and its cooperative agreement and strong partnership with NASA, NSBRI has memoranda of understanding and agreements with a variety of national and international entities. These include, but are not limited to, the U.S. Naval Academy, National Institute of Allergy and Infectious Diseases, Mars Institute, Loma Linda University Medical Center, Wyle Laboratories Life Sciences Group, Zero Gravity Corporation, Space Services Inc., Excalibur Almaz Ltd., Institute for Biomedical Problems of the Russian Academy of Sciences, DLR German Aerospace Center and the Operational Space Medicine and Life and Physical Sciences Directorates of the Canadian Space Agency.

Between 2010 and 2014, NSBRI will foster and expand partnerships with:

- BCM, other NSBRI consortium institutions and entities within the Texas Medical Center to facilitate the development of a CRF (see Sub-goal 4C).
- U.S. civilian aerospace medicine residency programs to promote integration of research and clinical training for the next generation of flight surgeons for space (see Sub-goal 3A).
- Major international institutes with emerging or established programs in space biomedicine, utilizing a cooperative model among institutions on an international scale similar to the approach NSBRI has cultivated nationally.
- U.S. and international institutions to promote student exchanges within the broad space community globally.

Sub-goal 4B - Increase the scope and utilization of the Industry Forum

Participation by industry in NSBRI programs is critical to conducting biomedical research necessary to support the long-term human presence, development and exploration of space. Industry involvement also facilitates NSBRI project maturation toward commercialization and the enhancement of life on Earth (Sub-goal 2B). The Institute has encouraged commercial participation to derive benefits from academic, government and industry collaborations.

Companies on the Institute's IF initially served to advise NSBRI on commercialization. The role of industry in NSBRI has expanded beyond this advisory capacity to include companies as recipients of peer-reviewed grants, partners and consultants on awards made to academic institutions, and donors to NSBRI programs in science, technology and education. Between one-third and one-half of NSBRI projects have commercial participation.

Over the next two years, NSBRI will reorganize and reconstitute its IF to reflect the broadened scope and participation of the commercial sector in Institute programs. Core industries of the IF, using the North American Industry Classification System, will include representation from:

- Aerospace Product and Parts Manufacturing
- Architectural, Engineering and Related Services
- Computer Systems Design and Related Services
- Electric Lighting Equipment Manufacturing
- Medical Equipment and Supplies Manufacturing
- Navigational, Measuring, Electromedical, and Control Instruments Manufacturing
- Pharmaceutical and Medicine Manufacturing
- Scientific Research and Development Services
- Semiconductor and Other Electronic Component Manufacturing

NSBRI will also develop partnerships with emerging commercial spaceflight entities, given their potential to provide suborbital and orbital flight opportunities to conduct science, transport science and technology resources to and from the ISS, and yield access to health risk data on commercial spaceflight passengers.

The Institute will continue to sponsor commercialization workshops bringing together university-based technology transfer personnel, NSBRI investigators and industry representatives, including IF members.

By 2012, and onward through 2014, NSBRI will:

- Possess a vibrant IF that:
 - Reflects the scope of NSBRI activities;
 - Forms a network of companies that are well informed about NSBRI projects and the development pipeline; and,
 - Assists the Institute in ways that are mutually beneficial to NSBRI and the IF companies.

- Create opportunities for the IF to support or match funding for select programs, such as the Space Biomedical Engineering Apprenticeship Program (see Sub-goal 3A).
- Work with industry to establish a Small Business Development Program focused on commercializing NSBRI-supported products.

Sub-goal 4C - Create a Consolidated Research Facility in partnership with BCM and other consortium institutions

Over the past decade, NSBRI has functioned as a virtual institute, bringing added value and demonstrable achievements to NASA's science, technology and education capabilities. To increase the return on NASA's investment in NSBRI, and to augment the Institute's ability to develop high-priority, operationally-relevant countermeasures, NSBRI plans to create a CRF consisting of reconfigurable laboratories for science and education, as well as space for NSBRI's administrative headquarters. The facility will be located in the Texas Medical Center area, in close geographical proximity to BCM, Rice University, other academic institutions and JSC.

The CRF will operate as a core resource for institutions receiving NSBRI support. It will be designed for demonstrating, testing, evaluating, accelerating and integrating countermeasures and technologies being developed by NSBRI investigators at their home institutions. The facility will operate in partnership with the Center for Space Medicine at BCM and will provide added visibility and functionality to NSBRI by having a prominent physical presence in a major academic medical center. It will (a) bring together the research, education and administrative components of NSBRI; (b) increase NSBRI product maturation and integration with HRP and other NASA programs; (c) provide an additional venue for collaborations between the academic biomedical community and NASA; and (d) focus on biomedical innovation consistent with NSBRI's mission to mitigate risks to human health in space and enhance life on Earth.

NSBRI will work with BCM, Rice University, NASA and other institutions to establish a CRF by 2011. The facility will be fully operational by 2014 and will favorably position the Institute for future activities to the benefit of all of its stakeholders.

Strategic Goal 5

Broaden capabilities as a national science and education resource

NSBRI has matured into a national leader in translational biomedical research and education for space, as originally envisioned by NASA. In several areas, NSBRI has exceeded expectations. Repeatedly, NSBRI is held as a model of how to conduct cost-efficient, responsible and productive translational research across multiple academic institutions, both nationally and internationally.

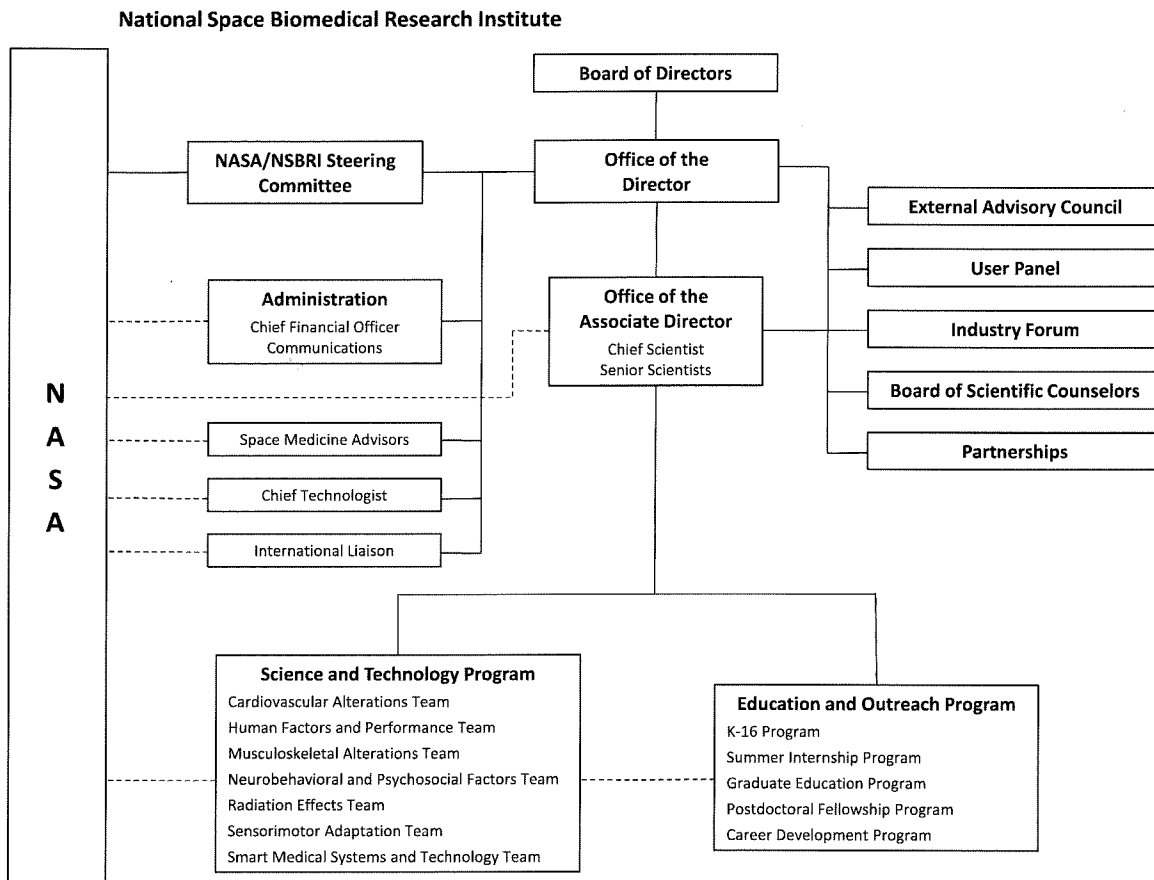
The next five-year period, spanning 2010-2014, corresponds to years 13 through 17 of NASA's 20-year cooperative agreement, NCC 9-58, with NSBRI. The depth, breadth and coordinated efforts of the NSBRI community, and the utilization of outstanding resources, remain strong. NSBRI's lean and efficient management structure (see figure) allows the Institute to adapt to and be in compliance with changing NASA priorities and requirements.

As NASA further integrates NSBRI into its strategic planning, as recommended in the *2005 Review for the NASA Chief Scientist of NSBRI Progress, Status and Plans*, the Institute will work with the agency to determine ways NSBRI can best serve as a national resource for HRP and other aspects of the U.S. human space program. This will broaden the capabilities of the Institute within the scope of its mission. Particular attention will be paid to NASA's intent, as stated in *Cooperative Agreement Notice 9-CAN-96-01*, to transfer responsibility for appropriate ISS human experiment opportunities to the Institute. Designation of the U.S. segment of the ISS as a National Laboratory, as specified in Section 507 of the NASA Authorization Act of 2005 (Public Law 109-155), underscores the importance of ISS as a facility for research and a means to enable exploration.

Over the next five years, NSBRI will transition a subset of its science and technology projects to the unique environment of the ISS. The ISS is an invaluable resource and affords an unprecedented opportunity for the United States and international partners to conduct scientific research, develop and demonstrate innovative technologies, test and evaluate procedures, protocols and products, and operationally integrate hardware, software and other components to advance space exploration goals. NSBRI is well positioned to not only support productive utilization, but by 2014, to have a prominent role in U.S. biomedical science for ISS.

To further capitalize on NSBRI's success, and to sustain and grow its efforts into the future, the Institute will also build on its portfolio of Earth-based applications. NSBRI science and technology teams are cohesive enterprises capable of tackling difficult problems that overlap civilian and military challenges, such as traumatic brain injury, with approaches used to address problems for NASA. Both the science and technology program, and the education and outreach program of NSBRI are emerging national resources. They embrace excellence in achievement and scale to meet new challenges. Over the next five years, NSBRI will build upon its programs for NASA and expand capabilities and financial support in new related areas where appropriate.

NSBRI will also maintain its excellent track record of productivity, abide by transparent and fiscally conscientious business practices, and exercise prudent fiscal stewardship of its budget from NASA and other sources. It is anticipated that NSBRI will continue to allocate approximately 83% of its budget for science and technology, with 9% designated for education and outreach, and 8% for administration. Institutional cost sharing will be maintained and augmentation of support will be sought to enrich NASA's sustained investment in the Institute.



Beyond 2014

NSBRI is a highly innovative and successful institute for conducting translational biomedical research and development on a national scale. Together with NASA, NSBRI has implemented recommendations from the *2005 Review for the NASA Chief Scientist of NSBRI Progress, Status and Plans* to further strengthen the Institute. These improvements ensure that NASA and the American people receive a solid return on the investment made in NSBRI. The Institute is committed to continued excellence in science, technology and education to achieve its noble mission.

The strategic plan for 2010 through 2014 sets forth five goals to advance the Institute on behalf of NASA and all stakeholders. NSBRI will work tirelessly to achieve these goals and to have a successful five-year review in early fiscal year 2011. A positive outcome will be important for continuing Cooperative Agreement NCC 9-58 into its fourth five-year increment of support, from 2013 through 2017. NSBRI also will pursue additional means of support and expand collaborations to achieve Institute goals.

As a prominent biomedical research institute, NSBRI will work with NASA to sustain its programs and provide lasting added impact to the nation's human space enterprise. The Institute is proud to be part of the country's strength in translational biomedical research and education. It is committed to helping NASA and the United States maintain prominence in science, technology and education in critical ways and on the world stage. NSBRI will emphasize continued excellence, develop scientific and technological advances that decrease human risks in critical and adventurous endeavors of national importance, and address some of the most interesting and challenging problems of our time.