

Biological and Physical Research Enterprise (BPRE)

FY 2003 Performance Plan

Mission

NASA's Office of Biological and Physical Research seeks

- to understand and enable the human experience in space, and
- use space to better understand the laws of nature and the evolution of life

The microgravity environment of space allows scientists to open a new window on the most basic and important biological, chemical, and physical processes. At the same time, the space environment poses major challenges to the well being of space travelers. Space flight exposes humans to low gravity and radiation environments never before encountered in our evolutionary history. As we seek to exploit the rich opportunities of space flight for fundamental research and commercial development, we must develop efficient and effective technologies and methods for protecting human health in space.

Goal 1: Conduct research to enable safe and productive human habitation of space.

BPRE conducts fundamental and applied research in the biological and physical sciences to reduce the health risks of space travel. We conduct research on technology for efficient, self-sustaining life-support systems to provide safe, hospitable environments for space exploration, and develop advanced technologies for healthcare delivery. Advances in healthcare first developed for the space flight environment are applied on Earth to enhance healthcare.

Goal 2: Use the space environment as a laboratory to test the fundamental principles of physics, chemistry, and biology.

The space environment offers a unique laboratory in which to study biological and physical processes. Researchers take advantage of this environment to conduct experiments that are impossible on Earth. For example, most combustion processes on Earth are dominated by the fact that hot gases rise. In space, this is not the case, and hidden properties of combustion emerge. Materials scientists study the role of gravity in important industrial processes. Physicists take advantage of microgravity to study exotic forms of matter that are better handled in space. Biological researchers investigate the role of gravity in life processes and how the space environment affects living organisms. The knowledge derived from BPRE's diverse research will inform and expand scientific understanding, support economic and technological progress, and help to enable human exploration of space.

Goal 3: Enable and promote commercial research in space.

BPRE provides knowledge, policies, and technical support to facilitate industry investment in space research. BPRE will continue to enable commercial researchers to take advantage of space flight opportunities for proprietary research. The commercial sector will

grow to become the premier mechanism for applying space knowledge to benefit the American people. Commercial applications of space knowledge will generate new products, new jobs, and new spin-off companies.

Goal 4: Use space research opportunities to improve academic achievement and the quality of life.

BPRE seeks to use its research activities to encourage educational excellence and to improve scientific literacy from primary school through the university level and beyond. We deliver value to the American people by facilitating access to the experience and excitement of space research. BPRE strives to involve society as a whole in the transformations that will be brought about by research in space.

Resource Requirements

(NOA, dollars in millions)

	<u>FY 1999</u>	<u>FY 2000</u>	<u>FY 2001</u>	<u>FY 2002</u>	<u>FY 2003</u>
\$M	--	--	313	820	842
CS FTE			427	1,242	1,273

Each annual performance goal is associated with a specific program budget; however, the majority of BPRE performance goals are overarching and interdependent in nature. They are not budgeted as discrete elements of BPRE programs.

Implementation Strategy

BPRE's program is implemented at seven NASA Field Centers and the Jet Propulsion Laboratory, as well as through the participation of Commercial Space Centers (CSCs), a National Space Biomedical Research Institute, and a National Center for Microgravity Research on Fluids and Combustion. BPRE relies upon an extensive external community of academic, commercial and government scientists and engineers for the implementation of its programs. BPRE-supported science and technology research projects are reviewed by scientific or technical peers. In selecting investigations and projects to support—and ultimately for access to space—BPRE follows peer-review processes appropriately designed for scientific research, technology research and development, and commercial research. Our peer review processes ensure the competitiveness and quality of BPRE research.

BPRE implements its research programs through ground-based as well as space flight research. Ground-based research precedes flight research and employs NASA facilities such as drop towers, centrifuges, and bed-rest facilities. The space flight research programs use the full spectrum of platforms, including free-flying satellites, Space Shuttle, and the International Space Station (ISS). In FY 2002, BPRE assumed responsibility for the ISS research budget. The ISS research budget funds continued build-up and utilization of research equipment on the ISS to support in flight research during fiscal years 2002 and 2003, leading to a broad-based, multidisciplinary flight research program upon completion of the ISS assembly phase.

Roadmap: [Source: NASA Strategic Plan]

Near-term Plans (2000-2005)	Mid-term Plans (2006-2011)	Long-term Plans (2012-2025)
<ul style="list-style-type: none"> • Identify mechanisms of health risk and potential physiological and psychological problems to humans living and working in space, and begin developing and testing countermeasures. • Conduct scientific and engineering research and enable commercial research activities on the ISS to enrich health, safety, and the quality of life on Earth. • Begin developing interdisciplinary knowledge (e.g., biology, physics, materials) to support safe, effective, and affordable human/robotic exploration. 	<ul style="list-style-type: none"> • Understand the effects of long-duration space flight (e.g., radiation), validate countermeasures and technology and begin developing countermeasures for long-duration space flight. • Extend our understanding of chemical, biological, and physical systems. • Test and validate technologies that can reduce the overall mass of human support systems by a factor of three (compared to 1990's levels). 	<ul style="list-style-type: none"> • Apply and refine countermeasures for safe, effective, and affordable long-duration human space flight. • Achieve a deep understanding of the role of gravity in complex chemical, biological, and physical processes. <ul style="list-style-type: none"> • Test and validate technologies for safe, self-sufficient, and self-sustaining life support systems that can enable humans to live and work in space and on other planets for extended periods.

BPRE is preparing for the transition to a new era in human space flight. The International Space Station (ISS) will provide a growing capability as a research platform. BPRE will work to extract the maximum scientific and commercial return from this promising research facility while conducting research to ensure the health and safety of space travelers in the near term and into the future.

BPRE will conduct a rigorous prioritization exercise during the spring and summer of 2002 to prioritize the research questions being pursued. This prioritization will help focus resources on priority questions, increasing the speed and likelihood that they will be answered. The strategic roadmap shown above is subject to change based on this ongoing assessment of priorities.

Performance Measures

The following performance measures rely heavily on review by BPRE's advisory committee using standard color-coded assessment criteria as follows:

Blue = Annual Performance Goal exceeded, or performance is exceptional

Green = Annual Performance Goal met

Yellow:= Annual Performance Goal not met, but a recovery plan is in place for the coming fiscal year

Red = Annual Performance Goal not met.

Goal 1: Conduct research to enable safe and productive human habitation of space.

Objective: Conduct research to ensure the health, safety, and performance of humans living and working in space.

Millions of years of evolution have molded the human body to cope with and rely upon gravity. Virtually every system of the body responds when a person travels to space. Weight-bearing bones lose about 1% of bone mass per month. Muscles atrophy, and nerves in the balance system begin to rewire their connections to take account of the sudden disappearance of up and down. Many of these changes pose significant health issues, especially when space travelers return to gravity. NASA research will identify methods that will efficiently control the effects of space travel and ensure the health and safety of future space travelers. Humans can only travel to space by bringing a microcosm of the Earth with us. We need an atmosphere, food, water, and protection from temperature extremes and space radiation. NASA research will develop advanced technologies for efficient life support systems to provide these needs with minimal resupply from Earth.

Public Benefit: The primary goal of this research is to improve health and safety for space travelers; however, this research also has the potential to make significant contributions to medical care on Earth. For example, space flight can provide models for exploring osteoporosis and other diseases of muscle and bone. It has provided unique insights into nerve regeneration and the capacity of the nervous system to grow, change, and adapt in response to environmental stimuli. The parallels between aging and space travel are currently under study by researchers at NASA and the National Institutes of Aging. BPRE research on life support technologies will reduce the cost of space travel. This technology will also find application in process control systems for industry, and may even in help to provide clean environments in homes, vehicles, and offices.

Annual Performance Goal 3B1: Earn external review rating of "green" or "blue" by making progress in the following research focus areas: identify and test biomedical countermeasures that will make space flight safer for humans, and identify and test technologies that will enhance human performance in space flight.

Performance Indicators:

- Complete experiments that will determine whether pulmonary edema occurs in spaceflight (West-PUFF).
- Complete studies that will provide knowledge for the improvement psychological well being of ground and flight crews for ISS (Kansas-Psychosocial).
- Maintain a cutting-edge, investigator-initiated peer-reviewed research program in Biomedical Research and Countermeasures and in Advanced Human Support Technology, including a National Space Biomedical Research Institute that will perform team-based, focused countermeasure-development research.
- Complete and commission the Brookhaven Booster Application Facility (BAF) in June, 2003 to enable investigators to perform research using heavy ion radiation.
- Analyze data from STS-107 Flight experiments
- Gather data from experiments using the Human Research Facility on ISS
- Produce scientific discoveries in Biomedical research, and publish in mainstream peer-reviewed archival journals.
- Publish results of Bioastronautics experiments conducted during early ISS Increments (1 through 6) and preliminary results from Increments 7 and 8.

Public Benefit: Research on the biomedical issues of space flight is important for improving the safety of all future space travelers. In addition to its direct application to space flight, this research contributes to biomedical research progress on Earth. NASA has 18 active cooperative agreements with the National Institutes of Health that help both organizations advance the state of medical knowledge and practice.

Annual Performance Goal 3B2: Earn external review rating of “green” or “blue” by making progress in the following research focus area: identify and test new technologies to improve life support systems for spacecraft.

Performance Indicators:

- BPRE will demonstrate, through vigorous research and technology development, a **40%** reduction in the projected mass of a life support flight system compared to the system baselined for ISS. The quantitative calculation of this metric will be posted on the Internet.

Public benefit: The primary benefit of research on technologies for life support systems is to reduce the cost of human space travel while increasing safety and efficiency. However, these technologies are frequently applicable to technical problems here on Earth. For example, the small, light, low-power technologies that NASA is developing for monitoring space craft atmosphere may find applications in monitoring industrial processes, monitoring air quality in confined environments, and possibly for detecting terrorist activities.

Goal 2: Use the space environment as a laboratory to test the fundamental principles of physics, chemistry, and biology.

Objective: Investigate chemical, biological, and physical processes in the space environment, in partnership with the scientific community.

Gravity's influence is everywhere. From the structure that gives steel its strength, to the structure of bone in a growing child, gravity plays a role. Researchers can only eliminate the effects of gravity in space. In space, we can study how gravity has shaped life on Earth and how living things respond to its absence. We enter a new realm of research in physics, chemistry, and biology. BPRE relies on the advice of the Space Studies Board of the National Research Council, as well as the NASA Advisory Committees and associated cross-disciplinary task groups to set the strategic direction of the program.

BPRE will conduct a rigorous prioritization exercise during the spring and summer of 2002 to prioritize the research questions being pursued. This prioritization will help focus resources on priority questions, increasing the speed and likelihood that they will be answered.

Public Benefit: BPRE uses the space environment to conduct research in focused areas with the potential to improve life on Earth. These focused areas of research range from fundamental physics, to biotechnology and from materials science to basic biology. The benefits of fundamental physical and biological research in space include improved understanding of physical and biological processes that provide the foundation for improving the quality of life on Earth. For example:

- Combustion science research contributes to the understanding of burning and help to improve energy efficiency and reduce pollution.
- Biotechnology research may contribute to the development of new drugs and improve medical care by exploring and expanding advanced technologies for growing tissues outside the body.
- Basic physics research may lead to future advances in information technology.
- Fundamental Biology research in space provides a new window on evolution and development which may lead to improved medical care and improved plants for agriculture
- Materials scientists exploit the space environment to benchmark novel materials as well as to improve understanding of industrial processes here on Earth.

Annual Performance Goal 3B3: Earn external review rating of “green” or “blue” by making progress in the following research focus areas as described in the associated indicators: advance the scientific understanding of complex biological and physical systems.

Performance Indicators:

- Maintain a peer-reviewed research program in Complex Systems physics and chemistry.
- Analyze ISS flight experiments results in colloidal physics.

Public Benefit: Research on complex physical and biological systems has the potential to benefit industrial applications in optical computing and communications, pharmaceutical packaging, food manufacturing, cosmetics, and polymer manufacturing.

Annual Performance Goal 3B4: Earn external review rating of “green” or “blue” by making progress in the following research focus areas as described in the associated indicators: elucidate the detailed physical and chemical processes associated with macromolecular crystal growth and cellular assembling processes in tissue cultures.

Performance Indicators:

- Maintain a peer-reviewed research program in macromolecular and cellular biotechnology.
- Analyze ISS flight experiments results in macromolecular and cellular biotechnology

Public Benefit: This biotechnology research may have applications in structural biology, rational drug design, and artificial tissues engineering for medical applications.

Annual Performance Goal 3B5: Earn external review rating of “green” or “blue” by making progress in the following research focus area: investigate fundamental and unresolved issues in condensed matter physics and atomic physics, and carry out atomic clock development for space-based utilization.

Performance Indicators:

- Maintain an outstanding and peer-reviewed research program in condensed matter physics, Bose-Einstein Condensation, and atomic clocks development for space-based utilization.
- Produce scientific discoveries in atomic and condensed matter physics, and publish in mainstream peer-reviewed archival journals.

Benefit: This basic research has the potential to substantially enhance the accuracy of our time-keeping standard, support development of ultra-precise Global Positioning System time measurements, and support the development of molecular-based medical diagnostic devices.

Annual Performance Goal 3B6: Earn external review rating of “green” or “blue” by making progress in the following research focus area: Investigate fundamental and unresolved issues in fluid physics, and materials and combustion science using gravity as a theoretical and experimental revealing tool.

Performance Indicators:

- Maintain an outstanding and peer-reviewed program in fluid physics, and materials and combustion sciences.
- Employ a new annual process to solicit and select peer-reviewed ground-based investigations in materials science, fluid physics, and combustion research
- Analyze results of STS-107 flight experiments in combustion research and fluid physics

Public Benefit: This research has the potential to support advances in energy production efficiency, combustion products emission control, advanced materials manufacturing, and the chemical engineering industry.

Annual Performance Goal 3B7: Earn external review rating of “green” or “blue” by making progress in the following research focus area: understand the role of gravity in biological processes at all levels of biological complexity.

Performance Indicators:

- Maintain an outstanding and peer-reviewed program in fundamental space biology
- Solicit ground-based research in all Fundamental Biology disciplines
- Analyze data from STS-107 flight experiments
- Determine baseline data requirements for model specimens to be used on ISS
- Plan for incorporation of baseline data collection in ISS hardware validation flights

Public Benefit: This basic research has the potential to support improved medical care and agricultural performance by strengthening our basic understanding of biological processes.

Objective: Develop strategies to maximize scientific research output on the International Space Station and other space research platforms.

Space flight opportunities for biological and physical research are very limited. BPRE develops strategies and approaches to enhance flight opportunities and to support a balanced research program that maximizes scientific return.

Public Benefit: By working with the scientific community, BPRE seeks to maximize scientific return from space flight opportunities to achieve the greatest benefit for the investment that taxpayers make into this research program.

Annual Performance Goal 3B8: In close coordination with the research community, allocate flight resources and develop facilities to achieve a balanced and productive research program.

Performance Indicators:

- Complete Phase A definition studies and award contract to manage ISS utilization to a Non Government Organization (NGO)
- Coordinate scientific community participation in the definition of ISS research.
- Balance resource allocations and flight opportunities through a Partner Utilization Plan.
- Deploy ISS research facilities on-orbit consistent with budget constraints and BPRE prioritization

Goal 3: Enable and promote commercial research in space.

Objectives: Provide technical support for companies to begin space research.

Foster commercial research endeavors with the International Space Station and other assets.

Ultimately, the solutions to the challenges of human space flight will open up new avenues of commerce. Even now, dozens of commercial firms conduct small-scale research projects in space. BPRE provides knowledge, policies, and technical support to facilitate industry investment in space research. BPRE will continue to enable commercial researchers to take advantage of space flight opportunities for proprietary research. The commercial sector will grow to become the premier mechanism for applying space knowledge to benefit the American people. Commercial applications of space knowledge will generate new products, new jobs, and new spin-off companies.

Public Benefit: The benefits of commercial research in space include improved products and services to enhance economic performance on Earth. In the long-term, economic activity in space will provide strengthened infrastructure for the exploration and development of space.

Annual Performance Goal 3B9: Engage the commercial community and encourage non-NASA investment in commercial space research by meeting at least two of three performance indicators.

Performance Indicators:

- Maintain a ratio of Non-NASA funding to NASA funding not less than 3:1
- Ensure that at least one of 39 product lines currently under investigation is brought to market in FY 03.
- Enable at least 10 new active industrial partnerships to be established with the Space Product Development Commercial Space Centers

Objective: Systematically provide basic research knowledge to industry.

Public Benefit: Conducting outreach to the commercial community extends the benefits of commercial research to the broadest set of participants and strengthens the contributions of commercial research for the development of space.

Annual Performance Goal 3B10: Highlight ISS-based commercial space research at business meetings and conferences.

Performance Indicators:

- Support at least 3 business/trade conferences to highlight ISS-based commercial space research.

Goal 4: Use space research opportunities to improve academic achievement and the quality of life.

Objective: Advance the scientific, technological, and academic achievement of the Nation by sharing our knowledge, capabilities, and assets.

Public Benefit: BPRE seeks to use its research activities to encourage educational excellence and to improve scientific literacy from primary school through the university level and beyond.

Annual Performance Goal 3B11: Provide information and educational materials to American teachers.

Performance Indicators:

- Develop electronic and printed educational materials that focus on biological and physical research, and distribute these materials at least three conferences and through the Internet.

Objective: Engage and involve the public in research in space.

Public Benefit: BPRE delivers value to the American people by facilitating access to the experience and excitement of space research. BPRE strives to involve society as a whole in the transformations that will be brought about by research in space.

Annual Performance Goal 3B12: Work with media outlets and public institutions to disseminate BPRE information to wide audiences.

Performance Indicators:

- Work with Life Science Museum Network members to explore opportunities for the development of projects, special events, or workshops focused on Life Sciences biology-related research themes to attract and engage public audiences.
- Make available to wide audiences an online database of Commercial Space Center activities, including publications listings, patents, and other information useful to the public.

Verification/Validation

BPRE cooperates with NASA's Inspector General during an annual review of the accuracy of our reporting process. In addition, BPRE reviews its performance with the Biological and Physical Research Advisory Committee (BPRAC) of the NASA Advisory Committee. The BPRAC is not expected to independently confirm the accuracy of data presented by BPRE. Rather, the Committee's role is to assess progress based on the data that BPRE presents and apply its expert judgment based on a set of criteria jointly developed with BPRE to produce an evaluation. The Office of the Inspector General selects a subset of targets for detailed audits to determine the accuracy and reliability of BPRE's data on performance targets.

Annual performance goals 3B1 and 3B3 through 3B9 are fundamentally qualitative in nature and the committee will work with NASA to establish guidelines and criteria for assigning scores on these goals based on performance indicators as well as other information. Annual performance goal 3B2 is evaluated using a novel formula developed by BPRE's Advanced Human Support Technology program. Details of this process are available for review on the program's website at <http://ADVLIFESUPPORT.JSC.NASA.GOV/> under the title "Advanced Life Support Metric Document

**FY 2003 MULTI-YEAR PERFORMANCE TREND
Biological and Physical Research Enterprise (BPRE)**

Strategic Objective: Conduct research to ensure the health, safety, and performance of humans living and working in space.

	<u>FY 99</u>	<u>FY 00</u>	<u>FY 01</u>
Annual Performance Goal and APG#	Perform component and subsystem ground tests without humans in the loop to demonstrate advanced technologies, including biological water processor, and flight test a new electronic "nose" sensor on a chip. (H29)	Complete the first phase (including outfitting three test chambers) of the Advanced Life Support System Integration Test Bed facility that will provide the capability to conduct a series of long duration, human-in-the-loop, advanced technology tests over the next six years. Demonstrate key technology capabilities for human support, such as advanced techniques for water processing using microbes, waste processing using biological degradation and fluidized bed incineration, a no-expendable trace gas contaminant control system, solid waste processing, and flight test of a miniature mass spectrometer. (0H31)	Demonstrate, in ground test, at least one technology that could reduce up to 25% of life support logistics over ISS baseline and release report of progress for review on the Internet. (1H18)
Assessment	Green	Green	

Strategic Objective: Conduct research to ensure the health, safety, and performance of humans living and working in space.

	FY 02	FY 03	
Annual Performance Goal and APG#	<p>Earn external review rating of “green” or “blue” by making progress in the following research focus areas as described in the associated indicators:</p> <ul style="list-style-type: none"> • Identify and test biomedical countermeasures that will make space flight safer for humans. • Identify and test technologies that will enhance human performance in space flight. (2B1) 	<p>Earn external review rating of “green” or “blue” by making progress in the following research focus areas:</p> <ul style="list-style-type: none"> • Identify and test biomedical countermeasures that will make space flight safer for humans. • Identify and test technologies that will enhance human performance in space flight. (3B1) 	
Assessment			

Strategic Objective: Conduct research to ensure the health, safety, and performance of humans living and working in space.

	<u>FY 99</u>	<u>FY 00</u>	<u>FY 01</u>
Annual Performance Goal and APG#	<p>Complete the development of countermeasure research protocols, and begin testing a minimum of three countermeasures intended to protect bone, muscle, and physical work capacity. (H25)</p> <p>Publish a report defining the time course adaptations in the balance system to altered gravitational environments. (H6)</p> <p>Document Mir radiation research data to facilitate ISS EVA planning. (H10)</p> <p>Document Mir data lessons learned to facilitate ISS biomedical and countermeasure research. (H7)</p>	<p>Develop medical protocols and test the capability of the Crew Health Care System as integrated in the ISS U.S. Laboratory. (0H26)</p> <p>Evaluate and develop for flight testing a minimum of three major research protocols intended to protect bone, muscle, and physical work capacity and prepare a minimum of 10 biomedical research experiments, (utilizing the capabilities of the STS and ISS HRF) to study human responses to the gravitational environment. (0H25)</p>	<p>Develop new biomedical and technological capabilities to facilitate living and working in space and safe return to Earth. (1H17)</p> <p>Initiate implementation of the Bioastronautics Initiative by beginning a NASA /NCI collaboration and conducting a peer review of NSBRI to assess expansion. (1H31)</p>
Assessment	Green	Green	

Strategic Objective: Conduct research to ensure the health, safety, and performance of humans living and working in space.

	<u>FY 02</u>	<u>FY 03</u>	
Annual Performance Goal and APG#	Earn external review rating of “green” or “blue” by making progress in the following research focus area: <ul style="list-style-type: none"> Identify and test new technologies to improve life support systems for spacecraft. (2B2) 	Earn external review rating of “green” or “blue” by making progress in the following research focus area: <ul style="list-style-type: none"> Identify and test new technologies to improve life support systems for spacecraft. (3B2) 	
Assessment			

Strategic Objective: Conduct research on biological and physical processes to enable future missions of exploration.

	<u>FY 99</u>	<u>FY 00</u>	<u>FY 01</u>
Annual Performance Goal and APG#	<p>Publish a report of comparison of 3 different biological models to understand the influence of gravity on the nervous system.</p> <p>H8 Document Mir data lessons learned to facilitate ISS research in fundamental biology and regenerative life support. (H5)</p>	<p>Complete Radiation Research Instrument for Mars 2001 mission to study transit, orbital, and surface radiation effects and conduct three workshops to define and prioritize research tasks in subjects such as radiation shielding materials, in situ resource utilization, and fluids management and heat transfer technology. Complete the science definition of granular flows, flight, and dust management experiments to begin gathering research data to alleviate critical problems of dust buildup, habitat foundation engineering, and rover performance during planetary exploration. (0H33)</p>	<p>Initiate implementation of the Bioastronautics Initiative by beginning a NASA /NCI collaboration and conducting a peer review of NSBRI to assess expansion. (1H31)</p>
Assessment	Green	Green	
Annual Performance Goal and APG#	<p>Initiate a collaborative program to design and develop instruments. (H26)</p>		<p>Complete testing and delivery for spacecraft integration of experiments for the Mars Surveyor Program 2001 missions. (1H1)</p>
Assessment	Green		

Strategic Objective: Conduct research on biological and physical processes to enable future missions of exploration.

	<u>FY 02</u>	<u>FY 03</u>	
Annual Performance Goal and APG#	<p>Earn external review rating of "green" or "blue" by making progress in the following research focus areas:</p> <ul style="list-style-type: none"> • Develop and test cutting-edge methods and instruments to support molecular-level diagnostics for physiological and chemical process monitoring. • Identify and study changes in biological and physical mechanisms that might be exploited for ultimate application to improving the health and safety of space travelers. (2B3) 		
Assessment			
Annual Performance Goal and APG#			
Assessment			

Strategic Objective: Investigate chemical, biological, and physical processes in the space environment, in partnership with the scientific community.

	<u>FY 99</u>	<u>FY 00</u>	<u>FY 01</u>
Annual Performance Goal and APG#	<p>Use data obtained by fluid physics experiments on suspensions of colloidal particles on MSL-1 to answer fundamental questions in condensed matter physics regarding the transition between liquid and solid phases and publish data on the transition from liquids to solids and the results in peer-reviewed open literature. (H13)</p> <p>Improve predictive capabilities of soot processes by at least 50% through analysis of MSL-1 data; publish results in peer-reviewed open literature. (H11)</p> <p>Use MSL-1 results to eliminate one of the three primary fluid flow regimes from consideration by casting engineers, and publish this result in peer reviewed literature. Casting engineers may use this information to improve metal casting processes in industry. (H12)</p>	<p>Using suborbital rockets, complete one combustion experiment on the flame spread of liquid fuels to better control Earth/space-based fire hazards, and conduct one investigation to test theories of fundamental physics properties and physical laws of fluids to provide key data for earth and space-based processing materials; report the results. (OH11)</p>	
Assessment	Green	Red	
Annual Performance Goal and APG#	Analyze Mir data to achieve a 3-year jump-start for cell culture and protein crystal growth research and document analyses & lessons learned. (H9)		
Assessment	Green		

Strategic Objective: Investigate chemical, biological, and physical processes in the space environment, in partnership with the scientific community.

	<u>FY 02</u>	<u>FY 03</u>	
Annual Performance Goal and APG#	Earn external review rating of “green” or “blue” by making progress in the following research focus areas as described in the associated indicators: <ul style="list-style-type: none"> • Advance the scientific understanding of complex biological and physical systems. (2B4) 	Earn external review rating of “green” or “blue” by making progress in the following research focus areas as described in the associated indicators: <ul style="list-style-type: none"> • Advance the scientific understanding of complex biological and physical systems. (3B3) 	
Assessment			
Annual Performance Goal and APG#	Earn external review rating of “green” or “blue” by making progress in the following research focus areas as described in the associated indicators: <ul style="list-style-type: none"> • Elucidate the detailed physical and chemical processes associated with macromolecular crystal growth and cellular assembling processes in tissue cultures. (2B5) 	Earn external review rating of “green” or “blue” by making progress in the following research focus areas as described in the associated indicators: <ul style="list-style-type: none"> • Elucidate the detailed physical and chemical processes associated with macromolecular crystal growth and cellular assembling processes in tissue cultures. (3B4) 	
Assessment			

Strategic Objective: Investigate chemical, biological, and physical processes in the space environment, in partnership with the scientific community.

	<u>FY 99</u>	<u>FY 00</u>	<u>FY 01</u>
Annual Performance Goal and APG#		Develop medical protocols and test the capability of the Crew Health Care System as integrated in the ISS U.S. Laboratory. (0H26)	Continue initial research on the International Space Station by conducting 6 to 10 investigations. (1H5)
Assessment		Green	
	<u>FY 99</u>	<u>FY 00</u>	<u>FY 01</u>
Annual Performance Goal and APG#			
Assessment			

Strategic Objective: Investigate chemical, biological, and physical processes in the space environment, in partnership with the scientific community.

	<u>FY 02</u>	<u>FY 03</u>	
Annual Performance Goal and APG#	Earn external review rating of “green” or “blue” by making progress in the following research focus areas as described in the associated indicators: <ul style="list-style-type: none"> Initiate a focused research program specifically integrating fluid physics and materials science with fundamental biology. (2B6) 		
Assessment			
Annual Performance Goal and APG#	Earn external review rating of “green” or “blue” by making progress in the following research focus area: <ul style="list-style-type: none"> Investigate fundamental and unresolved issues in condensed matter physics and atomic physics, and carry out atomic clock development for space-based utilization. (2B7) 	Earn external review rating of “green” or “blue” by making progress in the following research focus area: <ul style="list-style-type: none"> Investigate fundamental and unresolved issues in condensed matter physics and atomic physics, and carry out atomic clock development for space-based utilization. (3B5) 	
Assessment			

Strategic Objective: Investigate chemical, biological, and physical processes in the space environment, in partnership with the scientific community.

	<u>FY 99</u>	<u>FY 00</u>	<u>FY 01</u>
Annual Performance Goal and APG#			
Assessment			
	<u>FY 99</u>	<u>FY 00</u>	<u>FY 01</u>
Annual Performance Goal and APG#			
Assessment			

Strategic Objective: Investigate chemical, biological, and physical processes in the space environment, in partnership with the scientific community.

	<u>FY 02</u>	<u>FY 03</u>	
Annual Performance Goal and APG#	Earn external review rating of “green” or “blue” by making progress in the following research focus area: <ul style="list-style-type: none"> Investigate fundamental and unresolved issues in fluid physics, and materials and combustion sciences using gravity as a theoretical and experimental revealing tool. (2B8) 	Earn external review rating of “green” or “blue” by making progress in the following research focus area: <ul style="list-style-type: none"> Investigate fundamental and unresolved issues in fluid physics, and materials and combustion science using gravity as a theoretical and experimental revealing tool. (3B6) 	
Assessment			
Annual Performance Goal and APG#	Earn external review rating of “green” or “blue” by making progress in the following research focus area: <ul style="list-style-type: none"> Understand the role of gravity in biological processes at all levels of biological complexity. (2B9) 	Earn external review rating of “green” or “blue” by making progress in the following research focus area: <ul style="list-style-type: none"> Understand the role of gravity in biological processes at all levels of biological complexity. (3B7) 	
Assessment			

Strategic Objective: Develop strategies to maximize scientific research output on the International Space Station and other space research platforms.

	<u>FY 99</u>	<u>FY 00</u>	<u>FY 01</u>
Annual Performance Goal and APG#		Complete data reduction from the STS-95 Research Module mission. Begin to explore new cooperative efforts with NIH in the area of aging and transfer space-derived research for industry development of a new drug to treat Chagas' disease. (0H9)	Conduct outstanding peer-reviewed and commercial research on STS-107 to advance knowledge in the fields of medicine, fundamental biology, biotechnology, fluid physics, materials processing and combustion. (1H4)
Assessment		Green	
Annual Performance Goal and APG#	Support an expanded research program of approximately 800 investigations, an increase of ~9% over FY 1998. (H1) Publish 90% of FY 1998 science research progress in the annual OLMSA Life Sciences and Microgravity Research Program Task Bibliographies and make it available on the Internet. (H2) Establish a National Center for Evolutionary Biology with participation of at least 5 research institutions and engaging at least 20 investigators. (H3)	Support an expanded research program of approximately 935 investigations, an increase of ~17% over FY 1999. Publish 100 percent of science research progress in the annual OLMSA Life Sciences and Microgravity Research Program Task Bibliographies and make this available on the Internet. (0H1)	Support an expanded, productive research community to include 975 investigations annually by 2001. (1H3)
Assessment	Green	Green	
Annual Performance Goal and APG#			
Assessment			

Strategic Objective: Develop strategies to maximize scientific research output on the International Space Station and other space research platforms.

	<u>FY 02</u>	<u>FY 03</u>	
Annual Performance Goal and APG#	In close coordination with the research community, allocate flight resources to achieve a balanced and productive research program. (2B10)	In close coordination with the research community, allocate flight resources and develop facilities to achieve a balanced and productive research program. (3B8)	
Assessment			
Annual Performance Goal and APG#			
Assessment			
Annual Performance Goal and APG#	Demonstrate progress toward ISS research hardware development. (2H13)		
Assessment			

Strategic Objective: Foster commercial research endeavors with the International Space Station and other assets.
Strategic Objective: Provide technical support for companies to begin space research.

	<u>FY 99</u>	<u>FY 00</u>	<u>FY 01</u>
Annual Performance Goal and APG#	<p>Increase non-NASA investment (cash and in-kind) in space research from \$35M in FY96 to at least \$50M in FY 1999, a 40% increase. (H35)</p> <p>Complete the development of a commercialization plan for the ISS and Space Shuttle in partnership with the research and commercial investment communities and define and recommend policy and legislative changes. (H30)</p> <p>Establish a new food technology Commercial Space Center. (H36)</p>	<p>Establish up to 2 new Commercial Space Centers. (0H47)</p> <p>Foster the establishment of a telemedicine hub in Western Europe. NASA and CNES will develop an international telemedicine program to incorporate and connect existing medical informatics capabilities into a user-friendly commercial electronic telemedicine hub and apply lessons learned to human space flight. (0H49)</p> <p>Utilize at least 30% of Space Shuttle and ISS FY 2000 capabilities for commercial investigations, per the U.S. Partner Utilization Plan. (0H46)</p>	<p>Foster commercial endeavors by reviewing and/or implementing new policies and plans such as the Space Station resource pricing policy and intellectual property rights policy. Ensure that Space Station resources allocated to commercial research are utilized by commercial partners to develop commercial products and improve industrial processes. (1H23)</p> <p>Establish at least ten new, active industrial partnerships to research tomorrow's space products and improve industrial processes through NASA's Commercial Space Centers, and find opportunities for space experiments. (1H22)</p>
Assessment	Green (H35, H36); Yellow (H30)	Green	

Strategic Objective: Foster commercial research endeavors with the International Space Station and other assets.
Strategic Objective: Provide technical support for companies to begin space research.

	<u>FY 02</u>	<u>FY 03</u>	
Annual Performance Goal and APG#	Engage the commercial community and encourage non-NASA investment in commercial space research by meeting at least three of four performance indicators. (2B11)	Engage the commercial community and encourage non-NASA investment in commercial space research by meeting at least two of three performance indicators. (3B9)	
Assessment			

Strategic Objective: Advance the scientific, technological, and academic achievement of the Nation by sharing our knowledge, capabilities, and assets.

	<u>FY 99</u>	<u>FY 00</u>	<u>FY 01</u>
Annual Performance Goal and APG#	<p>Initiate a curriculum development program, in partnership with the International Technology Education Association (ITEA), for gravity related educational modules for national distribution which meet the current National Science Teachers Association (NSTA) National Standards for Science for Grades K-12, and the ITEA National Standards for Technology Education to be published June 1999. (H37)</p> <p>Conduct at least two demonstrations of the applicability of the “Telemedicine Instrumentation Pack” for health care delivery to remote areas. (H39)</p> <p>Demonstrate the application of laser light scattering technology for early detection of eye-tissue damage from Diabetes; publish results in peer-reviewed open literature. (H40)</p>	<p>The NASA-Sponsored National Space Biomedical Research Institute will conduct an open symposium relaying the results of space-oriented research activities focusing on up to 10 ground-related applications with the participation of interested investigators; publish results in a conference proceedings report. (0H56)</p>	<p>Support participation in HEDS research. (1H26)</p>
Assessment	Green	Green	

Strategic Objective: Systematically provide basic research knowledge to industry.

	<u>FY 99</u>	<u>FY 00</u>	<u>FY 01</u>
Annual Performance Goal and APG#			
Assessment			

Strategic Objective: Advance the scientific, technological, and academic achievement of the Nation by sharing our knowledge, capabilities, and assets.

	<u>FY 02</u>	<u>FY 03</u>	
Annual Performance Goal and APG#	Provide information and educational materials to American teachers. (2B13)	Provide information and educational materials to American teachers. (3B11)	
Assessment			

Strategic Objective: Systematically provide basic research knowledge to industry.

	<u>FY 02</u>	<u>FY 03</u>	
Annual Performance Goal and APG#	Highlight ISS-based commercial space research at business meetings and conferences. (2B12)	Highlight ISS-based commercial space research at business meetings and conferences. (3B10)	
Assessment			

Strategic Objective: Engage and involve the public in research in space.

	<u>FY 99</u>	<u>FY 00</u>	<u>FY 01</u>
Annual Performance Goal and APG#	Expand the microgravity research program's World Wide Web-based digital image archive established in 1998 by 50%. (H38)		
Assessment	Green		

Strategic Objective: Engage and involve the public in research in space.

	<u>FY 02</u>	<u>FY 03</u>	
Annual Performance Goal and APG#	Work with media outlets and public institutions to disseminate OBPR information to wide audiences. (2B14)	Work with media outlets and public institutions to disseminate BPRE information to wide audiences. (3B12)	
Assessment			

**Biological and Physical Research
FY 2003 Budget Link Table**

	Budget Category	Advanced Human Support Technology	Biomedical Research & Countermeasures	Fundamental Space Biology	Physical Sciences Research	Space Product Development	Mission Integration
Annual Performance Goals & APG#							
3B1: Earn external review rating of "green" or "blue" by making progress in the following research focus areas: 1) Identify and test biomedical countermeasures that will make space flight safer for humans; 2) Identify and test technologies that will enhance human performance in space flight.		X	X				
3B2: Earn external review rating of "green" or "blue" by making progress in the following research focus area: Identify and test new technologies to improve life support systems for spacecraft.			X				
3B3: Earn external review rating of "green" or "blue" by making progress in the following research focus areas as described in the associated indicators: Advance the scientific understanding of complex biological and physical systems.				X	X		
3B4: Earn external review rating of "green" or "blue" by making progress in the following research focus areas as described in the associated indicators: Elucidate the detailed physical and chemical processes associated with macromolecular crystal growth and cellular assembling processes in tissue cultures.					X		
3B5: Earn external review rating of "green" or "blue" by making progress in the following research focus area: Investigate fundamental and unresolved issues in condensed matter physics and atomic physics, and carry out atomic clock development for space-based utilization.					X		
3B6: Earn external review rating of "green" or "blue" by making progress in the following research focus area: Investigate fundamental and unresolved issues in fluid physics, and materials and combustion science using gravity as a theoretical and experimental revealing tool.					X		

**Biological and Physical Research
FY 2003 Budget Link Table**

	Budget Category	Advanced Human Support Technology	Biomedical Research & Countermeasures	Fundamental Space Biology	Physical Sciences Research	Space Product Development	Mission Integration
Annual Performance Goals & APG#							
3B7: Earn external review rating of "green" or "blue" by making progress in the following research focus area: Understand the role of gravity in biological processes at all levels of biological complexity.				X			
3B8: In close coordination with the research community, allocate flight resources and develop facilities to achieve a balanced and productive research program.		X	X	X	X	X	X
3B9: Engage the commercial community and encourage non-NASA investment in commercial space research by meeting at least two of three performance indicators.						X	
3B10: Highlight ISS-based commercial space research at business meetings and conferences.						X	
3B11: Provide information and educational materials to American teachers.		X	X	X	X	X	
3B12: Work with media outlets and public institutions to disseminate OBPR information to wide audiences.		X	X	X	X	X	