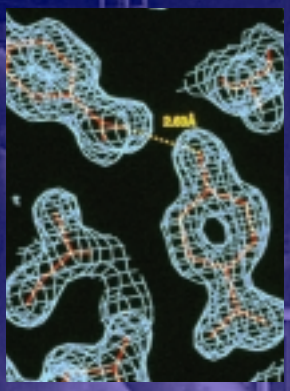
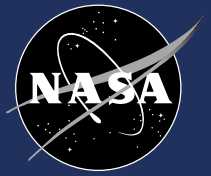
NASA's Biological and Physical Research

Space Research: Transforming Tomorrow Today





National Aeronautics and
Space Administration

Headquarters
Washington, DC

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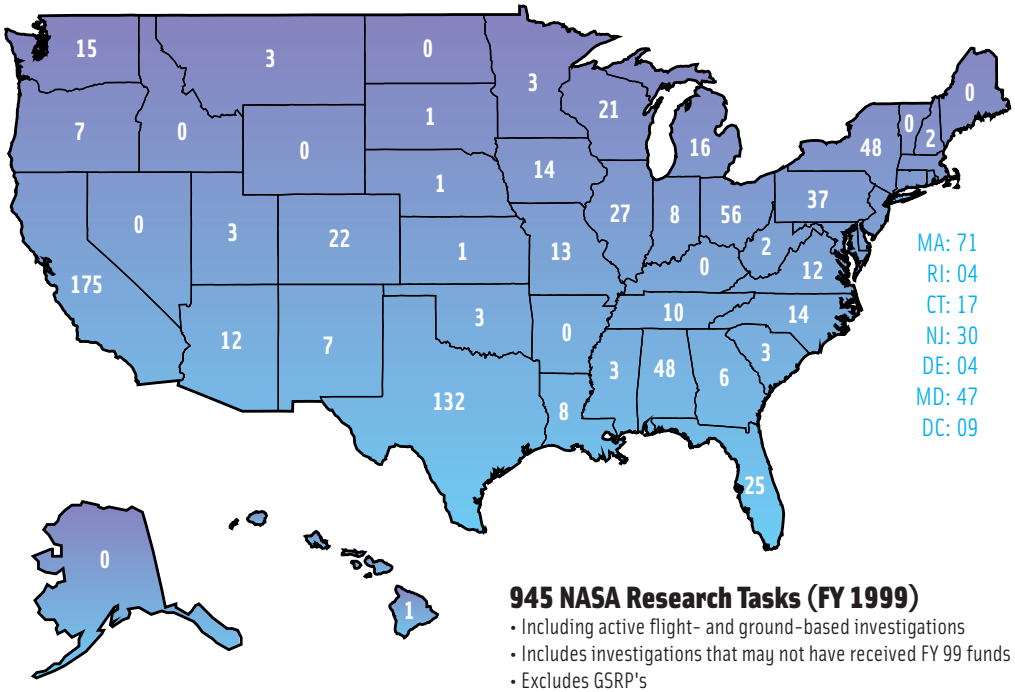
NASA'S BIOLOGICAL AND PHYSICAL RESEARCH

SPACE RESEARCH: TRANSFORMING TOMORROW TODAY

Introduction

The Office of Biological and Physical Research (OBPR) was established on October 2, 2000 to affirm NASA's commitment to the essential role biology plays in the 21st century, to establish the core of biological and physical sciences research needed to support Agency strategic objectives, to foster commercial development in space, and to ensure an effective management structure to optimize implementation of the Agency's scientific and technological goals. Revolutionary solutions to science and technology problems are likely to emerge from scientists, clinicians, and engineers who are working at the frontiers of their respective disciplines and are also engaged in dynamic interdisciplinary interactions. OBPR will foster and enhance rigorous interdisciplinary research, closely linking fundamental biological and physical sciences. OBPR is dedicated to using the unique characteristics of the space environment to understand biological, physical, and chemical processes, conduct science and technology research required to enable humans to safely and effectively live and work in space, trans-



945 NASA Research Tasks (FY 1999)

- Including active flight- and ground-based investigations
- Includes investigations that may not have received FY 99 funds
- Excludes GSRP's

OBPR's programs of research and technology development rely upon broad participation by researchers from academia, Government agencies, and industry. All OBPR-supported science and technology research projects are peer-reviewed and 95 percent of these projects are selected from open national competition.

fer knowledge and technologies for Earth benefits, and support investment in space research by the private sector.

Advances in biology, medicine, physics, and chemistry, associated analytical tools, and information systems have opened an era of unprecedented opportunities for bringing space-based knowledge to benefit human life on Earth. This increased understanding will transform the technological foundations not only of the space program, but also of our society. NASA researchers stand on the brink of using this knowledge to develop "smart" materials and "intelligent" spacecraft systems that are programmed to sense changes and adapt to them, a capability that will enable widespread advances in Earth-based technology, engineering, biomedical, and commercial products through insights gained in space.

Commercial endeavors have always been important factors in the opening of new frontiers: from early trade routes, to fast clipper ships plying the oceans, to the "iron horse" that spanned the continent. With space as the "final frontier," commercial initiatives continue to play an important role by fostering research advances in space for new or improved products and services on Earth.

Early OBPR ISS research begins in the 2001 and 2002 timeframe when the first elements of the research facilities will be installed. By completion of the assembly phase, OBPR will use eight major research facilities in addition to those provided by and shared with our international partners. These facilities include the equipment needed to conduct research in molecular, cellular, developmental, organismal, and evolutionary biology using a variety of specimens, space medical research, and human physiology. Research in the physical sciences will include fluid physics, combustion, materials science, biotechnology, and fundamental physics. Commercial space research will encourage industry to use insights gained in the environment of space to foster or improve products and services on Earth.

The Fundamental Space Biology Program

Former Senator John Glenn is shown participating in research performed aboard STS-95. This flight and future flights will explore the role of gravity on fundamental aging mechanisms.

Overview: Studies the comprehensive discipline of biology, including its genomics, evolution, cell biology, development, and biological and physical interactions, as well as gravitational ecology.

These elements of the Fundamental Space Biology Program provide a continuum of research that investigates the role of gravity and other space flight factors at all levels of biological processing. These elements are focused on answering key scientific questions aimed at achieving the goals of the program. These include determining the role of gravity in how living organisms develop, understanding how biological systems sense and respond to gravity as cells grow into organs with specific functions, and determining how gravity has shaped the evolution of life on Earth.

Fundamental Space Biology also plans to support new research thrusts that cut across the areas of biology. These efforts will capitalize on previous research accomplishments and expand the program into key specialized topic areas such as space neurobiology, which builds on the results from the Neurolab mission; gravitational radiobiology, which will study the interaction of microgravity

and space environment radiation; space genomics, which focuses on gene function and expression in the space environment; and mechanisms of aging in space, which will expand the current developmental biology program element to include studies of the full life span. These research thrusts will take advantage of recent cutting edge advances in fields such as neurobiology and molecular biology, and represent new opportunities for leveraging of resources through cooperative activities with the National Institutes of Health and the National Science Foundation.

Bioastronautics Research Program

Overview: OBPR Bioastronautics Research has two main objectives that support space flight crew health, safety, and performance. The first is to understand physiological and psychological adaptation to space flight and return to Earth in order to develop countermeasures and technologies that will mitigate risks to the crew. The second is to develop technologies that will augment spacecraft habitability, environmental controls, planetary habitability, and space systems.

The goals of Bioastronautics Research are to:

- Understand the medical requirements for protecting human health and well-being during space flight.
- Identify and characterize the medical risks of space flight to humans.
- Determine the way that space flight changes how biomedical systems work.
- Provide the scientific rationale and evidence that will lead to the development of preventive countermeasures to the negative effects of space flight.
- Provide data and results that can be used by operational medicine to optimize crew health and performance.
- Develop advanced technologies to enable humans to live and work in space safely and effectively.

Japanese Astronaut Chiaki Mukai changes a videocassette during a biomedical experiment on the STS-95 mission.

To achieve these goals, the program sponsors research that provides answers to essential questions about space flight effects on human physiology, behavior/performance, radiation health, environmental health, operational/clinical medicine, and advanced human support technology. The research provides rational tests and evidence that enable the development and implementation of therapeutics, procedures, techniques, or equipment required to reduce flight medical, safety, and performance risks to acceptable levels. Technology development to augment spacecraft habitability, environmental controls, planetary habitability, and space systems technology is an essential element of work. The programs neither deliver medical care nor certify crew health. They are responsible for integrating science and medical research to generate the knowledge required to enable flight crews to leave low-Earth orbit, perform their assigned tasks, and return to Earth with their health intact.

Results of NASA's Bioastronautics Research provide tangible returns to people on Earth. For example, state-of-the-art, compact, portable technologies and tools that must be developed for remote, autonomous treatment of medical problems in a non-hospital environment will contribute to a revolution in medical care on Earth in the next 10–50 years. Knowledge gained in treating neurological changes, as well as muscle and bone deterioration resulting from space flight may be directly applied

to spinal cord or bedridden patients experiencing similar changes. New technologies, such as the electronic noses needed to monitor toxins in spacecraft environments may be widely used on Earth to monitor and control environmental quality.

The Physical Sciences Research Program

Overview: Physical sciences and engineering research will combine cutting-edge experimental facilities with long-duration access to low-Earth orbit and beyond to overcome gravity-induced limitations and to enable new scientific discoveries. The program is sponsoring vibrant and interdisciplinary ground-based and flight research to drive technological innovation for space exploration and Earth-based applications.

Research on the International Space Station will further the Space Shuttle research currently being conducted in space in fields such as combustion science.

The goals of the Physical Sciences Research program are to:

- Carry out groundbreaking, peer-reviewed, and multidisciplinary basic research enabled by the space environment to address NASA's goal of advancing and communicating knowledge
- Develop a rigorous scientific capability bridging physical science and biology to address the Nation's human and robotic space exploration goals
- Establish the International Space Station facilities as unique onorbit science laboratories addressing targeted scientific and technological issues of high significance
- Enhance the knowledge base impacting Earth-bound technological and industrial applications

The specific objectives of this program will be carried out through a broadly based and multidisciplinary research community recruited from academia, industry, and other Government research agencies. The major technical disciplines of relevance include atomic and molecular physics, materials science, condensed matter and complex fluids physics, combustion research, bio-molecular and nanotechnology systems research, tissue engineering, and structural biology. The program sponsors over five hundred scientific investigations selected through a nationally competed peer-review process, and has already identified over 90 flight experiments slated for the International Space Station.

Some examples of the ongoing research are sketched below:

- The microgravity environment will enable some very precise experiments targeting the complex behavior of atoms, the building blocks of all matter. Planned investigations on Bose-Einstein condensates, dubbed "The Coolest Gas in the Universe" by the December 2000 issue of *Scientific American* magazine, are believed to yield technology that will allow a hundredfold improvement in the accuracy of atomic clocks, leading to ultra-precise deep space navigation and more definitive tests of Einstein's fundamental theory of gravitation.

- Long-duration exposure to low-gravity will also allow further exciting development in the technology of three-dimensional tissue engineering. The unique environment of space will enable the detailed

investigations of the effects of gravity on the cellular assembling mechanisms involved in the manufacture of artificial complex tissues such as human organs and other useful biomaterials. This effort will greatly benefit from the implementation of newly introduced advanced atomic and molecular scale experimental tools used to manipulate matter at the smallest components level.

- Another example of cutting-edge research only possible in microgravity can be found in the field of combustion science where accurate measurements can finally be carried out in the highest temperature region of flames. This will lead to a better understanding of the important factors in the burning processes of fuels and in the formation of polluting byproducts, significantly impacting the energy production industry on Earth.

Education and Outreach

Overview: As we enter the new millennium, a citizenry well prepared in mathematics, science, and engineering is critical to the United States' social and economic viability. It is of prime importance to NASA that we prepare our youth with the knowledge and skills necessary to thrive in the mathematics, science, and technology-based careers that will define the leadership role of the United States. OBPR strives to involve all elements of society in the transformations that will be brought about by research in space.

In order to fulfill the OBPR goal to use space research opportunities to improve academic achievement and the quality of life, OBPR education activities include teacher and student preparation programs and undergraduate and graduate student support, all of which focus on NASA-related disciplines. The process begins in grades K–12 and continues through college and graduate school, with many students conducting NASA-related research as part of their graduate and postdoctoral programs.

OBPR provides information, materials, and services to a large educational and public community through a multifaceted dissemination network. OBPR annually distributes electronic and printed curriculum material and media products that focus on physical sciences, fundamental space biology, biomedical and human support research, and commercial research through participation in exhibits at major education, professional society, and business/trade annual conferences; featuring science activity "kits" for classrooms at museums; providing CD-ROM learning tools; and Internet activities such as interactive Web sites.

Priscilla Madison of Tuskegee University is collecting water samples from the Mosquito Lagoon while working on her Pre-Vet degree.

OBPR invites applications from promising graduate students to participate in an annual fellowship program that supports research in the OBPR disciplines, and also provides undergraduates a summer internship in research at one of the OBPR research centers. High school students participate in a program that matches students with trained teachers and a space biology discipline expert, as well as allowing the students to develop CD-ROM learning tools for their classrooms.

Joint Agreement Activities

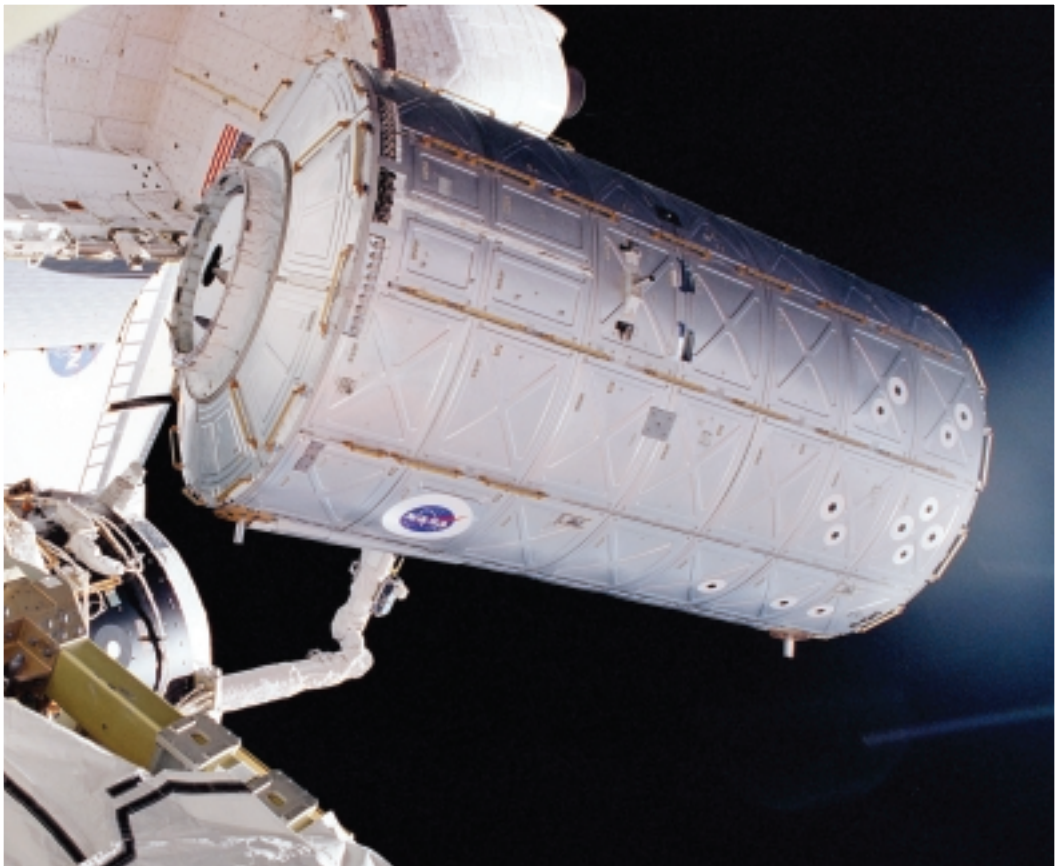
Overview: OBPR continues to leverage resources and expertise to broaden the effectiveness of our programs. Currently, 34 active agreements with Government, university, and research organizations are underway. Our partners include:

- Health and Human Services (1)
- National Institutes of Health (15)
- National Cancer Institute (2)
- Department of Defense (2)
- Department of Energy (3)
- National Science Foundation (1)
- Centers for Disease Control and Prevention (1)
- Juvenile Diabetes Research Foundation (1)
- White House (1)
- Food and Drug Administration (1)
- American Federation for Aging Research (1)
- American College of Sports Medicine (1)
- U.S. Department of Agriculture (1)
- National Oceanographic and Atmospheric Administration (1)
- U.S. Army Institute of Surgical Research (1)
- U.S. Geological Survey (1)

During FY 2000 specifically, the following OBPR partnerships were implemented:

- NASA and the National Cancer Institute signed an agreement to initiate a joint research program on fundamental technologies for development of biomedical sensors
- NIH opened their review process to NASA biomedical challenges, including radiation biology, spinal cord injury, cardiovascular and neurologic function, genomics, musculoskeletal system, medical imaging, and technology transfer of advanced cell culturing technology
- Joint Tissue Engineering Study was initiated with the National Science Foundation

In the grasp of the Space Shuttle *Atlantis*' remote manipulator system (RMS) robot arm, the Destiny laboratory is moved from its stowage position in the Space Shuttle's cargo bay. The photo was taken by astronaut Thomas D. Jones, who was participating in one of three STS-98/5a space walks at the time.



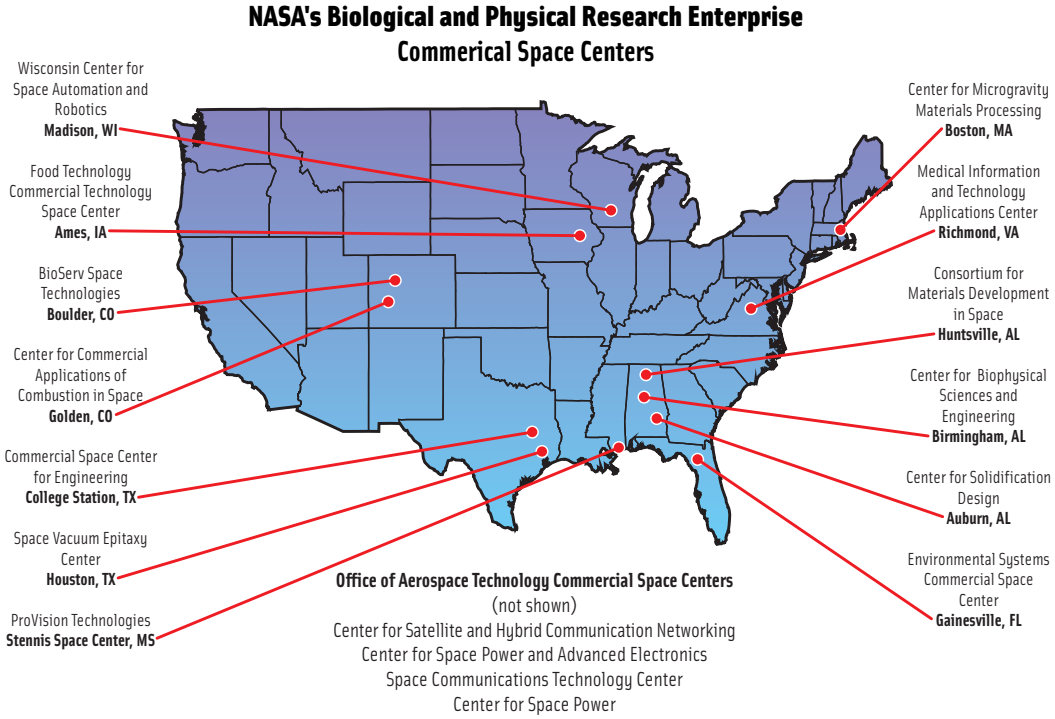
The Space Research Integration Program

Overview: With the International Space Station, what has been termed "the final frontier" will continue to support commercial space research that began with Space Shuttle research missions.

The Division of Space Research Integration manages all ISS-related NASA research. The Division also collaborates with the Office of Space Flight in exploration mission planning, ISS-based partnerships, and the potential non-Government organization (NGO) interface to the ISS. Included in their responsibilities are planning of commercial activities, including the Commercial Space Centers, commercial outreach, and managing flight research payloads.

Through NASA-sponsored agreements and the Commercial Space Centers, new or improved product research in fields as diverse as agriculture/plant growth, pharmaceutical products, new sensor technology, refining processes, combustion research for improved fuel efficiency, materials development, electronics, and other endeavors, will be enhanced through insight gained by research conducted in the unique environment of space. With the ISS emerging as an orbital laboratory, new commercial initiatives will also play an active role in space.

NASA's Commercial Space Centers



Currently Planned Events

NASA will fly two research-dedicated Space Shuttle missions between now and FY 2002. The first of these missions, STS-107, is currently scheduled for launch in April 2002. In addition to a series of combustion experiments, research questions addressed in this mission focus on crew health and safety and ISS risk mitigation.

Another Space Shuttle research mission, STS-118, is scheduled for launch in FY 2003. This mission is to provide additional access to space for the scientific and commercial communities during ISS assembly. As such, biological, biomedical, and physical sciences, as well as commercial projects that require microgravity for a Space Shuttle mission duration rather than the long periods afforded by ISS will be selected for this mission. During ISS assembly, NASA is aggressively pursuing opportunities to maximize research with currently manifested Space Shuttle missions, through the use of middeck lockers on planned assembly flights, utilization flights, and NASA's two budgeted interim Space Shuttle research missions, STS-107 and STS-118. Once completed, research onboard the ISS will be increased by an order of magnitude. By assembly completion, OBPR will use eight major research facilities, in addition to those provided by and shared with our international partners. These facilities include the equipment needed to conduct research in all areas of fundamental biology including molecular, cell, and developmental biology, plant biology, human physiology, biotechnology, advanced human support technology, fluid physics, combustion science, materials science, fundamental physics, and commercial research. Thirty percent of the ISS will be devoted to research for commercial purposes.

Information concerning OBPR's FY 2000 accomplishments and experiments on upcoming research missions appear as Fact Sheets in the cover pockets of this publication. This information will help the reader become more familiar with the exciting advances in OBPR research.

Please visit our Web sites to learn more about OBPR's "Biophysical" world!

- **Biological and Physical Research Enterprise**
  http://spaceresearch.nasa.gov
- **Human Space Flight**
  http://spaceflight.nasa.gov
- **Science on the International Space Station**
  http://spaceflight.nasa.gov/station/science/
- **Commercial Research**
  http://www.commercial.nasa.gov

NASA Centers:

- **Life Sciences**
  http://weboflife.arc.nasa.gov/
- **Physical Sciences**
  http://microgravity.msfc.nasa.gov

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Front Cover: Trailing a column of flame-bright smoke, Space Shuttle *Atlantis* clears Launch Pad 39A as it climbs into the early evening sky. Along with a crew of five, *Atlantis* is carrying the U.S. Laboratory Destiny, a key module in the growth of the Space Station. Destiny will be attached to the Unity node on the Space Station using the Shuttle's robotic arm. This mission marks the seventh Shuttle flight to the Space Station, the 23rd flight of *Atlantis* and the 102nd flight overall in NASA's Space Shuttle program. **Back Cover:** With its new Destiny laboratory contrasted over Earth, the International Space Station (ISS) was photographed by one of the STS-98 crew members aboard *Atlantis* following separation of the Space Shuttle and the outpost at the end of several days of joint activities. The crews of *Atlantis* and the station parted company at 8:06 a.m. (CST), 16 February 2001, as astronaut Mark L. Polansky, pilot, flew the Shuttle halfway around the outpost and its new Destiny laboratory before moving off.

http://spaceresearch.nasa.gov/

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