MATHEMATICAL AND PHYSICAL SCIENCES $1,150,300,000

The FY 2007 Budget Request for the Mathematical and Physical Sciences (MPS) Directorate is $1.15 billion, an increase of $64.85 million, or 6.0 percent, over the FY 2006 Current Plan of $1.09 billion.

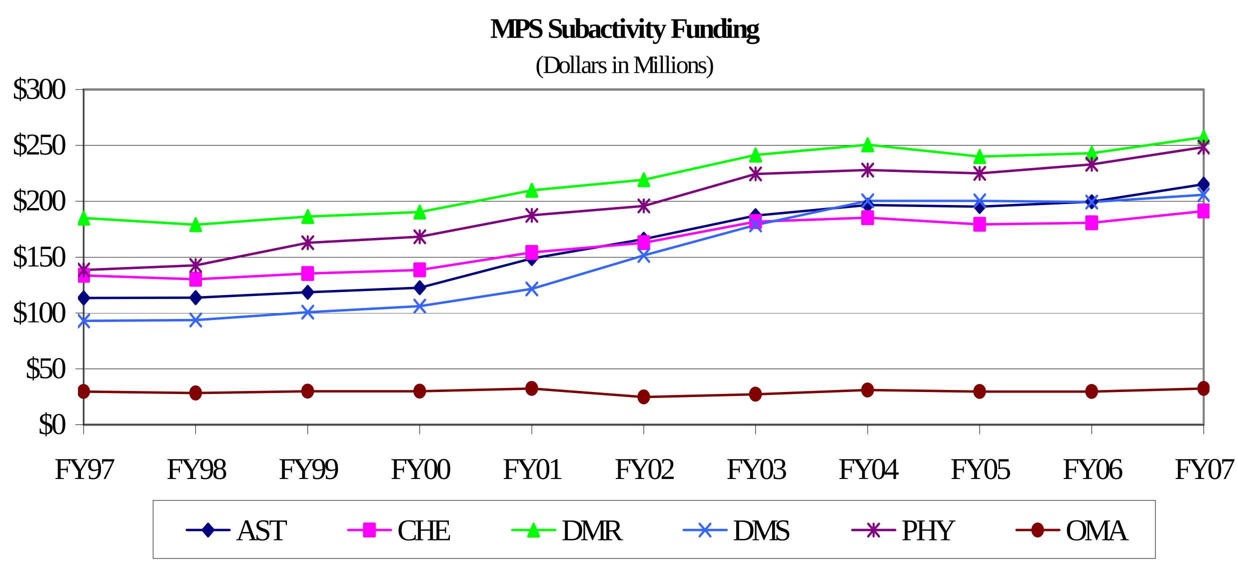
Mathematical and Physical Sciences Funding

(Dollars in Millions)

	FY 2005 Actual	FY 2006 Current Plan	FY 2007 Request	Change over FY 2006 Amount	Change over FY 2006 Percent
Astronomical Sciences (AST)	$195.11	$199.65	$215.11	$15.46	7.7%
Chemistry (CHE)	179.26	180.78	191.10	10.32	5.7%
Materials Research (DMR)	240.09	242.91	257.45	14.54	6.0%
Mathematical Sciences (DMS)	200.24	199.30	205.74	6.44	3.2%
Physics (PHY)	224.86	233.13	248.50	15.37	6.6%
Multidisciplinary Activities (OMA)	29.80	29.68	32.40	2.72	9.2%
Total, MPS	$1,069.36	$1,085.45	$1,150.30	$64.85	6.0%

Totals may not add due to rounding.

The Mathematical and Physical Sciences Directorate (MPS) provides funds for research, infrastructure, and development of human resources in the mathematical and physical sciences. The portfolio of investments contains a mixture of research and education grants (including awards for groups, centers, and institutes), facilities (including the national astronomy centers), instrumentation, and awards that enhance opportunities for undergraduate and graduate students and postdoctoral researchers and broaden participation in MPS fields. It includes MPS participation in NSF-wide and interagency research and education, and emphasizes discovery, innovation, and learning aligned with NSF and national priorities.

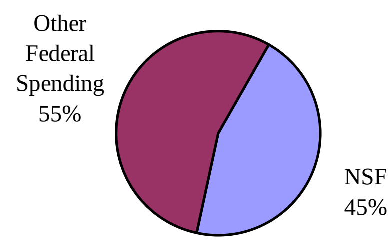


RELEVANCE

From the structure and evolution of the universe to the fundamental particles and processes of matter, from the behavior and control of molecules at the nanoscale to the complexity of their chemical interactions in materials and life processes, from developing new mathematical structures and theories to transforming them into models of natural systems that connect to computation, experimentation, and observation, MPS-supported research advances the frontiers of knowledge, drives technological developments, and stirs the imagination. It spans the spatial scales from quarks to the cosmos and time scales from the incredibly short to the unimaginably long, and it brings the perspective and methodologies of the physical sciences to exploring the molecular basis of life processes, human and social dynamics, and sustainability of energy and environment. Increasingly, MPS research draws on sophisticated and mathematically precise computer models, application-specific software to implement the models, and capabilities for manipulating and extracting information from large, complex data sets.

MPS-supported research in the physical and mathematical sciences provides the backbone for advances in other technical, engineering, and health-related disciplines, and provides a broad basis for industrial and technological development and national security. Knowledge of the fundamental processes of matter, of the structure and evolution of the universe, of the complex laws governing chemical interactions, of the behavior and control of molecules at the nanoscale, and of the mathematical tools needed to formulate and solve such problems have played a fundamental role in the technological leadership of the United States and in maintaining its health, economy, defense, and homeland security. At the same time this research sparks the innovation that is crucial to maintaining U. S. competitiveness and generating new industries. In addition, by linking research with education and training, MPS promotes development of the future U.S. science, engineering, and technological workforce, with particular emphasis on broadening participation to engage the Nation's entire talent pool.

Federal Support of Basic Research in Math and Physical Sciences at Academic Institutions



MPS provides about 45 percent of federal funding for basic research at academic institutions in the mathematical and physical sciences and serves as the federal steward for ground-based astronomy. MPS provides about 40 percent of the federal support for academic astronomy; in chemistry, about 38 percent; in physics, approximately 32 percent; in materials research approximately 55 percent; and in mathematics more than 77 percent. MPS collaborates with other disciplines within NSF and partners with other agencies, the private sector, and other nations in exploring areas such as the physics of the universe, nanoscale science and engineering, molecular processes in the life and environmental sciences, mathematical modeling across scales of time and space, and the evolving scientific capabilities provided by emerging cyberinfrastructure.

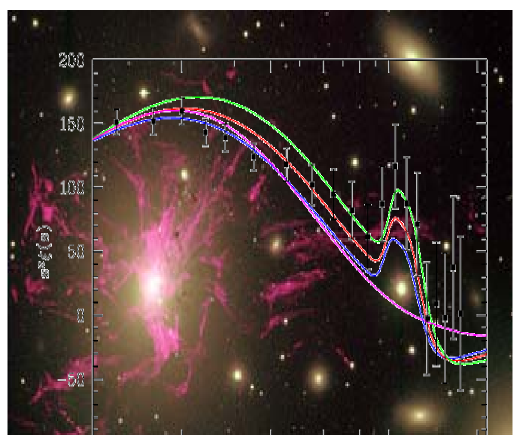
The MPS investment portfolio is designed to enable strong, flexible disciplines that generate discoveries across the MPS frontiers, reach out to other disciplines, accept high-risk undertakings that promise significant advances on fundamental questions, and drive innovation. The portfolio provides broad support across all MPS fields and catalytic support that promotes advances in areas of opportunity, including investments in the infrastructure supporting the conduct of MPS research and education and enabling broad access to it. In FY 2007, the MPS portfolio will include an expanded investment in elementary particle physics to capture a unique opportunity (see next page), as well as an expanded investment in nanoscale science and engineering. MPS infrastructure investments range from tabletop instruments to international facilities with hundreds of users as well as the development of next-generation instrumentation.

MPS integrates these investments in research and infrastructure with investments aiming to improve the quality and diversity of the U.S. science and engineering workforce and to enhance the public's knowledge of MPS fields by linking both formal and informal education and training programs to forefront research activities in the U.S. and other countries.

The strength of the U.S. technical and instructional workforce is dependent on an adequate supply of talented scientists and teachers. To ensure a diverse, internationally competitive and globally-engaged workforce of scientists, engineers and well-prepared citizens, MPS will make investments in all phases of education – from K-12 through undergraduate, graduate, postgraduate, and continuing education, as well as outreach activities. In order to attract the large, diverse population found in today's undergraduate student body to careers in science and engineering, MPS is emphasizing activities connecting undergraduate education with research. MPS will also support partnerships aimed at enhanced teacher preparation, broadened graduate and postdoctoral opportunities, and more informed teaching and learning strategies. In all these activities, the MPS strategy relies on using the excitement of research on the frontiers to attract the next generation of scientists and engineers.

Elementary Particle Physics Investment. The opportunities for discovery in elementary particle physics (EPP) are greater than at any time in the last half-century. Recent discoveries strongly suggest that we are on the verge of a revolution in our understanding of the nature of matter, energy, space, and time, as well as the origin, evolution and destiny of the Universe. The questions that define EPP now involve the related fields of nuclear physics, astrophysics and cosmology, and the tools needed for breakthrough discoveries now include telescopes, ultra-sensitive detectors housed in underground laboratories, and beams of particles from reactors and the cosmos, as well as accelerators. These developments have made the field more interdisciplinary, exciting and vital, prompting a coordinated investment of $15 million, provided over FY 2006 and FY 2007, for university-based EPP research.

Cosmic Sound and Dark Energy: NSF-supported researchers have provided strong new evidence that the universe took on its present shape because the cosmic equivalent of sound waves rolled through its contents for about a million years after the Big Bang some 13.7 billion years ago.



Credit: Graph: Daniel Eisenstein, University of Arizona. Background Image: NOAO/AURA/NSF.

Using data from the Sloan Digital Sky Survey, which is funded in part by NSF, astronomers searched for clues in the distances between hundreds of thousands of galaxies. What they found is exactly the kind of distribution that would appear if the early cosmos were permeated by alternating waves of compression and rarefaction that moved much as a resonant musical note travels through air. Daniel Eisenstein of the University of Arizona, along with colleagues there and elsewhere, made the discovery of a small but clear "bump" in an otherwise smooth curve depicting the separation between galaxies. (See illustration.) The celebrated finding confirms and refines scientists' current view of the universe in which expansion is accelerating, and 95 percent of the contents are in the form of exotic "dark matter" and "dark energy."

Summary of Major Changes by Division *(Dollars in Millions)*

MPS FY 2006 Current Plan……………………………………………………………... **$1,085.45**

Astronomical Sciences Division (AST) +$15.46

Increased funding for research grants and instrumentation, with emphasis on areas relevant to the interagency Physics of the Universe (POU) activity in partnership with the Physics Division, DOE and NASA; cyberscience and cyberinfrastructure, including implementation of a national virtual observatory; Gemini Observatory operations and instrumentation; and strategic public-private partnerships, including design and development for the Giant Segmented Mirror Telescope.

Chemistry Division (CHE) +$10.32

Increased funding for a strong, flexible grants program that advances the frontiers of chemical sciences, emphasizing areas such as the molecular basis of life processes, sustainability in energy and environment, nanoscale science and technology, and improved sensors for homeland security; developing cyber-enabled chemistry; and broadening participation through investments in undergraduate participation in research.

Division of Materials Research (DMR) +$14.54

Increased funding for materials research programs that generate new ideas and novel materials and undergird innovative technologies, with emphasis on materials and phenomena at the nanoscale, biologically related materials, computational materials research and materials theory, and materials for future cyberinfrastructure; broadening participation in materials research; and maintaining support for world-class user facilities while enabling the development of future instrumentation.

Division of Mathematical Sciences (DMS) +$6.44

Increased funding for the fundamental mathematics component of the Mathematical Sciences Priority Area (MSPA), while initiating the mainstreaming of MSPA activities; algorithm development and computational tools for large-scale problems of scientific importance; enhanced opportunities for undergraduate participation in cross-disciplinary research involving mathematics; and broadening participation.

Physics Division (PHY) +$15.37

Increased funding to advance the frontiers of physics, with emphasis on elementary particle physics, the interagency Physics of the Universe activities with the Division of Astronomical Sciences, DOE, and NASA; research and education grants to create new ideas and technologies and attract and train students; and provide levels of support for user facilities that enable them to reach their potential. Phase out of the terminated RSVP project is complete.

Office of Multidisciplinary Activities (OMA) +$2.72

Increased funding for collaborative activities aimed at initiating innovative cross-disciplinary research, as well as broadening participation in and informing the public about MPS disciplines.

Subtotal, Changes +$64.85

FY 2007 Request, MPS………………………………………………………………… **$1,150.30**

Summary of Major Changes by Directorate-wide Investments *(Dollars in Millions)*

MPS FY 2006 Current Plan……………………………………………………………..$1,085.45

Advancing the Frontier +$31.24

MPS places high priority on its investments in fundamental research aimed at advancing the frontiers of knowledge, including support for the research of individual investigators, groups, and larger collaborative activities, including institutes. In approaching its investments in core research in support of the NSF strategic goals, MPS looks for opportunities that excite the imagination, connect with areas of national priority as articulated in Administration guidance, and create synergy. MPS recognizes the importance of maintaining a significant component of activity that, while viewed as high risk, has high potential payoff. MPS staff aim for balance in award size and duration and success rate across the fundamental research portfolio. Emphases include:

- *Elementary Particle Physics (EPP)*, a coordinated investment of $10.0 million ($5.0 million in FY 2006 and $5.0 million additional in FY 2007) in fundamental research across (1) the energy frontier – the attempt to discover new fundamental particles and laws of physics by studying collisions at the highest energies achievable with current and future accelerators (+$2.0 million); (2) the neutrino frontier – exploration of the properties of the neutrino, a particle now known to carry mass and believed to be fundamental to understanding the developing universe (+$5.0 million); and (3) the cosmic frontier – the study of dark matter and dark energy (+$3.0 million). Investments in the cosmic frontier intersect with emphases in the Physics of the Universe. (The remainder of the $15.0 million EPP investment is found under Facilities and Instrumentation.)
- *Physics of the universe (POU)*, a set of activities that builds on the National Science and Technology Council report of the same name and partners with DOE and NASA in an interagency effort to explore the mysteries of dark matter and dark energy; the earliest phases in development of the universe, the fundamental nature of time, matter and space; and the role of gravitation. Funding will increase by $8.50 million over FY 2006, with $2.50 million of these funds overlapping with the EPP investment.
- *Fundamental mathematical and statistical science*, activities that strengthen the core of the Mathematical Sciences Priority Area and enable effective partnering with all other parts of NSF as well as NIH and DARPA. Funding for this priority area remains constant in DMS and scales back in the other divisions in accordance with NSF-wide planning for mainstreaming the priority area's activities in ongoing programs. An additional $5.10 million is provided for related research activities in DMS.
- *Physical sciences at the nanoscale*, activities that provide the foundation for innovative nanoscale technologies. These activities are undertaken in partnership with other NSF organizations and the government-wide National Nanotechnology Initiative and include efforts to address societal impacts of nanotechnology and the need for an educated workforce and an informed public. The activities emphasize the use of interdisciplinary teams conducting forefront research. Funding increases by $14.88 million, with DMR taking the lead in this activity for MPS.
- *Cyberinfrastructure and the cyberscience it enables*, connecting with NSF's high priority activities in this area and related activities government-wide in Networking and Information Technology R&D. MPS funding for domain-specific cyberinfrastructure increases by $4.26 million to a total of $63.56 million in a mix of core and infrastructure investments.
- *Molecular basis of life processes*, a set of activities linked to Administration priorities aimed at understanding complex biological systems. It will enable explorations in areas such as how disordered collections of molecules assemble themselves into the elements of living

systems; how proteins fold and membranes work; and how physiological processes such as breathing and thinking emerge out of complex, coupled arrays of individual reactions. CHE leads this effort, with DMR, PHY, and OMA as active participants. The increase is $9.35 million in a mix of individual, group and center research activities and infrastructure development.

- *Sustainability,* a newly focused investment in areas that link the physical sciences with environmental sustainability, including green chemistry, water chemistry and energy, with an increment of $2.0 million to leverage existing activities.

<u>Facilities and Instrumentation</u> +$17.32

Within an overall increase of $17.32 million for facilities and instrumentation, MPS targets the additional funds on increasing support for new and emerging facilities and for instrumentation development, including design and development for future facilities, cyberinfrastructure, and mid-scale projects, generally maintaining the base of funding for established facilities at FY 2006 levels.

- *Current facilities.* Funding for the Large Hadron Collider increases by $4.64 million; for LIGO by $1.32 million. The Cornell Electron Storage Ring (CESR) receives $5.0 million in funding from the focused EPP investment for a total of $14.71 million, slightly above the FY 2006 level. This funding will enable enhanced accelerator research and development, redirection of particle physics efforts towards the energy frontier, and completion of CESR's approved collider program over a somewhat longer period than originally planned. The extended time frame for CESR will also allow its partner facility, the Cornell High Energy Synchrotron Source (CHESS; included in Other MPS Facilities) to maintain cost-effective operations during this period. Base funding for astronomy facilities is at the FY 2006 level. Funding for the Gemini Observatory increases by $1.74 million for second generation instrumentation. Other facilities receive modest increases to support maintenance and operations at effective levels. (See the facilities table below for additional detail.)
- *Design and development.* Priority was accorded to design and development activities for potential future facilities, including $5.0 million for the Giant Segmented Mirror Telescope. Funding for the Large Synoptic Survey Telescope and the Energy Recovery Linac is maintained at planned levels.
- *Construction of facilities.* In addition, there are two MPS-related projects in construction phases with funding requested in FY 2007 from the MREFC account: the Atacama Large Millimeter Array (ALMA) and IceCube. Early operations funding for ALMA increases by $2.0 million. The termination of the Rare Symmetry Violating Processes (RSVP) project, also proposed for the MREFC account, is now complete. For more information, see the MREFC chapter.
- *Cyberinfrastructure.* The portfolio of world-class facilities that MPS maintains for the science and education communities represents a capital investment of well over $1.0 billion. Remote access to these facilities and analysis of the data they generate are aided by increasingly sophisticated cyberinfrastructure.
- *Instrumentation.* In addition to supporting these state-of-the-art facilities, which are open to all on the basis of scientific merit, MPS activities include public-private partnerships for research and development on astronomical instruments; development of new instrumentation in chemistry; enhanced user support and instrumentation for research at materials research facilities; expanded efforts in accelerator physics and physics instrumentation for experiments in particle and nuclear astrophysics and research; and enhanced computational investments for mathematics.

MPS Facilities Funding
(Dollars in Millions)

Facilities	FY 2005 Actual	FY 2006 Current Plan	FY 2007 Request	Change over FY 2006 Amount	Change over FY 2006 Percent
Cornell Electron Storage Ring (CESR)	$16.62	$14.56	$14.71	$0.15	1.0%
GEMINI Observatory	15.48	18.26	20.00	1.74	9.5%
Large Hadron Collider (LHC)	10.51	13.36	18.00	4.64	34.7%
Laser Interferometer Gravitational Wave Observatory (LIGO)	32.00	31.68	33.00	1.32	4.2%
MSU Cyclotron	17.50	17.32	17.60	0.28	1.6%
Nanofabrication (NNUN/NNIN)	2.80	2.77	2.80	0.03	1.1%
National High Magnetic Field Laboratory (NHMFL)	25.50	25.74	26.50	0.76	3.0%
Rare Symmetry Violating Processes (RSVP)	2.65	0.99	-	-0.99	-100.0%
National Astronomy and Ionosphere Center (NAIC)	10.52	10.46	10.46	-	-
National Center for Atmospheric Research (NCAR)	1.04	1.12	1.12	-	-
National Optical Astronomy Observatories (NOAO) [1]	37.94	36.91	40.05	3.14	8.5%
National Radio Astronomy Observatory (NRAO)	47.03	50.74	50.74	-	-
Other MPS Facilities	13.49	12.31	12.47	0.16	1.3%
Total, MPS	**$233.08**	**$236.22**	**$247.45**	**$11.23**	**4.8%**

[1] The NOAO total includes funding for instrumentation programs that build public-private partnerships. In FY 2007, the Telescope System Instrumentation Program increases by $2.0 million and the Adaptive Optics Development Program increases by $1.14 million, while the operations base for NOAO remains constant.

Broadening Participation in the S&E Enterprise +$5.21

Funding will emphasize inclusion of the professional societies and departments associated with MPS disciplines in addressing the issues related to broadening participation of women and underrepresented minorities, as well as investments aimed at broadening the base of institutions receiving MPS funds. Activities will emphasize partnerships, including linkages to facilitate the involvement of MPS communities in key NSF-wide programs such as LSAMP, AGEP, HBCU-UP, and CREST, and will use research experiences as the core of a strategy of partnering for diversity to attract members of underrepresented groups to MPS fields. OMA serves as a focal point for enhancing these investments.

Education and Workforce +$3.23

MPS will provide increases in support for CAREER, IGERT, Research Experiences for Undergraduates (REU) Sites, and Research Experiences for Teachers (RET). Enhancing the Mathematical Sciences Workforce for the 21st Century (EMSW21) increases by $500,000. Interdisciplinary undergraduate research experiences in computational sciences also increases by $500,000. MPS funding for Centers for Learning and Teaching decreases by $1.0 million with the planned termination of the higher education track. Investments in international opportunities for graduate students and internships in public science education will increase by $500,000.

Centers Programs +$7.85

MPS supports a number of activities that aggregate resources in support of disciplinary and interdisciplinary research that requires a greater level of effort in its conduct and meets NSF's center criteria. The Center for Layered Polymeric Systems at Case Western University was selected in the FY 2005 STC competition. In FY 2007, MPS will add $4.0 million to include this center, having transferred the funding from the Office of Integrative Activities budget line. The phase-out of three Materials Research Science and Engineering Centers is complete in FY 2006.

MPS Centers Funding
(Dollars in Millions)

Centers	FY 2005 Actual	FY 2006 Current Plan	FY 2007 Request	Change over FY 2006 Amount	Change over FY 2006 Percent
Chemistry Centers	$3.00	$1.48	$3.00	$1.52	102.7%
Materials Centers	$52.41	$53.66	$55.70	$2.04	3.8%
Nanoscale Science and Engineering Centers (NSEC)	13.00	12.83	12.96	0.13	1.0%
Science and Technology Centers (STC)	15.60	15.44	19.60	4.16	26.9%
Total, MPS	$84.01	$83.41	$91.26	$7.85	9.4%

Subtotal, Changes +$64.85

FY 2007 Request, MPS……..……………………………………..…………………………………. $1,150.30

NSF-wide Investments

In FY 2007, the MPS Directorate will support research and education efforts related to broad, Foundation-wide investments in a number of areas including NSF's multi-disciplinary priority areas and the Administration's interagency R&D priorities.

MPS NSF-wide Investments
(Dollars in Millions)

	FY 2005 Actual	FY 2006 Current Plan	FY 2007 Request	Change over FY 2006 Amount	Change over FY 2006 Percent
Biocomplexity in the Environment	$3.83	$3.36	$1.00	-$2.36	-70.2%
Climate Change Science Program	5.45	5.45	5.45	-	-
Cyberinfrastructure	56.52	59.30	63.56	4.26	7.2%
Human and Social Dynamics	0.50	0.50	0.50	-	-
Mathematical Sciences	70.21	69.69	69.26	-0.43	-0.6%
National Nanotechnology Initiative	143.27	141.54	156.42	14.88	10.5%
Networking and Information Technology R&D	77.52	67.82	69.00	1.18	1.7%

Funding for the **Biocomplexity in the Environment** priority area will decrease in FY 2007 as part of the planned phasing down of the priority area. Funds will support activities related to environmental molecular science.

The MPS investment in the **Climate Change Science Program** is led by CHE through the U.S. Global Change Research Program. It is focused on sustainability, including green chemistry, water chemistry, and energy.

NSF's **Cyberinfrastructure** activities are related to NITRD investments. All MPS divisions emphasize ways in which cyberinfrastructure – high-end computing, networking, and data collection and management – can enable the science they conduct. The developing capabilities create new opportunities for collaboration in science. Modeling, simulation, and visualization are increasingly important tools for MPS fields, particularly for work that crosses scales of time and space. Investments in improving hardware, software, and data management capabilities enable researchers to ask new kinds of questions, which, in turn, stimulate the need for new, more powerful capabilities in cyberinfrastructure. In addition, MPS divisions contribute to research for the next generation of cyberinfrastructure through the development of software and algorithms and through research on next-generation materials for computation and computing.

Funding for **Human and Social Dynamics** includes support for areas such as interdisciplinary research modeling the development and evolution of social and organizational behavior in complex systems. Within MPS, the Division of Mathematical Sciences will support research on dynamic and agent-based models used in studying human and social dynamics.

As the **Mathematical Sciences** priority area is phased out, support within MPS will decrease slightly, but will continue targeting fundamental mathematical sciences, interdisciplinary mathematical sciences, and mathematical sciences education, with the balance among these areas reflecting the evolving nature of the interdisciplinary partnerships. It is vital for mathematicians and statisticians to collaborate with engineers and scientists to extend the frontiers of discovery where science and mathematics meet, both in research and in educating a new generation for careers in academia, industry, and government.

MPS plays an important role, both within NSF and in the interagency working environment in the **National Nanotechnology Initiative**, investing a total of $156.42 million in FY 2007. Key areas for investment include fundamental nanoscale phenomena and processes and nanomaterials, with significant investments in instrumentation research, major research facilities, societal dimensions, and education. Many of the activities are carried out through interdisciplinary research teams. DMR is the lead division, with significant participation from CHE, PHY, and DMS.

All MPS divisions participate in funding for the **Networking and Information Technology R&D** (NITRD) program. The investment is focused in high-end computing infrastructure and applications, with contributions in high-end computing R&D and human-computer interaction and information management as well. GRID computing and the developing national virtual observatory are high-profile examples of MPS investments.

QUALITY

MPS maximizes the quality of the R&D it supports through the use of a competitive, merit-based review process. The percent of research funds that were allocated to projects that undergo external merit review was 87 percent in FY 2005, the last year for which complete data exist.

To ensure the highest quality in processing and recommending proposals for awards, MPS convenes Committees of Visitors, composed of qualified external evaluators, to review each program every three years. These experts assess the integrity and efficiency of the processes for proposal review and provide a retrospective assessment of the quality of results of NSF's investments.

The Directorate also receives advice from the Mathematical and Physical Sciences Advisory Committee (MPSAC) on such issues as: the mission, programs, and goals that can best serve the scientific community; how MPS can promote quality graduate and undergraduate education in the mathematical and physical sciences; and priority investment areas in MPS-supported research. The MPSAC meets twice a year. Members represent a cross section of the mathematical and physical sciences with representatives from many different sub-disciplines within the field; and include members from institutions and industry. The Committee includes a balanced representation of women, members of underrepresented minorities and geographic regions. MPS also participates in three advisory committees that advise multiple agencies: the High Energy Physics Advisory Panel (with DOE); the Nuclear Science Advisory Committee (with DOE); and the Astronomy and Astrophysics Advisory Committee (with DOE and NASA). Standing committees and studies of the National Research Council provide another mechanism for obtaining advice.

PERFORMANCE

NSF's FY 2007 budget is also aligned to reflect funding levels associated with the Foundation's four strategic outcome goals and the ten investment categories highlighted in the FY 2003-2008 Strategic Plan. These categories were designed as a mechanism to better enable assessment of program performance and to facilitate budget and performance integration.

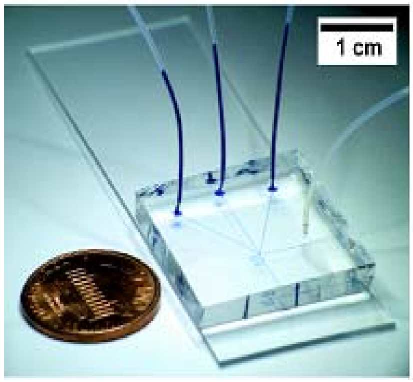
Mathematical and Physical Sciences
By Strategic Outcome Goal and Investment Category
(Dollars in Millions)

	FY 2005 Actual	FY 2006 Current Plan	FY 2007 Request	Change over FY 2006 Amount	Change over FY 2006 Percent
Ideas					
Fundamental Science and Engineering	$582.99	$606.87	$637.26	$30.39	5.0%
Centers Programs	84.01	83.41	91.26	7.85	9.4%
Capability Enhancement	-	-	-	-	N/A
	667.00	690.28	728.52	38.24	5.5%
Tools					
Facilities	136.55	136.99	145.08	8.09	5.9%
Infrastructure and Instrumentation	37.41	37.88	43.97	6.09	16.1%
Polar Tools, Facilities and Logistics	-	-	-	-	N/A
Federally-Funded R&D Centers	96.53	99.23	102.37	3.14	3.2%
	270.49	274.10	291.42	17.32	0.06
People					
Individuals	108.99	95.25	100.48	5.23	5.5%
Institutions	5.44	5.43	5.56	0.13	2.4%
Collaborations	10.32	13.86	17.19	3.33	24.0%
	124.75	114.54	123.23	8.69	7.6%
Organizational Excellence	7.12	6.53	7.13	0.60	9.2%
Total, MPS	$1,069.36	$1,085.45	$1,150.30	$64.85	6.0%

Totals may not add due to rounding.

Recent Research Highlights

► **Microfluid Technology on a Chip:** A group of NSF-supported researchers have invented a new way of testing biological reactions on a plastic chip – and then have used that technology to show that proper blood clotting depends critically on the precise arrangement of junctions between channels.

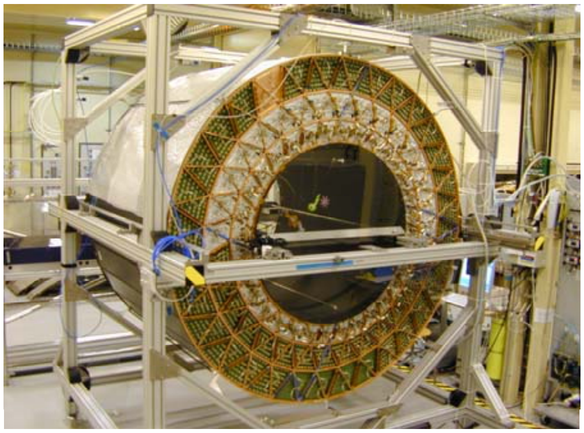


Credit: Helen Song, Rustem Ismagilov, University of Chicago.

Such reactions have been extremely difficult to study because it is hard to control conditions in an experiment. Now Rustem Ismagilov's lab at the University of Chicago is the first to recreate a chemical reaction network on a plastic chip, with micron-sized grooves many times thinner than a human hair. Chemical solutions flow through these grooves in a way that is controlled by the experimenter.

The team discovered that the proper function of clotting is dependent on the geometry of the junctions between the channels. This is a new principle in understanding the geometry of blood vessels and its role in proper clotting. The chip approach to reaction networks, now in its infancy, could make possible numerous new studies about reaction networks that result in emergent biological behavior. (CHE)

► **Detecting Progress:** Progress continues in NSF-funded work on the Large Hadron Collider (LHC), which is now under construction at the CERN laboratory in Geneva. Designed to be the world's most powerful particle accelerator, and scheduled to begin operations in 2007, the LHC will explore some of the deepest questions in science, including the nature of mass and why so many practically dimensionless subatomic particles have such a perplexingly wide array of masses. NSF is supporting the construction of two large detectors for this accelerator. Hampton University has been a partner in the development of one of these detectors (known as ATLAS). Hampton researchers have been heavily involved in the development of the complex particle tracking system known as the transition radiation tracker (TRT), and recently completed a number of sensitive tests successfully. (PHY)



The Transition Radiation Tracker (TRT) of the ATLAS detector. ATLAS, when completed, will be the largest particle detector ever constructed. *Credit: Hampton University.*

► **The Search for Other Worlds:** Using a relatively new planet-hunting technique that can spot worlds one-tenth the mass of our own, researchers have discovered a potentially rocky, icy body that may be the smallest planet yet found orbiting a star outside our solar system. Located more than 20,000 light years away in the constellation Sagittarius, close to the center of our Milky Way galaxy, the new planet is approximately five-and-a-half times the mass of Earth. Orbiting a star one-fifth the mass of the sun at a distance almost three times that of Earth's orbit, the newly discovered planet is frigid: the estimated surface temperature is -364 degrees Fahrenheit (-220 degrees Celsius). Although astronomers doubt this cold body could sustain organisms, researchers believe the new planet-hunting technique will bring opportunities for observing other rocky planets in the "habitable zones" of stars - regions where temperatures are perfect for maintaining liquid water and spawning life. (AST)

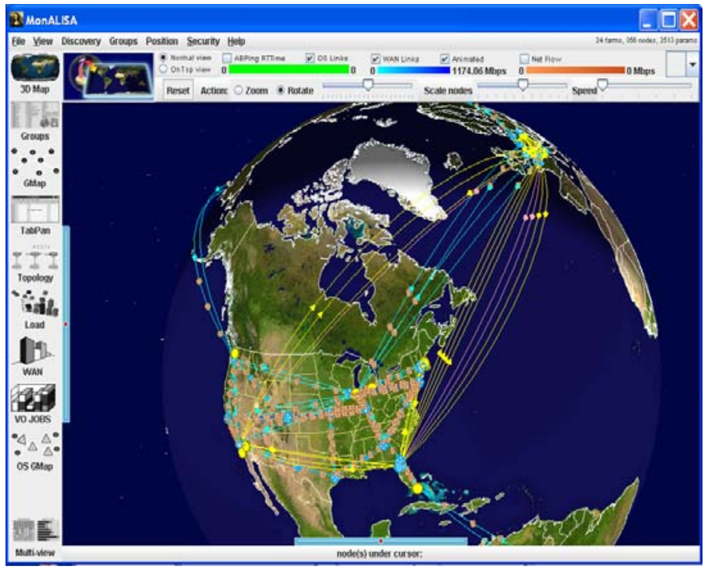
European Southern Observatory artist's rendition of the newly discovered extrasolar planet. *Credit: European Southern Observatory.*

► **The Search for Dark Matter:** Large-scale astronomical observations have shown that the universe is dominated by a haze of invisible "dark matter" having five times the total mass of normal matter. This dark matter remains unidentified because it cannot be detected directly by telescopes. However, its presence is inferred through the gravitational effects this matter exerts on visible matter. Theoretical calculations have led to the conclusion that the most likely candidate for dark matter is a massive particle called a WIMP (Weakly-Interacting Massive Particle).

This particle would rarely interact with normal matter. Nevertheless, it will interact on occasion and should be, in principle, detectable. The detection of WIMPS would provide a dramatic advance in our understanding of the material content of the universe and in our understanding of the nature of elementary particles. A team led by a Berkeley group has developed the world's most sensitive detector for this purpose. It is the CDMS (Cold Dark Matter Search) detector, located underground in the Soudan mine in Minnesota. The detector consists of vertical arrays of hockey-puck sized germanium and silicon detectors, which sense the tiny signal resulting when WIMPS interact with the germanium and silicon nuclei. The CDMS detector is operated at temperatures that are just a few thousands of a degree higher than absolute zero. Recent results have set new limits on the interaction between WIMPS and ordinary matter. These results have already ruled out certain theoretical models but will help shape and constrain future theories. (AST, PHY)

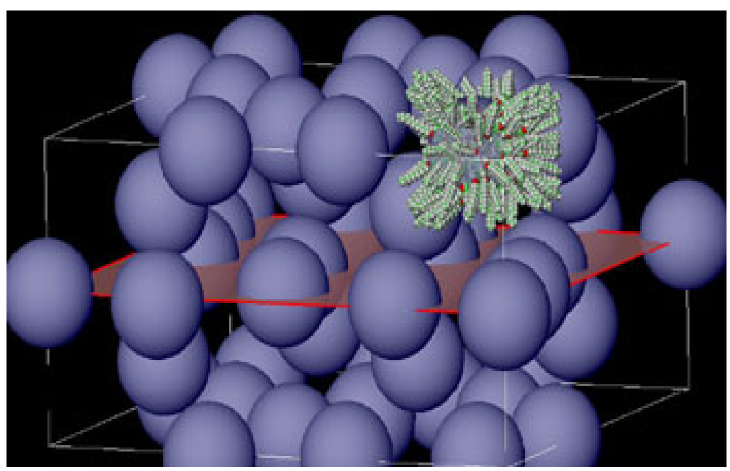
Four of the Silicon and Germanium detectors in their mounts at the Soudan mine in Minnesota. *Credit: University of California, Berkeley.*

► **Global Collaboration Networks:** Within the next decade, scientists working at the outermost frontiers of high-energy physics and astronomy will be generating data in unprecedented volume – billions of gigabytes per year from just four NSF-funded projects alone. Since the processing and analyzing of that tsunami of information will demand far more computing power than any single facility can bring to bear, NSF is providing pioneering support for international computing networks, or “grids,” that will do the job collaboratively. Examples include the nationwide Grid Physics Network (GriPhyN) to manage the data from two detectors at the Large Hadron Collider at CERN; the Laser Interferometer Gravitational Wave Observatory; and the Sloan Digital Sky Survey. Other programs, such as the International Virtual Data Grid Laboratory (iVDGL) and the UltraLight programs, have U.S., European, Asian and South American partners and will encompass more than 100 university- and laboratory-based grid sites that are collectively capable of meeting enormous data challenges. (PHY)



State-of-the art network, computing grid and software technologies are enabling global collaborations and discoveries in high energy physics and other data-intensive fields. *Credit: California Institute of Technology.*

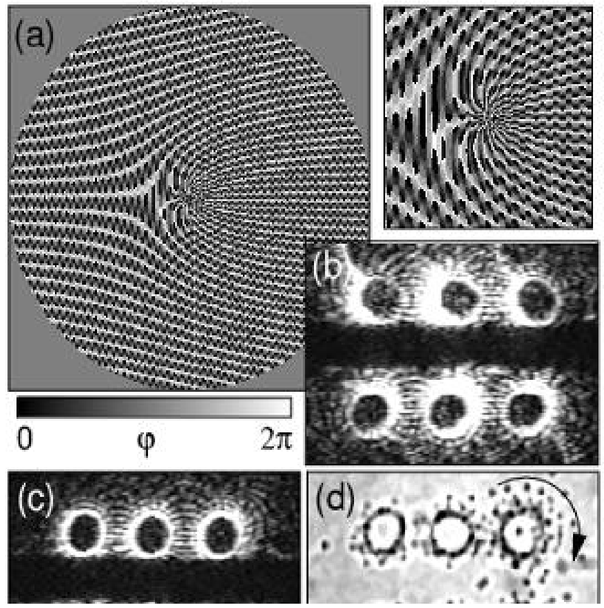
► **Molecular Self-Assembly:** NSF is enabling research into one of the most promising areas in science: the effort to understand – and to duplicate or even improve synthetically – the way that atoms and molecules in nature arrange themselves into various arrays with a host of specific functions. This kind of “bottom-up” programmed self-fabrication of materials is a key goal of nanoscience and may revolutionize manufacturing.



Credit: Virgil Percec, University of Pennsylvania.

In one striking example of such research, scientists at the University of Pennsylvania created spherical branching molecules that assemble themselves into groups of precisely structured building blocks totaling about 250,000 atoms. The illustration shows two layers of these self-assembled nanostructures that form a complex lattice with a repetitive arrangement of 30 ball-like molecules, each represented as a blue sphere. (Each spherical molecule actually more closely resembles the tree-like shape shown in green and red at top right.) The spherical molecules form a liquid crystal material that may help build nanostructures for molecular electronics or photonics materials. Each repetitive unit of 30 spheres occupies a rectangular volume nearly 20 nanometers (billionths of a meter) by 10 nanometers. (DMR)

► **Pumping with Light:** An NSF-supported research team has created one of the world's smallest fluid pumps – with no mechanical moving parts. As biomedical and chemical technology shrinks to ever smaller dimensions, there is an increasingly pressing need for active pumps and mixers that operate at length scales ranging from a few molecules to the size of microbes. David Grier's research team (recently moved to New York University from the University of Chicago) has developed a novel approach to that challenge that avoids all of the technological hurdles posed by micro- and nanofabrication by employing a recent breakthrough in creating computer-generated holograms with precisely directed beams of light.



Computer-designed "phase" hologram (a) transforms a laser beam into six optical vortices (b). The optimized array (c) drives particles in counter-rotating circles, thereby pumping surrounding fluid(d). *Credit: David Grier, New York University.*

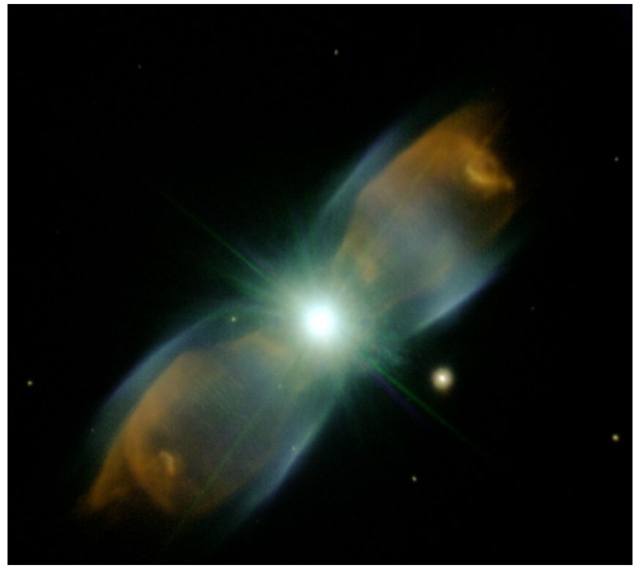
Holograms are produced when light rays are aimed so that they interact in specific ways to make up a multi-dimensional image. The NYU group harnesses the same fine control to make light beams act as "optical tweezers" to move objects on the scale of microns – millionths of a meter. (One micron is about 1/50th the width of a human hair.) The method works extremely well for investigating microscopic processes underlying everyday events such as melting and freezing, the lifecycle of cells and the emergent properties of materials. Although originally designed for fundamental research, the technique has applications that range from surgery within living cells, to manufacturing tiny sensors, to rapidly sorting fluid-borne objects with unparalleled selectivity. This technology has been commercialized and is being rapidly adopted for a wide range of industrial applications. (DMR)

► **Doctoring Computer Security:** The language of computer security is highly biological – systems are said to be "infected" by "viruses," "worms" and so on – and as a result, computer scientists often look to biological systems for inspiration. That's how Anil Somayaji, an NSF-supported Ph.D. student at the University of New Mexico, came to think about homeostasis: the physiological process by which the internal systems of the body are maintained within normal ranges despite variations in operating conditions. The body achieves homeostasis, for example, through its reactions to temperature variations, physical and psychological stresses, and microbial invaders. In the case of germs, containment and regulated coexistence are often the best strategies: drastic countermeasures are rarely called for.

How secure is your secure information? *Credit: William Rundell, National Science Foundation.*

With that in mind, Somayji and a colleague at the University of Minnesota began applying the notion of homeostasis to the "health" of computer systems under attack from security threats. Somayaji developed an extension for the Linux operating system, called pH, that maintains computer system stability by slowing the response to system calls when aberrant behavior is detected. That is, he modified the goal for computer security systems from rushing to destroy a perceived intruder when it is first recognized, to adapting the system to maintain stability. The ideas were commercialized and subsequently incorporated into a software program called Virus Throttle released by Hewlett-Packard Co. in February 2005. (DMS)

► **Adaptive Optics and the Search for Planets:** Researchers at the Gemini Observatory are developing next-generation instrumentation that will build on and expand the observatory's capabilities in adaptive optics: a technique that virtually eliminates the distortion in astronomical images produced by the atmosphere. The first application of such systems will be to search for planets around nearby stars. An example of the detail that can be obtained with the use of adaptive optics is the image shown here, taken with the ALTAIR adaptive optics system on the Gemini North 8-meter diameter telescope. A color composite image of the planetary nebula M2-9, it reveals remarkable details in the dynamic gas outflows from a dying star. The concentric shells of gas are still a mystery to astronomers and these data will help them to understand the complexities surrounding this beautiful object. (AST)



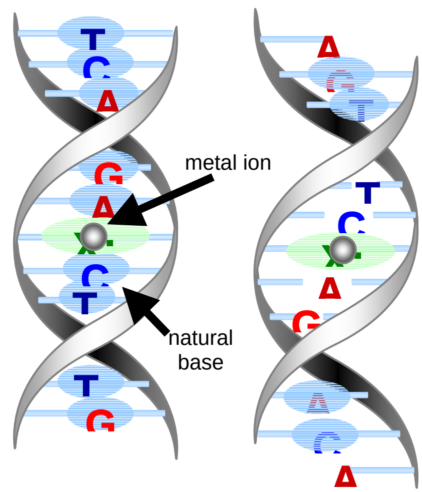
Credit: Gemini Observatories.

► **Fireflies, Neurons, and the Wobbling of the Millennium Bridge:** NSF-supported mathematicians have helped solve the strange case of the Millennium Bridge. This sleekly designed, pedestrian-only suspension bridge was the first new bridge constructed across London's Thames River in more than one hundred years, and its opening in June 2001 was eagerly awaited.

Credits: Steven H. Strogatz, Cornell University. Image of Millenium Bridge: http://en.wikipedia.org/wiki/London_Millenium_Bridge.

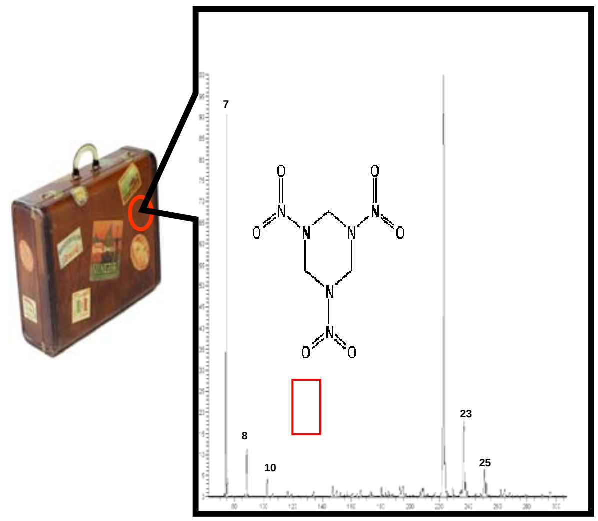
Disconcertingly, however, the large crowds that tried the bridge in its first weeks of service encountered swaying motions much larger than architects and engineers had anticipated – or could explain. Only recently has a convincing solution been advanced by Steven H. Strogatz (Cornell University), Edward Ott (University of Maryland) and their collaborators in the United Kingdom and Germany. Drawing on mathematical ideas originally used to describe the collective synchronization of independent biological oscillators such as fireflies and neurons, the researchers were able to explain how pedestrians were spontaneously falling into step with the bridge's small vibrations, and amplifying those vibrations well beyond what the standard engineering analyses had predicted. Their analysis even explained the curious fact that the Millennium Bridge was steady with 150 pedestrians on its deck, but swayed when the numbers rose above 160. Meanwhile, the bridge itself was closed for several months after the embarrassing opening, experiments were conducted, and dampers were installed between the bridge deck and the supporting piers to tame side-to-side motions. The refitted bridge is now a model of stability, and has become a well-used landmark. (DMS)

► **Electronic Circuits of the Future May Look A Lot Like DNA:** At Carnegie Mellon University, a research group lead by Catalina Achim has created a new class of DNA-like molecules that may eventually be used to store information, just as DNA itself does. The new molecules have a standard double-helix structure, with two strands winding around and around one another. But only one of their strands is formed from the standard DNA "backbone" of linked sugar molecules; the other is a protein-like chain of peptide molecules. Achim's group has shown that when metal ions are incorporated in the nucleic acids at specific locations, these artificial double helices, known as PNAs, can acquire a completely new set of magnetic and electrical properties. That result, in turn, opens new opportunities to create molecular-scale replicas of today's electronic circuit components, such as wires, diodes and transistors. (CHE)



Peptide and nucleic acid strands linked together by metal ions connecting the artificial bases. *Credit: Catalina Achim, Carnegie Mellon University.*

► **A Sensitive Nose for Explosives:** With funding from the National Science Foundation and the Office of Naval Research, the Graham Cooks research team at Purdue University has developed a powerful, new tool that simply and quickly analyzes surfaces for the presence of a common explosive. This tool, known as Desorption Electrospray Ionization Mass Spectrometry (DESI-MS), offers rapid, specific and sensitive detection of trace amounts of the explosive. In a demonstration, triacetone triperoxide (TATP) was detected on paper, brick, and metal surfaces. TATP is an easy-to-make, but hard-to-detect explosive that was used by terrorists for numerous suicide bombings, including the bombing of London subway trains in the summer of 2005. The detection of the explosive by DESI-MS is fast (less than 5 seconds) and no pretreatment of the surface is needed. In all of the cases studied so far, the tool has been highly selective and highly sensitive, detecting TATP at low nanogram limits. It provides a powerful, sensitive new tool for simply and rapidly analyzing surfaces for the presence of a common explosive. (CHE)



Rapid mass spectrometric detection of an explosive on an exposed surface. *Credit: Graham Cooks, Purdue University.*

► **Why So Few? Women in Physics from around the World Compare and Strategize:** How many women had the potential to be great physicists, but . . . ? Both nationally and internationally, women are seriously under-represented in physics and in other fields, such as engineering, for which physics knowledge is an essential prerequisite. The nature and magnitude of the problem varies from country to country, with some doing considerably better than the United States, and others doing considerably worse. However, there is remarkable consistency in one pattern: the percentage of women in physics in all countries decreases markedly with each step up the academic ladder, and with each level of promotion in industrial and government laboratories. Why is this true and what can be done? In May 2005, with NSF support for the U.S. delegation, 145 participants (93% women) from 42 countries met in Rio de Janeiro, Brazil, to discuss these issues, compare progress, and develop effective strategies. General discussion topics ranged from "Attracting Girls into Physics" to "Getting Women into the Physics Leadership Structure Nationally and Internationally" while individual presentations ranged from "Participation of Females in Physics Programs at the University of Botswana" to "Korean Physical Society's Physics Camp for High School Girls" to "Women in the Physical Sciences in Sweden: Do We Have True Gender Equality in a `Gender-Neutral' Country?" The Conference Proceedings are available. (PHY)

► **The Adventure of the Apprentice's Stone:** The Pennsylvania State University Materials Research Science and Engineering Center for Nanoscale Science has collaborated with The Action Potential Science Experience to develop "*The Adventure of the Apprentice's Stone*": an innovative materials and nanoscience summer camp program designed to connect art, history, and science. The week-long journey transports students in grades 4 through 8 into the magical world of the Penn State School of Potions, where a series of hands-on explorations into the nanoworld will teach the young wizards that science is all around them. Activity topics include ferrofluids, nitinol, zeolites, and lithography. Each day's activities help students to unlock a secret message, which will eventually combine with other messages collected during the week to reveal the knowledge contained in the Apprentice's Stone. In the image an Apprentice Wizard is trapped on a straw model of a zeolite. (DMR)

An Apprentice Wizard is captured on a straw model of a zeolite. *Credit: Pennsylvania State University Materials Research Science and Engineering Center.*

Other Performance Indicators

Number of People Involved in MPS Activities

	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate
Senior Researchers	6,373	6,400	6,500
Other Professionals	1,954	1,950	1,900
Postdoctorates	2,076	2,080	2,150
Graduate Students	7,042	7,100	7,200
Undergraduate Students	5,616	5,650	5,750
K-12 Students	250	275	320
K-12 Teachers	400	450	500
Total Number of People	23,711	23,905	24,320

MPS Funding Profile

	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate
Statistics for Competitive Awards:			
Number	2,073	2,100	2,150
Funding Rate	29%	29%	30%
Statistics for Research Grants:			
Number of Research Grants	1,591	1,600	1,650
Funding Rate	27%	27%	28%
Median Annualized Award Size	$99,999	$100,000	$103,000
Average Annualized Award Size	$135,374	$135,000	$140,000
Average Award Duration, in years	3.1	3.1	3.1

ASTRONOMICAL SCIENCES $215,110,000

The FY 2007 Request for the Astronomical Sciences Division (AST) is $215.11 million, an increase of $15.46 million, or 7.7 percent, over the FY 2006 Current Plan of $199.65 million.

Astronomical Sciences Funding

(Dollars in Millions)

	FY 2005 Actual	FY 2006 Current Plan	FY 2007 Request	Change over FY 2006 Amount	Change over FY 2006 Percent
Astronomical Sciences	**$195.11**	**$199.65**	**$215.11**	**$15.46**	**7.7%**
Major Components:					
Research and Education Grants	80.14	79.32	89.86	10.54	13.3%
Centers Programs	4.00	3.96	4.00	0.04	1.0%
Facilities	110.97	116.37	121.25	4.88	4.2%
Gemini Observatory	15.48	18.26	20.00	1.74	9.5%
National Astronomy and Ionosphere Center (NAIC)	10.52	10.46	10.46	-	-
National Optical Astronomy Observatory (NOAO) [1]	37.94	36.91	40.05	3.14	8.5%
National Radio Astronomy Observatory (NRAO)	47.03	50.74	50.74	-	-

Totals may not add due to rounding.
[1] Includes the National Solar Observatory.

About AST:

AST is the federal steward for ground-based astronomy in the U.S., working in partnership with private institutions to enhance overall observing capacity and capability. Research support covers a broad array of observational, theoretical, and laboratory research aimed at understanding the origins and characteristics of planets, the Sun, other stars, our galaxy, extragalactic objects, and the structure and origin of the Universe. Special grants and fellowship programs for young faculty, postdoctoral researchers, and undergraduate students encourage the activities of researchers engaged in education and outreach and increase the participation of underrepresented minorities in science. AST provides the U.S. share of funding for the operation of the international Gemini Observatory and supports the operation of four National Astronomy facilities: the National Astronomy and Ionosphere Center (NAIC), the National Optical Astronomy Observatory (NOAO), including the National Solar Observatory (NSO), and the National Radio Astronomy Observatory (NRAO). AST programs support the development of advanced technologies and instrumentation, planning and design for future observational facilities and major collaborative projects in astronomy, and management of the electromagnetic spectrum for scientific use.

The AST portfolio has two major modes of support: research and education grants and facilities.

- AST research and education grants range in scope from awards to individual-investigators to large collaborations carrying out extensive surveys or developing instrumentation.
- AST also supports major world-class facilities that provide access to a wide range of observational resources on a competitive basis. (Additional information about AST facilities is provided in the Facilities chapter of this document.)

Facilities are approximately 56 percent of the AST portfolio. In FY 2005, AST received 578 research proposals and made 155 competitive awards for a success rate of 27 percent.

AST Priorities for FY 2007:

Research Grants Programs are AST's highest priority in stewardship of the portfolio. Emphasis will be given to addressing scientific priorities articulated in the National Research Council's "Astronomy and Astrophysics for the New Millennium," supporting activities in the area of cyberinfrastructure/ cyberscience including a national virtual observatory in partnership with NASA, and ensuring a healthy and balanced program of research and education grants to the community.

Physics of the Universe (POU), the highest scientific priority, addresses the compelling questions that have arisen at the interface of physics and astronomy and were posed by the National Research Council (NRC) report, "Connecting Quarks with the Cosmos." A subsequent National Science and Technology Council report, "The Physics of the Universe: A 21st Century Frontier for Discovery," outlines a national investment plan involving NSF, DOE, and NASA. Within NSF, POU is coordinated and supported by the AST and PHY Divisions. Activities include funding within the grants program, instrumentation development, and new facilities.

Public-Private Partnerships are a keystone of the division's strategy. In FY 2007, there will be renewed investments in the **Telescope System Instrumentation Program** (TSIP) and the **Adaptive Optics Development Program** (AODP), as well as increased support for **Giant Segmented Mirror Telescope** (GSMT) technology development.

Gemini Observatory operations and instrumentation are AST's highest priority in facility stewardship. Ensuring the optimum performance and future instrumentation of our premier and newest optical/IR (infrared) facility enables forefront research by the scientific community and their students in this international partnership and strengthens the public-private partnerships.

Changes from FY 2006:

Research and education grants increase by $10.54 million to a total of $89.86 million. AST will continue to support a wide range of astrophysical investigations from the search for extrasolar planets to the origin of the universe. Development of tools for handling large data sets and implementation of the Virtual Astronomical Observatory in partnership with NASA are emphases in AST's approach to cyberinfrastructure/cyberscience. Education and outreach activities will receive continued emphasis. Support for technology development for the **Large-Aperture Synoptic Survey Telescope** (LSST) continues and that for GSMT will increase to $5.0 million.

Funding for the **Science and Technology Center for Adaptive Optics** is restored to $4.0 million.

Facilities increase by $4.88 million to a total of $121.25 million. Base operations funding for all facilities remains at the FY 2006 level, pending the results of the on-going Senior Review of AST facilities. See the Facilities chapter for details. Changes include:

- The increase of $1.74 million for the **Gemini Observatory** will enable enhanced operational and visitor support and continue the funding of a new generation of advanced instrumentation.
- The **NOAO/NSO** total includes design and development for the **Advanced Technology Solar Telescope** (ATST). NOAO support for TSIP increases by $2.0 million to $4.0 million, and support for AODP increases by $1.14 million to $1.50 million. Both are administered for the community through NOAO.
- **NRAO** is supported at the level of $50.74 million, as in the FY 2006 Current Plan. The total includes an increase of $2.0 million for ALMA early operations to a total of $6.0 million.

CHEMISTRY $191,100,000

The FY 2007 Request for the Chemistry Division (CHE) is $191.10 million, an increase of $10.32 million, or 5.7 percent, over the FY 2006 Current Plan of $180.78 million.

Chemistry Funding
(Dollars in Millions)

	FY 2005 Actual	FY 2006 Current Plan	FY 2007 Request	Change over FY 2006 Amount	Change over FY 2006 Percent
Chemistry	**$179.26**	**$180.78**	**$191.10**	**$10.32**	**5.7%**
Major Components:					
Research and Education Grants	156.84	159.09	167.39	8.30	5.2%
Centers Programs	8.60	8.01	9.60	1.59	19.9%
Instrumentation/Facilities	13.82	13.68	14.11	0.43	3.1%

Totals may not add due to rounding.

About CHE:

The Chemistry Division (CHE) advances the intellectual frontiers of chemistry, which seeds innovation and competitiveness more broadly across society. CHE supports research that enables matter to be manipulated, measured, and modeled. Exquisite control in designing and synthesizing new molecules and molecular assemblies is the result. Understanding matter from this perspective is essential to advances in many allied fields, including the life, environmental, and materials sciences, as well as nanoscale science and engineering. CHE supports cyber-enabled chemistry, a new paradigm for chemical research and education. CHE invests substantially in the development of a diverse, internationally competitive workforce for the chemical sciences that can contribute to these advances.

Research supported by CHE covers a broad range of subfields, including organic and macromolecular chemistry; experimental physical chemistry; theoretical and computational chemistry; inorganic, bioinorganic and organometallic chemistry; and analytical and surface chemistry. Progress in these areas is vital to the health, wealth and security of the U.S. Strength in the chemical sciences is essential to fostering innovation that will maintain the U.S. as a leader and preferred partner in an increasingly global chemical enterprise. Chemistry directly impacts our daily lives through its contributions to production of food, shelter, clothing, energy, medicine, and countless products that enhance our quality of life.

The CHE portfolio has three major modes of support: research and education grants, centers, and instrumentation and facilities.

- CHE research and education grants range in scope from individual investigator awards to multi-investigator awards that allow groups of researchers to collaborate on disciplinary and multidisciplinary projects.
- CHE Centers include six Chemical Bonding Centers (CBCs), a Science and Technology Center (STC) in environmentally responsible solvents and processes, and three Nanoscale Science and Engineering Centers (NSECs). Centers are funded on a competitive basis to support focused efforts on the most important science questions requiring this level of concentration in order to make major advances.
- Through its Chemistry Research Instrumentation and Facilities (CRIF) program, CHE provides modern multi-user instrumentation, such as X-ray diffractometers and nuclear magnetic resonance

spectrometers; support for the development of instrumentation that permits new kinds of chemical measurements and broadens access; and support for large cyberinfrastructure projects and facilities, such as the National High Magnetic Field Laboratory.

The total portfolio of CHE in FY 2005 included 422 awards with a proposal success rate of 26 percent.

CHE priorities for FY 2007:

- **Maintaining a strong, flexible program of research and education grants that advance the frontiers of the chemical sciences.** Forefront research and education projects reflected in individual investigator and multi-investigator awards define future scientific and technological opportunities in the chemical sciences. CHE seeks to identify and nurture pioneering research that is potentially transformative, albeit high risk. The involvement in forefront research of undergraduate and graduate students, postdoctoral researchers, and beginning investigators builds national innovation capacity in the chemical sciences.
- **Special areas of emphasis** include: molecular basis of life processes (MBLP), sustainability, nanoscale science and technology, and homeland security (through the Engineering-led initiative on improvised explosive devices), aligning with multiple Administration R&D priorities.
- **Investments in cyber-enabled chemistry.** The development of databases, data mining tools, molecular visualization and computational capabilities, and remote and networked use of instrumentation and facilities, for example – promise to be transformative in the chemical sciences, allowing individuals and teams to address research challenges of unprecedented complexity working in entirely new ways.
- **Broadening participation.** Investments in the Research Experiences for Undergraduates (REU) and Undergraduate Research Collaboratives (URC) programs provide opportunities for far larger numbers of students, including first- and second-year college students and those at 2-year institutions, to create and communicate new knowledge in the chemical sciences and fuel the expansion of a culture of innovation in academic institutions. CHE will enhance efforts to increase the participation of women and underrepresented minorities in academic chemistry departments.

Changes from FY 2006:

- Research and education grants increase by $8.30 million to a total of $167.39 million. CHE will continue to support cutting-edge areas of chemistry, with emphasis on nanoscale science, MBLP, sustainability, and cyber-enabled chemistry.
- Instrumentation/Facilities increase by $430,000, to a total of $14.11 million. This includes enhanced investments in cyberinfrastructure to develop tools for cyber-enabled chemistry and contributions to the NHMFL and other facilities. Many of the investments in cyber-enabled chemistry will be made through the CRIF program, which also provides funds for multi-user instrumentation and instrumentation development.
- Chemistry Centers increase by $1.59 million, reflecting the establishment of one full-scale Chemical Bonding Center.

MATERIALS RESEARCH $257,450,000

The FY 2007 Request for the Materials Research Division (DMR) is $257.45 million, an increase of $14.54 million, or 6.0 percent, over the FY 2006 Current Plan of $242.91 million.

Materials Research Funding
(Dollars in Millions)

	FY 2005 Actual	FY 2006 Current Plan	FY 2007 Request	Change over FY 2006 Amount	Change over FY 2006 Percent
Materials Research	**$240.09**	**$242.91**	**$257.45**	**$14.54**	**6.0%**
Major Components:					
Research and Education Grants	136.04	138.68	146.13	7.45	5.4%
Centers Programs	64.01	65.14	71.30	6.16	9.5%
Facilities	40.04	39.09	40.02	0.93	2.4%
National High Magnetic Field Laboratory (NHMFL)	24.00	24.26	25.00	0.74	3.1%
National Nanofabrication Infrastructure Network (NNIN)	2.55	2.52	2.55	0.03	1.2%
Other MPS Facilities	13.49	12.31	12.47	0.16	1.3%

Totals may not add due to rounding.

About DMR:

The Materials Research Division advances the intellectual frontiers of materials research which underpins innovation and national competitiveness. It enables the materials community to make new discoveries about the fundamental behavior of matter and materials; to create new materials and new knowledge about materials phenomena; to address questions about materials that often transcend traditional scientific and engineering disciplines and may lead to new technologies; to prepare the next generation of materials researchers; to develop and support the instruments and facilities that are crucial to advance the field; and to share the excitement and significance of materials and condensed-matter science with the public at large. DMR supports research over a broad range of subfields, including condensed matter and materials physics; solid state chemistry; polymers; ceramics; metals; electronic, magnetic and photonic materials; and materials theory. The division maintains a balanced portfolio of research topics through individual investigator grants, focused research groups, centers, and awards for instrumentation and user facilities. DMR programs support a variety of interagency and international partnerships to advance materials research and education.

The DMR portfolio has three major components: research and education awards, centers, and user facilities. Support for international collaboration and for broadening participation in materials research and education is integrated throughout the portfolio.

- DMR research and education awards comprise grants to individual investigators and small groups, and to teams of several investigators addressing complex problems in materials and condensed-matter research. DMR also supports six International Materials Institutes based at U.S. universities to enhance international cooperation in materials, and a program to support the acquisition and development of instrumentation for materials research. Partnerships for Research and Education in Materials are aimed at broadening participation in the materials research field by linking minority serving institutions with centers and groups at research intensive institutions. DMR will continue strong support for the seven existing partnerships, having added three during FY 2006.

- Materials Research Science and Engineering Centers (MRSECs) address major interdisciplinary problems in materials and condensed-matter science. DMR will continue support for 29 MRSECs in FY 2007, with three phasing out in FY 2006. The division also supports three Nanoscale Science and Engineering Centers (NSECs), a Science and Technology Center (STC) on Materials and Devices for Information Technology Research, and provides partial support for a further seven NSECs.
- DMR supports world-class facilities for high magnetic fields, synchrotron radiation, and neutron scattering, and provides partial support for the National Nanofabrication Infrastructure Network. Researchers use these facilities to address challenging problems across a very broad spectrum of science and engineering.

Facilities and centers comprise approximately 43 percent of the DMR portfolio in FY 2006. In FY 2005, DMR received 1,194 research proposals and made 266 awards for a success rate of 22 percent.

DMR Priorities for FY 2007:

Enhancing support for materials research programs that generate new ideas and novel materials and undergird innovative technologies. These core programs include awards to individual investigators, groups, interdisciplinary teams, and centers. Increased emphasis will be given to research on materials and phenomena at the nanoscale (including activities that address educational aspects and societal impact of nanotechnology); on biologically related materials including soft condensed matter; on computational materials research; and on materials for future cyberinfrastructure.

Broadening participation in materials research by maintaining vigorous programs for the participation of undergraduates, pre-college students and pre-college teachers in research, and by maintaining and enhancing partnerships that strengthen the links between institutions serving underrepresented groups and DMR-supported research teams, centers, and facilities.

Maintaining support for world-class user facilities while enabling the development of future user facilities and major instrumentation for synchrotron radiation, neutron scattering, and high magnetic fields. (For more detailed information about the National High Magnetic Field Laboratory, please see the Facilities chapter.)

Changes from FY 2006:

DMR will increase support for **research and education grants** by $7.45 million to a total of $146.13 million. The increase will enhance support for interdisciplinary research on nanoscale materials that also addresses educational needs and societal impact of nanotechnology. Support for research on cyberinfrastructure materials and biologically-related materials will also increase.

DMR will increase support for **centers programs** by $6.16 million to a total of $71.30 million. The increase will support a new Science and Technology Center for advanced polymer layer structures led by researchers at Case Western University. With funds from other centers being phased out, the increment will also support additional interdisciplinary groups at selected materials research centers addressing nanoscale research and the educational and societal aspects of nanotechnology.

DMR will increase support for **facilities** by $930,000 to a total of $40.02 million, maintaining critical support for state-of-the-art user facilities for synchrotron radiation, neutron scattering, and nanofabrication, and supporting increased operational costs at the National High Magnetic Field Laboratory. Funding for instrumentation will continue to be refocused to enhance support for the design and development of mid-scale instruments.

MATHEMATICAL SCIENCES $205,740,000

The FY 2007 Request for the Mathematical Sciences Division (DMS) is $205.74 million, an increase of $6.44 million or 3.2 percent above the FY 2006 Current Plan of $199.30 million.

Mathematical Sciences Funding
(Dollars in Millions)

	FY 2005 Actual	FY 2006 Current Plan	FY 2007 Request	Change over FY 2006 Amount	Change over FY 2006 Percent
Mathematical Sciences	**$200.24**	**$199.30**	**$205.74**	**$6.44**	**3.2%**
Major Components:					
Research and Education Grants	200.24	199.30	205.74	6.44	3.2%

About DMS:

The Mathematical Sciences Division advances the intellectual frontiers of the mathematical sciences and contributes to advancing knowledge in other scientific and engineering fields and national competitiveness. It plays a key role in the training of the Nation's science and engineering workforce. Driven in part by increasingly sophisticated and readily available computing environments, advances in science and engineering are requiring more sophisticated mathematical and statistical tools.

NSF has a crucial role in the support of basic academic research in the mathematical sciences, providing almost 80 percent of all federal university-based support. In the core mathematical areas this percentage is much higher as NSF support involves a broader range of infrastructure and fundamental and multidisciplinary research topics than that sponsored by other federal agencies that support academic mathematical sciences research. DMS plays a dominant role in developing the next generation of mathematical scientists, providing nearly all of the NSF support for graduate students and postdoctoral positions in the mathematical sciences.

DMS includes areas such as analysis, geometry, topology, foundations, algebra, number theory, combinatorics, applied mathematics, statistics, probability, mathematical biology, and computational mathematics. Awards in these areas support a variety of research projects, as well as for workshops, computing equipment and other research and education needs. In addition, DMS supports infrastructure, including national research institutes and postdoctoral, graduate, and undergraduate training opportunities. The DMS portfolio includes a variety of support modes and mechanisms:

- DMS research grants range in scope from individual-investigator awards to awards for multidisciplinary groups of researchers attacking problems of major scientific importance.
- DMS provides major support for education and training, particularly through Enhancing the Mathematical Sciences Workforce for the 21st Century (EMSW21), which focuses on research training activities in the mathematical sciences and mentoring activities aimed at increasing the number of U.S. students choosing careers in the mathematical sciences.
- DMS provides core support for five mathematical sciences research institutes as well as major support for three other institutes, all funded on a competitive basis to serve as an incubator for new ideas and directions in the mathematical sciences and address the growing interface with other disciplines.

In FY 2005, DMS received 2,172 research proposals and made 687 awards, for a success rate of 32 percent.

DMS Priorities for FY 2007:

Single investigator as well as small group research grants form the core of the DMS portfolio and play a central role in advancing the frontier of knowledge. DMS emphasis areas include algorithm development and computational tools for large-scale problems of scientific importance, particularly stochastic or probabilistic models and modeling scientific phenomena that occur over a large range of spatial and temporal scales. Finding patterns in and, in general, understanding the structure of large data sets are fundamental problems.

Broadening participation in the mathematical sciences will emphasize the support of interactions and research networks among a diverse population that will include graduate students and researchers at a wide array of institutions. DMS will continue to emphasize the role of institutes in broadening the participation of researchers and students in the mathematical sciences.

Education and training activities include research experiences and mentoring activities aimed at increasing the number of U.S. students choosing careers in the mathematical sciences.

Mathematical Sciences Priority Area (MSPA). DMS will continue its strong support for the priority area, while initiating the mainstreaming of its activities in the DMS portfolio. The priority area will continue to have three major foci for DMS: (1) fundamental mathematical and statistical research, (2) interdisciplinary research that connects the mathematical sciences with other sciences and engineering, and (3) targeted investments in mathematical sciences training activities through research. Interdisciplinary investments will focus on challenges posed by large data sets, managing and modeling uncertainty, and modeling complex nonlinear systems.

Changes from FY 2006:

- **Support for the core** increases by $5.07 million in order to sustain the success rate for individual investigator proposals. Award size and duration will be maintained to the extent possible by providing adequate support levels for the most compelling projects and without reducing the success rate for unsolicited proposals. Investments in formal interdisciplinary partnerships through the MSPA will be redirected to unsolicited proposals and the fundamental mathematical sciences component of the MSPA, while retaining their spirit, and integrating them fully into the core with the continuing fundamental purpose of advancing the frontiers of knowledge. DMS will allocate approximately $1.0 million of this amount to activities related to computational science, specifically algorithm development for future computational tools.
- **Undergraduate research experiences in computational sciences** increases by $500,000, to $1.50 million total. This activity is designed to enhance computational aspects of the education and training of students in the mathematical sciences and to better prepare students to pursue careers in fields that require integrated strengths in computation and the mathematical sciences.
- **Enhancing the Mathematical Sciences Workforce in the 21st Century (EMSW21)** increases overall by $500,000. This will involve a realignment of EMSW21 by reducing the number of components to two, thereby consolidating and better focusing these efforts.
- **Support for the National Nanotechnology Initiative** increases by $170,000.

PHYSICS $248,500,000

The FY 2007 Request for the Physics Division (PHY) is $248.50 million, an increase of $15.37 million, or 6.6 percent, over the FY 2006 Current Plan of $233.13 million.

Physics Funding
(Dollars in Millions)

	FY 2005 Actual	FY 2006 Current Plan	FY 2007 Request	Change over FY 2006 Amount	Change over FY 2006 Percent
Physics	**$224.86**	**$233.13**	**$248.50**	**$15.37**	**6.6%**
Major Components:					
Research and Education Grants	145.58	155.22	165.19	9.97	6.4%
Facilities	79.28	77.91	83.31	5.40	6.9%
Laser Interferometer Gravitational Wave Observatory (LIGO)	32.00	31.68	33.00	1.32	4.2%
Large Hadron Collider (LHC)	10.51	13.36	18.00	4.64	34.7%
Rare Symmetry Violating Processes (RSVP)	2.65	0.99	-	-0.99	-100.0%
National Superconducting Cyclotron Laboratory (NSCL)	17.50	17.32	17.60	0.28	1.6%
Cornell Electron Storage Ring (CESR)	16.62	14.56	14.71	0.15	1.0%

Totals may not add due to rounding.

About PHY:

PHY advances the intellectual frontiers of physics; contributes to advances in other scientific and engineering fields and to the ultimate benefit of the economy, health, and defense of the country; works toward early inspiration of the young, training the next generation of scientists and the high-tech workforce, and sharing the stimulation and understanding provided by science to the general public through the integration of research and education; and stewards the physics community to ensure it remains world-class as it evolves in the future. PHY supports research over a broad range of physics subfields, including atomic, molecular, optical, and plasma physics; elementary particle physics; gravitational physics; nuclear physics; astrophysics; theoretical physics; biological physics; physics cyberscience and cyberinfrastructure; accelerator physics; complex systems; and turbulence. The division maintains a balanced portfolio of research topics using appropriate modes of support and partnering across agency and national boundaries.

The PHY portfolio has two major modes of support: research and education grants and facilities.

- PHY research and education grants range in scope from individual-investigator awards to awards to major user groups, including groups with responsibility for experiments at national or international user facilities, and awards for frontier research efforts involving centers, institutes, and other multi-investigator collaborations.
- PHY also supports major world-class facilities that are needed by certain subfields to answer the highest priority science questions. (Additional information about PHY facilities is provided in the Facilities chapter of this document.)

In FY 2005, PHY made a total of 230 competitive awards and 541 continuing and supplementary award actions based on reviews from prior years. The funding rate was 37 percent for competitive actions.

PHY Priorities for FY 2007:

- **A strong, flexible program of research and education grants to create new ideas and technology and attract and train students** is the highest priority in overall stewardship of the portfolio. Emphasis will be given to increasing the support for cyberinfrastructure and cyberscience, theoretical research across the portfolio, and biological physics.
- **Elementary Particle Physics (EPP) Investment**. The opportunities for discovery in EPP and the challenges to addressing them are greater than at any time in the last half-century. The tools needed for breakthrough discoveries are more diverse and interdisciplinary, and NSF is well positioned to address the broader needs of EPP. By making the strategic, coordinated investment needed to realize the stunning opportunities laid out in numerous studies and plans, NSF will enable university researchers to participate fully in the emerging discovery period in EPP. The investment has three main components: the Energy Frontier, the Neutrino Frontier, and the Cosmic Frontier.
- **Physics of the Universe (POU)**, the highest scientific priority, addresses the compelling questions that have arisen at the interface of physics and astronomy and were posed by the National Research Council (NRC) report, "Connecting Quarks with the Cosmos." A subsequent National Science and Technology Council report, "The Physics of the Universe: A 21st Century Frontier for Discovery," outlines a national investment plan involving NSF, DOE, and NASA. Within NSF, POU is coordinated and supported by the AST and PHY Divisions. Activities include funding within the grants program, instrumentation development, and new facilities.

Changes from FY 2006:

- Research and education grants increase by $9.97 million to a total of $165.19 million. PHY will make a major new investment in EPP and related areas of POU research. PHY will continue to enhance support for cyberinfrastructure, theoretical physics, biological physics, and computational physics. Education and outreach activities will receive continued emphasis: enhancing K-12 science teacher training, expanding diversity within the research community, integrating research and education, including the training of new physicists.
- Facilities increase by $5.40 million to a total of $83.31 million. For detail, see the Facilities chapter. This includes:
  - An increase of $4.64 million for early operations (including data analysis support) of the LHC ATLAS and CMS detectors for a total of $18.0 million.
  - Increased support for operations of the Laser Interferometer Gravitational Wave Observatory (LIGO) and for advanced detector R&D at a total of $33.0 million, an increase of $1.32 million.
  - Increased support for operations of Michigan State University's National Superconducting Cyclotron Laboratory radioactive ion beam facility at a total of $17.60 million, an increase of $280,000, and for the Cornell Electron Storage Ring (CESR) facility at a total of $14.71 million, an increase of $150,000.
  - Phase out of the terminated RSVP project will be completed, a decrease of $990,000.

MULTIDISCIPLINARY ACTIVITIES $32,400,000

The FY 2007 Request for the Office of Multidisciplinary Activities (OMA) is $32.40 million, an increase of $2.72 million, or 9.2 percent, over the FY 2006 Current Plan of $29.68 million.

Multidisciplinary Activities Funding
(Dollars in Millions)

	FY 2005 Actual	FY 2006 Current Plan	FY 2007 Request	Change over FY 2006 Amount	Change over FY 2006 Percent
Multidisciplinary Activities	**$29.80**	**$29.68**	**$32.40**	**$2.72**	**9.2%**
Major Component:					
Research and Education Grants	29.80	29.68	32.40	$2.72	9.2%

About OMA:

The Office of Multidisciplinary Activities enables and facilitates MPS support of particularly novel, challenging, or complex projects of varying scale in both research and education that are not readily accommodated by traditional organizational structures and procedures. This is done primarily in partnership with the five MPS disciplinary divisions to encourage multidisciplinary proposals from all segments of the MPS community and especially to encourage initiatives by multi-investigator, multidisciplinary teams pursuing problems on a scale that exceeds the capacity of individual investigators. Most often, these cooperative undertakings involve two or more partners – within MPS or beyond – that join with OMA to push in new directions of scientific understanding and that broaden and enrich education and research training activities in the MPS disciplines. Such partnerships are critically important to the pursuit of the strategic goals of the Foundation and of the MPS community and contribute significantly to the preparation of a diverse workforce for the new century that is broadly trained, flexible, and globally competitive. Facilitation by OMA of both disciplinary partnerships and organizational partnerships is vital to the accelerated discovery of new ideas, the development of new tools, and the broadened training necessary to enable the Nation's workforce to meet new and rapidly evolving demands.

Because OMA plays a catalytic role in initiating new multidisciplinary activities and enabling broadening participation, the portfolio contains few commitments from prior years. Almost all awards are managed in the MPS divisions with co-funding from OMA.

OMA Priorities for FY 2007:

Enabling the creativity of the MPS community by facilitating partnership-enabled multidisciplinary and high-risk research that extends the intellectual frontiers of the MPS disciplines. Such activities include fundamental multidisciplinary research at the interface between the AST and PHY Divisions that enables advances in our understanding of the physics of the universe; at the interface between the MPS disciplines and the biological sciences that provides insights into the molecular basis of life processes, bio-inspired materials, and biological physics; and by multidisciplinary teams of scientists, mathematicians, and engineers which leads to the development of next-generation instrumentation, particularly instrumentation at the mid-scale level, that enables fundamental advances across a wide spectrum of disciplines.

Catalyzing the development of a diverse, well-prepared, internationally competent, and globally engaged STEM workforce includes both MPS participation in Foundation-wide programs and MPS-centric activities that leverage the directorate's research investment. These activities enrich the education and training continuum at all levels and facilitate the formation of research-based partnerships that not only increase diversity and broaden participation in the STEM enterprise directly, but also build the physical and intellectual capacity of educational institutions, particularly minority serving institutions (MSIs), to produce larger, more diverse cohorts of U.S. graduates who are well prepared to both support and to lead the Nation's STEM enterprise in the 21st Century.

Changes from FY 2006:

Funding for **research-enabled broadening participation in the MPS disciplines**, including the MPS-wide **Research Partnerships for Diversity**, diversity-targeted outreach from MPS centers and facilities, and diversity-building partnerships with MPS professional societies, increases by $2.75 million to the level of $4.25 million. These co-investments with the five disciplinary MPS divisions enable research-based collaborative activities primarily between MPS-supported centers and facilities and MSIs. These collaborative interactions build research capacity of the MSI faculty, strengthen the research infrastructure of the MSIs, and engage, stimulate, retain, and develop an increasingly diverse cadre of students in the MPS disciplines at the undergraduate and graduate levels.

Support for **collaborative public education and outreach** activities at MPS-supported research centers and facilities will be maintained at the level of $3.0 million. This investment includes the MPS Internships in Public Science Education program and related activities that enable effective leveraging of the MPS research investment for public science education, and clear public articulation of MPS science themes such as Physics of the Universe.

The OMA investment in the **Research Experiences for Teachers** activity (RET) will be sustained at the FY 2006 level of $3.0 million, to provide more than 300 pre-service and in-service K-12 teachers with discovery-based learning experiences in the MPS disciplines.

Support for the restructured Foundation-wide **NSF Director's Distinguished Teaching Scholars** (DTS) program will be provided at the level of $500,000. This represents an increase of $500,000 from FY 2006 when the program did not solicit proposals. One important new facet of this activity will be its impact on broadening participation through recognition of diverse teacher-scholar role models. Support for the NSF-wide **GK-12** program increases by $530,000 to a total of $3.0 million.

Investment in cooperative **international research and training activities** will be increased by $200,000 to the level of $1.2 million, which will enhance the global competitiveness of U.S. scientists, engineers, and students. Included in this international portfolio are investments in the NSF-wide Pan-American Advanced Study Institutes, international research training networks, and opportunities for graduate students to establish and enrich international dimensions of their individual research and education programs.

All the above activities take place in the context of **disciplinary and interdisciplinary research**. OMA places particular emphasis on cooperative, high-risk research at the AST-PHY interface focused on Physics of the Universe, to be co-supported at the level of $2.50 million, and on innovative research in multidisciplinary areas that enhance our understanding of the molecular basis of life processes, biological physics, and bio-inspired materials, to be co-supported at the level of $2.0 million.