MATHEMATICAL AND PHYSICAL SCIENCES $1,086,230,000

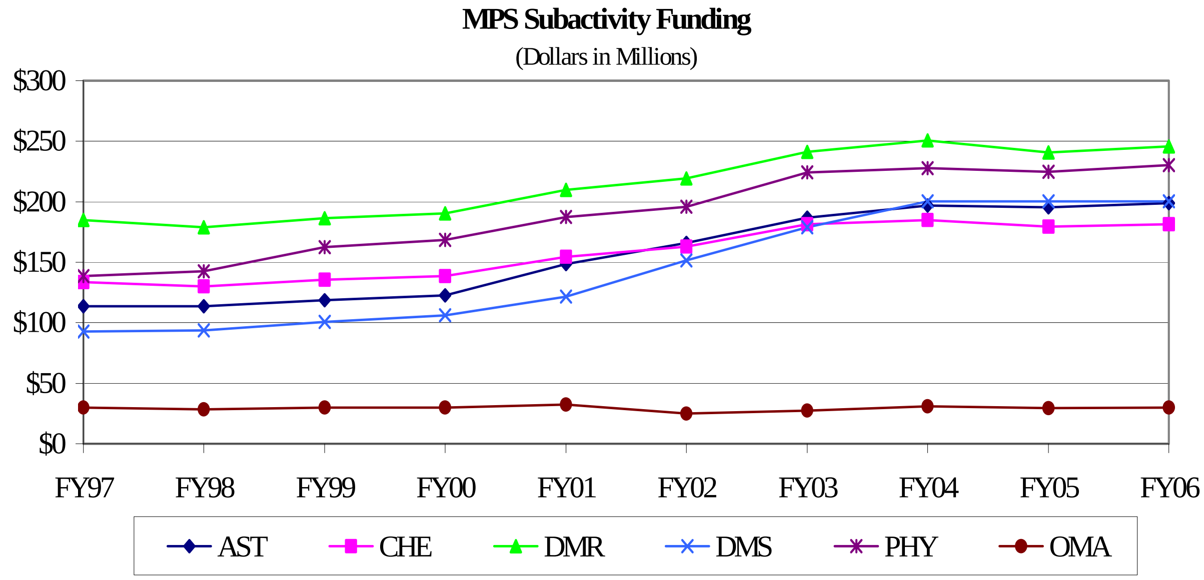
The FY 2006 Budget Request for the Mathematical and Physical Sciences (MPS) Directorate is $1.09 billion, an increase of $16.37 million, or 1.5 percent, over the FY 2005 Current Plan of $1.07 billion.

Mathematical and Physical Sciences Funding
(Dollars in Millions)

	FY 2004 Actual	FY 2005 Current Plan	FY 2006 Request	Change over FY 2005 Amount	Change over FY 2005 Percent
Astronomical Sciences (AST)	196.63	195.10	198.64	3.54	1.8%
Chemistry (CHE)	185.12	179.45	181.37	1.92	1.1%
Materials Research (DMR)	250.65	240.50	245.70	5.20	2.2%
Mathematical Sciences (DMS)	200.35	200.38	200.38	0.00	0.0%
Physics (PHY)	227.77	224.94	230.14	5.20	2.3%
Multidisciplinary Activities (OMA)	31.07	29.49	30.00	0.51	1.7%
Total, MPS	$1,091.59	$1,069.86	$1,086.23	$16.37	1.5%

Totals may not add due to rounding.

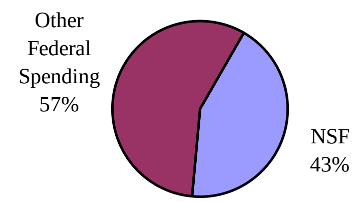
The Mathematical and Physical Sciences Directorate provides funds for research, supporting infrastructure, and development of human resources in the mathematical and physical sciences. The portfolio of investments contains a mixture of research and education grants, group and center awards, facilities and instrumentation, including the national astronomy centers, 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.



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, the questions of MPS-supported research both stir the imagination and drive technological advances. Most of the research is of an exploratory nature. It requires sustained investment as well as access to the tools of advanced discovery. MPS-supported research provides the backbone for advances in other technical, engineering, and health-related disciplines, and provides a broad basis for industrial and technological development. It has played a fundamental role in the technological leadership of the United States and in maintaining its health, economy, defense, and homeland security. By linking research with education and training, MPS also 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



NSF's role as lead agency in MPS research is appropriate, given its basic research mission. MPS provides about 43 percent of the federal funding for basic research at academic institutions in the mathematical and physical sciences. Within the astronomical sciences, MPS provides about 40 percent of the federal support; in chemistry, about 38 percent; in physics, approximately 32 percent; in materials research approximately 55 percent; and in mathematics more than 75 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. Such cooperation enhances the synergistic impact of MPS investments.

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 connect with national interests. 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. Such investments range from tabletop instruments to international facilities with hundreds of users as well as the development of next-generation instrumentation. Remote access to facilities made possible by increasingly sophisticated cyber-infrastructure complements on-site capabilities. MPS continually explores the needs and opportunities for investments in infrastructure, enabling new capabilities and assuring sound operation, maintenance and upgrades of existing state-of-the-art facilities needed to perform world-class research. 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. This approach invigorates education through the excitement of discovery and significantly contributes to the increasing globalization of the MPS enterprise.

Major changes were made in MPS plans in adjusting to the level of the FY 2005 Current Plan. MPS-wide investment strategies for making that adjustment – highlighting core research and education programs; decreasing the number of centers when competitions provide the opportunity to do so; investing in development of the research resources and facilities of the future; and broadening participation in MPS programs – provided the framework for changes in FY 2006.

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

MPS FY 2005 Current Plan.………………………………………………………………... **$1,069.86**

Astronomical Sciences +$3.54

Increased support for research and instrumentation development related to the physics of the universe and cyberinfrastructure, as well as Gemini operations and instrumentation development. Decreases for other areas of research and instrumentation programs.

Chemistry +$1.92

Increased support for research and education and center activities related to the molecular basis of life processes and sustainability. Support for facilities and infrastructure will be partially redirected toward promoting cyber-enabled chemistry.

Materials Research +$5.20

Increased support for research and education and center activities related to nanoscale science and engineering balanced by decreasing support for older facilities and small-scale instrumentation.

Mathematical Sciences No change

Continued strong support for the Mathematical Sciences priority area, particularly fundamental mathematical sciences. Enhanced efforts to broaden participation across the portfolio balanced by decreases in the Enhancing the Mathematical Sciences Workforce for the 21st Century (EMSW21) program.

Physics +$5.20

Increased support for core research and education programs with emphasis on physics of the universe and theoretical physics, including additional support for new applicants to the program. Increased funding for operations of the Large Hadron Collider balanced by a decrease for the Cornell Electron Storage Ring and a decrease reflecting completion of concept and design funding for the Rare Symmetry Violating Processes (RSVP) project.

Multidisciplinary Activities +$0.51

Increased support for collaborative activities aimed at broadening participation in and informing the public about MPS disciplines balanced by decreased support in other areas.

Subtotal, Changes *$16.37*

FY 2006 Request, MPS……………………………………………………………………… **$1,086.23**

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

MPS FY 2005 Current Plan…………………………………………………………………..$1,069.86

Fundamental Science and Engineering +$9.81

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, and create synergy. In FY 2006, MPS is emphasizing the following scientific themes:

- *Physics of the universe*, a set of activities that build on the National Science and Technology Council report of the same name and partner with the Department of Energy and NASA in exploring 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.
- *Fundamental mathematical and statistical science*, activities that strengthen the core of the Mathematical Sciences priority area and enable effective partnering with other disciplines.
- *Physical sciences at the nanoscale*, activities that provide the foundation for efforts to develop nanoscale technologies in partnership with other NSF activities and the government-wide National Nanotechnology Initiative.
- *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.
- *Molecular basis of life processes*, a set of activities linked to the biology of complex systems that 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.

Research Resources for the Future +$3.46

MPS researchers and educators require access to research resources (ranging from desktop instrumentation to detectors at beamlines to computational capacity) that enable them to carry out their work. In FY 2006, MPS emphasizes concept development and design leading to new capabilities for the future, including extremely large telescopes, the next generation of light sources, and cyberinfrastructure.

Preparing the Next Generation and Broadening Participation -$2.10

MPS emphasizes integration of research and education and embedding broader participation in all programs. Participation in all NSF-wide programs in support of undergraduate research experiences, graduate fellowships and traineeships, and advancing the role of women in academia will remain constant. Support for the targeted EMSW21 program and targeted postdoctoral research programs will decrease, enabling integration of their purposes in the wider MPS program. MPS plans increased funding for partnerships aimed at broadening participation and public outreach.

Facilities +$1.37

Facilities stewardship in MPS emphasizes funding facilities at a level that supports scientific needs, enhancing facilities deemed likely to be most productive in the future and decreasing support for those where equal or greater capabilities are otherwise available.

MPS Facilities Funding
(Dollars in Millions)

Facilities	FY 2004 Actual	FY 2005 Current Plan	FY 2006 Request	Change over FY 2005 Amount	Change over FY 2005 Percent
Cornell Electron Storage Ring (CESR)	18.00	16.62	14.71	-1.91	-11.49%
GEMINI Observatory	13.27	14.81	18.50	3.69	24.92%
Large Hadron Collider (LHC)	7.00	10.50	13.50	3.00	28.57%
Laser Interferometer Gravitational Wave Observatory (LIGO)	33.00	32.00	32.00	0.00	0.00%
MSU Cyclotron	15.65	17.50	17.50	0.00	0.00%
Nanofabrication (NNUN/NNIN)	2.80	2.80	2.80	0.00	0.00%
National High Magnetic Field Laboratory (NHMFL)	24.50	25.50	25.50	0.00	0.00%
Rare Symmetry Violating Processes (RSVP)	6.00	2.30	0.00	-2.30	-100.00%
National Astronomy and Ionosphere Center (NAIC)	10.54	10.52	10.60	0.08	0.76%
National Center for Atmospheric Research (NCAR)	1.17	1.17	1.17	0.00	0.00%
National Optical Astronomy Observatories (NOAO)	41.35	37.92	37.36	-0.56	-1.48%
National Radio Astronomy Observatory (NRAO)	54.98	47.03	47.40	0.37	0.79%
Other MPS Facilities	13.39	12.70	11.70	-1.00	-7.87%
Total, MPS	**$241.65**	**$231.37**	**$232.74**	**$1.37**	**0.59%**

In addition, there are three MPS-related projects in construction phases with funding requested in FY 2006 from the MREFC Account: Atacama Large Millimeter Array (ALMA), IceCube, and the Rare Symmetry Violating Processes (RSVP) project. For more information, see the MREFC Chapter.

Centers Programs +$3.83

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. These include centers, institutes, and, in some instances, group-level activity. MPS expects to decrease the number of centers in its portfolio over time as planned competitions permit, while ensuring that active centers are funded at levels that enable them to carry out their work. The FY 2006 increase will enable MPS to meet responsibilities from competitions conducted in earlier years.

MPS Centers Funding
(Dollars in Millions)

Centers	FY 2004 Actual	FY 2005 Current Plan	FY 2006 Request	Change over FY 2005 Amount	Change over FY 2005 Percent
Chemistry Centers	17.44	13.01	14.81	1.80	13.84%
Materials Centers	57.20	57.00	58.00	1.00	1.75%
Mathematical Sciences Research Institutes	15.05	17.15	17.15	0.00	0.00%
Nanoscale Science and Engineering Centers	12.28	12.28	12.51	0.23	1.87%
Physics Centers	14.27	18.72	19.52	0.80	4.27%
Science and Technology Centers	14.77	15.60	15.60	0.00	0.00%
Total, MPS	**$131.01**	**$133.76**	**$137.59**	**$3.83**	**2.86%**

Subtotal, Changes *+$16.37*

FY 2006 Request, MPS……..………………………………………..…………………………. $1,086.23

PRIORITY AREAS

In FY 2006, MPS will support research and education efforts related to broad, Foundation-wide priority areas in Biocomplexity in the Environment, Nanoscale Science and Engineering, Mathematical Sciences, and Human and Social Dynamics.

MPS Investments in NSF Priority Areas
(Dollars in Millions)

	FY 2004 Actual	FY 2005 Current Plan	FY 2006 Request	Change over FY 2005 Amount	Change over FY 2005 Percent
Biocomplexity in the Environment	4.70	4.03	3.36	-0.67	-16.6%
Nanoscale Science and Engineering	111.48	131.62	95.82	-35.80	-27.2%
Mathematical Sciences	70.23	70.23	70.23	0.00	0.0%
Human and Social Dynamics	0.53	0.50	0.50	0.00	0.0%

Funding for the **Biocomplexity in the Environment** priority area will decrease in FY 2006 as part of the planned phasing down of the priority area. Funds will support activities related to green chemistry, materials use, and theoretical and statistical modeling of complex environmental systems.

Support for **Nanoscale Science and Engineering** will decrease in FY 2006 as part of the planned phasing down of the priority area, with the reduction coming mainly in fundamental research as these activities begin to become part of core programs. Funds will support research on structures, phenomena, and quantum control.

Support for the **Mathematical Sciences** priority area will remain constant, 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.

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.

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 2004, 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 Advisory Committee for Mathematical and Physical Sciences (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 Board (with DOE); the Nuclear Science Advisory Board (with DOE); and the Astronomy and Astrophysics Advisory Committee (with DOE and NASA).

PERFORMANCE

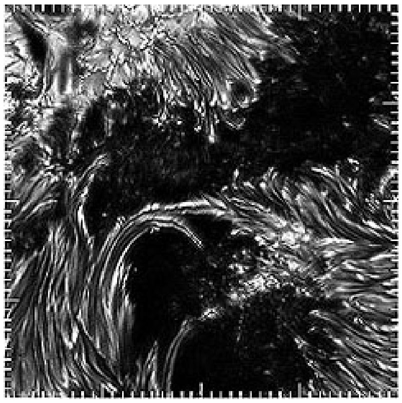
NSF's FY 2006 budget is also aligned to reflect funding levels associated with the Foundation's four strategic outcome goals and the ten investment categories highlighted in the FY 2003-2008 Strategic Plan. These categories were designed as a mechanism to better enable assessment of program performance and to facilitate budget and performance integration.

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

	FY 2004 Actual	FY 2005 Current Plan	FY 2006 Request	Change over FY 2005 Amount	Change over FY 2005 Percent
People					
Individuals	107.46	99.19	96.56	-2.63	-2.7%
Institutions	5.53	5.64	5.48	-0.16	-2.8%
Collaborations	16.26	13.29	14.38	1.09	8.2%
	129.25	118.12	116.42	-1.70	-1.4%
Ideas					
Fundamental Science and Engineering	541.68	537.17	546.62	9.45	1.8%
Centers Programs	131.31	133.76	137.59	3.83	2.9%
Capability Enhancement	9.33	9.21	9.17	-0.04	-0.4%
	682.32	680.14	693.38	13.24	1.9%
Tools					
Facilities	133.61	134.73	136.21	1.48	1.1%
Infrastructure and Instrumentation	31.84	33.70	37.16	3.46	10.3%
Polar Tools, Facilities and Logistics	-	-	-	-	-
Federally-Funded R&D Centers	108.04	96.64	96.53	-0.11	-0.1%
	273.49	265.07	269.90	4.83	1.8%
Organizational Excellence	6.53	6.53	6.53	-	-
Total, MPS	$1,091.59	$1,069.86	$1,086.23	$16.37	1.5%

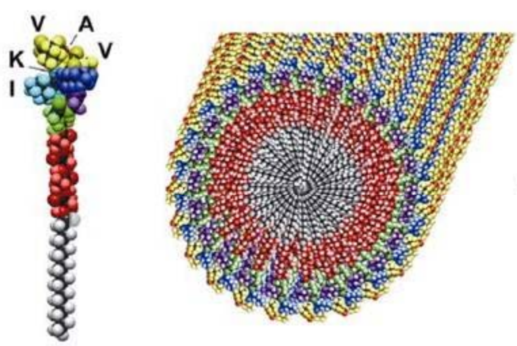
Totals may not add due to rounding.

Recent Research Highlights



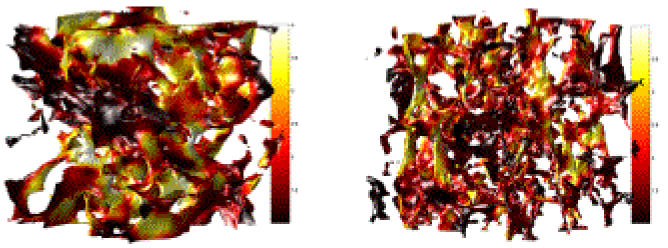
Images at the Heart of Solar Storms – Scientists at the National Solar Observatory used a new set of instruments to record the sharpest-ever images of the heart of the solar flares. They were able to record images and magnetic field strengths on scales of two-tenths of an arcsecond (the angular size of a quarter as viewed from a distance of sixteen miles) using the techniques of adaptive optics to correct for the distorting effects of the Earth's atmosphere. The new instruments will allow scientists to study the fine structure magnetic activity on the Sun, an area that is key to understanding the genesis of solar flares – giant explosions that can disrupt terrestrial communications systems and satellites. (Photo Credit – National Solar Observatory)

The Manufacture of Ammonia – Synthesis of ammonia, a vital component of fertilizers, under mild laboratory conditions has been a challenge for chemists for the past century. Traditional methods for the synthesis of ammonia require very high temperatures and pressures. Paul Chirik and his group at Cornell University have discovered a zirconium compound that assembles nitrogen-hydrogen bonds from molecular nitrogen. Remarkably, breakage of the nitrogen-nitrogen bond (one of the strongest chemical bonds in nature) can be observed at a temperature of only 45º C. Continued heating under hydrogen or exposure to acid results in the synthesis of ammonia. This project is making progress on the synthesis of agriculturally important ammonia under milder conditions than are currently viable for industrial scale production, with potentially strong impact on energy use and the environment.

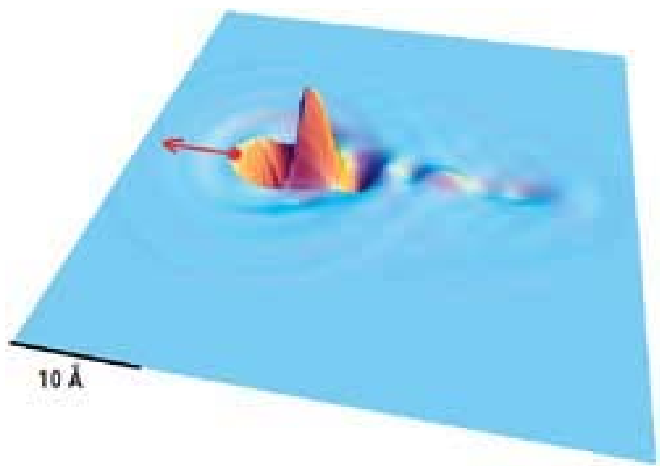


Polymer Nanofibers for Nerve Repair – The repair of injuries to the spinal cord or other parts of the nervous system is a "holy grail" in medicine. The ability to bridge broken nerves, grow new neural pathways, and help the spinal cord regenerate would bring new hope to victims of paralysis, disabling accidents, and neurological diseases. Sam Stupp and his colleagues at Northwestern University have designed very imaginative molecules that self-assemble into nanofibers. The researchers successfully incorporated throughout the surface of these polymer nanofibers a sequence of biologically active groups (peptides) that are known to promote sprouting of nerve cells and to direct growth of neurons. The nanofibers are able not only to grow nerve cells (neurons), but also to block the formation of nerve-tissue scars (astrocytes). Dr. Stupp is collaborating with John Kessler, a neurologist at Northwestern, to bring this technique into clinical testing. (Photo Credit – Dr. Sam Stupp, Northwestern University)

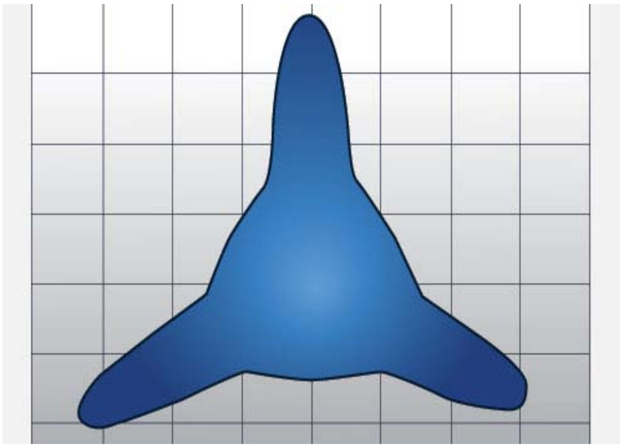
Computer Modeling of Osteoporosis – Osteoporosis is a major socio-economic problem in western societies. It is estimated that osteoporosis-related fractures in the U.S. number in the millions annually, and cost tens of billions of dollars in therapy and rehabilitation. Although therapeutic agents are available to slow its progress, physicians need to be confident that such therapy is essential prior to prescribing medication. Bone density tests are currently used for the purpose. One approach to understanding the relationship between bone density and bone strength involves the use of modeling. Dr. Gemunu Gunaratne of the University of Houston conducted computations on three-dimensional digitized images of bone obtained from micro-computed tomography. The relationship between bone density and bone strength derived from the model provides good agreement with published data on the strength of bones from 101 human subjects ranging in age from 18-90 years. Thus, bone density measurements can be used to predict the strength of weak bones and to suggest the amount of medication required in specific cases. (Photo Credit – University of Houston)



Electron Movies in Attoseconds: X-ray scattering, data analysis method lead to ultrafast imaging of electrons – Cornell University researchers demonstrated that x-rays, when coupled with a new data analysis procedure, can be used to determine the motion of electrons on attosecond (a billionth of a billionth of a second) time scales. The experimental procedures were developed at the NSF-supported synchrotron source at Cornell and then the final measurements were taken using the DOE-supported synchrotron x-ray source at Argonne National Laboratory. The procedure may offer a new way to monitor chemical reactions on unprecedented attosecond time scales. See Abbamonte et al., Phys. Rev. Lett. 92 (2004) 237401



RNA and the Origin of Life – An important hypothesis concerning the origin of life on Earth is that life began in an “RNA World” in which RNA was an early self-replicating molecule. However, a weakness in this hypothesis has been the fact that the sugar ribose, a major component of RNA, is too unstable to persist under prebiotic conditions. In an experiment that has major implications in origin-of-life research, Steven Benner and his colleagues at the University of Florida have shown that borate minerals on the early Earth could have helped to concentrate and stabilize compounds such as ribose. The experiments by Benner and his coworkers demonstrate the idea that simple inorganic material may have played a role in the origin of life on Earth by facilitating the development of an "RNA World."



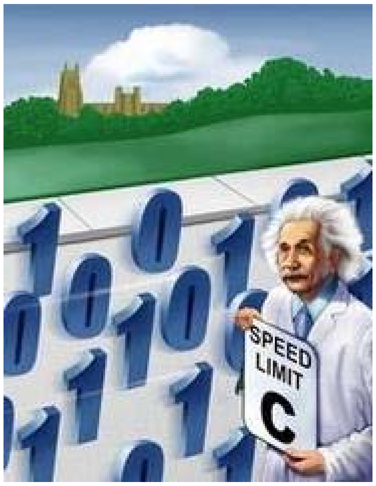
Starting from a slightly tweaked circle, calculations by Harvard's Henry Chen and Michael Brenner showed that more triangular shapes made better faucets and that a sort-of "sucked-in triangle" was the optimal faucet. Credit: *H.H. Chen and M.P. Brenner, Harvard University*

Triangular Nozzles Make the Smallest Droplets – One of the primary technologies for creating small fluid droplets pressurizes a nozzle until a critical volume is reached, when the droplet detaches. The amount of fluid that is released by this process is set by the size of the nozzle. Creating small droplets requires using smaller nozzles; however, smaller nozzles require dramatically larger pressures to release the fluid. Current implementations of this method all use circular nozzles. Drops of about 10 picoliters (10 billionths of a milliliter) are the smallest anyone has managed. Using a mathematical optimization procedure, Harvard University mathematicians Henry Chen and Michael Brenner discovered that specially shaped nozzles decrease the fluid released by 21 percent. The optimum shape is a sort of sucked-in triangle. The triangular taps have potential uses ranging from boosting the resolution of ink-jet printers, to cutting the size of patterns on electronic components that are created by droplet deposition. The mathematical methods developed for solving this problem are of general use for engineering design.

The Biggest and the Brightest Star – A University of Florida-led team of astronomers using the NSF-supported Blanco Telescope at the Cerro Tololo Interamerican Observatory may have discovered the brightest star yet observed in the universe, a fiery behemoth that could be as much as seven times brighter than the current record holder. The bright star, denoted LBV 1806-20, is estimated to be about 45,000 light years away, on the other side of our Milky Way galaxy.

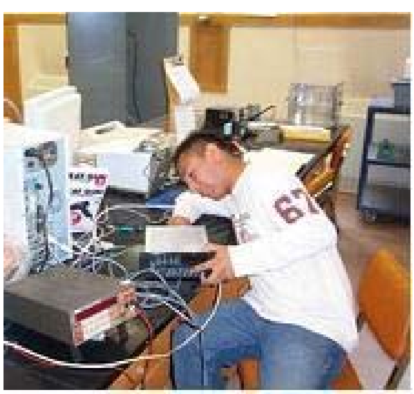
Greening the Cleaning Industry – A multidisciplinary team of scientists and engineers led by Joseph DeSimone of the University of North Carolina, Chapel Hill is working at the Science and Technology Center for Environmentally Responsible Solvents and Processes to 'green' the cleaning industry. They have demonstrated the efficacy of using carbon dioxide and specially designed surfactants, or detergents, to clean clothes in the dry cleaning industry and electronic devices in the microelectronics industry. The carbon dioxide-based garment dry cleaning process was commercialized through Hangers Cleaners and was voted "Best Choice" by *Consumer Reports* in 2003. The Science and Technology Center is also pioneering "dry" carbon dioxide-based processes for use in the microelectronics industry as well as part of a broader vision of a "dry fabrication facility of the future." Researchers have shown that carbon dioxide–based formulations can be effective at etching copper silicon oxide from wafers. Dry lithographic processes are also being developed using specially designed surfactants.

Colliding Electrons in Atoms – Recent experiments conducted by Robert Jones of the University of Virginia with fast laser sources have made it possible to excite two electrons in an atom in a controlled fashion, first one then the other. The electrons are observed to move in orbits around the nucleus like planets and asteroids around the sun. As asteroids sometimes do, at some point the electrons violently collide with each other, resulting in one electron being knocked completely out of the atom and the other left behind. This ability to monitor in real time the details of electron motion within the atom has important consequences for the possible storage of information within the atom.



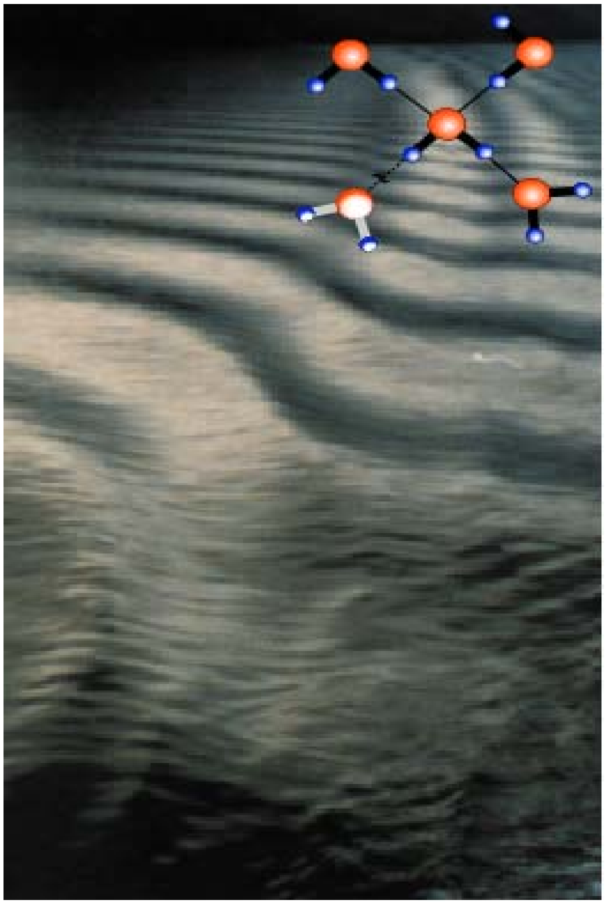
Can Information be Transmitted Faster than the Speed of Light? – In our modern computer world, light is one of the main forms of transmission of information. In the special theory of relativity, Einstein said that nothing can travel faster than the speed of light in vacuum. But recent experiments have shown that a pulse of light can travel through a medium faster than the speed of light in vacuum. Can information be transmitted faster than the speed of light? Recent experiments by Daniel Gauthier of Duke University have shown that this is not possible. By transmitting two information signals, 0 and 1, in separate pulses, this research has shown that, no matter how fast the pulse might travel, the information stored in the pulse can only travel at the speed of light in vacuum.

Novel Microfabricated Mounts for Macromolecular Crystallography – Working at the NSF-supported Cornell High Energy Synchrotron Source (CHESS), physicist Rob Thorne has developed a novel variation of a method for freezing and mounting crystals of small macromolecular samples, such as proteins. The crystals can then be studied by "X-ray crystallography," a method in which a beam of X-rays scattered by the atoms in a material is used to determine the positions of those atoms within the molecular crystal. The new type of sample mount allows the use of much smaller crystals than had heretofore been possible. It also promises to make possible faster collection of macromolecular crystallographic data, enabling even more complicated biomolecules to be studied. The image illustrates a beam of X-rays emerging from capillary optics and focused on a protein crystal sample held in one of the novel sample holders. The drainage channel leads away from the hole in which the sample is mounted. (Photo Credit – Cornell University)



Native American Undergraduate Research – Northern Arizona University has one of the Nation's largest Native American student populations, drawing from approximately 30 different tribes in the Four-Corners region. Timothy Porter leads a group that has recruited some of these undergraduate students to be involved in research in chemistry and physics. Students work one-on-one with faculty supported by the NSF on a project to evaluate novel materials for new chemical sensors used to monitor and identify the presence and concentration of gases. The chemistry and physics graduation rate for students involved with this project approaches 100 percent. In the image, undergraduate student Lambert Benally connects a precision flow-meter in the laboratory to test the response of a sensor under development to a variety of gases to be detected. (Photo Credit – University of Northern Arizona)

The structure and physical properties of liquid water continue to fascinate and perplex us – a major unsolved problem in science. Anomalies such as the density maximum at 4 degrees C, the minimum in the compressibility, or the unusually high proton transport rate in water are only a few of the unique properties of water. The nature of the excess proton in some water molecules still defies exact characterization. Questions about water networks around ions, proteins, geomedia, aerosols and surfaces cannot be answered without fundamental experimental and theoretical studies on water structure. Are the unusual features of water due to hydrogen bonding? Its tendency to form tetrahedral bonds? Or are these old models wrong? Chemists have recently applied new methods to the study of water, obtaining provocative and controversial results that are stimulating researchers to focus on water. *Science* picked these new results as one of the top 10 "Breakthroughs of the Year" in 2004, citing results from CHE-supported individual investigator awards, collaboratives, and Environmental Molecular Science Institutes.



Other Performance Indicators

The tables below show the number of people benefiting from MPS funding, and trends in award size, duration, and number of awards.

Number of People Involved in MPS Activities

	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate
Senior Researchers	6,571	6,400	6,400
Other Professionals	2,052	2,000	2,000
Postdoctorates	2,189	2,150	2,140
Graduate Students	7,418	7,200	7,200
Undergraduate Students	5,683	5,700	5,750
K-12 Students	320	320	320
K-12 Teachers	600	650	650
Total Number of People	24,833	24,420	24,460

MPS Funding Profile

	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate
Statistics for Competitive Awards:			
Number	2,175	2,110	2,110
Funding Rate	30%	30%	30%
Statistics for Research Grants:			
Number of Research Grants	1,606	1,600	1,600
Funding Rate	28%	28%	28%
Median Annualized Award Size	$100,000	$100,000	$100,000
Average Annualized Award Size	$130,114	$130,114	$130,114
Average Award Duration, in years	3.1	3.1	3.1

ASTRONOMICAL SCIENCES $198,640,000

The FY 2006 Request for the Astronomical Sciences Division (AST) is $198.64 million, an increase of $3.54 million, or 1.8 percent, over the FY 2005 Current Plan of $195.10 million.

Astronomical Sciences Funding
(Dollars in Millions)

	FY 2004 Actual	FY 2005 Current Plan	FY 2006 Request	Change over FY 2005 Amount	Change over FY 2005 Percent
Astronomical Sciences	**$196.63**	**$195.10**	**$198.64**	**$3.54**	**1.8%**
Major Components:					
Research and Education Grants	72.56	80.82	80.78	-0.04	0.0%
Centers Programs	3.93	4.00	4.00	0.00	0.0%
Facilities					
Gemini Observatory	13.27	14.81	18.50	3.69	24.9%
National Astronomy and Ionosphere Center	10.54	10.52	10.60	0.08	0.8%
National Optical Astronomy Observatory/ National Solar Observatory (NOAO/NSO)	41.35	37.92	37.36	-0.56	-1.5%
National Radio Astronomy Observatory	54.98	47.03	47.40	0.37	0.8%

About AST:

The Astronomical Sciences Division is the primary source of support for ground-based astronomy in the U.S. Division support ranges in scope from awards to individual-investigators to large collaborations engaged in 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 supports the operation of four National Astronomy facilities: the National Optical Astronomy Observatory (NOAO), the National Solar Observatory (NSO), the National Radio Astronomy Observatory (NRAO), and the National Astronomy and Ionosphere Center (NAIC) and provides the U.S. share of funding for the operation of the international Gemini Observatory. Division programs support the development of advanced technologies and instrumentation, the planning and design for future observational facilities and major collaborative projects in astronomy, and the 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 61 percent of the AST portfolio. Of the remaining 39 percent, approximately 55 percent of funds are committed to funding awards made in previous years.

AST Priorities for FY 2006:
Physics of the Universe (POU), the highest scientific priority, which addresses the compelling questions that have arisen at the interface of physics and astronomy. Questions include: What is dark energy? What is dark matter? Can we detect gravity waves as ripples in space-time? These and seven other profound questions 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, the Department of Energy (DOE) and NASA. Within NSF, POU is coordinated and supported by the AST and PHY Divisions.

Research Grants Programs, 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, and ensuring a healthy and balanced program of research and education grants to the community.

Gemini Observatory operations and instrumentation, AST's highest priority in facility stewardship. Ensuring the optimum performance and productivity of our premier optical/IR (infrared) facility enables forefront research by the scientific community and their students in this international partnership.

Changes from FY 2005:
Research and education grants decrease by $40,000 to a total of $80.78 million. AST will continue to support a wide range of astrophysical investigations, with expanded emphasis on the scientific questions outlined in the Physics of the Universe interagency activity in partnership with PHY, NASA and DOE, and continued emphasis on the development and implementation of the National Virtual Observatory, in partnership with NASA, as part of AST's activities in cyberinfrastructure/cyberscience. Education and outreach activities will receive continued emphasis through postdoctoral fellowship programs, expanding diversity within the research community, and integrating research and education, including the training of young scientists. Support for technology development for the **Large-Aperture Synoptic Survey Telescope** (LSST) and the **Giant Segmented Mirror Telescope** (GSMT) will increase.

Funding for the **Science and Technology Center for Adaptive Optics** remains unchanged at $4.0 million.

Facilities increase by $3.58 million to a total of $113.86 million including:

- Support for the **Gemini Observatory** at a level of $18.50 million, an increase of $3.69 million. As AST's highest priority among our optical and infrared facilities, this level of support will enable enhanced operational and visitor support and begin the funding of a new generation of advanced instrumentation. Included in this amount is $1.0 million for partial return of the Chilean construction capital, with which the U.S. assumes a portion of the Chilean share of the Observatory, along with increased observing access for U.S. astronomers.

- **NAIC** will be supported at the level of $10.60 million. This level of support will enable continued operation and maintenance of the renovated Arecibo telescope and the development of instrumentation to take advantage of its greater sensitivity.

- Support for **NOAO/NSO** base operations at the level of $35.0 million. NOAO is leading the community effort to establish a detailed scientific justification and conceptual design for the GSMT and the LSST, both of which were highly recommended future facilities in recent community reports. Activities at NSO in FY 2006 include design and development for the **Advanced Technology Solar Telescope** (ATST), an instrument that will use new techniques such as adaptive optics to provide a unique capability for investigating a wide range of important questions in solar physics. ATST will be of significant value to studies in atmospheric sciences and space weather in addition to astronomical research. Included within facilities support of NOAO is $2.0 million for the **Telescope System Instrumentation Program** (TSIP), and $360,000 for the **Adaptive Optics Development Program** (AODP), which are administered for the community through NOAO. TSIP, which began in FY 2002 and is being held at its FY 2005 funding level, is a program to unify the privately held and the national optical and IR observatory facilities through a program of support for instrument development and facility improvement in exchange for competitive public access to private facilities. The AODP program is reduced by $840,000 from FY 2005 and is sufficient to cover existing commitments, but allows no new activity.

° **NRAO** is supported at the level of $47.40 million. This level of support will provide for operations, maintenance, and instrumentation for the unique telescopes of NRAO, such as the Robert C. Byrd Green Bank Telescope, the Very Large Array, the Very Long Baseline Array and the early operations of the Atacama Large Millimeter Array (ALMA). Activities in FY 2006 include making continued improvements and enhancements to the Expanded VLA and optimization of science operations of the Byrd Telescope.

CHEMISTRY $181,370,000

The FY 2006 Request for the Chemistry Division (CHE) is $181.37 million, an increase of $1.92 million, or 1.1 percent, over the FY 2005 Current Plan of $179.45 million.

Chemistry Funding
(Dollars in Millions)

	FY 2004 Actual	FY 2005 Current Plan	FY 2006 Request	Change over FY 2005 Amount	Change over FY 2005 Percent
Chemistry	**$185.12**	**$179.45**	**$181.37**	**$1.92**	**1.1%**
Major Components:					
Research and Education Grants	152.70	150.07	149.50	-0.57	-0.4%
Centers Programs	23.05	19.38	21.41	2.03	10.5%
Instrumentation/Facilities	9.37	10.00	10.46	0.46	4.6%

Totals may not add due to rounding.

About CHE:

The Chemistry Division advances the intellectual frontiers of chemistry. The chemical bond, the bond that links atoms together into myriad forms of matter that define our existence, is the unifying intellectual theme in chemistry. CHE supports research that enables matter to be manipulated, measured, and modeled through management of both strong and weak chemical bonds; the result is exquisite control in designing and synthesizing new molecules and molecular assemblies. Understanding matter from this perspective is essential to advances in many allied fields, including the life, environmental, and materials sciences. 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. 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. Basic research, education, instrumentation, and facilities supported by CHE contribute to environmental quality and to industrial strength through advancements in fundamental knowledge and the professional development of our technical workforce. A large majority of the CHE investment supports individual investigators and collaborative research centers, with the balance in instrumentation and human resource development.

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 seven Environmental Molecular Science Institutes (EMSIs), fifteen Collaborative Research in Chemistry (CRCs) centers, five Chemical Bonding Centers (CBCs), the Science and Technology Center (STC) for Environmentally Responsible Solvents and Processes, and three Nanoscale Science and Engineering Centers. 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 cyberinfrastructure and facilities, such as the National High Magnetic Field Laboratory.

In general, 58 percent of the CHE portfolio is available for new awards and activities. The remaining 42 percent funds awards made in previous years.

CHE Priorities for FY 2006:

Maintaining a strong, flexible program of research and education grants that will lead to new opportunities in the chemical sciences. The broad range of forefront research and education projects reflected in individual investigator and multi-investigator awards defines future scientific and technological opportunities in the chemical sciences. The Division's portfolio management encourages beginning investigators through CAREER awards and seeks to identify pioneering research that is high risk and potentially high impact. Along with the various subdisciplines of chemistry, these awards support the MPS emphasis area of the molecular basis of life processes. Examples of science drivers in this area include the tracking of molecules in cells across multiple length, time and organizational scales and understanding the networks of chemical reactions that characterize life. CHE awards also underpin efforts to acquire the fundamental knowledge that will provide a basis for the sustainability of the Earth. For example, chemistry will play a leading role in supporting fundamental molecular research needed for a sustainable hydrogen economy and for environmentally benign manufacturing. CHE will continue to provide substantial support for interdisciplinary work in nanoscale science, which depends heavily on chemists' abilities to manipulate strong and weak chemical bonds.

Developing cyber-enabled chemistry. 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. They will allow research challenges of unprecedented complexity to be addressed by individual researchers and teams of researchers working in entirely new ways. Moreover, the educational platform provided by cyber-enabled chemistry will provide new paradigms for teaching and learning in the chemical sciences.

Broadening participation. Investments in the Research Experiences for Undergraduates (REU) and Undergraduate Research Centers (URC) programs will provide opportunities for far larger numbers of students, including first- and second-year college students, to create and communicate new knowledge in the chemical sciences. Furthermore, the aforementioned investments in cyber-infrastructure will create national and international platforms that will allow chemical scientists to collaborate with other researchers, anywhere, at any time, permitting greatly enhanced access to resources.

Changes from FY 2005:

Research and education grants and centers increase by $1.46 million to a total of $170.91 million. CHE will continue to support forefront areas of chemistry, with emphasis on molecular basis of life processes and on sustainability. Education and outreach activities will receive continued emphasis, including undergraduate research, integration of research and education, and efforts to broaden participation.

Instrumentation/Facilities increase by $460,000 to a total of $10.46 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 that provides funds for multi-user instrumentation and instrumentation development.

MATERIALS RESEARCH $245,700,000

The FY 2006 Request for the Materials Research Division (DMR) is $245.70 million, an increase of $5.20 million, or 2.2 percent, over the FY 2005 Current Plan of $240.50 million.

Materials Research Funding
(Dollars in Millions)

	FY 2004 Actual	FY 2005 Current Plan	FY 2006 Request	Change over FY 2005 Amount	Change over FY 2005 Percent
Materials Research	**$250.65**	**$240.50**	**$245.70**	**$5.20**	**2.2%**
Major Components:					
Research and Education Grants	143.85	133.10	138.30	5.20	3.9%
Centers Programs	68.35	68.15	69.15	1.00	1.5%
Facilities					
National High Magnetic Field Laboratory (NHMFL)	24.00	24.00	24.00	0.00	0.0%
National Nanofabrication Infrastructure Network (NNIN)	2.55	2.55	2.55	0.00	0.0%
Other MPS Facilities	11.90	12.70	11.70	-1.00	-7.9%

Totals may not add due to rounding.

About DMR:

The Materials Research Division advances the intellectual frontiers of materials research. 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 the acquisition and development of instrumentation for materials research.
- DMR Centers include 27 Materials Research Science and Engineering Centers (MRSECs) established through open competitions to address major interdisciplinary problems in materials and condensed-matter science. In addition, the division supports the Science and Technology Center (STC) on Materials and Devices for Information Technology Research and three Nanoscale Science and Engineering Centers (NSECs), and provides partial support for a further seven NSECs. DMR also supports six International Materials Institutes based at U.S. universities to enhance international cooperation in materials.

- DMR supports world-class user 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 are approximately 15 percent of the DMR portfolio. Of the remaining 85 percent, approximately 55 percent of funds are committed to awards made in previous years.

DMR Priorities for FY 2006:

Maintaining strong support for materials research programs that generate new ideas and novel materials and undergird new technologies. These core programs include awards to individual investigators, groups, and centers. Emphasis will be given to research on materials and condensed-matter phenomena at the nanoscale, biomolecular and bio-inspired materials, computational and theoretical materials research, and 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 fostering new partnerships that strengthen the links between institutions serving under-represented 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 2005:

DMR will increase support for **research and education** awards by $5.20 million to a total of $138.30 million, enhancing support for research on novel phenomena and new materials, nanoscale materials, biomolecular and bio-inspired materials, and materials for cyberinfrastructure. DMR will establish up to three new **Partnerships for Research and Education in Materials** (PREMs) at institutions serving under-represented groups, bringing the total number of PREMs to seven.

DMR will increase support for Centers by $1.0 million to a total of $69.15 million, phasing in full support for new **Materials Research Science and Engineering Centers** established in FY 2005.

DMR will reduce overall support for **user facilities** by $1.0 million to a total of $38.25 million, while maintaining critical support for state-of-the-art user facilities for synchrotron radiation, neutron scattering, high magnetic fields, and nanofabrication. Support for instrumentation will be refocused to enhance support for the design and development of mid-scale instruments.

MATHEMATICAL SCIENCES $200,380,000

The FY 2006 Request for the Mathematical Sciences Division (DMS) is $200.38 million, level with the FY 2005 Current Plan of $200.38 million.

Mathematical Sciences Funding
(Dollars in Millions)

	FY 2004 Actual	FY 2005 Current Plan	FY 2006 Request	Change over FY 2005 Amount	Change over FY 2005 Percent
Mathematical Sciences	**$200.35**	**$200.38**	**$200.38**	**$0.00**	**0.0%**
Major Components:					
Research and Education Grants	185.30	183.23	183.23	$0.00	0.0%
Mathematical Sciences Research Institutes	15.05	17.15	17.15	$0.00	0.0%

Totals may not add due to rounding.

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. It plays a key role in the training of the nation's science and engineering workforce. Advances in science and engineering, driven in part by increasingly sophisticated and readily available computing environments, have lifted the mathematical sciences to the forefront of science and engineering, reshaping modern discovery through quantitative predictions, instrumentation development, modeling, visualization, computational algorithms, and optimization methods. Science and engineering are requiring more sophisticated mathematical and statistical tools. This is true not only in the physical, engineering and informational sciences, but also in the biological, geophysical, environmental, social, behavioral, and economic sciences.

NSF has a crucial role in the support of basic academic research in the mathematical sciences, providing more than 75 percent of all federal university-based support. 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. Especially important is the critical function of the mathematical sciences in the training of the nation's scientific and engineering workforce.

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, multidisciplinary projects, Focused Research Groups, and Research Training Groups with some grants including funding for graduate and postdoctoral students as well as for workshops, computing equipment and other research and education needs. In addition, DMS supports infrastructure efforts across the mathematical sciences, including national research institutes, postdoctoral, graduate, and undergraduate training opportunities, broadened career experiences for researchers, increased participation in the nation's research personnel base, research conferences and workshops, and scientific computing research equipment.

The DMS portfolio has two major modes of support: research and education grants, and institutes.

- DMS research grants range in scope from individual-investigator awards to awards for multidisciplinary groups of researchers to attack 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. EMSW21 includes Grants for the Vertical Integration of Research and Education (VIGRE), Research Training Grants in the Mathematical Sciences (RTG), and Mentoring through Critical Transition Points in the Mathematical Sciences (MCTP).

- DMS provides core support for five mathematical sciences research institutes as well as major support for two other institutes. These institutes are funded on a competitive basis and address the growing interface with other disciplines and the mathematical and statistical problems whose solutions will contribute to both fundamental knowledge and national needs. In addition, they often serve as an incubator for new ideas and directions in the mathematical sciences.

In general, 72 percent of the DMS portfolio is available for new awards and activities. The remaining 28 percent funds awards made in previous years.

DMS Priorities for FY 2006:

Maintaining a strong program of research grants. At a minimum, the intention is to maintain the investments in single investigator as well as small group grants. This is the core of the mathematical sciences portfolio.

Investing in algorithm development and computational tools for large-scale problems of scientific importance. Emphasis will be given to stochastic or probabilistic models and modeling of large data sets and, in general, to modeling scientific phenomena that occur over a large range of spatial and temporal scales.

Broadening participation in the mathematical sciences. Emphasis will be given to the support of interactions and networks among a diverse population that will include graduate students and researchers at a wide array of institutions.

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

Continuing support for the Mathematical Sciences Priority Area. This reflects the importance of mathematical and statistical sciences in the kinds of crosscutting science and engineering research areas described above. It will include maintaining the investment in focused mathematical sciences research teams, interdisciplinary training groups, and other collaborative mechanisms related to advancing science and engineering. The priority area will continue to have three major foci for DMS: (1) fundamental mathematical and statistical sciences, (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 the mathematical and statistical challenges posed by large data sets, managing and modeling uncertainty, and modeling complex nonlinear systems.

Changes from FY 2005:

- **Broadening participation** increases by $3.0 million. This will support interactions among a broader set of researchers with the objective of reaching a more diverse population. These investments are at a scale between individual investigator awards and institutes and focus on the creation of networks of researchers at a diverse set of institutions. Examples include summer schools focused on a given research area; regional, multi-year conferences and workshops; and special years of emphasis. The activities would emphasize involvement of students and postdoctoral researchers.
- **Enhancing the Mathematical Sciences Workforce** in the 21st Century decreases by $3.0 million. These funds are re-targeted to divisional efforts in broadening participation described above and include modes of training that complement EMSW21.

PHYSICS $230,140,000

The FY 2006 Request for the Physics Division (PHY) is $230.14 million, an increase of $5.20 million, or 2.3 percent, over the FY 2005 Current Plan of $224.94 million.

Physics Funding
(Dollars in Millions)

	FY 2004 Actual	FY 2005 Current Plan	FY 2006 Request	Change over FY 2005 Amount	Change over FY 2005 Percent
Physics	**$227.77**	**$224.94**	**$230.14**	**$5.20**	**2.3%**
Major Components:					
Research and Education Grants	127.69	121.14	126.55	5.41	4.5%
Centers Programs	20.43	24.88	25.88	1.00	4.0%
Facilities					
Laser Interferometer Gravitational Wave Observatory (LIGO)	33.00	32.00	32.00	0.00	0.0%
Large Hadron Collider (LHC)	7.00	10.50	13.50	3.00	28.6%
Rare Symmetry Violating Processes (RSVP)	6.00	2.30	0.00	-2.30	-100.0%
Nationl Superconducting Cyclotron Laboratory (NSCL)	15.65	17.50	17.50	0.00	0.0%
Cornell Electron Storage Ring (CESR)	18.00	16.62	14.71	-1.91	-11.5%

Totals may not add due to rounding.

About PHY:

The Physics Division 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; high-performance computing; accelerator physics; complex systems, turbulence; etc. 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 three major modes of support: research and education grants, centers, and facilities.

- PHY research and education grants range in scope from individual investigator awards for research based at the investigator's home institution, to awards to major user groups with responsibility for experiments at national or international user facilities.
- PHY centers include ten Physics Frontiers Centers (PFCs), the Science and Technology Center (STC) for Biophotonics Science and Technology, and two Nanoscale Science and Engineering Centers. 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.
- 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.)

Facilities are approximately 31 percent of the PHY portfolio. Of the remaining 69 percent, approximately 67 percent of funds are committed to awards made in previous years.

PHY Priorities for FY 2006:

Physics of the Universe (POU), the highest scientific priority, addresses the compelling questions that have arisen at the interface of physics and astronomy. Questions include: What is dark energy? What is dark matter? Can we detect gravity waves as ripples in space-time? These and seven other profound questions 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 strategy involving NSF, the Department of Energy (DOE) and NASA. The Physics and Astronomical Sciences Divisions will work together and with other federal programs to maximize their impact on this research.

Ramping up the maintenance, operations, and data analysis support for the U.S. Large Hadron Collider (LHC) activity is the highest facility stewardship priority. This is being coordinated with DOE. It will enable the U.S. physics community to fully participate in the discovery potential of the LHC, to capitalize on the large facility construction investment by the U.S., and to be a good partner in global collaboration.

Maintaining a strong, flexible program of research and education grants to create new ideas and technology and attract and train students, the highest priority in stewardship of the portfolio. Emphasis will be given to increasing the support for cyberinfrastructure and cyberscience, theoretical research across the portfolio, and biological physics.

Changes from FY 2005:

Research and education grants and centers increase by $6.41 million to a total of $152.43 million. PHY will continue to support forefront areas of physics, with expanded emphasis on POU, 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 young physicists. A new R&D effort to develop a next generation source of x-ray synchrotron radiation is being co-funded by the Physics, Materials Research, and Chemistry Divisions, and the Office of Multidisciplinary Activities.

Facilities decrease by $1.21 million to a total of $77.71 million. This includes:

- Continued support for operations of the **Laser Interferometer Gravitational-Wave Observatory** (LIGO) and for advanced detector R&D at a total of $32.00 million. LIGO, the world's leading effort to discover gravitational waves and use them to study such objects as colliding neutron stars and black holes and to create a new field of gravitational-wave astronomy, is completing commissioning and beginning science runs.
- An increase of $3.0 million for early operations (including data analysis support) of the **LHC** ATLAS and CMS detectors for a total of $13.50 million. The LHC is an energy frontier high-energy particle collider with the potential to discover the Higgs boson, supersymmetric particles, extra spatial dimensions, etc., if these predicted phenomena occur in nature.
- A decrease of $2.30 million for planning activities for the **Rare Symmetry Violating Processes** (RSVP) project, as funding for construction of this project is requested through the MREFC Account in FY 2006.
- Continued support for operations of the **National Superconducting Cyclotron Laboratory** radioactive ion beam facility at Michigan State University at a total of $17.50 million.
- A decrease of $1.91 million for **Cornell Electron Storage Ring** (CESR) operations to a total of $14.71 million, to continue exploration of critical weak and strong elementary particle interaction phenomena and to support important accelerator physics research activity at Cornell University.

MULTIDISCIPLINARY ACTIVITIES $30,000,000

The FY 2006 Request for the Office of Multidisciplinary Activities (OMA) is $30.0 million, an increase of $510,000, or 1.7 percent, over the FY 2005 Current Plan of $29.49 million.

Multidisciplinary Activities Funding
(Dollars in Millions)

	FY 2004 Actual	FY 2005 Current Plan	FY 2006 Request	Change over FY 2005 Amount	Change over FY 2005 Percent
Multidisciplinary Activities	**$31.07**	**$29.49**	**$30.00**	**$0.51**	**1.7%**
Major Component:					
Research and Education Grants	31.07	29.49	30.00	$0.51	1.7%

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 other 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 2006:

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, 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. Effective workforce development is achieved through a portfolio of activities that includes both MPS participation in Foundation-wide programs and MPS-centric activities that leverage the Directorate's research investment to positively impact and enrich the education and training continuum at all levels, that 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 2005:
Support for **disciplinary research** will be reduced by $1.20 million to the level of $13.16 million. At this level, particular emphasis will be placed on the support of cooperative, high-risk research at the AST-PHY interface focused on physics of the universe at the level of $2.0 million, and on support of innovative research in multidisciplinary areas that enhance our understanding of the molecular basis of life processes that will be sustained at the FY 2005 level of $1.0 million.

Funding for the MPS-wide **Research Partnerships for Diversity** activity will be increased by $1.0 million to the level of $3.0 million. This co-investment with the five disciplinary MPS divisions enables 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 increased by $1.0 million to 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 increased by $500,000 to the level of $3.0 million, which will provide more than 300 pre-service and in-service K-12 teachers with discovery-based learning experiences in the MPS disciplines. Begun in MPS in FY 1999, there are now RET activities in all Directorates. RET builds long-term collaborative K-12 – Research Community relationships, enriches disciplinary content, builds educational capacity, brings research frontiers to the classroom, develops an intellectual resource network, provides professional development opportunities, builds and sustains interest in STEM disciplines, and catalyzes diversification of the STEM workforce.

The overall investment in postdoctoral researchers will be reduced by $600,000 to the level of $1.0 million. Following the elimination of the MPS **Distinguished International Postdoctoral Fellowships** program in FY 2005, the OMA investment in postdoctorals will focus on (1) co-investment with the Office of International Science and Engineering in international postdoctoral research fellowships (through the International Research Fellowship Program) having strong MPS disciplinary focus, (2) coinvestment with the CHE Division in the **Discovery Corps Fellowship** program, and (3) co-investment with the five MPS disciplinary divisions in postdoctoral activities that promote multidisciplinarity and enhance diversity among young physical scientists and mathematicians.

Funds in the amount of $500,000 previously used in support of the NSF Director's Awards for **Distinguished Teaching Scholars** (DTS) will be reallocated to a similar MPS-level activity that provides a new element in the MPS portfolio for broadening participation through its recognition of diverse teacher-scholar role models.