

**DIRECTORATE FOR MATHEMATICAL
AND PHYSICAL SCIENCES (MPS)**

**\$1,366,230,000
+\$29,510,000 / 2.2%**

MPS Funding
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate	
				Amount	Percent
Astronomical Sciences (AST)	\$238.36	\$244.16	\$246.55	\$2.39	1.0%
Chemistry (CHE)	235.18	243.85	251.20	7.35	3.0%
Materials Research (DMR)	267.09	306.99	315.80	8.81	2.9%
Mathematical Sciences (DMS)	224.97	231.73	235.47	3.74	1.6%
Physics (PHY)	267.09	274.99	277.37	2.38	0.9%
Office of Multidisciplinary Activities (OMA)	35.17	35.00	39.84	4.84	13.8%
Total, MPS	\$1,267.86	\$1,336.72	\$1,366.23	\$29.51	2.2%

Totals may not add due to rounding.

About MPS

MPS serves the Nation by supporting fundamental research at the forefront of mathematical and physical sciences. These discoveries are the wellspring of knowledge and innovations that enrich the lives of our citizens. The FY 2016 Request for MPS supports a robust collection of disciplinary and multidisciplinary research programs that foster discovery and develop the technical workforce of the future. Research programs in MPS provide the foundation of basic research in astronomical sciences (AST), chemistry (CHE), materials research (DMR), mathematical sciences (DMS), and physics (PHY) that transforms the frontiers of science.

The portfolio of programs in MPS spans the range from individual investigator awards to large facilities. The majority of awards go to individual investigators and small teams, but centers, institutes, and multi-user facilities are all crucial for MPS-funded science. The MPS mid-scale research infrastructure program, begun over the last few years to meet a critical research need, has received a strong response from the community, and this Request continues to sustain that effort. MPS is also growing research in optics and photonics, one of the promising areas with well-articulated and exciting possibilities.

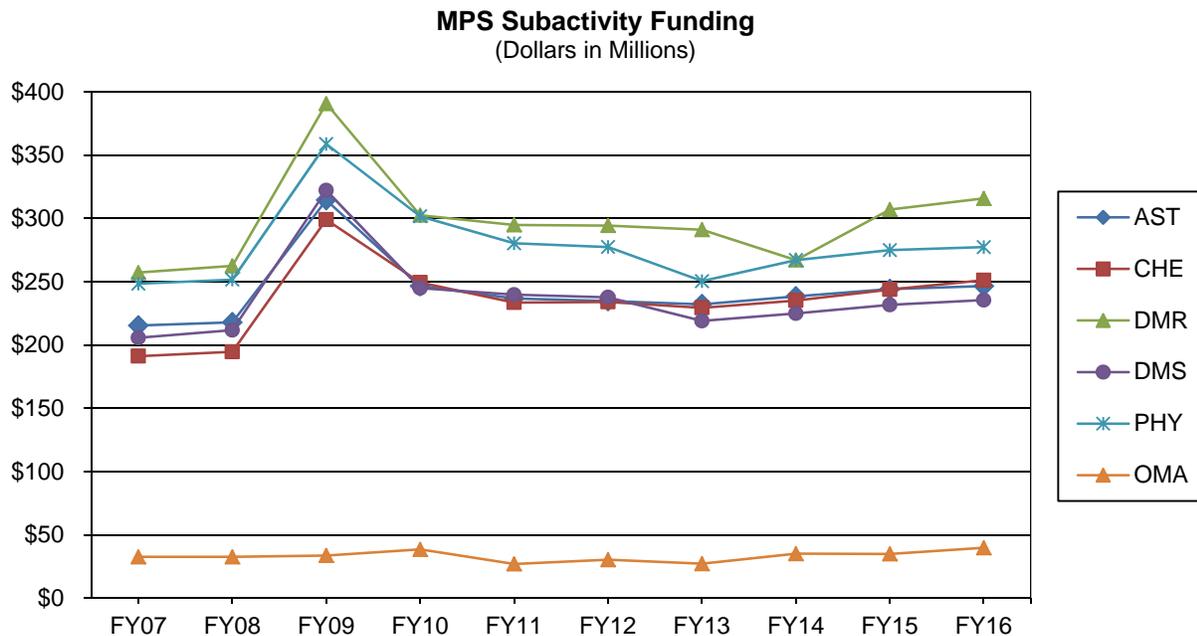
Programs in the MPS divisions respond to special intellectual opportunities and reflect careful choices about directions that provide the greatest return on the research investment. Discussion with the MPS Advisory Committee (MPSAC) is one means of assessing these opportunities, and three recent reports to the MPSAC have informed plans for research in optics and photonics, for research in food, energy, and water, and for materials research instrumentation. The creation of mid-scale materials innovations platforms and participation in the new multi-directorate program on Innovation at the Nexus of Food, Energy, and Water Systems (INFEWS) follow in part from those reports. The emerging area of Risk and Resilience is also part of the directorate’s plan, with MPS participating in aspects such as space weather and modeling of complex systems.

Facilities are an integral part of MPS and enable unique science that is impossible without the special resources of a shared, multi-user environment. Some of these facilities are observatories for photons, neutrinos, or gravitational waves. Others provide unique resources such as the largest controlled magnetic fields in the world or beams of rare ions. Stewardship of the MPS facilities portfolio and the

balance among the different awards programs are critical issues that have engendered extensive community consultation. MPS continues assessing the future of different facilities and fostering partnerships for those facilities.

MPS continues to participate in Foundation-wide and multi-directorate activities. The MPS program in optics and photonics is a partnership with the Directorates for Engineering (ENG) and Computer and Information Science and Engineering (CISE). MPS also partners with them on Enhancing Access to the Radio Spectrum (EARS). Investments continue in cross-Foundation priorities such as Research at the Interface between Biological and Mathematical and Physical Sciences (BioMaPS), which includes research in Understanding the Brain (UtB); Cyber-Enabled Materials, Manufacturing, and Smart Systems (CEMMSS), which includes both Advanced Manufacturing and Designing Materials to Revolutionize and Engineer the Future (DMREF); Cyberinfrastructure Framework for 21st Century Science, Engineering, and Education (CIF21); Secure and Trustworthy Cyberspace (SaTC); and Innovation Corps (I-Corps™). As mentioned above, MPS joins other NSF directorates in initiating INFEWS in FY 2016. Core research funds also contribute to research in clean energy technology and support the program of Research Experiences for Undergraduates (REU). The Sustainable Chemistry, Engineering, and Materials (SusChEM) program is also part of this Request and will continue to evolve even as the NSF program in Science, Engineering, and Education for Sustainability (SEES) ramps-down over the next few years.

MPS provides about 47 percent of the federal funding for basic research at U.S. academic institutions in the mathematical and physical science disciplines.



FY 2009 funding reflects both the FY 2009 omnibus appropriation and funding provided through the American Recovery and Reinvestment Act of 2009 (P.L. 111-5).

FY 2016 Summary by Division

- AST's FY 2016 Request will support individual investigator awards and astronomical observatories, as well as investment in the NSF priority areas of EARS and CIF21 and the major MPS priority area of mid-scale research infrastructure. Funding for individual investigator research is balanced against funding for facilities. Among facilities, support for the Daniel K. Inouye Solar Telescope (DKIST) increases.
- CHE's FY 2016 Request provides enhanced support for core programs and features a focus on INFEWS as a major research driver. CHE will continue commitment to research in clean energy technologies, advanced manufacturing, CIF21, and DMREF. CHE also strongly supports research at the interfaces with biology and materials research, within both experimental and theoretical/computational frameworks, including the major cross-Foundation effort, UtB.
- DMR's FY 2016 Request includes plans to increase its portfolio of individual investigator awards, specifically in NSF focus areas where advanced materials are essential such as CEMMSS through DMREF, BioMaPS, and UtB. DMR will continue its Materials Innovation Platforms (MIP) program started in FY 2015 and will continue a strong commitment to research in the area of clean energy technologies.
- DMS's FY 2016 Request is focused on enhancing support for frontier research, training a diverse group of researchers in mathematical and statistical sciences with computational skills, investing in mathematical sciences institutes, and providing support through efficient mechanisms to foster multidisciplinary research activities in, but not limited to, CIF21, SEES, BioMaPS, CEMMSS, SaTC and UtB.
- PHY's FY 2016 Request includes continued support for individual investigator awards, particularly those in NSF-wide priority areas such as CIF21, BioMaPS, and UtB. PHY also requests increased funding for investigators using its major facilities, and for operations and maintenance of these facilities. In FY 2016, PHY will maintain its program in accelerator science and will also increase its commitment to the MPS priority area of mid-scale research infrastructure.
- OMA will continue its role of supporting multidisciplinary research and activities in education and broadening participation. OMA will emphasize research relevant to NSF priorities such as SEES, CIF21, BioMaPS, UtB, and CEMMSS. OMA will coordinate MPS activities related to I-Corps™, NSF Research Traineeship (NRT), and INSPIRE. In addition, OMA will support responsible decisions regarding portfolio composition, including studies of possible environmental issues, stewardship transition costs, or partnership start-up costs; in FY 2016, the focus will be on implementing recommendations pursuant to the facilities portfolio analysis.

Major Investments

MPS Major Investments

(Dollars in Millions)

Area of Investment	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate	
				Amount	Percent
BioMaPS	\$18.85	\$11.96	\$13.00	\$1.04	8.7%
CAREER	77.22	66.56	69.89	3.33	5.0%
CEMMSS	68.10	40.66	49.84	9.18	22.6%
<i>Advanced Manufacturing</i>	64.86	40.66	49.84	9.18	22.6%
Clean Energy Technology	135.50	144.13	143.34	-0.79	-0.5%
CIF21	32.34	11.50	16.15	4.65	40.4%
I-Corps™	1.42	1.00	1.70	0.70	70.0%
INFEWS	-	-	8.90	8.90	N/A
INSPIRE	1.33	3.00	3.00	-	-
NRT ¹	4.64	4.51	4.47	-0.04	-0.9%
Risk and Resilience	-	-	1.00	1.00	N/A
SEES	25.36	22.50	16.00	-6.50	-28.9%
SaTC	2.00	0.50	1.50	1.00	200.0%
Understanding the Brain	13.08	14.18	18.70	4.52	31.9%

Major investments may have funding overlap and thus should not be summed.

¹ Outyear commitments for Integrative Graduate Education and Research Traineeship (IGERT) are included in the NRT line and are \$4.64 million in FY 2014, \$2.0 million in FY 2015, and \$820,000 in FY 2016.

- BioMaPS is increased by \$1.04 million (to a total of \$13.0 million). This interface continues to be an exciting growth area, the focus of which is the partnership with BIO and ENG that will emphasize research towards Understanding the Brain (UtB) and other emerging areas of multidisciplinary science.
- CAREER remains a top priority for MPS, with an increase of \$3.33 million (to a total of \$69.89 million), ensuring that top young scientists in all of the MPS disciplines are funded at an appropriate level. The CAREER program is an important element in the growth and maturity of young scientists, and MPS commensurately directs investments into the CAREER program.
- MPS's contribution to Advanced Manufacturing, part of Cyber-Enabled Materials Manufacturing and Smart Systems (CEMMSS), is made through its DMREF program. This is a response to the Administration's Materials Genome Initiative. The DMREF program has received very strong interest from MPS communities, and with an increase of \$9.18 million (to a total of \$49.84 million) in FY 2016, MPS will be able to fund additional highly meritorious proposals to advance materials discovery by closely linking theory, modeling, and experimentation, an approach critical to solving related research challenges in areas such as optics and photonics, clean energy, and the brain.
- Clean energy technology research remains strong in MPS core programs with FY 2016 support of \$143.34 million.

- MPS's Computational and Data-Enabled Science and Engineering (CDS&E) program has been successful because of its effective interdisciplinary and interdirectorate management process, a process that assures the awareness of submitted CDS&E proposals among interested and participating programs in MPS, ENG, and CISE. MPS increases this portion of the CIF21 initiative by \$4.65 million to a total of \$16.15 million.
- MPS nearly doubles its investment in the NSF I-Corps™ program (up \$700,000 to a total of \$1.70 million) in FY 2016, primarily to fund I-Corps™ teams. In FY 2013 through FY 2015, the MPS investment in I-Corps™ supported a combination of Teams and Nodes. Beginning in FY 2016, the MPS investment in I-Corps™ will be directed exclusively to support Team awards. The increase will permit support for about 10 additional Teams. Investments in I-Corps™ are directed to an assessment of the commercial viability of the scientific discoveries in MPS disciplines through the individual investigator award program.
- In FY 2016, MPS joins other NSF directorates to initiate Innovations at the Nexus of Food, Energy, and Water Systems (INFEWS), with an initial investment of \$8.90 million. MPS divisions will publicize relevant funding opportunities via Dear Colleague Letters (DCLs), organize and conduct workshops in FY 2015 on selected INFEWS topics, and use an incubator program as one mechanism to fund research to address challenges related to INFEWS. These activities provide the potential for cross directorate cooperation and further building of research communities to address sustainability issues.
- MPS maintains its \$3.0 million commitment to INSPIRE.
- MPS will invest \$4.47 million in FY 2016 for NRT and finish the out-year commitments for Integrative Graduate Education & Research Traineeship (IGERT). This total includes both an increase for the NRT program (+\$1.14 million to a total of \$3.65 million) as well as the final increment on the sunsetting IGERT awards (-\$1.18 million to a total of \$820,000).
- MPS joins GEO, ENG, and SBE in funding programs under the Risk and Resilience portfolio. Contributions in FY 2016 will start at \$1.0 million, split among AST, CHE, and DMS. Scientific research supported by MPS will improve predictive and risk-assessment capabilities, increasing resilience to reduce the impact on civilization of extreme events. Work on fundamental scientific issues, such as understanding the dynamic processes that produce extreme events, will advance knowledge and help to create tools for increased resilience of societal infrastructure to natural and man-made hazards.
- SEES investments drop \$6.50 million (to a total of \$16.0 million) as this initiative continues to sunset. Much of the remaining funding will focus on sustainable chemistry (SusChEM) research.
- MPS's contribution to SaTC, all within DMS, increases \$1.0 million (to a total of \$1.50 million). Questions surrounding securing information networks against hostile intrusion and ensuring individual privacy in anonymized data sets present crucial challenges for society. Research supported by DMS through SaTC will provide a fresh look at such current cybersecurity challenges from the viewpoint of the mathematical sciences.
- UtB funding in MPS is increased \$4.52 million (to a total of \$18.70 million) as this important interdisciplinary area ramps up within NSF. In FY 2016, the MPS investment in UtB will focus on advancing the understanding of model animal and healthy human brains, including an emphasis on computational modeling and simulation and the exploration of inter-neuronal communications.

MPS Funding for Centers Programs and Facilities

MPS Funding for Centers Programs

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate	
				Amount	Percent
Total, Centers Programs	\$68.89	\$93.77	\$92.79	-\$0.98	-1.0%
Centers for Analysis & Synthesis (DMS)	0.20	0.10	0.20	0.10	100.0%
Centers for Chemical Innovation (CHE)	35.49	30.51	32.00	1.49	4.9%
Materials Centers (DMR) ¹	24.82	56.00	56.00	-	-
Nanoscale Science & Engineering Centers (CHE, DMR, PHY)	1.19	0.52	0.50	-0.02	-3.8%
Science & Technology Centers (DMR)	7.19	6.64	4.09	-2.55	-38.4%

Totals may not add due to rounding.

¹ Due to end-of-fiscal year deadlines, \$29.81 million in funding for new Materials Center awards was carried over from FY 2014 and obligated in early FY 2015.

For detailed information on individual centers, please see the NSF-Wide Investments chapter.

- Centers for Analysis and Synthesis (+\$100,000 to a total of \$200,000). This increase returns support for the BIO-managed National Institute for Mathematical and Biological Synthesis to its historic commitment level.
- Centers for Chemical Innovation (+\$1.49 million to a total of \$32.0 million): In FY 2016 up to nine Phase II CCIs will be funded at \$32.0 million (\$1.49 million below the FY 2015 Estimate). Total funding required to support nine CCIs in FY 2016 is \$36.0 million. Of this total, \$32.0 million is provided in this Request. The remaining \$4.0 million will be provided via co-funding and forward funding from previous years. The last set of Phase I Centers will compete for Phase II awards in FY 2015 with no new Phase I Centers supported until the program is evaluated and redesigned in future years.
- The Materials Research Science and Engineering Centers (MRSECs) advance materials research through collaborations of groups of principal investigators, provide students with a rich, interdisciplinary education, and address fundamental research problems of intellectual and strategic importance that will advance U.S. competitiveness. MRSEC competitions are usually held triennially, the last in FY 2014. In FY 2016, 21 new and continuing awards are expected to be supported.
- MPS divisions continue to support (-\$20,000 to a total of \$500,000) two nanoscale-related center awards as support for NSECs agency-wide winds down as planned.
- Science and Technology Centers (STCs) (-\$2.55 million to a total of \$4.09 million): Funding for the STCs reflects the planned sunset of the Center for Layered Polymeric Systems in FY 2015. In FY 2016, support for the Center on Integrated Quantum Materials increases as planned (+\$110,000 for a total \$4.09 million).

MPS Funding for Facilities

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate	
				Amount	Percent
Total, Facilities	\$281.13	\$271.38	\$281.78	\$10.40	3.8%
Arecibo	4.50	4.00	4.10	0.10	2.5%
Atacama Large Millimeter/Submil. Array (ALMA)	34.27	40.17	40.35	0.18	0.4%
Cornell High Energy Synchrotron Source (CHESS)	10.00	10.00	10.00	-	-
Daniel K. Inouye Solar Telescope (DKIST)	2.00	7.00	11.00	4.00	57.1%
Gemini Observatory	19.58	20.61	19.77	-0.84	-4.1%
IceCube Neutrino Observatory (IceCube)	3.45	3.45	3.45	-	-
Large Hadron Collider (LHC)	17.37	18.00	18.00	-	-
Large Synoptic Survey Telescope (LSST)	6.59	-	-	-	N/A
Laser Interferometer Gravitational-wave Observatory (LIGO)	36.43	39.43	39.43	-	-
National High-Magnetic Field Laboratory (NHMFL)	42.26	24.04	34.66	10.62	44.2%
National Nanotechnology Coordinated Infrastructure (NNCI)	-	2.88	2.88	-	-
National Nanotechnology Infrastructure Network (NNIN)	2.88	-	-	-	N/A
National Optical Astronomy Observatory (NOAO)	25.50	25.50	21.75	-3.75	-14.7%
National Radio Astronomy Observatory (NRAO)	43.14	43.14	41.73	-1.41	-3.3%
National Solar Observatory (NSO) ¹	8.00	8.00	9.50	1.50	18.8%
National Superconducting Cyclotron Laboratory (NSCL)	22.50	22.50	22.50	-	-
Center for High Resolution Neutron Scattering (CHRNS)	2.66	2.66	2.66	-	-

¹ The totals presented in FY 2015 and FY 2016 do not include \$5.0 million and \$9.0 million, respectively, for operations and maintenance support for the DKIST facility construction project. That funding is captured within the total presented on the DKIST line above.

For detailed information on individual facilities, please see the Facilities chapter.

MPS sustains operations and maintenance budget levels for most of its large user facilities. Exceptions to this include:

- Daniel K. Inouye Solar Telescope (DKIST): Funding (+\$4.0 million to a total of \$11.0 million) represents the second year of the ramp to full DKIST operations, expected in FY 2019. The total is comprised of \$9.0 million for basic DKIST operations support provided through the National Solar Observatory and \$2.0 million in a separate award as part of the cultural mitigation process for DKIST construction. (See the MREFC chapter for more on DKIST.)
- National High-Magnetic Field Laboratory (NHMFL): Funds (+\$10.62 million to a total of \$34.66 million) are requested to continue transformational research using high magnetic fields. In FY 2014, NHMFL was forward funded by \$9.63 million, reducing the amount needed in FY 2015. FY 2016 funding returns to the level in the current cooperative agreement.
- National Nanotechnology Coordinated Infrastructure (NNCI): Funds (a total of \$2.88 million) are requested for MPS's contribution to NNCI, the successor to the National Nanotechnology Infrastructure Network (NNIN).

- National Optical Astronomy Observatory (NOAO): In FY 2016, this observatory will execute a transformation to a new operations model emphasizing data science, with a reduction in base funding (-\$3.75 million to a total of \$21.75 million) associated with a reduction in telescope operations. This includes initiation of a joint NSF-NASA Exoplanet Research Program (NN-EXPLORE) on the 3.5m WIYN telescope and discussions regarding potential partnerships for the Mayall telescope.
- National Radio Astronomy Observatory (NRAO): Funding for domestic NRAO (-\$1.41 million to a total of \$41.73 million) returns to the level outlined in the baseline plan.
- National Solar Observatory (NSO): This increase (+\$1.50 million to a total of \$9.50 million) includes a decrement of \$1.0 million to basic NSO operations (for a total of \$7.0 million) and a one-time increment of \$2.50 million for refurbishment of the Global Oscillation Network Group (GONG) telescopes in order to facilitate robust space-weather predictions. The total presented does not include \$9.0 million in support of the ramp to operations for DKIST; that funding is captured within the DKIST line in the table above.

Summary and Funding Profile

MPS supports core research and education as well as research infrastructure. MPS will invest heavily in areas such as INFEWS, Advanced Manufacturing, CIF21, and UtB, while increasing its investment in core research areas. Mid-scale research infrastructure in several MPS divisions will continue to increase in response to community needs in these areas.

In FY 2016, the number of research grant proposals to MPS is expected to be similar to FY 2015, with research grant award funding rates expected to rise slightly as a function of greater availability. Average annual award size and duration are not expected to materially fluctuate in FY 2014 through FY 2016.

In FY 2016, MPS will invest \$92.79 million for Centers, accounting for 6.8 percent of the MPS budget. This total is very similar to the FY 2015 Estimate. Centers are an important modality for MPS sciences as research in many MPS-supported disciplines, especially CHE and DMR, has evolved to be more collaborative and interdisciplinary.

Operations and maintenance funding for MPS-supported user facilities comprises 20.6 percent of MPS's FY 2016 Request. MPS has sustained operations budgets for most facilities to maintain current operational capacity. Several have budgets decreased as a function of reductions in scope, while others have budgets increased as new facility capabilities have come online.

MPS Funding Profile

	FY 2014 Actual Estimate	FY 2015 Estimate	FY 2016 Estimate
Statistics for Competitive Awards:			
Number of Proposals	8,856	8,900	9,000
Number of New Awards	2,344	2,500	2,500
Funding Rate	26%	28%	28%
Statistics for Research Grants:			
Number of Research Grant Proposals	7,732	7,700	7,800
Number of Research Grants	1,854	1,900	2,000
Funding Rate	24%	25%	26%
Median Annualized Award Size	\$120,000	\$120,000	\$120,000
Average Annualized Award Size	\$140,683	\$140,000	\$140,000
Average Award Duration, in years	3.2	3.2	3.2

Program Monitoring and Evaluation

External Program Evaluations and Studies:

- The MPS Advisory Committee (MPSAC) released three Subcommittee reports in 2014:
 - *Food, Energy, and Water: Transformative Research Opportunities in the Mathematical and Physical Sciences* informs the Directorate’s future plans to invest in sustainability science.
 - *Optics and Photonics: Transformative Research Opportunities in the Mathematical and Physical Sciences* informs future plans to invest to advance optics and photonics science.
 - *Closing the Loop: Report of the MPSAC Subcommittee on Materials Instrumentation* informs future plans to invest to support materials synthesis and discovery.¹
- The Astronomy and Astrophysics Advisory Committee (AAAC) completed their annual report on interagency activities by the Department of Energy (DOE), NASA, and NSF in March 2014. The next annual report is expected in March 2015.
- The Committee on Astronomy and Astrophysics of the National Academy of Sciences (NAS), National Research Council (NRC), has been commissioned to carry out a study of “A Strategy to Optimize the U.S. Optical/Infrared System in the Era of the Large Synoptic Survey Telescope.” A report is expected in Spring 2015.
- AST, together with the NASA Astrophysics Division and the High Energy Physics Branch of the DOE Office of Science, is commissioning a mid-decadal study through the NRC Committee on Astronomy and Astrophysics. The committee is expected to receive a complete charge in FY 2015 and issue a report in FY 2016.
- DMS implemented recommendations of the 2013 report *The Mathematical Sciences in 2025*² by the Board on Mathematical Sciences and their Applications of the National Research Council. In response to the report, DMS instituted the Mathematical Sciences Innovation Incubator (MSII) activity.³
- NSF and DOE received a report in May 2014 from a subcommittee of the Nuclear Science Advisory Committee (NSAC) that was charged with developing evaluation criteria for a next-generation

¹ www.nsf.gov/mps/advisory/mpsac_other_reports/materials_instrumentation-final_from_subcommittee.pdf

² www.nap.edu/catalog/15269/the-mathematical-sciences-in-2025

³ www.nsf.gov/funding/pgm_summ.jsp?pims_id=505044

detector of neutrino-less nuclear double beta decay.

- NSF and DOE received a report in May 2014 from the High-Energy Physics Advisory Panel (HEPAP) to reform the Particle Physics Project Prioritization Panel (P5) and to develop a strategic plan for particle physics covering the next 10 years. The MPS Advisory Committee formed a subcommittee to provide advice on NSF-specific implementation options for the strategic plan. The subcommittee is expected to issue a report in early 2015.
- NSF and DOE have asked NSAC to develop a long-range strategic plan for nuclear physics covering the next 10 years. A report is expected by mid-2015.

Science and Technology Policy Institute (STPI) Reports:

- STPI completed a pilot study in FY 2014 of the DMS Mathematical Sciences Research Institutes to examine the feasibility of evaluation for institute programs using qualitative methods. The study provided options for further evaluation of program outcomes and recommendations regarding case study logistics, currently under review by DMS.

Workshops and Reports:

- CHE sponsored the U.S. Young Observer (YO) Program for the 2013 and 2015 Congress and General Assembly of the International Union of Pure and Applied Chemistry (IUPAC). Data collection from the YOs on the impact of the experience on their professional careers is continuing. Eleven YOs from the U.S. attended the 2013 event and presented papers at the General Assembly and World Chemistry Congress. The results have been shared with the U.S. National Committee for IUPAC in written and verbal forms via meeting materials.
- CHE sponsored a workshop on Laboratory Safety in March 2012 at the National Academy of Sciences' Beckman Center in Irvine, CA. Workshop outcomes and recommendations were published in the *Journal of Chemical Health & Safety*, January/February 2013.⁴ The final report, *Safe Science: Promoting a Culture of Safety in Academic Chemical Research*, was published in July 2014.⁵
- In concert with the focus on Advanced Manufacturing, CHE co-sponsored with BIO the workshop, "Industrialization of Biology: A Roadmap to Accelerate Advanced Manufacturing of Chemicals" in 2014. A final report is forthcoming.
- In the context of Big Data, CHE sponsored the workshop, "Data-Driven Organic Chemistry" in September 2014 and will sponsor "Mass Spectrometry Big Data to Knowledge" in May 2015. The latter workshop is co-sponsored by DMS and SBE internally, NIH and NIST externally.
- CHE and the NASA Astrobiology Program co-sponsored an international workshop on "Alternative Chemistries of Life" in 2013. The highly interdisciplinary nature of the workshop produced interesting suggestions for future areas/lines of research. The final report was published in 2014.⁶
- DMR sponsored a Partnerships for Research and Education in Materials (PREM) Workshop as part of the MRS Fall Meeting in Boston in November 2014. This workshop brought together past and present PREM students for professional and career development activities.
- In May 2014, DMR sponsored a workshop on "Combinatorial Approaches to Functional Materials," which focused on challenges and opportunities to maximize the impact of theoretical and experimental combinatorial materials science to the Materials Genome Initiative. This workshop identified grand challenges for combinatorial materials research, assessing current practice to determine the approach, costs, risks, timescales, and payoffs in going forward.
- DMR and the DOE Office of Basic Energy Sciences (BES) co-sponsored a joint DOE/NSF Materials Genome Initiative (MGI) Principal Investigators' Meeting on January 12-13, 2015. This meeting brought together principal investigators from NSF's DMREF program and the DOE's Predictive Theory and Modeling Program.

⁴ www.dx.doi.org/10.1016/j.jchas.2012.10.002

⁵ www.nap.edu/catalog.php?record_id=18706

⁶ <http://chemistry.emory.edu/home/assets/alternativechem.pdf>

- The report *Materials Genome Initiative: The Interplay of Experiment, Theory and Computation 2013* was published in the Current Opinion in Solid State and Materials Science in 2014. This was the follow up to the DMR-sponsored “The Materials Genome Initiative and the Synergy Between Computation and Experiment” in December 2012.
- In response to the 2013 report of the project “Investing in the Next Generation through Innovative and Outstanding Strategies for Mathematics and Statistics” (INGenIOuS),⁷ DMS designed and implemented a new program in FY 2015, "Enriched Doctoral Training in the Mathematical Sciences" (EDT).⁸ This program, through research training, prepares Ph.D. students to recognize, and find solutions to, mathematical challenges arising in other fields and in areas outside today's academic setting.
- To spotlight opportunities for mathematical sciences research in connection with the DMREF program, DMS is sponsoring a Symposium on Mathematical and Computational Aspects of Materials Science in connection with the Society for Industrial and Applied Mathematics conference on Computational Science & Engineering in March 2015.⁹

Committees of Visitors (COV):

- In FY 2013, COVs reviewed CHE and DMS. The COV reports and the divisions' responses can be found on the MPS AC website. The divisions are responding to and implementing recommendations from these reviews.
- In FY 2015, COVs will review AST, DMR, and PHY.
- In FY 2016, COVs will review DMS.

The Performance chapter provides details regarding the periodic reviews of programs and portfolios of programs by external Committees of Visitors and directorate Advisory Committees. Please see this chapter for additional information.

Number of People Involved in MPS Activities			
	FY 2014	FY 2015	FY 2016
	Actual	Estimate	Estimate
	Estimate	Estimate	Estimate
Senior Researchers	7,813	8,200	8,400
Other Professionals	2,995	3,200	3,200
Postdoctorates	1,983	2,000	2,100
Graduate Students	8,419	8,900	9,000
Undergraduate Students	5,307	5,600	5,700
Total Number of People	26,517	27,900	28,400

⁷ www.maa.org/programs/faculty-and-departments/ingenious

⁸ www.nsf.gov/funding/pgm_summ.jsp?pims_id=505083

⁹ www.siam.org/meetings/cse15/symposium.php

DIVISION OF ASTRONOMICAL SCIENCES (AST)

\$246,550,000
+\$2,390,000 / 1.0%

AST Funding
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over	
				FY 2015 Estimate Amount	Percent
Total, AST	\$238.36	\$244.16	\$246.55	\$2.39	1.0%
Research	64.04	67.08	62.72	-4.36	-6.5%
CAREER	4.76	4.82	4.72	-0.10	-2.1%
Education	6.24	5.90	6.66	0.76	12.9%
Infrastructure	168.08	171.18	177.17	5.99	3.5%
Arecibo Observatory	4.50	4.00	4.10	0.10	2.5%
Atacama Large Millimeter/submm Array (ALMA)	34.27	40.17	40.35	0.18	0.4%
Daniel K. Inouye Solar Telescope (DKIST)	2.00	7.00	11.00	4.00	57.1%
Gemini Observatory	19.58	20.61	19.77	-0.84	-4.1%
Nat'l Optical Astronomy Obs. (NOAO)	25.50	25.50	21.75	-3.75	-14.7%
Nat'l Radio Astronomy Obs. (NRAO)	43.14	43.14	41.73	-1.41	-3.3%
Nat'l Solar Observatory (NSO) ¹	8.00	8.00	9.50	1.50	18.8%
Mid-Scale Innovations Program (MSIP)	14.15	13.00	18.72	5.72	44.0%
Research Resources	10.35	9.76	10.25	0.49	5.0%
Facilities Pre-Construction Planning (total)	6.59	-	-	-	N/A
Large Synoptic Survey Telescope (LSST)	6.59	-	-	-	N/A

Totals may not add due to rounding.

¹ The totals presented in FY 2015 and FY 2016 do not include \$5.0 million and \$9.0 million, respectively, for operations and maintenance support for the DKIST facility construction project. That funding is captured within the total presented on the DKIST line above.

AST is the federal steward for ground-based astronomy in the United States, funding research with awards to individual investigators and small research groups, and via cooperative agreements for operation of large telescope facilities. These national and international telescope facilities provide world-leading, one-of-a-kind observational capabilities on a competitive basis to thousands of astronomers per year. These facilities also enable scientific advances by making archived data products available to researchers. Along with funding telescope facilities and research awards, AST supports the development of advanced technologies and instrumentation and manages the electromagnetic spectrum for scientific use by the entire NSF community.

In general, 24 percent of the AST portfolio is available for new research grants and 76 percent is available for continuing grants and cooperative awards.

AST supports research to understand the origins and characteristics of planets, stars, and galaxies, as well as the structure that has evolved in the Universe since its origin more than 13 billion years ago. The results of this research will lead to a better understanding of the cosmos in which we live, of the possibility of life existing on planets circling other stars, and of the nature of the mysterious dark matter and dark energy that comprise more than 95 percent of the mass-energy of the Universe.

Approximately 72 percent of AST's budget supports the forefront instrumentation and facilities needed

for progress at the frontiers of observational astronomy, while the remaining 28 percent supports the research of individual investigators. Through the MREFC account, AST also oversees the construction of the Large Synoptic Survey Telescope (LSST) and the Daniel K. Inouye Solar Telescope (DKIST).

In 2010, the National Research Council conducted its sixth decadal survey in astronomy and astrophysics. In their report, *New Worlds, New Horizons in Astronomy and Astrophysics*,¹⁰ the NRC committee recommended that “NSF-Astronomy should complete its next senior review before the mid-decade independent review that is recommended in this report, so as to determine which, if any, facilities NSF-AST should cease to support in order to release funds for (1) the construction and ongoing operation of new telescopes and instruments and (2) the science analysis needed to capitalize on the results from existing and future facilities.” In response to this recommendation, AST conducted a community-based review of its portfolio. The resulting Portfolio Review Committee (PRC) report, *Advancing Astronomy in the Coming Decade: Opportunities and Challenges*,¹¹ was released in August 2012 and included recommendations about all of the major AST telescope facilities.

In FY 2012 and FY 2013, AST began to engage actively in facility partnership discussions with other federal agencies and with university-based groups. In FY 2014, AST continued those discussions, and NSF brought a general engineering contractor on-board for all its engineering and environmental reviews. In FY 2015, that contractor is producing feasibility reports for divestment alternatives, which will provide the results of baseline structural and environmental surveys of a number of individual telescopes and observatories. Once NSF has identified viable options for divestment, it will embark on formal reviews (in FY 2015 and FY 2016) to evaluate environmental impacts of these options, including partnership opportunities that could have impacts to the environment. Details for individual facilities are described in the Facilities chapter of this Budget Request.

FY 2016 Summary

All funding decreases/increases represent change over the FY 2015 Estimate.

Research

- Astronomy and Astrophysics Research Grants program (-\$2.74 million to a total of \$41.36 million): Following an increase in FY 2015 that was enabled by the conclusion of construction planning and development for LSST, in FY 2016 this program is decreased.
- The Theoretical and Computational Astrophysics Networks program executed in conjunction with NASA is decreased 100 percent (-\$1.50 million to zero). A joint program evaluation with NASA will be conducted to determine whether another cycle of this program is instituted in FY 2017.

Education

- Astronomy and Astrophysics Postdoctoral Fellowship program (+\$100,000 to a total of \$2.40 million): Increased funding enables one additional fellowship award in FY 2016.
- Partnerships in Astronomy and Astrophysics Research and Education (+\$1.0 million to a total of \$2.0 million): AST enhances its efforts to diversify the astronomical research community by increasing support in this program by 100 percent.

Infrastructure

- Atacama Large Millimeter/Submillimeter Array (+\$180,000 to a total of \$40.35 million): Funding sustains the transition from construction to full operations. A major operations review will take place

¹⁰ www.nap.edu/catalog.php?record_id=12951

¹¹ www.nsf.gov/mps/ast/ast_portfolio_review.jsp

in FY 2015 to evaluate future funding requirements.

- Daniel K. Inouye Solar Telescope (+\$4.0 million to a total of \$11.0 million): Funding represents the second year of the ramp to full DKIST operations, expected in FY 2019. The total is comprised of \$9.0 million for basic DKIST operations support provided through the National Solar Observatory and \$2.0 million in a separate award as part of the cultural mitigation process for DKIST construction. (See the MREFC chapter for more on DKIST.)
- Gemini (-\$840,000 to a total of \$19.77 million): Funding represents a flat operations budget (\$18.02 million) and a decrease in new instrumentation funding (-\$840,000 to \$1.75 million) as Gemini transitions to a new partnership model emphasizing in-kind instrumentation contributions.
- National Optical Astronomical Observatory funding (-\$3.75 million to a total of \$21.75 million): The observatory will transform to a new operations model emphasizing data science, with a reduction in base associated with a reduction in telescope operations. This includes initiation of a joint NSF-NASA Exoplanet Research Program (NN-EXPLORE) on the 3.5m WIYN telescope and discussions regarding potential partnerships for the Mayall telescope.
- National Radio Astronomical Observatory (-\$1.41 million to a total of \$41.73 million): The funding reduction for domestic, non-ALMA NRAO represents a return to the baseline NRAO plan.
- National Solar Observatory (+\$1.50 million to a total of \$9.50 million): This increase includes a decrement of \$1.0 million to basic NSO operations (for a total of \$7.0 million) and a one-time increment of \$2.50 million for refurbishment of the Global Oscillation Network Group (GONG) telescopes in order to facilitate robust space-weather predictions. The total presented does not include \$9.0 million in support of the ramp to operations for DKIST; that funding is captured within the DKIST line in the table above. For more information, see the Facilities chapter.
- Mid-Scale Innovations Program (MSIP) (+\$5.72 million to a total of \$18.72 million): A significant funding increase supports the second AST solicitation for MSIP proposals, sustaining experiments, student instrumentation training, and access to non-federal observatories and data sets at funding levels of up to ~\$20.0 million for individual projects, a research scale not accessible for normal individual investigator grants.

DIVISION OF CHEMISTRY (CHE)**\$251,200,000**
+\$7,350,000 / 3.0%**CHE Funding**
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate	
				Amount	Percent
Total, CHE	\$235.18	\$243.85	\$251.20	\$7.35	3.0%
Research	221.11	233.30	238.00	4.70	2.0%
CAREER	25.53	23.57	24.66	1.09	4.6%
Centers Funding (total)	33.89	30.76	32.25	1.49	4.8%
Centers for Chemical Innovation	33.49	30.51	32.00	1.49	4.9%
Nanoscale Science & Engineering Centers	0.40	0.25	0.25	-	-
Education	7.45	6.25	6.01	-0.24	-3.8%
Infrastructure	6.62	4.30	7.19	2.89	67.2%
National High Magnetic Field Laboratory (NHMFL)	3.58	-	1.88	1.88	N/A
National Nanotechnology Coordinated Infrastructure (NNCI)	-	0.30	0.30	-	-
National Nanotechnology Infrastructure Network (NNIN)	0.30	-	-	-	N/A
Research Resources	2.74	4.00	5.01	1.01	25.3%

Totals may not add due to rounding.

CHE supports a large and vibrant research community engaged in fundamental research linked to key national priorities. CHE will enable research in sustainability and clean energy, providing new molecules and tools that are essential to our economy and well-being. Through the development of new methodologies in chemical synthesis, CHE is a natural contributor to advancing manufacturing technology. CHE strongly supports research at the interfaces with biology and materials research, within both experimental and theoretical/computational frameworks. CHE's programs invite research in catalysis for energy capture and storage as well as for the formation of new chemical bonds, appreciation of, and insight into, the chemistry of life processes, new nano-structured materials that will revolutionize electronics and photonics, and better awareness of how nano-size aerosols and particles impact our environment. In addition, CHE supports curiosity-driven research that leads to increased understanding of molecules and their chemical transformations, as well as the development of new instrumentation to study and detect molecules.

In general, 59 percent of the CHE portfolio is available for new research grants and 41 percent goes to continuing grants; the Centers for Chemical Innovation program constitutes 43 percent of continuing grant commitments in FY 2016. Almost 85 percent of CHE's budget is used to support individuals and small groups of researchers, while about 15 percent of the budget supports centers and facilities.

FY 2016 Summary

All funding decreases/increases represent change over the FY 2015 Estimate.

Research

- CAREER (+\$1.09 million to a total of \$24.66 million): CHE continues its commitment to young investigators. This increase will fund two to three additional awards.
- Centers for Chemical Innovation (+\$1.49 million to a total of \$32.0 million): This increase in FY 2016 is due to forward funding in FY 2014, which allowed lower level in FY 2015. The last set of Phase I Centers will compete for Phase II awards in FY 2015 with no new Phase I Centers supported until the program is evaluated and redesigned in future years.
- Advanced Manufacturing continues to be important, increasing 8.6 percent, with projects supported through unsolicited individual investigator grants and the Centers for Chemical Innovation program (+\$1.33 million to a total of \$16.74 million).
- SEES (-\$3.0 million to a total of \$10.0 million): Plans are being developed to mainstream the SusChEM activities into the CHE individual investigator award programs and thematically-related centers in the Centers for Chemical Innovation program. The SEES Postdoctoral Fellows Program is discontinued in FY 2015 and the funds folded into SusChEM activities.
- CHE begins a new investment (\$7.20 million) in sustainability through the NSF-wide program, Innovations at the Nexus of Food, Energy, and Water Systems, via joint solicitations, Dear Colleague Letters, and unsolicited proposals through the Environmental Chemical Sciences and Chemical Measurement and Imaging Programs.
- Understanding the Brain (+\$260,000 to a total of \$3.80 million): CHE continues to grow investments in this cross-Foundation activity.

Education

- CHE maintains a commitment to Research Experiences for Undergraduates at \$5.05 million.
- CHE maintains its commitment to diversity through programs such as ADVANCE at \$800,000.
- CHE's overall education investments are down (-\$240,000 to a total of \$6.01 million) mainly due to the discontinuation of the SEES Postdoctoral Fellows Program and the Office of Multidisciplinary Activities assumption of MPS's commitments to the NRT program.

Infrastructure

- National High Magnetic Field Laboratory (+\$1.88 million to a total of \$1.88 million): CHE funding for NHMFL supports the maintenance and operation of the recently installed 21-Tesla magnet at the Ion Cyclotron Resonance (ICR) facility. NHMFL was forward-funded in FY 2014 to cover the entire FY 2015 increment; FY 2016 funding returns to the level in the current cooperative agreement.
- National Nanotechnology Coordinated Infrastructure (no change at \$300,000): Funds are requested for CHE's contribution to NNCI, the successor to the NNIN.
- Research Resources (+\$1.01 million to a total of \$5.01 million): This includes support for ChemMatCARS at Argonne National Laboratory (+\$270,000 to a total of \$970,000), consistent with the renewal award funding level, and adds support for highly meritorious Major Research Instrumentation proposals (+\$1.50 million to a total of \$3.50 million).

DIVISION OF MATERIALS RESEARCH (DMR)

\$315,800,000
+\$8,810,000 / 2.9%

DMR Funding
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate	
				Amount	Percent
Total, DMR	\$267.09	\$306.99	\$315.80	\$8.81	2.9%
Research	201.60	251.91	248.54	-3.37	-1.3%
CAREER	25.11	21.22	23.03	1.81	8.5%
Centers Funding (total)	32.78	62.89	60.34	-2.55	-4.1%
Materials Centers ¹	24.82	56.00	56.00	-	-
Nanoscale Science & Engineering Centers	0.77	0.25	0.25	-	-
STC1: Center for Layered Polymeric Materials	3.32	2.66	-	-2.66	-100.0%
STC2: Center for Integrated Quantum Materials	3.87	3.98	4.09	0.11	2.8%
Education	6.80	6.30	5.76	-0.54	-8.6%
Infrastructure	58.69	48.78	61.50	12.72	26.1%
National High Magnetic Field Laboratory (NHMFL)	38.68	24.04	32.78	8.74	36.4%
Center for High Resolution Neutron Scattering (CHRNS)	2.66	2.66	2.66	-	-
Cornell High Energy Synchrotron Source (CHESS)	10.00	10.00	10.00	-	-
National Nanotechnology Coordinated Infrastructure (NNCI)	-	2.58	2.58	-	-
National Nanotechnology Infrastructure Network (NNIN)	2.58	-	-	-	N/A
Research Resources	4.77	1.50	1.00	-0.50	-33.3%
Mid-scale Research Infrastructure	-	8.00	12.48	4.48	56.0%

Totals may not add due to rounding.

¹ Due to end-of-fiscal year deadlines, \$29.81 million in funding for new Materials Center awards was carried over from FY 2014 and obligated in early FY 2015.

Research in DMR focuses on advancing materials discovery and characterization. Programs focus on condensed matter physics, solid-state chemistry, and the science of materials that are multifunctional, hybrid, electronic, photonic, metallic, superconducting, ceramic, polymeric, biological, and nano-structured. DMR awards enable materials scientists to advance understanding of the electronic, atomic, and molecular mechanisms and processes that govern macroscale properties. The community seeks to manipulate and control these properties, discover and understand emerging phenomena, and create novel synthesis and processing strategies that lead to new materials with unique characteristics. These discoveries and advancements transcend traditional scientific and engineering disciplines. They enable new technologies that meet societal needs, including those with the goal of sustainability. Research supported by DMR is essential for the development of future technologies and industries including clean energy, advanced optics and electronics, and health. A key and critical enabler to these scientific advances is the investment in development and support of the materials workforce, cyberinfrastructure, and next generation instruments and facilities, including support for mid-scale user facilities called Materials Innovation Platforms (MIP). A MIP, in addition to developing and providing access to new instrumentation, conducts research on a materials challenge by integrating synthesis, characterization, and materials theory or modeling. Finally, conveying the exciting science and the societal benefit enabled by

materials research to students and to the general public remains an important aspect of the division's mission.

In general, 35 percent of the DMR portfolio is available for new research grants and 65 percent goes to continuing grants.

FY 2016 Summary

All funding decreases/increases represent change over the FY 2015 Estimate.

Research

- CAREER (+\$1.81 million to a total of \$23.03 million): DMR places high priority on these grants in order to develop a pipeline of new faculty in materials research who will help form the community of the future. This increase will fund about 14 additional awards.
- DMR participates in the CEMMSS Initiative through investments in Designing Materials to Revolutionize and Engineer our Future (DMREF) (+\$5.25 million to a total of \$12.25 million), a program DMR is leading in response to the national Materials Genome Initiative, and Advanced Manufacturing (+\$6.07 million to a total of \$23.67 million) through individual investigator programs, MRSEC investments, and participation in the Sustainable Nanomanufacturing solicitation. DMREF is a major effort to accelerate the discovery and deployment of new materials with a specific and desired function or property through synergistic integration of theory and computation, experiments, and systematic use of materials data.
- SEES: DMR contributes to this cross-agency initiative (-\$1.0 million to a total of \$6.0 million) through participation in the Sustainable Chemistry, Engineering and Materials (SusChEM) program. DMR focuses this research on the preservation and extension of natural resources aimed at improved material usage and overall lifecycle management. The decrease reflects the planned sunset of SEES in 2017.
- Clean energy (+\$60,000 to a total of \$70.12 million): Additional research in the DMR clean energy portfolio includes hydrogen, fuel cells, biomass, solar energy, hydrocarbon conversion, the capture and use of CO₂, and energy storage.
- BioMaPS (+\$260,000 to a total of \$3.24 million): DMR supports a large and growing amount of research in this area, not only in its Biomaterials program, but throughout the portfolio including the centers and facilities.
- Understanding the Brain (+\$250,000 to a total of \$3.80 million): DMR increases support this agency-wide focus in brain-related research.
- CIF21 (+\$800,00 to a total of \$2.65 million): DMR will accelerate research, especially related to CEMMSS/DMREF, by investing in new functional capabilities in computational methods, algorithms, tools and data core methods, and technologies.
- Materials Research Science and Engineering Centers (MRSECs) (no change at \$56.0 million): MRSEC competitions are usually held triennially, the last in FY 2014 with awards made in early FY 2015. In FY 2016, 21 new and continuing awards are expected to be supported.
- Nanoscale Science and Engineering Centers (NSECs): Support remains unchanged for the NSEC program, which is winding down agency-wide as planned.
- Science and Technology Centers (-\$2.55 million to a total of \$4.09 million): Funding reflects the planned sunset of the Center for Layered Polymeric Systems (-\$2.60 million to zero) and a ramp up in support for the Center on Integrated Quantum Materials (+\$110,000 for a total of \$4.09 million).

Education

- Research Experiences for Undergraduates (-\$300,000 to a total of \$5.17 million): DMR's education portfolio maintains commitments to this program but with a small reduction.
- Integrative Graduate Education and Research Traineeship (-\$240,000 to a total of \$160,000): Support decreases as the program is sunseting as planned.

Infrastructure

- Mid-scale Research Infrastructure (+\$4.48 million to a total of \$12.48 million): Funding supports the Material Innovation Platforms (MIP) program started in FY 2015. The MIP program, which includes a user program, focuses on technical priorities for advancing materials research and is comprised of specialized instrumentation and computation for characterization, modeling, synthesis, and processing for new materials.
- Research Resources (-\$500,000 to a total of \$1.0 million): Funding for helium reclamation decreases due to less demand from the community.
- National Nanotechnology Coordinated Infrastructure (NNCI) (no change at \$300,000): Funds are requested for DMR's contribution to NNCI, the successor to the National Nanotechnology Infrastructure Network (NNIN).
- National High Magnetic Field Laboratory (NHMFL) (+\$8.74 million to a total of \$32.78 million): Funding continues transformational research using high magnetic fields. This facility serves researchers in fields ranging from biology to materials and condensed matter physics. In FY 2014, DMR forward funded NHMFL by \$7.79 million, reducing the amount required in FY 2015. In FY 2016, funding returns to the level committed to in the current cooperative agreement.

DIVISION OF MATHEMATICAL SCIENCES (DMS)

\$235,470,000
+\$3,740,000 / 1.6%

DMS Funding
(Dollars in Millions)

	FY 2014	FY 2015	FY 2016	Change Over	
	Actual	Estimate	Request	FY 2015 Estimate	Amount
Total, DMS	\$224.97	\$231.73	\$235.47	\$3.74	1.6%
Research	197.95	218.15	227.82	9.67	4.4%
CAREER	12.31	9.51	10.03	0.52	5.5%
Centers Funding (total)	0.20	0.10	0.20	0.10	100.0%
Centers for Analysis & Synthesis	0.20	0.10	0.20	0.10	100.0%
Education	27.02	13.58	7.65	-5.93	-43.7%

Totals may not add due to rounding.

DMS plays a critical role in providing more than 50 percent of all U.S. federal support basic research at the frontiers of discovery in the mathematical sciences.

The influence of mathematical sciences on daily life is fundamental and pervasive; for example, every secure commercial transaction on the internet is an application of research in number theory and algebraic geometry. Modern communication, transportation, medicine, manufacturing, security, and finance all depend on developments in the mathematical sciences.

DMS investments catalyze research at the frontiers of fundamental, applied, and computational mathematics and statistics, and also enable discovery and innovation in other fields of science and engineering linked to key national priorities. In turn, advances in science and engineering inspire development of ever more sophisticated mathematical and statistical methodology, theory, and tools. DMS investments underpin these developments as well as the training of future researchers in the mathematical sciences.

In addition to supporting a vibrant research community through core research programs in mathematics and statistics, DMS supports national mathematical sciences research institutes that advance research, increase the impact of the mathematical sciences, respond to national needs, and expand the U.S. talent base engaged in mathematical and statistical research. DMS also continues to develop interdisciplinary activities that reflect national priorities. Successful multi-agency programs, such as joint activity in biosciences with the National Institute of General Medical Sciences, are continuing, and newer DMS activities, such as the Mathematical Sciences Innovation Incubator and the Computational and Data-Enabled Science and Engineering program, are attracting broad interest. The DMS Workforce Program offers funding opportunities that support efforts to increase the number of well-prepared students who pursue careers in the mathematical sciences and in other NSF-supported disciplines. These investments in mathematical sciences discovery, connections, and community are essential components of the innovation engine that drives the nation's economy in the 21st century.

In general, 48 percent of the DMS portfolio is available for new research grants and 52 percent is available for continuing grants.

FY 2016 Summary

All funding decreases/increases represent change over the FY 2015 Estimate.

Research

- CAREER (+\$520,000 to a total of \$10.03 million): Support for early-career researchers is a division priority. This increase allows DMS to support two to three additional CAREER awards.
- Optics and photonics (+\$3.60 million to a total of \$4.60 million): Divisional investment in this emphasis area reflects increased interest in this important area. DMS will lead MPS participation in this multidisciplinary NSF-wide activity to invest in fundamental research in optics and photonics, which are key enabling technologies in a multitude of application areas. DMS will coordinate MPS activities in optics and photonics in collaboration with other participating directorates. The activity will be highlighted through community workshops and the development of a program solicitation.
- BioMaPS (+\$260,000 to a total of \$3.26 million): DMS invests in innovative research at the intersection of the mathematical and physical sciences and the biological sciences in a comprehensive approach to acquire insight into and inspiration from the living world.
- Understanding the Brain (+\$1.75 million to a total of \$5.30 million): DMS support increases in this NSF goal to enable scientific understanding of the full complexity of the brain, in action and in context, through targeted, cross-disciplinary investments.
- Secure and Trustworthy Cyberspace (+\$1.0 million to a total of \$1.50 million): Funding reflects increased national need for fundamental cybersecurity research. This research investigates questions surrounding securing information networks against hostile intrusion and ensuring individual privacy in anonymized data sets.
- CEMMSS (+\$1.73 million to a total of \$6.10 million): Funding will accelerate fundamental discoveries in materials science by investing in new capabilities for mathematical modeling, computational simulation, numerical algorithms, and data analysis and management.
- SEES (-\$2.50 million to zero): Decreased investment here is offset by DMS investment in new interdisciplinary research, including Innovations at the Nexus of Food, Energy, and Water Systems (INFEWS) (+\$1.70 million to \$1.70 million total) and Risk and Resilience (+\$500,000 to a total of \$500,000). Research on fundamental scientific issues, such as understanding the dynamical processes that produce extreme events, will advance knowledge and help to create tools for increased resilience of societal infrastructure to natural and man-made hazards.
- Mathematical Sciences Research Institutes (level at \$29.50 million): Eight domestic DMS-supported institutes will continue to catalyze frontier research through an array of scientific programs.

Education

- Decreased investment in the overall Education portfolio (-\$5.93 million to a total of \$7.65 million in FY 2016) reflects the mainstreaming into core programs of support for graduate students and postdoctoral researchers. Most of these decreases are achieved through the sunset of the Enhancing the Mathematical Sciences Workforce in the 21st Century program.
- The Education portfolio maintains a commitment to Research Experiences for Undergraduates (REU) program at \$3.39 million.
- Mathematical Sciences Postdoctoral Research Fellowships (level at \$4.10 million): DMS continues investments in a number of education and diversity activities through the program.

DIVISION OF PHYSICS (PHY)

\$277,370,000
+\$2,380,000 / 0.9%

PHY Funding
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over	
				FY 2015 Estimate Amount	Percent
Total, PHY	\$267.09	\$274.99	\$277.37	\$2.38	0.9%
Research	163.82	176.05	176.19	0.14	0.1%
CAREER	8.57	7.44	7.45	0.01	0.1%
Centers Funding (total)	0.02	0.02	-	-0.02	-
Nanoscale Science & Engineering Centers	0.02	0.02	-	-0.02	-
Education	5.38	5.56	5.32	-0.24	-4.3%
Infrastructure	97.89	93.38	95.86	2.48	2.7%
IceCube Neutrino Observatory	3.45	3.45	3.45	-	-
Large Hadron Collider (LHC)	17.37	18.00	18.00	-	-
Laser Interferometer Grav. Wave Obs. (LIGO)	36.43	39.43	39.43	-	-
National Superconducting Cyclotron Laboratory (NSCL)	22.50	22.50	22.50	-	-
Research Resources	11.56	-	-	-	N/A
Mid-scale Research Infrastructure	6.58	10.00	12.48	2.48	24.8%

Totals may not add due to rounding.

PHY supports fundamental research addressing frontier areas of physics that lead to the understanding of the make-up of the Universe, from the formation of stars and galaxies to the principles of life processes on Earth. This research covers a range of physics subfields: atomic, molecular, optical and plasma physics, elementary particle physics, gravitational physics, nuclear physics, particle and nuclear astrophysics, physics of living systems, physics at the information frontier, and theoretical physics. PHY is the primary supporter of all U.S. research in gravitational physics and the leading supporter of fundamental research in atomic, molecular, and optical physics in the U.S. PHY is a major partner with DOE in support of elementary particle physics, nuclear physics, and plasma physics. PHY also has the only U.S. program designed for the support of physics research in living systems. The development of the most advanced cutting-edge computational resources, innovative technology, and new instrumentation is a key part of physics research, and tools developed by the physics community continuously have major impact in other scientific and engineering fields.

In general, 22 percent of the PHY portfolio is available for new research grants. The remaining 78 percent is used primarily to fund continuing grants made in previous years (49 percent) and to support operations and maintenance for four facilities that are a key part of the division portfolio (29 percent).

FY 2016 Summary

All funding decreases/increases represent change over the FY 2015 Estimate level.

Research

- Added funding for research grants will support additional individual investigator awards. Changes in NSF-wide investments are accommodated through strategic funding through PHY core programs.

These include:

- BioMaPS (+\$260,000 million to a total of \$3.26 million): This provides for programs that support research at the interface between the mathematical and physical sciences and the life sciences.
- Understanding the Brain (+\$2.05 million to \$5.80 million): This provides support for physics-based research that enables scientific understanding of the full complexity of the brain.
- CIF21 (+\$800,000 to a total of \$2.65 million): Additional funding for the extremely successful Computational and Data-Enabled Science and Engineering (CDS&E) portion of the CIF21 initiative.

Education

- Research Experiences for Undergraduates Sites and Supplements program (REU) (level at \$5.06 million): \$100,000 of this funding will support enhanced research experiences for students in their first two years of college, as recommended by the President's Council of Advisors on Science and Technology (PCAST) in their 2014 report, *Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics*.¹² In addition, \$650,000 will support efforts to broaden participation by groups traditionally underrepresented in the physical sciences.

Infrastructure

- Large Hadron Collider (level at \$18.0 million): This supports operations of the ATLAS and CMS detectors at LHC.
- Laser Interferometer Gravitational Wave Observatory (level at \$39.43 million): This supports operations of LIGO and commissioning of its upgraded interferometer following completion of the Advanced LIGO construction project.
- National Superconducting Cyclotron Laboratory (level at \$22.50 million): This supports operations of the NSCL at Michigan State University.
- Mid-scale Research Infrastructure (+\$2.48 million to a total of \$12.48 million): Funding supports instrumentation for high-priority experiments that cannot be accommodated within individual program budgets.

¹² www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-executive-report-final_2-13-12.pdf

OFFICE OF MULTIDISCIPLINARY ACTIVITIES (OMA)

\$39,840,000
+\$4,840,000 / 13.8%

OMA Funding
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate	
				Amount	Percent
Total, OMA	\$35.17	\$35.00	\$39.84	\$4.84	13.8%
Research	34.43	31.89	33.17	1.28	4.0%
CAREER	0.92	-	-	-	N/A
Education	0.74	3.11	6.67	3.56	114.5%

Totals may not add due to rounding.

OMA enables and facilitates MPS support of novel, challenging, or complex projects of varying scale, in both research and education, which are not readily accommodated by traditional organizational structures and procedures. This is done primarily in partnership with MPS disciplinary divisions and is especially directed at activities by multi-investigator, multidisciplinary teams, as well as cross-NSF and interagency activities.

In general, approximately 62 percent of the OMA portfolio is available for new research grants and 38 percent is available for continuing grants.

In FY 2016, OMA will focus on multidisciplinary research that emphasizes the mathematical and physical scientific foundations of sustainability, including issues that affect food systems and the nexus of food, energy, and water; fundamental science critical to the discovery, understanding, and development of new materials; basic research at the interface between the mathematical and physical sciences and the life sciences that will lead to new insights into the molecular basis of life processes and to a better understanding of the healthy human brain and that of model animal species; computational and data-enabled science across the MPS divisions; multidisciplinary explorations in optics and photonics, including light-matter interaction at the nanoscale that encompass materials, devices, and systems; the understanding, control, and manipulation of the behavior of quantum matter and the limitations of quantum information processing; and team efforts aimed at the development of next-generation instrumentation to enable fundamental advances across a wide spectrum of disciplines. OMA also will provide leadership and support for INSPIRE and I-Corps™ activities within MPS.

MPS divisions have undertaken, or are engaged in, wide ranging reviews of their facilities portfolios. Of particular note is the portfolio analysis carried out by the MPS Advisory Committee, which is addressed further in the AST division narrative.

FY 2016 Summary

All funding decreases/increases represent change over the FY 2015 Estimate.

Research

- In FY 2016, OMA will focus on multidisciplinary research that addresses the key MPS and NSF-wide priority areas of optics and photonics, INFEWS, CIF21, CEMMSS, BioMaPS, clean energy, Understanding the Brain, INSPIRE, and I-Corps™.
- I-Corps™ (+\$700,000 to a total of \$1.70 million): This investment nearly doubles, primarily to support I-Corps™ teams. Investments are directed to an assessment of the commercial viability of the scientific discoveries in MPS disciplines through the individual investigator award program.
- INSPIRE: No change at \$3.0 million.
- CIF21: OMA will continue to coordinate MPS' participation with BIO, CISE, and ENG.

Education

- OMA will contribute \$400,000 to the Career-Life Balance supplements.
- OMA will provide the entire NRT contribution of \$3.65 million (+\$1.14 million) for the MPS directorate.

Facilities

- OMA will invest up to \$7.0 million (no change) in FY 2016 to support responsible decisions regarding implementation of portfolio analysis recommendations. This investment will support studies of possible environmental issues, stewardship transition costs, or partnership start-up costs.

