NSF Fiscal Year 2011 Budget Request

This article is the 38th in a series of annual reports outlining the president's request to Congress for the budget of the National Science Foundation. Last year's report appeared in the September 2009 issue of the *Notices*, pages 962–966.

In February 2010 the Obama administration released its budget request for the 2011 fiscal year, which starts on October 1, 2010. Under the terms of this request, the National Science Foundation (NSF) would have a budget of US$7.4 billion, an 8.0 percent increase over the previous fiscal year. Even in sunnier economic times, such a requested increase would be quite substantial. Given the strains on the federal budget, it amounts to a big vote of confidence in the power of scientific research to fuel economic growth and address major issues confronting the nation. In fact, the administration's support for science could be seen early in Obama's term, in the form of theAmerican Recovery and Reinvestment Act (ARRA), which provided the one-time "stimulus package" funds designed to jump-start the flagging economy. ARRA upped the NSF's budget by almost 40 percent in fiscal 2009. ARRA brought a similar percentage increase to the budget of the NSF'sDivision of Mathematical Sciences (DMS). Now, as it adjusts to living without the extra funds, the DMS finds itself with a relatively small increase for fiscal 2011, just 5.0 percent, considerably less than the percentage increase for the foundation overall. Forced to do some belt-tightening, the division has decided to cancel some programs in the "workforce" portion of its portfolio, which focuses on education, training, and mentoring. But the main challenge for the DMS continues to be, as in previous years, keeping the right balance between participating in targeted initiatives and supporting core research in the mathematical sciences.

Looking Back: Fiscal 2009 and the Stimulus Package

The 2009 stimulus package allowed the DMS to run an unusual and possibly unique experiment: to spend almost US$100 million more than it had been counting on. ARRA gave the NSF overall a

Table 1: National Science Foundation (Millions of Dollars)

	2007 Actual	Change	2008 Actual	Change	2009 Actual*	Change	2010 Estimate	Change	2011 Request
(1) Mathematical Sciences Research Support	$ 205.7	2.9%	$ 211.7	6.2%	$ 224.8 (97.3)	7.4%	$ 241.4	5.0%	$ 253.5
(2) Other Research Support (Note a)	4718.9	1.9%	4808.3	5.8%	5088.4 (2219.4)	6.9%	5439.8	9.0%	5930.5
(3) Education and Human Resources (Note b)	695.6	10.2%	766.3	10.3%	845.5 (85.0)	3.2%	872.8	2.2%	892.0
(4) Salaries and Expenses (Note c)	264.1	12.7%	297.7	4.2%	310.1 (0.0)	2.7%	318.5	9.4%	348.4
(5) Totals	$5884.4	3.4%	$6084.0	6.3%	$6468.8 (2401.7)	6.2%	$6872.5	8.0%	$7424.4
(6) (1) as a % of the sum of (1) and (2)	4.18%		4.22%		4.23%		4.25%		4.10%
(7) (1) as a % of (5)	3.50%		3.48%		3.48%		3.51%		3.41%

Tables prepared by Notices *staff. Totals may not add up due to rounding.* *The amounts in parentheses indicate additional funds appropriated in fiscal year 2009 in accordance with the American Recovery and Reinvestment Act (ARRA) economic stimulus legislation. **Note a:** Support for research and related activities in areas other than the mathematical sciences. Includes scientific research facilities and instrumentation. **Note b:** Support for education in all fields, including the mathematical sciences. **Note c:** Administrative expenses of operating the NSF, including the National Science Board and the Office of the Inspector General.

37 percent boost to its budget, and, in the distribution of these funds across the foundation, the DMS received US$97.3 million, an increase of 43 percent over its 2009 appropriated budget of US$224.8 million. According to the rules set by Congress, the ARRA funds could be used only during fiscal years 2009 and 2010; the NSF chose to use the funds only for proposals it had in hand during fiscal 2009. Congress also stipulated that the ARRA money should be used to create jobs and stimulate the economy. As a result, the DMS made increasing support for postdocs and graduate students a main priority for the ARRA funds and in particular sought to relieve the difficulties young mathematicians face in the tight job market. Together with the directors of the seven mathematical sciences institutes that it funds, the DMS set up the Joint Institutes Postdoctoral Fellowship program. Through this program, the division created 45 one- and two-year postdoctoral positions at the institutes and at their partner institutions and corporations. Technically, the postdocs were

Table 2: Directorate for Mathematical and Physical Sciences (Millions of Dollars)

	2007 Actual	2007 % of Total	2008 Actual	2008 % of Total	2009 Actual*	2009 % of Total	2010 Estimate	2010 % of Total	2011 Request	2011 % of Total
(1) Mathematical Sciences	$ 205.7	17.9%	$ 211.7	18.1%	$ 224.8 (97.3)	18.1% (20.5%)	$ 241.4	17.9%	$ 253.5	18.0%
(2) Astronomical Sciences	215.4	18.7%	217.9	18.6%	228.7 (85.8)	18.4% (18.1%)	245.7	18.2%	251.8	17.9%
(3) Physics	248.5	21.6%	251.6	21.5%	262.5 (96.3)	21.1% (20.3%)	290.0	21.5%	298.2	21.2%
(4) Chemistry	191.2	16.6%	194.6	16.6%	211.7 (87.4)	17.0% (18.4%)	233.7	17.3%	247.6	17.6%
(5) Materials Research	257.3	22.4%	262.5	22.4%	282.5 (108.2)	22.7% (22.8%)	302.7	22.4%	319.4	22.7%
(6) Office of Multidisciplinary Activities	32.6	2.8%	32.7	2.8%	33.7 (0.0)	2.7% (0.0%)	38.3	2.8%	39.6	2.8%
(7) Totals	$1150.7	100.0%	$1171.3	100.0%	$1243.9 (475.0)	100.0% (100.0%)	$1351.8	100.0%	$1409.9	100.0%

Table 3: Compilation of NSF Budget, 2002–2008 (Millions of Dollars)

	2005 Actual	2006 Actual	2007 Actual	2008 Actual	2009 Actual	2010 Estimate*	2011 Request	2005–2009 Change	2005–2011 Change
(1) Mathematical Sciences Research Support	$ 200.2	$ 199.5	$ 205.7	$ 211.7	$ 224.8 (97.3)	$ 241.4	$ 253.5	12.3%	26.6%
Constant Dollars	*102.5*	*99.0*	*99.2*	*98.3*	*104.8 (45.4)*			*2.2%*	
(2) Other Research Support (Note a)	4199.7	4483.5	4718.9	4808.3	5088.4 (2219.4)	5484.9	5930.5	21.2%	40.6%
Constant Dollars	*2150.4*	*2224.0*	*2275.9*	*2233.3*	*2371.8 (1034.5)*			*10.3%*	
(3) Education and Human Resources (Note b)	843.5	700.3	695.6	766.3	845.5 (85.0)	872.7	892.0	0.2%	5.7%
Constant Dollars	*431.9*	*374.4*	*335.5*	*355.9*	*394.1 (39.6)*			*-8.8%*	
(4) Salaries and Expenses (Note c)	237.3	262.5	264.1	297.7	310.1 (0.0)	318.5	348.4	30.7%	46.8%
Constant Dollars	*121.5*	*130.2*	*127.4*	*138.3*	*144.5 (0.0)*			*18.9%*	
(5) Totals	$5480.8	$5645.8	$5884.4	$6084.0	$6468.8 (2401.7)	$6872.5	$7424.4	18.0%	35.5%
Constant Dollars	*2806.3*	*2800.5*	*2838.0*	*2825.8*	*3015.2 (1119.5)*			*7.4%*	

Current dollars are converted to constant dollars using the Consumer Price Index (based on prices during 1982–84).
For Notes a, b, and c, see Table 1.

not funded through ARRA, because Congressional rules forbade commingling of ARRA funds with existing grants. But the ARRA funds did allow the DMS to free up US$7 million to support the fellowships. As Ronald J. Stern put it, through this program, "dozens of postdocs were employed who otherwise would have been dropped into the worst job market in decades." Stern, who is at the University of California, Irvine, was chair of the Committee on Science Policy from the beginning of 2007 through 2009 (the current chair is Rebecca Goldin of George Mason University).

The ARRA money has helped young mathematicians stay employed in the field, but, Stern noted, there could be unintended negative consequences. "These stimulus funds have allowed for the funding of high-quality and high-impact research that otherwise would have gone unfunded," said Stern. However, "unless similar stimulus is injected until the economy fully recovers, this initial stimulus could have the contradictory effect of exacerbating an already disastrous job market, fueling the graduate student and postdoctoral work force, but dumping them into a significantly reduced pool of positions."

In addition to the Congressional rules, use of the ARRA funds was governed by two directives from the NSF: first, to increase funding rates (the number of proposals funded divided by the number received), so that new grants could be awarded, and second, to fund high-risk, potentially high-payoff research. Historically, the DMS has had a higher funding rate than the rest of the NSF. The DMS rate for research awards was 35 percent in 2007 and 31 percent in 2008; the corresponding rates for the foundation as a whole in those years were 22 percent and 21 percent. With the large increase afforded by the ARRA funds, one might think that the funding rates for research awards rose dramatically in 2009, but in fact, they were 37 percent for the DMS and 28 percent for the NSF overall. In addition, within the DMS, the total number of proposals received did not rise greatly in response to the stimulus package funding. NSF budget documents indicate that the number of proposals submitted to the DMS was around 2200 per year between 2005 and 2008; the number was about 2300 in 2009. In 2005, 2006, and 2008, the DMS made about 680 awards, and in 2007 it made 770. The number of awards made in 2009 was about 840.

One reason the DMS funding rate was not larger in 2009 is that the division used the ARRA funds partly to increase the median annualized award size, which went from US$61,200 in 2008 to US$70,100 in 2009. The division's emphasis on using the ARRA funds for postdocs and graduate students brought support for these groups substantially higher in total dollar amounts, dollars per person, and numbers of people supported than in the previous year. The funding rate for new researchers, that is, researchers without previous DMS support, was 26 percent, 6 percentage points more than in fiscal 2008. It is important to note that the DMS did not decide which proposals to fund with its original budget and then afterward choose additional proposals to support through the ARRA funds. Rather, the program directors looked at the whole spectrum of proposals received and made funding decisions, subject to the constraints on use of ARRA funds, to optimize the entire budget available to them.

As the main funder of mathematics in the federal government, and the only one that supports all branches of the field, the DMS is under perennial budget pressure. According to Peter March, who was division director at the time the ARRA funds came in, the boost to the division's budget helped, but it did not relieve the pressure as much as one might think. He noted that the additional funds did not close the gap between what he called the "science line"—the line between what one should and should not fund based purely on scientific excellence—and the "pay line"—the line "where available funds run out". "Even with ARRA funds available there is still too much unfunded excellence," he said. He believes the DMS would need, at a minimum, to double its base budget to around US$500 million to fully fund mathematics to the "science line". "I'm afraid this is not a realistic figure in the current fiscal environment but a cogent argument can be made for such a figure." (March is returning to his home institution of Ohio State University; his successor, as of September 2010, is Sastry Pantula of North Carolina State University.)

Looking Ahead: Fiscal 2011 and Interdisciplinary Initiatives

Unlike programs such as Social Security, for which funding is mandatory, the NSF falls under the discretionary portion of the federal budget. Exactly how much money is appropriated for the NSF is hashed out through negotiations between Congress and the administration, with Congress having the final say. There is no overt opposition to an increase for the foundation, but there is stiff competition from other urgent spending priorities. Whether Congress will appropriate a budget close to that requested for the NSF is an open question, one that will not be answered until the fall or later.

Even though the NSF's fiscal 2011 budget could ultimately be quite different from the amount proposed in the budget request, the request documents do provide insight into the areas the NSF will be emphasizing. Among these are information and communications technology, cybersecurity, climate change, and energy science. These priorities are reflected in the requested increases for the NSF directorates: the largest increases, 11 percent and 10.6 percent, would go, respectively,

to Engineering, and to Computer and Information Sciences and Engineering. The directorate with the smallest requested increase—though with the largest base budget—is Mathematical and Physical Sciences (MPS), with just 4.3 percent.

Of course, the mathematical sciences can contribute to each of the areas of emphasis mentioned above. Indeed, the DMS participates in several interdisciplinary initiatives within the NSF, such as the Solar Energy Initiative (SOLAR), Science and Engineering Beyond Moore's Law (SEBML), and Cyber-enabled Discovery and Innovation. Such initiatives have in recent years become the basis for the NSF's budget and have led to increases for the DMS. But they have also contributed to strains on the DMS budget.

In a document prepared in 2010 for the DMS Committee of Visitors, which provides the division with advice and evaluation, division director March wrote that "support for the core—meaning budget increases for undirected research across the whole range of the mathematical sciences—has not increased as fast as support for interdisciplinary activities in the last three fiscal years. Striking an appropriate balance between 'Discovery' [core research in the mathematical sciences] and 'Connections' [to other disciplines] remains a top priority for the Division."

One can see the struggle to strike this balance in the fiscal 2011 request. The DMS requests an additional US$13.6 million for "core research programs", an increase of 6.6 percent. These programs include grants for investigator-initiated research and for the seven NSF-supported mathematical sciences research institutes. The request for funds for interdisciplinary initiatives is far smaller in dollar terms, but much larger in percentage terms. The DMS would devote an additional US$2.5 million to "Climate and Energy Research" (which includes the SOLAR program), an increase of 36 percent; and SEBML would rise by US$1.20 million, an increase of 44 percent. The DMS budget would increase by US$2.4 million for the MPS Life Sciences Interface initiative, which starts in fiscal 2011.

The biggest change in the DMS budget for fiscal 2011 is the consolidation of its "workforce" portfolio. This set of programs has supported such activities as Vertical Integration of Research and Education (VIGRE), the Mathematical Sciences Postdoctoral Research Fellowships, and Mentoring Through Critical Transition Points. In the past the DMS considered workforce proposals only in response to specific solicitations. March said that, starting in 2008, the division began to accept unsolicited workforce proposals for one-of-a-kind projects that draw on the individual strengths of the principal investigators and their institutions, and that also meet the division's workforce goals. "This is a natural evolutionary step, after a decade or more of fairly prescriptive solicitations, that we hope will result in highly innovative workforce projects," he said.

VIGRE, the most visible of the DMS workforce programs, has now been phased out. Although a fall 2009 study by the National Academy of Sciences recommended that the DMS retain VIGRE, with some changes, the division decided nevertheless to discontinue the program. "We found the study very helpful in guiding our thinking, not just about VIGRE, but about workforce programs more generally," said March. But the DMS concluded that continuing VIGRE was not practical. "First, some of the additional recommendations, such as extension of VIGRE stipends to international students, were difficult to impossible to achieve," he said. "Second, VIGRE proposal pressure had declined to such low levels that the program was no longer viable." The DMS will still consider VIGRE-like proposals that mathematics departments submit as unsolicited workforce proposals.

The DMS has also terminated a couple of other workforce programs. Some of them were moribund, but others—notably Computational Science Training for Undergraduates in the Mathematical Sciences (CSUMS) and Proactive Recruitment in Introductory Sciences and Mathematics (PRISM)—had

An Opportunity for Math Students

The NSF Graduate Research Fellowships program supports graduate students across the sciences and mathematics. In fiscal 2009 the NSF began an effort to triple the number of new fellowships awarded each year, to reach a total of 3,000 in fiscal 2013. The requested increase for this program in fiscal 2011 is in keeping with this plan. Historically, the mathematical sciences have had low participation this program, perhaps because the "elite" image of the fellowships discouraged all but the very top undergraduates from applying—and discouraged their mentors from suggesting they apply. But this seems to be changing. According to Stern, "The word has gotten out to the mathematical community that these fellowships are (roughly) funded by area and proportional to the numbers of applicants within each area,' he said. "This year it appears that there were many more math applicants and hence more math awardees. It also appears that these awardees were not just restricted to the usual 'elite' institutions. This success should further engender broader participation of the mathematics community. This is an opportunity not to be missed." The webpage for this program is `http://www.nsf.gov/grfp`.

—*A.J.*

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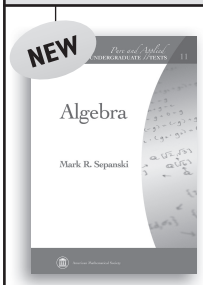

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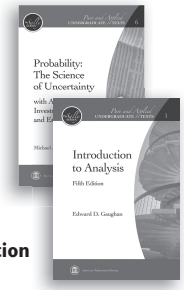

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been established fairly recently and were still active. Regarding CSUMS and PRISM, March explained that it was a tough decision to end them, but "our projected budget growth did not permit us to grow these programs to a sustainable level." Again, as with VIGRE, the division is open to unsolicited proposals for projects that might previously have fallen under CSUMS and PRISM. The NSF budget request documentation indicates that the division's consolidation of its workforce programs will free up about US$3.5 million, which will be reinvested in workforce proposals.

As the DMS looks to the future, it will continue to face the challenge of making the case for strong support of investigator-driven research, in an environment where emphasis on targeted initiatives is increasing. Stern noted that, when it comes to solving specific societal and scientific problems, mathematicians offer unique skills that often allow them to uncover counterintuitive solutions. "However, at the core of this problem-solving skill is the ability to think deeply about problems that initially have no clear relevance to any of the problems of immediate interest," he said. "So while mathematical insight is essential into many of these immediate problems, the fuel for these insights is our ability to pursue internally-defined research programs. The NSF should not lose sight of this fact and should fund larger numbers of smart mathematicians and trust their instincts for further research agendas."

—Allyn Jackson