MAJOR INVESTMENTS IN SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS (STEM) GRADUATE EDUCATION

Overview

The future of science and engineering, and our Nation's ability to contribute significantly to the solution of global problems, depends on human capital. A diverse workforce with advanced research training is essential for transforming the frontiers of science and engineering. NSF's commitment to advancing science, technology, engineering, and mathematics (STEM) and developing human capital in tandem has been a hallmark of the agency's investments since its founding in 1950. As the 21st century progresses, the nature and practice of research and development in the STEM fields, as well as the growing role of STEM experts across a wide range of career areas, are evolving rapidly. Increasingly, research is undertaken as a team effort, with collaborators across institutions, across national boundaries, and across educational levels. Interdisciplinary approaches are needed to solve complex societal problems, fuel the production of scientific advances, take scientific findings to scale through innovation, and apply scientific solutions across settings. The growth of computationally intensive and data-enabled science has changed the knowledge and experience requirements of scientists across fields. With these changes, graduate education in STEM must continue to evolve in order to provide a supply of scientists and engineers who not only meet the needs of the emerging STEM enterprise, but who also have the knowledge, skills, and preparation to advance it, both within and outside of academia.

NSF makes a substantial investment in STEM graduate education through traineeship and fellowship mechanisms, although the majority of NSF's investment in graduate students comes through faculty research grants supporting research assistants.[1] To underscore the importance of these investments and to plan for the future, NSF is developing a five-year strategic plan for its investments in graduate students and graduate education; the target completion date is June 1, 2015. This plan builds on four related efforts: 1) the recommendations of the National Science and Technology Council's Committee on Science, Technology, Engineering, and Mathematics Education (Co-STEM) 5-Year Strategic Plan;[2] 2) on-going interagency discussions about leveraging assets; 3) recent national reports on graduate education;[3,4,5,6] and 4) NSF-wide efforts to ensure that its many forms of investment in graduate education form a coherent agency strategy.

NSF's collective investments in graduate education support two of NSF's Strategic Goals and corresponding objectives: *Goal 1*: Transform the Frontiers of Science and Engineering – Objective 2: Integrate education and research to produce a diverse STEM workforce with cutting-edge capabilities and *Goal 2*: Stimulate Innovation and Address Societal Needs through Research and Education – Objective 2: Build the capacity of the Nation to address societal challenges using a suite of formal, informal, and broadly available STEM educational mechanisms.

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[1] At NSF, about 40,000 graduate students are supported annually at a level of about $1 billion.

[2] National Science and Technology Council, Committee on STEM Education (2013) *Federal Science, Technology, Engineering and Mathematics (STEM) 5-Year Strategic Plan*,
www.whitehouse.gov/sites/default/files/microsites/ostp/stem_stratplan_2013.pdf

[3] Council of Graduate Schools (2012) *Pathways through Graduate School and Into Careers*,
http://pathwaysreport.org/rsc/pdf/19089_PathwaysRept_Links.pdf

[4] National Institutes of Health (2012) *Biomedical Research Workforce Working Group Report*,
http://acd.od.nih.gov/biomedical_research_wgreport.pdf

[5] American Chemical Society (2012) *Advancing Graduate Education in the Chemical Sciences*,
www.acs.org/content/dam/acsorg/about/governance/acs-commission-on-graduate-education-summary-report.pdf

[6] National Research Council (2012) *Research Universities and the Future of America*,
www.federalrelations.wisc.edu/docs/FutureofAmericaU.pdf

Goals

The goal of NSF's collective investments in STEM graduate education and STEM graduate students is to prepare a diverse workforce with advanced research training that is equipped to transform the frontiers of science and engineering, and to prepare professionals, through various levels and approaches to graduate education, to participate and innovate in STEM intensive careers in ongoing and emerging areas.

NSF's graduate STEM investments will:
- Support training in areas of national science and engineering priorities.
- Catalyze development of innovative models for graduate education with potential for scalability.
- Build the research knowledge base to inform improvements in graduate education.
- Promote professional development of graduate students for both academic and non-academic careers.

NSF will establish frameworks for graduate education investments that can be applied across fellowship, traineeship, and research assistantship investments.

Approach

NSF's extensive investment in graduate education spans the entire agency through a set of traineeship and fellowship programs, in addition to research assistantships and other investments that are discipline-specific. The two primary agency-wide programs are the Graduate Research Fellowship (GRF) program and the NSF Research Traineeship (NRT) program, both of which are administered for the agency by the Directorate for Education and Human Resources (EHR). Management of these programs is guided by input from a cross-directorate working group with representatives from all relevant NSF directorates and offices. Each group contributes to programmatic plans, policy decisions, and the application review processes.

Programs that support graduate STEM education, as well as other education levels, are CyberCorps®: Scholarships for Service (SFS), a cybersecurity education and workforce development program; and three programs that support STEM education and workforce development: Robert Noyce Teacher Scholarship (NOYCE); Louis Stokes Alliance for Minority Participation Bridge to the Doctorate (LSAMP – BD); and the H1-B visa-supported NSF Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM) program.

Across the Research and Related Activities (R&RA) directorates, there are dissertation completion award programs, travel grant programs, and traineeship-style support within large centers. Additionally, in all directorates, there is support for research assistants on research awards. Taken together, this broad suite of programs and investments comprises the NSF investment in the graduate education of the STEM research and education workforce of the future.

The approach in FY 2016 will include the development and revision of solicitations for fellowship and traineeship programs that align with the five-year NSF Graduate Education Strategic Plan currently being developed. The effective collaboration underway across NSF directorates in the preparation of the STEM workforce through graduate education will continue and expand. The agency will also develop common outcomes of NSF investments in graduate education and graduate students that can be used agency-wide. A major emphasis in FY 2016 will be the development of expanded opportunities for professional development of graduate students.

Investment Framework

The NSF Graduate Education Strategic Plan will serve as the foundation for our efforts in FY 2016 and beyond. NSF expects to focus on: strengthening the professional development opportunities for graduate students in all of our programs; increasing investment through EHR programs in research to better understand how to improve the learning experiences and professional preparation of STEM graduate students; analysis and pilot activities in fellowship and research assistantship investments to promote cohort models within and across institutions and disciplines; and implementation of more comprehensive tracking and follow-up for NSF graduate student investments. Initiatives begun in FY 2014 to enhance the capacity of minority-serving institutions to increase the number of students who successfully compete for GRF awards will continue. The development of a pilot study of the feasibility of data collection of early career outcomes of GRF recipients, launched in FY 2013, will also continue. This activity is being conducted in partnership with the NSF Evaluation and Assessment Capability (EAC), the EHR Evaluation Group, and the National Center for Science and Engineering Statistics. In FY 2016, data will become available from the first survey of GRF PhD recipients participating in this study.

Graduate Research Fellowship (GRF) Program

The goal of GRF is to help build the U.S. STEM human capital necessary to ensure the Nation's leadership in advancing innovations in science and engineering. To enhance professional development for graduate students, address agencies' workforce needs, and strengthen interagency collaboration, GRF launched the Graduate Research Internships Program (GRIP) in FY 2015 to offer GRF fellows internships in government laboratories and other federal research settings. International internships for GRF fellows are available through the Graduate Research Opportunities Worldwide (GROW) program. GRF selects, recognizes, and financially supports graduate students with demonstrated high potential for excellence in STEM and in their ultimate chosen career. Applications are welcomed from students in all STEM disciplines and in STEM interdisciplinary areas. In FY 2016, NSF will support approximately 2,000 new fellowships. GRF awardees receive a competitive stipend, $34,000 per year, and a cost of education allowance (COE) of $12,000 per year for three years of their choosing within a five-year award window.

GRF Funding by Account

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request
Education and Human Resources	$149.62	$166.72	$168.75
Research and Related Activities	150.00	166.72	168.75
Total GFRP	**$299.62**	**$333.44**	**$337.50**
Number of New Fellows	2,000	2,000	2,000
Projected Fellows on Tenure[1]	5,927	7,000	7,000

Totals may not add due to rounding.

[1] Fellowship tenure status is the period of time during which fellows actively utilize the fellowship award to pursue an advanced degree in a STEM field.

NSF Research Traineeship (NRT) Program

NRT, an NSF-wide program, aims to create and promote new, innovative, effective, and scalable models for STEM graduate student training in emerging research emphasis areas. NRT provides a mechanism for developing a knowledge base about the implementation and impact of innovative graduate traineeship programs and graduate education policies. The NRT program is distinguished from prior traineeship programs by its emphasis on training for multiple career pathways, rotating priority research themes, inclusion of both masters and doctoral students, a broader definition of trainees, and greater budgetary and programmatic flexibility.

In the NRT program, the priority research theme area for FY 2014 and FY 2015 addresses fundamental challenges advancing computation- and data-enabled science and engineering. Proposals for FY 2016 will be solicited in two additional NSF-wide priority research areas: Innovations at the Nexus of Food, Energy, and Water Systems (INFEWS) and Understanding the Brain (UtB). Investigator-initiated interdisciplinary and disciplinary-themed proposals will also be accepted. The goal is to design and create innovative graduate education approaches in areas of national need and/or emerging scientific priority. The Innovation in Graduate Education track is being launched in FY 2015 to develop and study innovative graduate education models and conduct research needed to inform implementation, adaptability, and scalability and will be sustained in FY 2016.

NRT Funding by Directorate[1]
(Dollars in Millions)

	FY2014 Actual	FY 2015 Estimate	FY 2016 Request
Biological Sciences	$3.12	$3.39	$2.33
Computer and Information Science and Engineering	1.40	13.38	9.69
Education and Human Resources[2]	13.93	28.27	35.38
Engineering	4.72	2.85	2.59
Geosciences	2.21	6.63	4.43
Mathematical and Physical Sciences	4.64	4.51	4.47
Social, Behavioral, and Economic Sciences	3.38	2.52	3.12
Total	**$33.40**	**$61.55**	**$62.01**

Totals may not add due to rounding.

[1] Outyear commitments to the Integrative Graduate Education and Research Traineeship (IGERT) program are included in the NRT line and total $32.81 million in FY 2014, $12.12 million in FY 2015, and $10.33 million in FY 2016.

[2] EHR's NRT funding includes $7.0 million for Innovation in Graduate Education (IGE) as a track within the NRT program.

Additional Programs Supporting STEM Education and Workforce Development at the Graduate Level

CyberCorps®: Scholarships for Service (SFS) Program

The SFS program addresses cybersecurity education and workforce development. The Scholarship Track provides funding to institutions for awarding scholarships to undergraduate and graduate students in cybersecurity. Approximately 37 percent of the Scholarship Track supports graduate program activities. In return for their scholarships, tuition, fees, health insurance, travel and book allowances, recipients work after graduation for a federal, state, local, or tribal government organization in a position related to cybersecurity for a period equal to the length of the scholarship. The Capacity Track seeks innovative proposals leading to an increase in the ability of the U.S. higher education enterprise to produce cybersecurity professionals.

CyberCorps®: Scholarships for Service (SFS)
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request
SFS	$44.87	$45.00	$45.00

The Louis Stokes Alliance for Minority Participation – Bridge to the Doctorate (LSAMP-BD)
The LSAMP program assists universities and colleges in diversifying the STEM workforce through their efforts at significantly increasing the number of students successfully completing high quality degree programs in STEM disciplines. Particular emphasis is placed on transforming STEM education through innovative recruitment and retention strategies and experiences in support of groups historically under-represented in STEM disciplines: African-Americans, Alaskan Natives, American Indians, Hispanic Americans, Native Hawaiians, and Native Pacific Islanders.

Established LSAMP Alliances are eligible to apply for Bridge to the Doctorate support. LSAMP-BD funding allows institutions to provide stipend support ($30,000 per year) along with a COE allowance to the institution for tuition, health insurance, and other fees up to $10,500 per year for up to two years of post-baccalaureate study. A plan for connecting a significant number of newly matriculated LSAMP students, including masters degree graduates, to doctoral degree programs is expected.

The NSF Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM) Program
The S-STEM program provides institutions with funds for student scholarships to encourage and enable academically talented U.S. students demonstrating financial need to enter the STEM workforce or STEM graduate school following completion of an associate, baccalaureate, or graduate degree in STEM fields. S-STEM provides individual scholarships of up to $10,000 per year, depending on financial need.

The Robert Noyce Teacher Scholarship Program (NOYCE)
The NOYCE Scholarship Program seeks to encourage talented science, technology, engineering, and mathematics majors and professionals to become K-12 mathematics and science teachers. Through the NOYCE NSF Teaching Fellowship/Master Teaching Fellowship Track, funding is provided to support STEM professionals who enroll as NSF Teaching Fellows in masters degree programs leading to teacher certification by providing academic courses, professional development, and salary supplements while they are fulfilling a four-year teaching commitment in a high-need school district. This track also supports the development of NSF Master Teaching Fellows by providing professional development and salary supplements for exemplary mathematics and science teachers to become Master Teachers while they fulfill a five-year teaching commitment in high-need school districts.

Programs in Support of Graduate Education and Workforce Development
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request
LSAMP-BD	$11.84	$17.00	$17.00
S-STEM	1.93	0.30	0.30
NOYCE Teaching and Master Teaching Fellows (10A)	18.49	18.00	22.00
Total	**$32.26**	**$35.30**	**$39.30**

Totals may not add due to rounding.

Evaluation
The evaluation approach to assess the impact of the NSF-wide investment in graduate education will include a variety of components and will be developed in FY 2015 and FY 2016, with plans for a combination of program-specific and thematic evaluation efforts. Key metrics currently under consideration encompass student development (e.g., quality of education and career development, comparing student experiences based on funding mechanism) and career impact (e.g., career trajectories, productivity appropriate for careers, and leadership roles in public and private sectors).