

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

Overview

A U.S. science, technology, engineering, and mathematics (STEM) workforce with advanced preparation in research and innovation, and in professional fields such as cybersecurity and STEM teaching, is essential for the progress of science and engineering. NSF's commitment to advancing STEM and developing human capital in tandem has been a hallmark of its investments since its founding in 1950. Today, emerging fields of science and engineering increasingly demand team efforts across institutions and national boundaries and rest on the use of sophisticated data infrastructure, instruments, and networks of researchers. Interdisciplinary approaches are needed to solve complex problems and fuel the production of scientific advances. The growth of computationally intensive and data-enabled science is dramatically changing the knowledge and experience required of researchers and other STEM professionals across fields. Thus, the preparation of graduate students in STEM must continue to evolve in order to provide a supply of scientists and engineers who not only meet the needs of the STEM enterprise, but who have the knowledge, skills, and preparation to advance it and lead innovation in academia, the private sector, and government.

Investing in discoverers – that is, building through inclusive processes a diverse and talented next generation of STEM research leaders and professionals across sectors – is an important NSF investment focus. A major portion of NSF's overall investment in graduate education and graduate students supports research assistants funded through research grants. In addition, NSF directorates have instituted several other approaches to supporting graduate students, ranging from dissertation completion awards, to scholarships for professional preparation in particular fields, to traineeship and fellowship mechanisms that advance the progress of science and engineering for the Nation.

NSF is active in government-wide coordination of graduate education, with an NSF representative serving as the co-chair of the Federal Coordination of STEM (FC-STEM) Interagency Working Group on Graduate Education, in partnership with a colleague from the National Institutes of Health. Through this group, NSF works to collaborate on activities, promote innovation, and disseminate effective models of graduate education practice and support across the FC-STEM agencies for the benefit of the graduate students in science and engineering.

NSF is developing an NSF strategic framework for graduate education that will be released in spring of 2016. In FY 2017, it will guide the review, renewal, and development of solicitations for fellowship and traineeship programs, promote effective collaboration across the NSF directorates, and enhance professional development opportunities for graduate students.

NSF also has established an Agency Priority Goal (APG) for FY 2016 and FY 2017 on improving graduate student preparedness: “Improve STEM graduate student preparedness for entering the workforce: By September 30, 2017, NSF will fund at least three summer institutes and 75 supplements to existing awards to provide STEM doctoral students with opportunities to expand their knowledge and skills to prepare for a range of careers.” The implementation of the APG will be integrated with the implementation of the strategic framework for graduate education.

Goal

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.

Approach

NSF's two major agency-wide programs in graduate education are the Graduate Research Fellowship Program (GRFP) and the NSF Research Traineeship (NRT) program. The Directorate for Education and Human Resources (EHR) has administrative leadership responsibility for both programs. Management of these programs is guided by NSF-wide working groups. Both programs contain design elements recommended in major national reports¹ as ways to better prepare graduates for a broad range of careers. GRFP has identified and supported future outstanding basic STEM researchers since 1952. The program also provides opportunities for graduate students to gain research experience internationally and in federal agencies. GRFP provides rich data that will be used for monitoring career outcomes longitudinally and will contribute to improving the understanding of STEM professional workforce development.

There are several other programs at NSF that focus on the development of sectors of the STEM workforce, and integrate support to students with the development and testing of new models and approaches to graduate education. For example, the CyberCorps®: Scholarship for Service (SFS) program, led by EHR, addresses government's need for a cybersecurity workforce as authorized by the Cybersecurity Enhancement Act of 2014. In addition to scholarships for undergraduate and graduate students, the program supports the expansion of existing educational opportunities and resources in cybersecurity through research on the teaching and learning of cybersecurity. Collaborators include the NSF Directorate for Computer and Information Science and Engineering (CISE), the U.S. Department of Homeland Security, and the Office of Personnel Management. The Robert Noyce Teacher Scholarship program (Noyce) provides fellowship support to master teachers at the graduate level and funds innovation and development in STEM teacher education approaches. East Asia and Pacific Summer Institutes for U.S. Graduate Students (EAPSI) provides international research experiences for U.S. graduate students.

In addition to GRFP, NRT, SFS, Noyce, and EAPSI, the Alliances for Graduate Education and the Professoriate (AGEP), Louis Stokes Alliances for Minority Participation's Bridge to the Doctorate (LSAMP-BD) track, and NSF Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM) support the successful entry and transition of underrepresented and underserved populations into STEM graduate education and into the STEM workforce. Taken together, this broad suite of programs contributes substantially to the NSF investment in graduate education of the STEM research and education workforce of the future.

In FY 2017, all R&RA directorates, the Office of International Science and Engineering, and the Office of

¹ American Chemical Society Presidential Commission (2012). *Advancing graduate education in the chemical sciences*. American Chemical Society, Washington, DC. Retrieved from www.acs.org/content/dam/acsorg/about/governance/acs-presidential-graduate-education-commission-full-report.pdf; Biomedical Research Workforce Working Group (2012) Biomedical Research Workforce Working Group Draft Report. National Institutes of Health, Bethesda Retrieved from http://acd.od.nih.gov/bmw_report.pdf

Integrative Activities are engaged in considering how to extend the range of professional development opportunities for graduate students in the various disciplines served by NSF and are undertaking several pilot activities. In FY 2017, the Division of Graduate Education (DGE) in EHR will extend opportunities for international research experiences, through Graduate Opportunities Worldwide (GROW), and internship opportunities, through Graduate Research Internship Program (GRIP), to graduate students in other EHR programs such as the Noyce, LSAMP, and S-STEM programs. EHR is pursuing collaborations with other directorates to establish additional partnerships with industry for internship opportunities to give graduate students the professional development needed to pursue successful careers in STEM and STEM-related occupations.

Finally, in FY 2017, the DGE component of EHR's core research program will emphasize research on the development of the STEM workforce.

Investment Framework

Graduate Research Fellowship Program (GRFP)

The goal of GRFP is to help build the U.S. STEM human capital necessary to ensure the Nation's leadership in advancing innovations in science and engineering. GRFP selects, recognizes, and financially supports graduate students with demonstrated high potential for excellence in STEM and in their chosen careers. Applications are welcome from students in all STEM disciplines supported by NSF and in STEM interdisciplinary areas, including STEM education. Fellows have opportunities for international research through Graduate Opportunities Worldwide (GROW) and federal internships through Graduate Research Internship Program (GRIP).

GRFP noteworthy activities are as follows:

- Program innovation has focused on professional development initiatives such as GROW and GRIP. The plans for evaluating GROW will begin in FY 2016, and the plans for evaluating GRIP will begin in FY 2017.
- In 2014, the review of GRFP applications transitioned to a completely online review of the entire application pool supported by virtual panels. In FY 2015, over 16,000 applications were reviewed by over 1,500 reviewers in 47 virtual panels. The online review and virtual panels expanded the ability of the community to participate in the review process.
- The pilot survey and initial data collection for monitoring career outcomes of GRFP recipients longitudinally began in the first quarter of FY 2016. This activity is conducted in partnership among the EHR Evaluation Team, the NSF Evaluation and Assessment Capability, and the National Center for Science and Engineering Statistics. This team will develop and pilot a GRFP survey instrument and process that may be used as an ongoing longitudinal monitoring system to assess program outcomes.
- EHR will conduct outreach to undergraduate institutions and encourage undergraduates to apply to GRFP. In FY 2017, the agency will continue initiatives begun in FY 2014 to enhance the capacity of minority-serving institutions to increase the number of students who successfully compete for GRFP awards. The GRFP and LSAMP programs have designed outreach activities to LSAMP institutions with significant cohorts of STEM students who are enrolled in or preparing for graduate training. In FY 2017, further work with LSAMP-BD institutions will continue.
- DGE will pilot activities in FY 2017 that promote professional development opportunities that prepare graduate students for careers in industry.
- In 2017, GRFP will continue to partner with the Experimental Program to Stimulate Competitive Research (EPSCoR) to provide outreach to students and faculty in EPSCoR states, with a special focus on minority-serving institutions located in EPSCoR jurisdictions.

GRFP Funding by Account

(Dollars in Millions)

	FY 2015 Actual	FY 2016 Estimate	FY 2017 Request
Education and Human Resources	\$166.52	\$165.96	\$166.08
Research and Related Activities	166.72	165.96	166.08
Total GFRP	\$333.24	\$331.92	\$332.16
Number of New Fellows	2,000	2,000	2,000
Projected Fellows on Tenure ¹	5,927	6,000	6,000

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)

The goals of NRT are to support highly effective training of STEM graduate students in interdisciplinary research areas of national priority as well as to create and promote new, innovative, effective, and scalable models for STEM graduate student training. 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 FY 2015, the scope of the NRT program was expanded to add the Innovation in Graduate Education (IGE) Track. The IGE track is dedicated to piloting, testing, and evaluating novel, innovative, and potentially transformative approaches to graduate education, both disciplinary and interdisciplinary, to generate the knowledge required for their customization, implementation, and broader adoption. In FY 2017, IGE is supported at a level of \$7.0 million.

NRT funds proposals to test, develop, and implement innovative and effective STEM graduate education models, to promote interdisciplinary and broad professional training of graduate students, and to foster fundamental research advances in support of national priorities. NRT thus provides a mechanism for developing a knowledge base about the implementation and impact of innovative graduate traineeship programs and graduate education policies. In FY 2017, NRT will support new STEM graduate education pilots and models in order to transform current practices in graduate education.

In FY 2017, the NRT traineeship track will continue to solicit proposals in the NSF-wide priority research areas of Innovations at the Nexus of Food, Energy, and Water Systems (INFEWS) and Understanding the Brain (UtB). Specifically, at the FY 2017 Request level, EHR will invest \$2.0 million to seek proposals that support a virtual resource platform for a graduate student network. Investigator-initiated interdisciplinary-themed proposals outside the priority research themes will continue to be accepted. In FY 2017, EHR will pilot a program that will enable NRT trainees to participate in federal internships in partnerships with GRIP.

NRT Funding by Directorate¹

(Dollars in Millions)

	FY 2015 Actual	FY 2016 Estimate	FY 2017 Request
Biological Sciences	\$3.24	\$2.33	\$2.82
Computer and Information Science and Engineering	13.38	6.69	7.10
Education and Human Resources ²	40.74	31.05	37.71
Engineering	2.85	2.59	2.50
Geosciences	6.63	4.43	3.32
Mathematical and Physical Sciences	5.04	4.47	4.54
Social, Behavioral, and Economic Sciences	2.52	2.59	0.64
Total	\$74.40	\$54.15	\$58.63

Totals may not add due to rounding.

¹ Outyear commitments to the Integrative Graduate Education and Research Traineeship program are included in the NRT amounts and total \$12.97 million in FY 2015 and \$6.35 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.

CyberCorps®: Scholarship for Service (SFS)

The SFS program addresses cybersecurity education and workforce development through scholarships and building institutional capacity. The Scholarship Track provides funding to institutions for awarding scholarships to undergraduate and graduate students in cybersecurity. The goal of the Capacity Track is to increase the ability of the United States higher education enterprise to effectively produce cybersecurity professionals. Of the total SFS budget, approximately half 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.

In FY 2017, SFS will support laying the groundwork for SFS alumni to serve as a national resource over the course of their careers.

FY 2017 activities will include increasing the number of Research Experiences for Undergraduates (REU) Sites focused on cybersecurity emphasizing experience for first- and second-year undergraduate students, especially veterans, and perhaps ultimately enabling more students to enter cybersecurity fields at the graduate level.

CyberCorps®: Scholarship for Service (SFS)

(Dollars in Millions)

	FY 2015 Actual	FY 2016 Estimate	FY 2017 Request
SFS	\$45.04	\$50.00	\$70.00

Additional Programs Supporting STEM Graduate Education and Workforce Development

Alliances for Graduate Education and the Professoriate (AGEP)

The AGEP program is committed to the national priority of increasing the numbers of underrepresented minorities, including those with disabilities, entering and completing STEM graduate education and postdoctoral training to levels representative of the available pool.

East Asia and Pacific Summer Institutes for U.S. Graduate Students (EAPSI)

The EAPSI program contributes to the development of a globally engaged U.S. science and engineering workforce by providing international research experiences for U.S. graduate students in the dynamic East Asia and Pacific region. EAPSI is a partnership with funding agencies in Australia, China, Japan, Korea, New Zealand, Singapore, and Taiwan. The program provides individually tailored summer research opportunities in leading labs and research sites around the region, allowing U.S. graduate students to benefit from world class expertise and leverage investments in cutting edge research in partner countries. EAPSI provides fellowships to more than 200 graduate students per year.

Louis Stokes Alliances 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 underrepresented 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 (\$32,000/year) along with cost of education allowance to the institution for tuition, health insurance, and other normal fees up to \$10,500 per year for up to two years of post-baccalaureate study. A plan for formally connecting a significant number of newly matriculated LSAMP students, including master's degree graduates, to doctoral degree programs is expected. LSAMP-BD projects are encouraged to partner with other NSF-funded programs, such as Centers of Research Excellence in Science and Technology (CREST), NSF research centers, NRT, or AGEP. In FY 2017, LSAMP-BD will continue to collaborate with GRFP on effective approaches to increase the diversity of the GRFP applicant pool.

NSF Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM)

The S-STEM program was established by NSF in accordance with the American Competitiveness and Workforce Improvement Act of 1998 (P.L. 105-277) as modified by P.L. 106-313 and P.L. 108-447 in 2004. The Act reflects the national need to increase substantially the number of American scientists and engineers. In addition to the long-standing scholarship support, S-STEM projects contribute to the knowledge base of research in education by carrying out research on factors such as recruitment and retention of STEM students. S-STEM is funded through H1B Nonimmigrant Petitioner Account receipts. See the H-1B Nonimmigrant Petitioner Fees section in the EHR chapter for more information.

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. The program emphasizes the importance of recruiting students to STEM disciplines, mentoring and supporting students through degree completion, and partnering with employers to facilitate student career placement in the STEM workforce. S-STEM provides individual scholarships of up to \$10,000 per year, depending on financial need.

Robert Noyce Teacher Scholarship (Noyce)

The Noyce program seeks to encourage talented STEM 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 master's 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.

Additional Programs Supporting STEM Graduate Education and Workforce Development

(Dollars in Millions)

	FY 2015 Actual	FY 2016 Estimate	FY 2017 Request
AGEP	\$8.00	\$8.00	\$8.00
EAPSI	1.33	1.80	2.50
LSAMP-BD	17.00	17.00	17.00
S-STEM	0.30	0.30	0.30
Noyce Teaching and Master Teaching Fellows (10A)	22.22	22.00	22.00
Total	\$48.85	\$49.10	\$49.80

Totals may not add due to rounding.

Evaluation Framework

The framework to assess the impact of the NSF-wide investment in graduate education will be developed in FY 2016 and FY 2017. Because the impact of graduate education investments develops over time, the assessment framework will include both immediate and longitudinal metrics that measure outcomes in a hierarchical fashion. Metrics may include indicators on participation in NSF programs, participant and faculty feedback, and evaluation of STEM education in regard to learning and learning environments, workforce development, and broadening participation. Indicators also may include impact on career outcomes. The metrics will be benchmarked to national indicators, to the extent possible; similar metrics will be used across programs to enable measurement of thematic investments. Evaluation plans will be coordinated with NSF's Evaluation Assessment Capability unit and the National Center for Science and Engineering Statistics.