National Institute of General Medical Sciences 5-Year Strategic Plan Progress and Outcomes

June 2020

Table of Contents

Message from the NIGMS Director **4**

Introduction **5**

Mission Statement **5**

Organizational Structure **6**

GOAL 1: MAXIMIZE INVESTMENTS IN INVESTIGATOR-INITIATED BIOMEDICAL RESEARCH TO DRIVE FUNDAMENTAL SCIENTIFIC DISCOVERIES THAT ADVANCE UNDERSTANDING OF HUMAN HEALTH AND DISEASE. **7**

Objective 1-1: Invest in and sustain a broad and diverse portfolio of highly meritorious research. 7

Objective 1-2: Promote the ability of investigators to pursue new research directions, novel scientific insights and innovative ideas. 10

GOAL 2: SUPPORT THE DEVELOPMENT OF A HIGHLY SKILLED, CREATIVE AND DIVERSE BIOMEDICAL RESEARCH WORKFORCE. **12**

Objective 2-1: Assess Institute research training and education programs and policies to ensure that they achieve positive outcomes related to the NIGMS mission. 13

Objective 2-2: Promote the identification of best practices to continually improve the quality of research training activities. 17

GOAL 3: SUPPORT THE DEVELOPMENT OF AND ACCESS TO ESSENTIAL RESEARCH TOOLS, RESOURCES, AND CAPABILITIES FOR BIOMEDICAL RESEARCH. **19**

Objective 3-1: Support access to essential research resources and the development of new technologies that enable novel scientific advances. 19

Objective 3-2: Continue the development of institutional research capacities and communities. 20

GOAL 4: ADVANCE UNDERSTANDING OF FUNDAMENTAL BIOMEDICAL RESEARCH AND THE NIGMS ROLE IN SUPPORTING IT. **25**

Objective 4-1: Use a broad range of approaches to inform the public about NIGMS goals, activities and results. 25

Objective 4-2: Continue to engage in an open dialogue with the scientific community and other stakeholders about NIGMS programs, processes, and policies. 26

GOAL 5: PROMOTE THE EFFICIENT USE OF HUMAN RESOURCES AND BUSINESS PRACTICES TO ADVANCE THE NIGMS MISSION. 28

Objective 5-1: Foster a proficient, diverse, and collegial NIGMS workforce. 28

Objective 5-2: Maximize the efficiency of NIGMS operations by continuously assessing, identifying, and applying the most effective business practices..... 29

Objective 5-3: Develop and maintain cooperative and synergistic partnerships with other NIH institutes and centers, other federal agencies and other organizations. 32

Message from the NIGMS Director

"As NIGMS continues its work over the next 5 years, it does so with an ongoing commitment to public service, the careful stewardship of taxpayer funds, and a focus on achieving outcomes such as those documented in this strategic plan progress summary. Recognizing that the achievement of such outcomes cannot occur in isolation, NIGMS maintains its commitment to open and reciprocal communication with its partners in the scientific community."

Jon R. Lorsch, Ph.D.
Director
National Institute of General Medical Sciences
National Institutes of Health
U.S. Department of Health and Human Services

Introduction

The National Institute of General Medical Sciences (NIGMS) has used its 2015-2020 strategic plan as a comprehensive guidance document and management tool over the past 5 years to make the most efficient and effective use of taxpayer funds in support of the Institute's mission. This document highlights NIGMS' specific implementation strategies to achieve its 2020 objectives, along with the specific results and outcomes from those efforts. By actively utilizing the strategic plan as a management document,[1] the Institute has been able to monitor and modify its implementation strategies to ensure the appropriate outcomes through greater efficiency and transparency, and therefore greater accountability, particularly through frequent data collection, analysis, evaluation, and review. Further, by functionalizing the strategic plan through the creation and implementation of a dynamic, enterprise-level dashboard with interactive data and metrics, NIGMS has transitioned this plan into a full-performance management framework that touches every aspect of the Institute's mission.

NIGMS is a component of the National Institutes of Health (NIH) in the U.S. Department of Health and Human Services. NIGMS supports basic biomedical research, research training and workforce development, and capacity building, which are the wellspring that feeds advances in medicine and technology. By defining the mechanisms of disease and providing targets for drug development, basic research is a critical driver of the U.S. economy. Keeping the basic research pipeline healthy and flowing requires a broad research portfolio of subject areas and research environments, as well as a diverse and well-trained scientific workforce.

NIGMS uses three major means to advance its mission:

- Grants that support scientific research at colleges, universities, medical schools, research institutes and small businesses that support NIGMS mission-related needs
- Training and education awards that support the development of a diverse biomedical research workforce
- Programs that support the development of, and widespread access to, high-quality research resources and technologies and that build capacity in under-resourced institutions and states

Through these activities, NIGMS plays a major role in advancing fundamental biomedical research and maintaining a healthy research enterprise in every state in the nation as well as in U.S. territories.

Mission Statement

NIGMS supports basic research that increases understanding of biological processes and lays the foundation for advances in disease diagnosis, treatment, and prevention. NIGMS-funded scientists investigate how living systems work at a range of levels, from molecules and cells to tissues, whole organisms, and populations. The Institute also supports research in certain

---

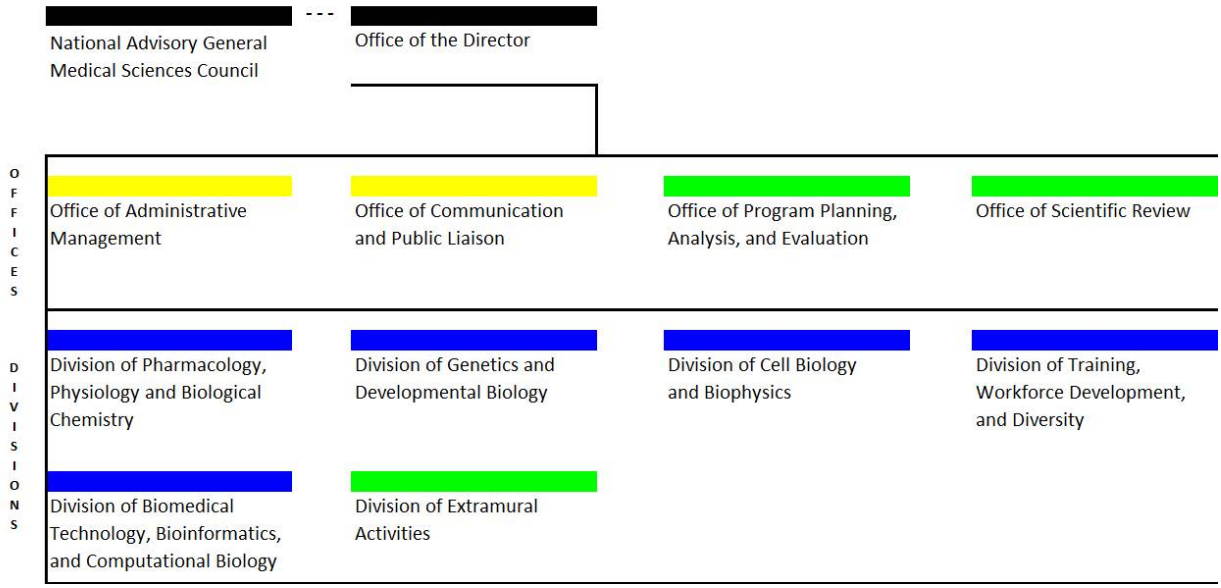
[1] Aragon, R., Miklos A., Schulkey C. (2019 Oct. 28). Government Executive. *How Agency Leaders Can Turn Vision Into Action.* Retrieved from https://www.govexec.com/management/2019/10/how-agency-leaders-can-turn-vision-action/160716/

clinical areas, primarily those that affect multiple organ systems. To assure the vitality and continued productivity of the research enterprise, NIGMS provides leadership in training the next generation of scientists, in enhancing the diversity of the scientific workforce, and in developing research capacities throughout the country.

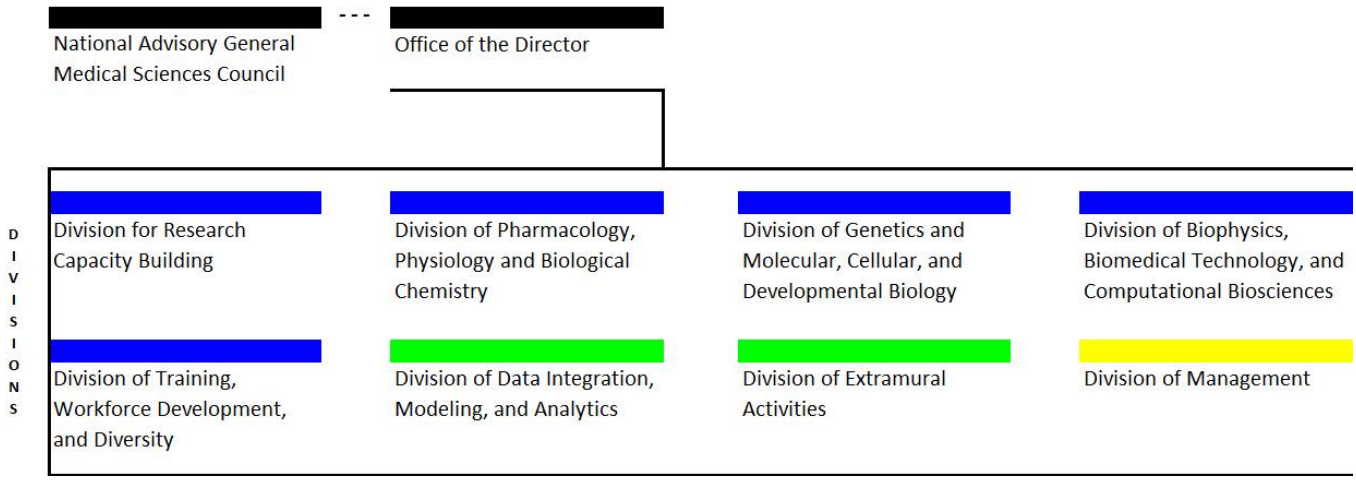
Organizational Structure

NIGMS is organized into divisions that support research and research training in a range of scientific fields. To minimize scientific overlap and optimize institutional structure relative to mission delivery, NIGMS reorganized its scientific divisions in 2018 and its administrative groups once again in early 2020. The 2015 organizational structure is depicted below, followed by the 2020 organizational structure to illustrate the changes made therein. Management and administration are depicted in yellow, scientific divisions in blue, and grants administration in green.

National Institute of General Medical Sciences (2015)



National Institute of General Medical Sciences (2020)



In the sections below, the NIGMS 2015-2020 strategic plan is shown in black text and the summary of progress and key outcomes is shown in blue text beneath each implementation strategy.

GOAL 1: MAXIMIZE INVESTMENTS IN INVESTIGATOR-INITIATED BIOMEDICAL RESEARCH TO DRIVE FUNDAMENTAL SCIENTIFIC DISCOVERIES THAT ADVANCE UNDERSTANDING OF HUMAN HEALTH AND DISEASE.

Introduction

NIGMS is widely known as NIH's "basic science Institute." The product of basic research is knowledge that creates a strong foundation for the entire scientific enterprise. This foundation includes research in a variety of biomedically relevant scientific disciplines. NIGMS-funded researchers employ diverse experimental models and approaches as they strive to understand how biological systems work at all levels, from molecules and cells to organs, organisms and populations. NIGMS investments in basic research not only advance fundamental knowledge of biological systems, they also underlie many important advances in medicine. Furthermore, NIGMS fosters public health through supporting research in selected clinical areas and through programs that manage collaborations between basic and clinical scientists.

Objective 1-1: Invest in and sustain a broad and diverse portfolio of highly meritorious research.

It is impossible to know in advance where and when the next breakthroughs in biomedical research will occur. Fundamental research can have unexpected outcomes and novel applications. For example, basic studies in bacteria spawned the multi-billion-dollar biotechnology industry and continue to provide new tools and approaches for both basic and translational research. To maximize the opportunities for important advances, NIGMS supports diverse studies in a wide array of scientific areas that encompass its broad mission, from fundamental chemistry and biology to selected aspects of clinical and behavioral research. The Institute will focus on supporting investigator-initiated research, in which the

curiosity and creativity of individual scientists drives the identification of the most important questions and development of the strategies needed to answer them. NIGMS will also strive to support a research portfolio that is diverse in the broadest sense: in scientific questions and research approaches, in career stages of investigators, in institution types and regions, and in investigators and trainees with a range of individual backgrounds.

Implementation Strategy: Support highly meritorious, investigator-initiated research in NIGMS mission areas.

Progress and Key Outcomes

Commensurate with its strategy of pursuing a broad and diverse research portfolio, NIGMS has worked diligently over the last 5 years to increase the total number of scientists supported by investigator-initiated research project grants (RPGs) within NIGMS' mission areas. As a result of these efforts, the total number of investigators supported by investigator-initiated awards has increased by 18%, meaning that since 2015, NIGMS has successfully funded more than 600 additional labs (Figure 1). To enhance our analytic capabilities, the Institute constructed dynamic data-first dashboards designed to enable real-time portfolio analysis focused on the diversification of our research portfolio. The strategic plan implementation dashboard[2] is an example of one such tool.

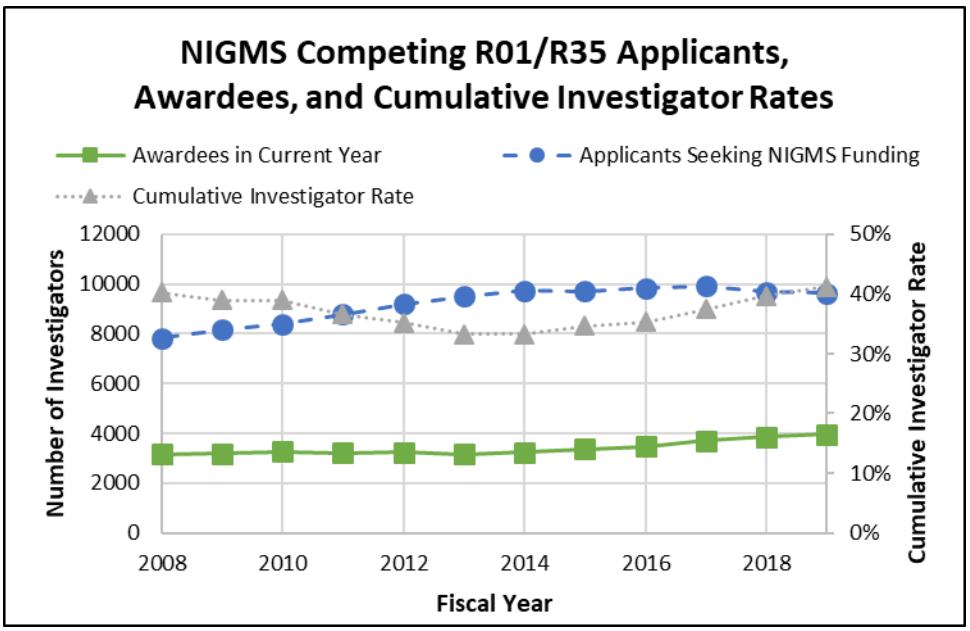


Figure 1

Implementation Strategy: Support new and early-stage scientists to develop the next generation of investigators and ensure the continued vitality of the scientific enterprise.

Progress and Key Outcomes

Early-stage investigators (ESIs) represent the next generation of the biomedical research workforce and are thus important to ensure a sustained source of scientific talent. NIH defines an ESI as an individual who has completed his or her terminal research degree (or

[2] Optimize NIH Newsletter; Issue 5, Fall 2019.

post-graduate clinical training) within the past 10 years *and* who has not previously competed successfully for a substantial NIH independent research award.[3] As "newer"

entrants to the research arena, ESIs face unique challenges to obtaining competitive NIH funding. Such challenges might include lacking a documented track record as an independent investigator, not holding tenure at an academic institution, and lacking familiarity with the NIH grants process. To ensure a consistent, inclusive, and sustained supply of talent, NIGMS has focused on ensuring that this critical component of the research workforce remains an Institute priority. As a result, since 2015, the total number of competing independent research grants ESIs have received per year from NIGMS has increased by 79%, from 128 ESIs funded in 2015 to a total of 229 ESIs funded in 2019 (Figure 2). Additionally, the average age of an ESI receiving an NIGMS-sponsored R35 Maximizing Investigators' Research Award (MIRA) during this time period dropped to 37.4 years compared with an average age of 38.7 years for ESIs funded under the R01 mechanism. This latter result is striking as it implies that early-career scientists are transitioning into career independence earlier through the MIRA program than they are through R01s.

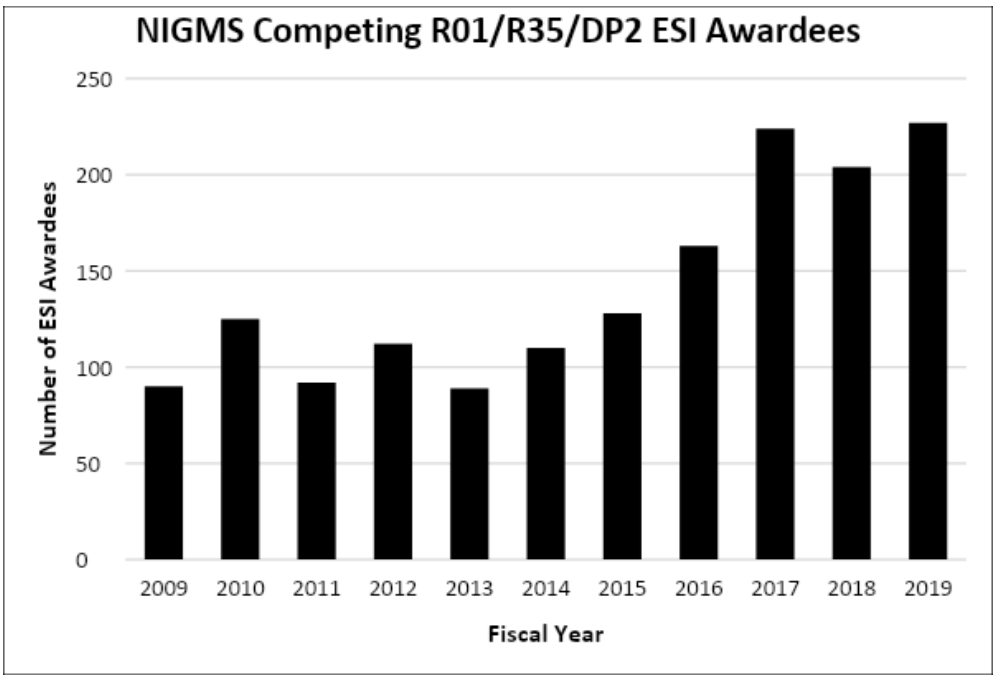


Figure 2

Implementation Strategy: Use data-driven analyses to regularly assess the diversity and breadth of the Institute's portfolio.

Progress and Key Outcomes

The ability to operationalize data is challenging but necessary for effective and efficient business practice. To this end, NIGMS initiated efforts in 2015 to create a first-of-its-kind data visualization dashboard that sources programmatic performance data from various representative programs and initiatives throughout the Institute. Completed in 2016 and continually refined, the enterprise-level dashboard (Figure 3) integrates data visually and

[3] https://grants.nih.gov/policy/early-investigators/index.htm

brings relevant, real-time information about program performance to the attention of NIGMS leadership and staff. Through tools such as this dashboard, NIGMS has been able to actively monitor the diversity, depth, and breadth of its national research, training, and capacity building portfolios to ensure that funding decisions maximize returns on taxpayer investments.

Figure 3

In addition to tracking the performance of its programs as described above, NIGMS has completed 11 large-scale program evaluations since March 2015. These evaluations encompassed a variety of programs, such as the Biotechnology Research Resources (BTRR), Bridges to the Doctorate training program (B2D), and the Support of Competitive Research (SCORE) awards. These data-driven evaluations examine and assess both outputs and outcomes, identify best practices and lessons learned, and provide concrete recommendations[4] on strengthening the public impact of individual programs commensurate with the changing landscape of science and technology. As part of its transparency function, NIGMS has published a list of completed program evaluations on its website.

Objective 1-2: Promote the ability of investigators to pursue new research directions, novel scientific insights and innovative ideas.

Biomedical research is a dynamic enterprise that creates opportunities to explore new ideas and paradigms while questioning established ones. Providing investigators with the flexibility and support needed to pursue new research directions and novel scientific insights can facilitate important advances. NIGMS will support investigators in the pursuit of novel, creative and flexible lines of work that have the potential to yield important new insights into biological processes and systems.

Effective support for investigator-initiated research must include an examination of current funding approaches and paradigms. To maximize efficiency, effectiveness, and return on

[4] https://www.nigms.nih.gov/about/dima/Pages/reports.aspx

investment, NIGMS will conduct ongoing evaluations of its research programs, funding mechanisms and overall research portfolio. The results of these analyses will guide the Institute as it adjusts its programs and funding strategies to focus on supporting individual investigators rather than individual projects in response to a constantly evolving scientific landscape.

Implementation Strategy: Pilot and assess alternative mechanisms of funding that emphasize individual investigators, rather than individual projects, to better meet NIGMS goals and objectives.

Progress and Key Outcomes

Due to its challenging and dynamic nature, scientific research rarely takes a linear path from investigation to discovery. To optimize and reliably support the flexibility needed to pursue unique and novel scientific opportunities and insights, NIGMS launched the Maximizing Investigators' Research Award (MIRA) in 2015. Consisting of a new paradigm of funding that utilized the NIH R35 mechanism, MIRA focused on cohesively supporting the *program* of research in an investigator's laboratory rather than individual research *projects*. In addition to this more cohesive approach to research funding, MIRA also diminished administrative burden, provided for enhanced stability of support by extending the period of award by one year, and allowed investigators the ability to shift research directions in real time to pursue novel data and unique insights. The program has enjoyed enthusiastic support from the research community (Figure 4a), particularly ESIs (Figure 4b). MIRA is currently entering its 6th year of operation and expects its first round of competitive renewals in 2020.

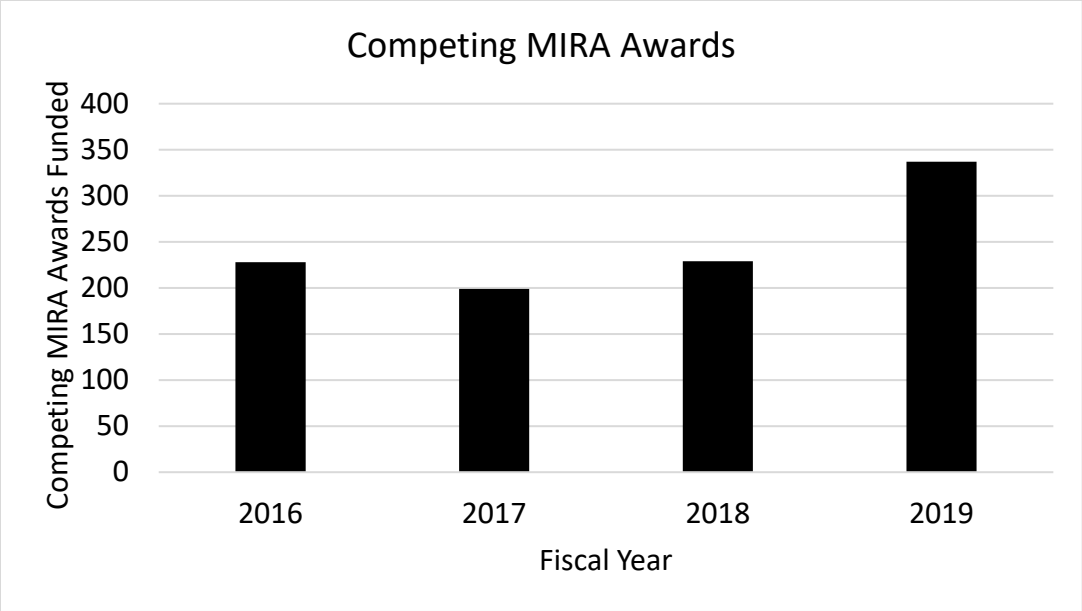


Figure 4a

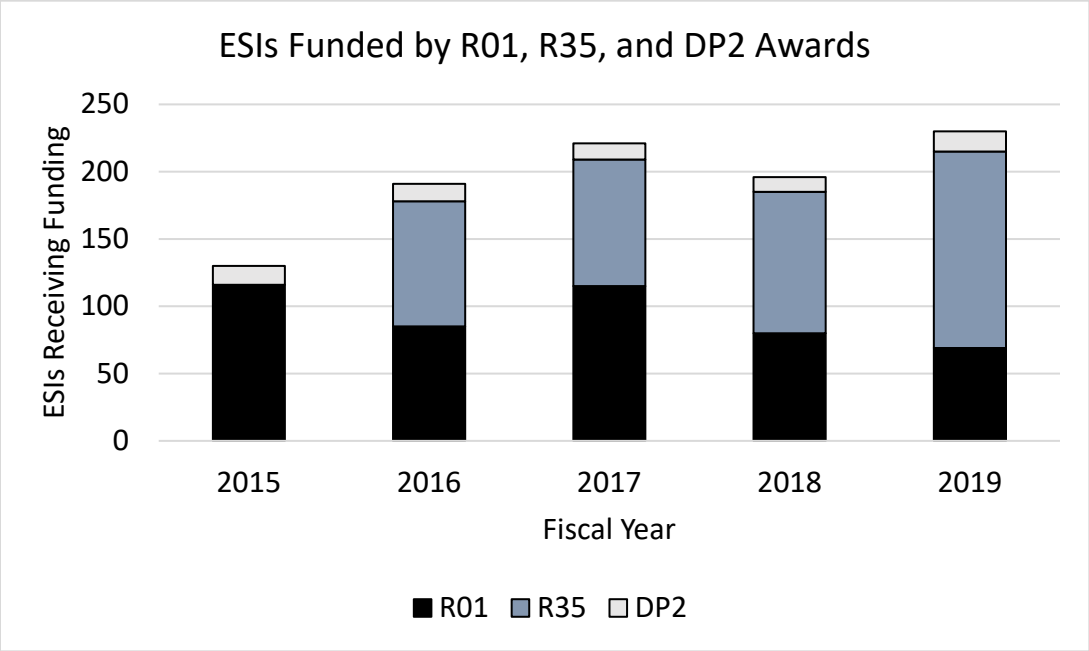


Figure 4b

Implementation Strategy: Increase the Institute's ability to conduct in-depth portfolio analyses and evaluation activities.

Progress and Key Outcomes

Since 2015, NIGMS has focused on developing an *in-house* evaluative capacity. In pursuit of this goal, NIGMS evolved and expanded the Office of Program Planning, Analysis, and Evaluation (OPAE). This growth in *internal* capabilities enabled a variety of stewardship functions at a fraction of the cost associated with contractors or outside vendors. OPAE has, for instance, provided the Institute with functions ranging from portfolio analyses requested by specific NIGMS scientific divisions to comprehensive analytical and technical support for larger, NIH- or HHS-wide reorganization and transformation efforts (e.g., Re-Imagine HHS). A key result of OPAE's work has been an administrative shift in the application and use of program evaluations from a *retrospective* to *prospective* orientation. Since 2015, applications for all new and ongoing NIGMS funding opportunity announcements (FOAs) *are required to contain* ***prospective*** *evaluation criteria (PAR-17-094, PAR-19-301, PAR-19-299, PAR-17-341)*. Based on the success of OPAE-facilitated evaluative activity to date, systematic program evaluations will continue to be a priority to ensure that NIGMS programs optimally meet their obligations to the scientific community and maximize returns on taxpayer investments.

GOAL 2: SUPPORT THE DEVELOPMENT OF A HIGHLY SKILLED, CREATIVE AND DIVERSE BIOMEDICAL RESEARCH WORKFORCE.

Introduction

Training the next generation of biomedical researchers is a fundamental aspect of the NIGMS mission. The Institute uses a variety of mechanisms to support students and trainees during multiple career stages and at varied institutions and educational settings to prepare them for a range of research and research-related careers and to develop a workforce

characterized by diversity and excellence. As evidence of its commitment to training, NIGMS supports nearly half of all NIH-sponsored predoctoral students in structured institutional training programs across the country, as well as significant numbers of undergraduates, predoctoral students and postdoctoral trainees on research grants. A key Institute principle is that research training and education programs must promote individual student development. In addition, NIGMS promotes training environments that are broadly inclusive. Students and trainees in such settings acquire important skills and perspectives that enable them to identify and solve problems of societal importance in preparation for a spectrum of biomedical careers. To advance its goals in research training and education, NIGMS broadly engages its stakeholder communities, because research training is a shared endeavor requiring participation from NIH, academia, industry, mentors and the trainees themselves.

Objective 2-1: Assess Institute research training and education programs and policies to ensure that they achieve positive outcomes related to the NIGMS mission.

NIGMS uses required progress reports for all funded research training and education programs to monitor their performance. The Institute will enhance its program evaluation efforts using regular, data-driven assessments to ensure that its programs and policies advance its mission related to training, diversity and workforce development. Such evaluations guide NIGMS in allocating its research training and education resources to support the most impactful programs at effective levels. Evaluations also enable iterative improvements in the Institute's training, diversity-building and workforce development portfolio. This approach increases responsiveness to changing needs in the biomedical research workforce, avoids duplication of effort and enhances efficiencies in recruitment, retention, diversity-building and mentorship.

Implementation Strategy: Develop retrospective and prospective methods to collect outcomes data from research training and education activities.

Progress and Key Outcomes

NIGMS engaged with the NIH Office of Extramural Research (OER) to improve the functionality and user experience as OER develops and deploys xTRACT—a specialized module designed for the simplified and ongoing collection of scientific trainee data directly from appointing universities and centers. In addition to improving the data quality on trainees, xTRACT ensures that such data are collected in an electronic (versus paper-based) format, making it more amenable to interim data analysis.

Implementation Strategy: Analyze data on key trainee outcomes, including degrees awarded and career trajectories.

Progress and Key Outcomes

Many of the large project evaluations undertaken since 2015 have focused on training, workforce development, and diversity programs. NIGMS has evaluated programs such as the Bridges to the Doctorate (B2D) and Clinical Translational Postdoctoral Research Training programs. Due to the complexity, high visibility, and potentially widespread impact of such programs, NIGMS convened and leveraged a working group of its scientific advisory council (the National Advisory General Medical Sciences Council) to review and assess data on how the programs individually performed. Each review resulted in a report delivered to the full

council. These reports and NIGMS' responding actions are publicly available on the NIGMS Evaluation Reports webpage.

The Institute's specific action(s) include public dissemination of evaluation findings via the *Feedback Loop* Blog, changes to data collection methods for trainees, restructuring of programs, revision and reissuances of existing program announcements, and changes to program funding mechanisms. Thus, NIGMS' robust, systematic, and transparent approach to program evaluations has improved the logical underpinnings of program design, provided valuable data on trainee progression and outcomes, and catalyzed collaborations across the NIH, federal government, and public sector. As an example, Table 1 below illustrates evaluation recommendations and responses for the B2D program.

NIGMS Bridges to the Doctorate (B2D) Program Evaluation			
	Recommendation 1	Recommendation 2	Additional Recommendations
Recommendation	Benchmark the B2D program against the NIGMS Postbaccalaureate Research Education Program (PREP) and NSF Louis Stokes Alliance for Minority Participation (LSAMP) Bridge to the Doctorate programs to identify the most successful and cost-effective mechanism(s) for increasing underrepresented Ph.D. graduates with the goal of reducing, remodeling, or phasing out the B2D program.	Increase resource flow toward (centralized) data collection mechanisms that improve the longitudinal tracking of trainees and trainee outcomes.	Conceive strategies to enhance research activity through partnership.
Recommendation Response	The NIGMS Training, Workforce Development and Diversity Division Director, the Undergraduate and Postdoctoral Branch Chief, and Program Staff met with National Science Foundation (NSF) officials overseeing the Louis Stokes Alliances for Minority Participation (LSAMP) Program and discussed the potential for the benchmark comparison. They arrived at the consensus that the NIGMS and NSF programs are distinct and therefore not comparable. The recent program evaluations based on progress reports show that PREP has similar outcomes for transitioning into and completing Ph.D. programs.	NIGMS has since formed collaborations with the Census Bureau to analyze student data longitudinally, and with the NIH Office of Extramural Research and eRA Commons to improve the collection of participant outcome data by requiring on-line data entry and establishing a centralized database with participant information.	Based on the outcome evaluation and analysis of successful long-standing programs, the funding opportunity announcement has been subsequently revised and reissued (PAR-19-300). Relevant outcome evaluation features include the following: The diversity enhancing programs have been restructured. One positive outcome of this restructuring is enhanced capacity for evaluation. For example, all diversity enhancing programs now focus on a specific career stage for better tracking of trainees through the research training pathway. The B2D program supports individuals as they make the transition from master's degree granting institutions to research-intensive Ph.D. degree granting institutions.

Table 1

Implementation Strategy: Use data to guide the development and optimization of research training and education programs.

Progress and Key Outcomes

The NIGMS Division of Training, Workforce Development, and Diversity (TWD) has been at

the forefront of both data collection and program evaluation within the Institute. These activities provide the information and knowledge necessary to effectively implement training and education programs that strive to achieve positive trainee outcomes, address critical needs, and avoid duplicating effort and resources. The Maximizing Opportunities for Scientific and Academic Independent Careers (MOSAIC) program, for instance, was created in response to the outcomes of diversity-focused training investments and the significant underrepresentation of women and certain other groups at the academic faculty level.[5,6] Launched in 2019, MOSAIC focuses on transitioning postdoctoral scholars from diverse backgrounds to independent research careers. As MOSAIC and the programs listed below (Figure 5) illustrate, NIGMS has evolved its TWD programs to support multiple stages of career development amidst an ever-changing landscape of workforce-related needs.

Information on all NIGMS-funded training programs can be found on the Research Training webpage.

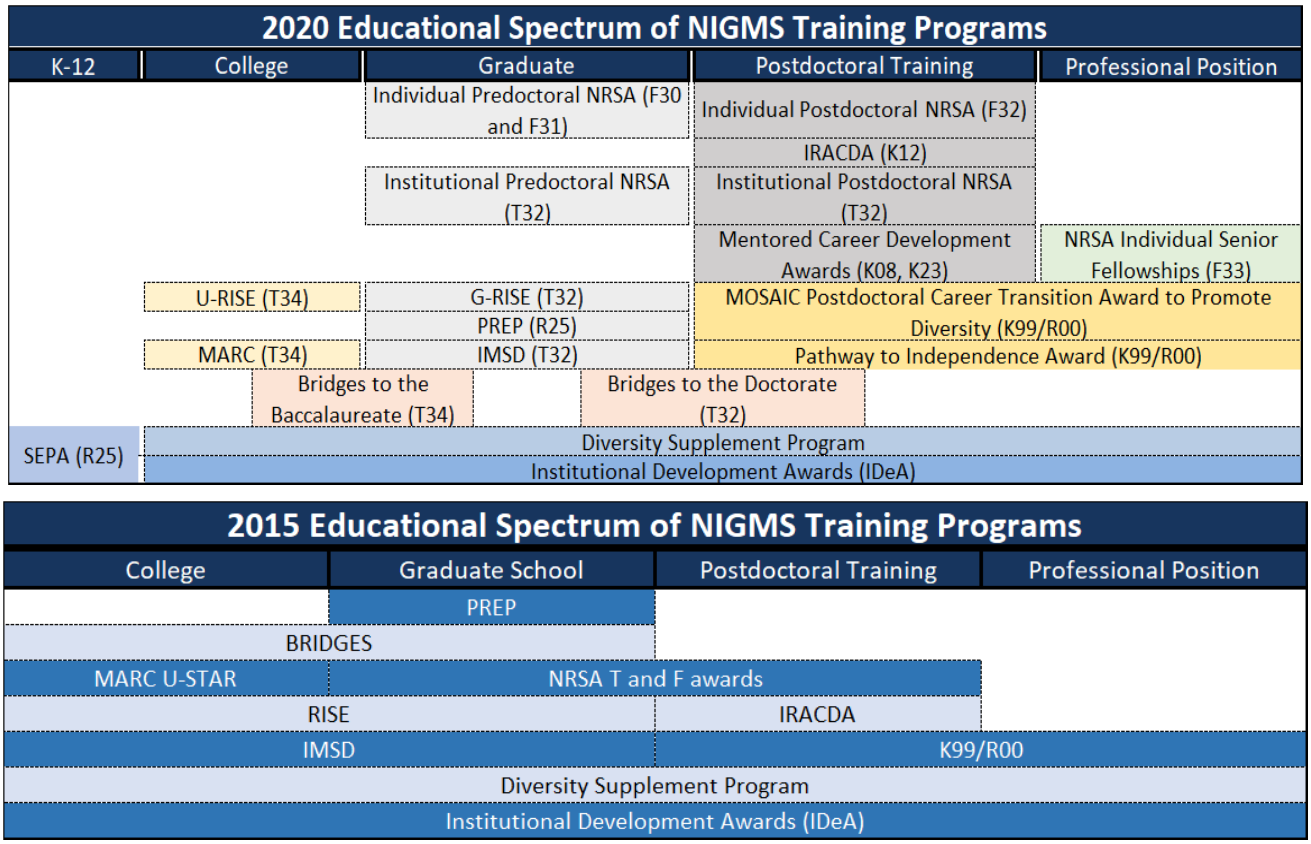


Figure 5

In addition to its individual or Institute-specific training programs, NIGMS also contributes to and/or manages broader, trans-NIH initiatives focused on building diversity within the

---

[5] Valantine, H. A., Lund, P. K., & Gammie, A. E. (2016). From the NIH: A Systems Approach to Increasing the Diversity of the Biomedical Research Workforce. *CBE life sciences education*, *15*(3), fe4. https://doi.org/10.1187/cbe.16-03-0138

[6] Gibbs, K. D., Basson, J., Xierali, I. M., & Broniatowski, D. A. (2016). Decoupling of the minority PhD talent pool and assistant professor hiring in medical school basic science departments in the US. *eLife*, *5*, e21393. https://doi.org/10.7554/eLife.21393

biomedical research workforce. One such initiative is the Diversity Program Consortium (DPC), which the NIGMS manages on behalf of the NIH Common Fund. The DPC is a national consortium in which awardees develop, implement, evaluate, and disseminate effective approaches to mentoring, student and faculty engagement, research capacity building, and institutional development. An innovative aspect of the DPC is a longitudinal evaluation that assesses outcomes in these specific areas. Although previous programs have shown positive outcomes for trainees and participants, data on specific interventions that contribute to success is limited. By collecting data on short-, medium-, and long-term outcomes, the DPC aims to provide and use robust evidence to design, build, and implement future effective interventions. Currently the DPC is conducting a comprehensive evaluation involving each of its 10 awardee sites. Findings from this multifaceted evaluation can be disseminated widely to build and support effective, diversity enhancing interventions at a wide variety of institutions across the United States.

Objective 2-2: Promote the identification of best practices to continually improve the quality of research training activities.

NIGMS recognizes that there is no "one-size-fits-all" approach to research training. Education research and the practices of successful training programs can provide insights into how to develop effective programs tailored to distinct educational levels and career stages. Evidence-based approaches can be used by programs to monitor and improve the recruitment and training of biomedical scientists at all levels. The Institute encourages those who conduct NIGMS-funded research training and education programs to develop and evaluate their practices, and the Institute provides online resources to help applicants develop effective evaluation plans. To ensure maximum return on its research training investment, NIGMS will encourage and assist programs in the dissemination of training practices that have proven to be effective.

Implementation Strategy: Support research training and education programs that facilitate the increased exposure of trainees to the range of possible career options and opportunities and the skills needed to pursue them.

Progress and Key Outcomes

While the research directions and technologies have changed tremendously over the past 3 decades, the way graduate students are prepared to conduct research often has not kept pace. Recognizing these changes, NIGMS launched an effort in November 2015 to more rapidly modernize graduate biomedical education. NIGMS issued supplements and awards for institutions to develop curricula and training modules that strengthen trainee development in areas promoting rigorous and reproducible research. The Institute also created a clearinghouse of these training modules for broader use. In addition, NIGMS held workshops, issued a request for information (NOT-GM-18-034), and presented webinars, all focused on developing and refining a new model for its predoctoral institutional training grant programs that enhances trainee development. Among the results of this revamping process was the creation and publication of a new NIGMS-issued T32 funding opportunity announcement (FOA) in 2017, aimed at ensuring that graduate student training keeps pace with the changing needs of researchers. Among the highlights of this new FOA are specific requirements for trainee-focused objectives; technical, operational and professional skills development; and a focus on training for the wide variety of careers in biomedical research.

Successful support of the scientific workforce must begin with outreach at an early age. In 2017, the Science Education Partnership Awards (SEPA) program was transferred into the NIGMS portfolio, broadening NIGMS' educational outreach efforts to students in the pre-kindergarten through high school (grade 12) levels. These awards support research and educational activities that complement other workforce capacity building programs within the NIGMS mission. With the addition of SEPA to its portfolio, NIGMS now supports workforce capacity building at earlier career stages by providing funding for innovative STEM educational programs, teacher training and skill building, interactive digital media resources, and science center exhibits. All efforts are aimed to improve overall community health, general science literacy, and an interest in careers in biomedical research among even the youngest members of society. Examples of SEPA's educational and teaching resources are accessible by and to the public through the NIGMS website.

Implementation Strategy: Enable the training community to pilot and evaluate new approaches aimed at building student skills and knowledge that will maximize the quality of research.

Progress and Key Outcomes

As described above, NIGMS funded administrative supplements and the development of online training modules to more effectively educate biomedical scientists for the 21st century workforce. In addition, in both 2016 and 2019, NIGMS reissued the Innovative Programs to Enhance Research Training (IPERT) (R25) award. IPERT supports creative and innovative research on educational activities designed to complement and/or enhance the training of the scientific workforce to meet the nation's ongoing biomedical research needs. These programs can be designed to support stages of research career development from the undergraduate to the faculty level and may consist of short courses. These courses may focus on skills building either in person or electronically; mentoring activities to provide participants with perspective on the biomedical research training pathway; and tools development for overcoming challenges and navigating career transition points. The IPERT FOA (PAR-19-383) requires any proposed programs to address NIGMS' strategic goal (as documented in the strategic plan) of creating a highly skilled and diverse workforce (see the IPERT webpage).

Implementation Strategy: Facilitate interactions across the full range of the research training and education community via outreach activities and meetings.

Progress and Key Outcomes

NIGMS strives to meet with grantees, trainees, and program participants for the widest range of interactions, conversations, and outreach possible. Below is a brief list of some of the workshops and meetings NIGMS has organized and attended to present information and data about various training programs and opportunities:

- American Society for Biochemistry and Molecular Biology Conference
- American Society for Cell Biology Annual Meeting
- Annual Biomedical Research Conference for Minority Students
- Council of Undergraduate Research
- Experimental Biology Conference
- HHMI Janelia Research Campus - Stakeholder Workshop on Ph.D. Career Development

- National Academies of Sciences Convocation on Re-envisioning Promotion and Advancement for STEM Faculty: Aligning Incentives with Values
- National Postdoctoral Association Meeting
- NIGMS TWD Program Directors' Meeting
- NIH Diversity Program Consortium Annual Meeting
- NIH IDeA National and Regional Meetings
- NIH SciED 2019 Conference
- NINDS workshop: *Strengthening a Neural Network: Pathways for Institutional Change Regarding Diversity and Inclusion*
- Society for the Advancement of Chicanos and Native Americans in Science Annual Meeting
- Understanding Interventions Meeting

GOAL 3: SUPPORT THE DEVELOPMENT OF AND ACCESS TO ESSENTIAL RESEARCH TOOLS, RESOURCES, AND CAPABILITIES FOR BIOMEDICAL RESEARCH.

Introduction

NIGMS seeks to advance the nation's capabilities for biomedical research and to enable the broadest possible community of scientists to create, expand and apply knowledge that leads to the improvement of human health. The Institute will continue to use a variety of approaches to advance the research capabilities of faculty and institutions and to ensure access to critical, shared research resources and technologies. One approach to achieving this goal is to support the development, maintenance and accessibility of high-quality technologies and research resources, including laboratory and computational tools as well as reagent, biological and database resources. Such new technologies enable scientific advances that, in turn, drive the development of additional technologies. Ensuring cost-effective, sustainable access to critical research resources is an NIGMS priority. The Institute, alone and in partnership with other NIH institutes and federal agencies, also fosters the establishment of standards to maximize resource usefulness and accessibility. Finally, NIGMS works to expand research capacities by targeted support for improvements in research infrastructure and environments that promote the success of faculty and institutions.

Objective 3-1: Support access to essential research resources and the development of new technologies that enable novel scientific advances.

NIGMS will continue to promote the development, maintenance and evaluation of the nation's biomedical research resource infrastructure. Scientists need powerful tools, methods and approaches to advance biomedical research, but a commercial market for these cutting-edge technologies does not always exist. NIGMS takes a leadership role in the development of a broadly-based infrastructure of cutting-edge and productive research resource facilities. The Institute will continue to support technology research and development that benefits research within and across scientific domain areas. To ensure the efficient use of taxpayer funds, NIGMS will routinely evaluate current resource operations, carefully assess new technical opportunities and seek to create economies of scale by supporting shared regional and national resources.

Implementation Strategy: Assess existing NIGMS resource provision efforts to ensure that they are meeting the current and evolving needs of the scientific community.

Progress and Key Outcomes

Often, the scientific community needs access to specific technologies or research resources that would be inefficient or otherwise untenable to obtain or maintain for a single research lab or institution's use. Since 2015, NIGMS has evolved and enhanced its investments in such resources to further support regional scientific communities. Examples include updated funding mechanisms for synchrotron resources in structural biology (PAR-19-232) and new mechanisms for high-resolution cryo-electron microscopy centers (RFA-RM-17-002). Both types of support provide broad access to these cutting-edge resources. NIGMS also recently released an FOA to support access to a wider variety of technologies through national and regional resources (PAR-19-301).

Implementation Strategy: Employ an appropriate range of funding mechanisms to optimally support technology development related to the NIGMS mission.

Progress and Key Outcomes

As an Institute that supports fundamental research, NIGMS' portfolio spans a breadth of scientific subjects, from determining the structure of proteins to understanding the biology of certain human diseases. All of these areas make use of and benefit from technological advances, whether they are point-of-care diagnostics for the early detection of sepsis or software developed to analyze data from high-powered microscopes employed to visualize cellular structures. A challenge associated with technology development applications is that their focus on prototyping, developing, scaling, and/or disseminating applied technologies, rather than on pursuing fundamental scientific knowledge, has made them misaligned with the usual research grant mechanisms and review groups.

To address these challenges, NIGMS staff began in 2017 to create and apply a machine learning/natural language processing algorithm that can differentiate applications focused on technology development from those focused on traditional hypothesis-driven research. This algorithm enabled NIGMS to conduct a retrospective analysis of technology development application success, which led to the creation of a technology development "pipeline" that includes new FOAs for R01 and R21 technology development grants (PAR-19-253, PAR-19-254) and a completely revised FOA for the Biomedical Technology Research Resources program, which is now called the Biomedical Technology Development and Dissemination Centers program (PAR-20-104). These programs offer researchers funding resources to encourage the development of biomedical technologies from early-stage proof of concept without the need to immediately answer biological questions to the hardening and dissemination of widely useful technologies.[7] These steps, taken in tandem with the provision of more mature technological resources such as those highlighted above, have established the first robust technology development pipeline for NIGMS.

Objective 3-2: Continue the development of institutional research capacities and

[7] https://loop.nigms.nih.gov/2016/03/new-nigms-initiatives-for-supporting-technology-development/

communities.

Developing the capacity for research involves providing a high-quality physical and technological infrastructure as well as fostering an environment that attracts and supports a scientific workforce that is highly skilled, collaborative, and multidisciplinary. NIGMS will facilitate the development of the infrastructure needed to conduct basic, clinical, and translational research, particularly at institutions with substantial enrollments of students from underrepresented groups and in states that historically have not received significant levels of NIH funding. Through these activities, NIGMS will aid institutions in providing strong research environments to address challenging biomedical questions and will promote a broad and diverse biomedical research enterprise.

A major component of NIGMS' capacity building portfolio is the Institutional Development Awards (IDeA) program.[8] Established in 1993,[9] the program offers specialized funding opportunities for states that have historically received lower levels of NIH funding.

The IDeA program has five main components:

1. The Centers of Biomedical Research Excellence (COBRE): Provide support for thematic multidisciplinary research centers that strengthen institutional biomedical research capacity.

2. The IDeA Networks of Biomedical Research Excellence (INBRE): Provide support for statewide biomedical research development networks in each IDeA-eligible state, partnering research-intensive institutions and primarily undergraduate institutions.

3. The IDeA Program Infrastructure for Clinical and Translational Research (IDeA-CTR): Provides support for clinical and translational research in IDeA-eligible states by developing research infrastructure and human resources, enhancing an investigator's ability to develop a competitive research program and increasing collaborative research activities targeted at health conditions prevalent in medically underserved and rural communities.

4. IDeA Co-funding: Provides support for applications from investigators in IDeA-eligible states submitted to any NIH institute or center and receiving meritorious scores in peer review.

5. STTR Regional Technology Transfer Accelerator Hubs for IDeA States: The newest component of the IDeA program, launched in 2018. Provide support for the commercialization of innovative technologies and methodologies developed in IDeA-eligible states.

Implementation Strategy: Broaden the community of IDeA-funded researchers and institutions that engage in highly meritorious biomedical research.

Progress and Key Outcomes

Since 2015, the Centers of Biomedical Research Excellence (COBRE), a component of the IDeA program, have expanded their support of investigators conducting independent

[8] https://www.nigms.nih.gov/Research/DRCB/IDeA/Pages/default.aspx

[9] https://www.congress.gov/bill/103rd-congress/senate-bill/1

research (known as research project leaders) from 183 to 345 per year (Figure 6). Each research project leader is funded for a single-year project supported by the regional COBRE. This level of support represents an 88% increase in the number of independently proposed funded research projects that could serve to catalyze research careers.

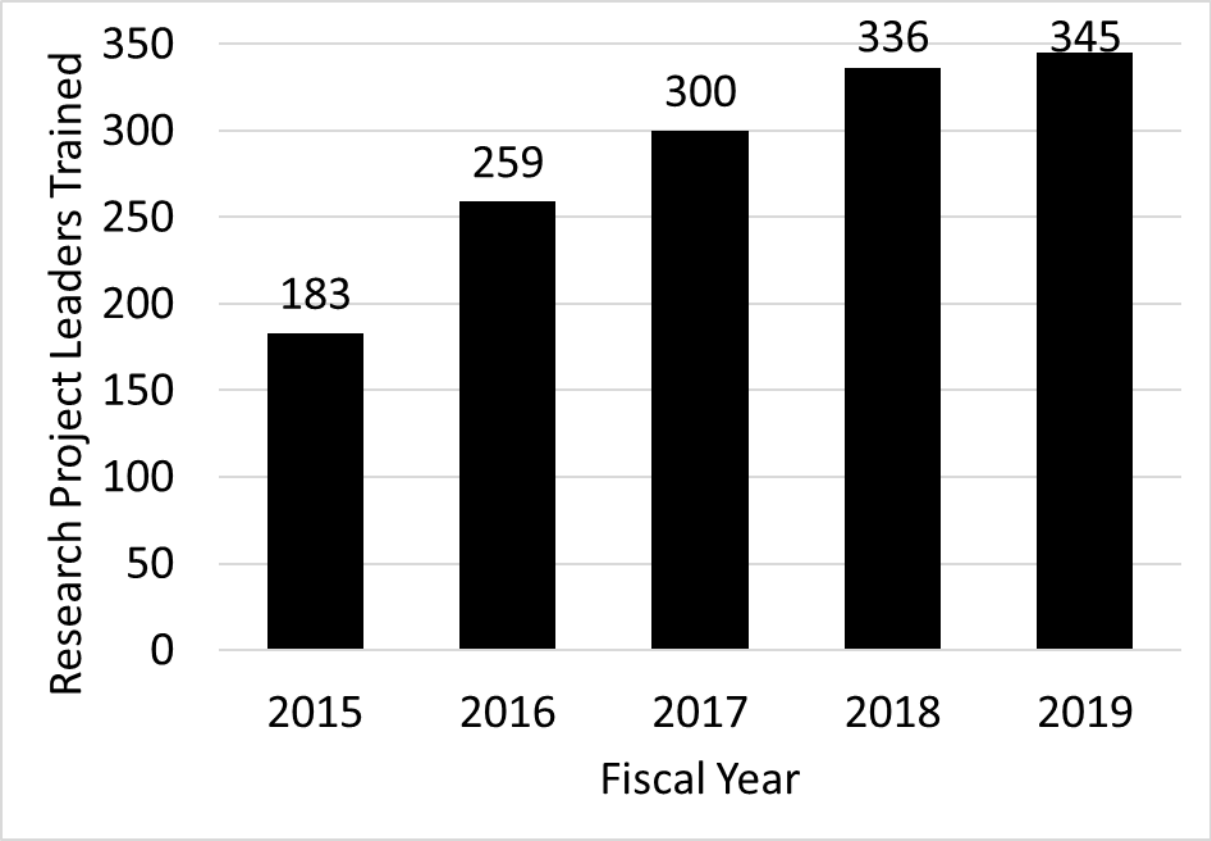


Figure 6

Similarly, the Clinical and Translational Research (IDeA-CTR) program supports clinical research in areas of the country that would otherwise not have the resources to conduct this type of research. Each CTR center supports multiple research subprojects per year. As the data below indicate, the IDeA-CTR program has expanded dramatically from 19 subprojects supported in 2015 to a total of 80 clinical research subprojects in 2019 (Figure 7).

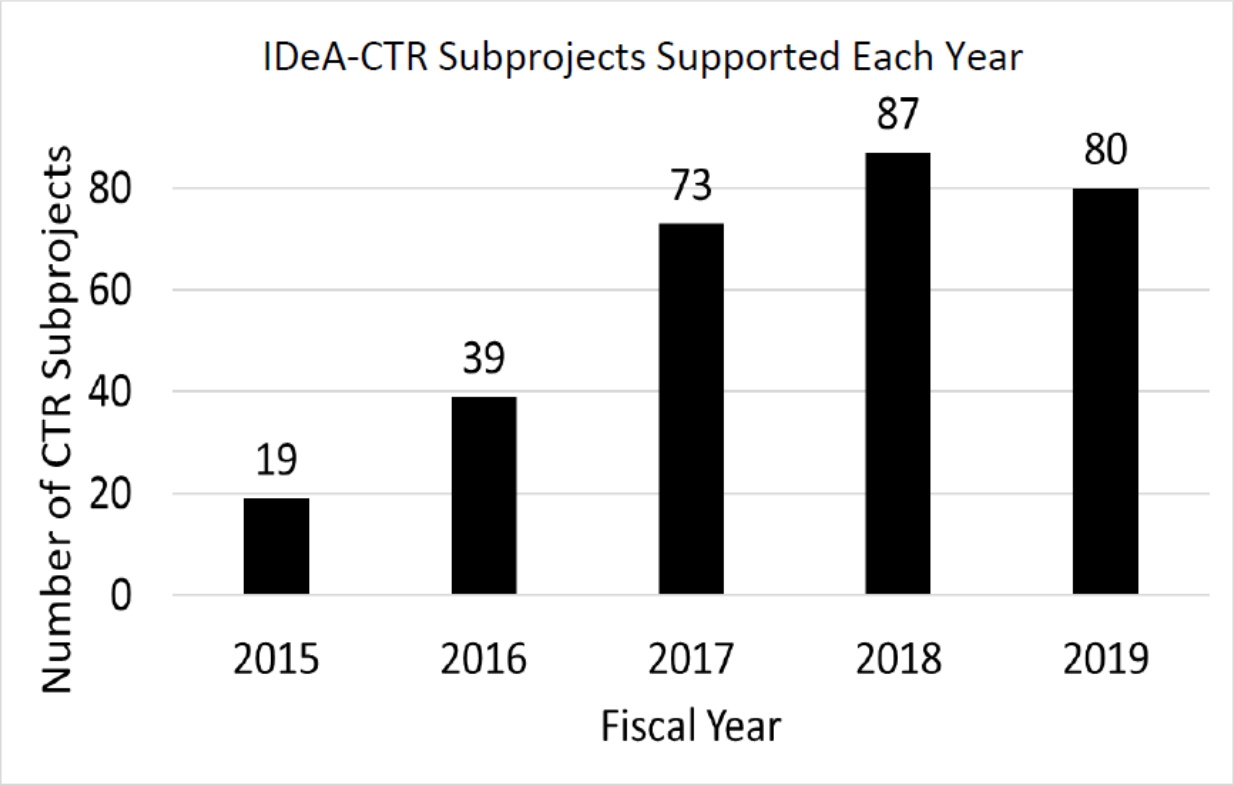


Figure 7

Implementation Strategy: Provide support for institutional research infrastructure enhancement through the IDeA program in IDeA-eligible states.

Progress and Key Outcomes

One goal of the IDeA program is to enhance geographic diversity and inclusiveness. Depicted below (Figure 8) are the numbers of funded NIGMS awards made in each of the IDeA states from 2015 to 2019. Each of these awards represents a research program or center, or a research training program bolstering the scientific community and infrastructure in these underserved regions. A total of 696 awards across 24 states and territories have been made. NIGMS awards nearly a quarter of all funding in IDeA states (24%) through both IDeA program support and investigator-initiated research awards.

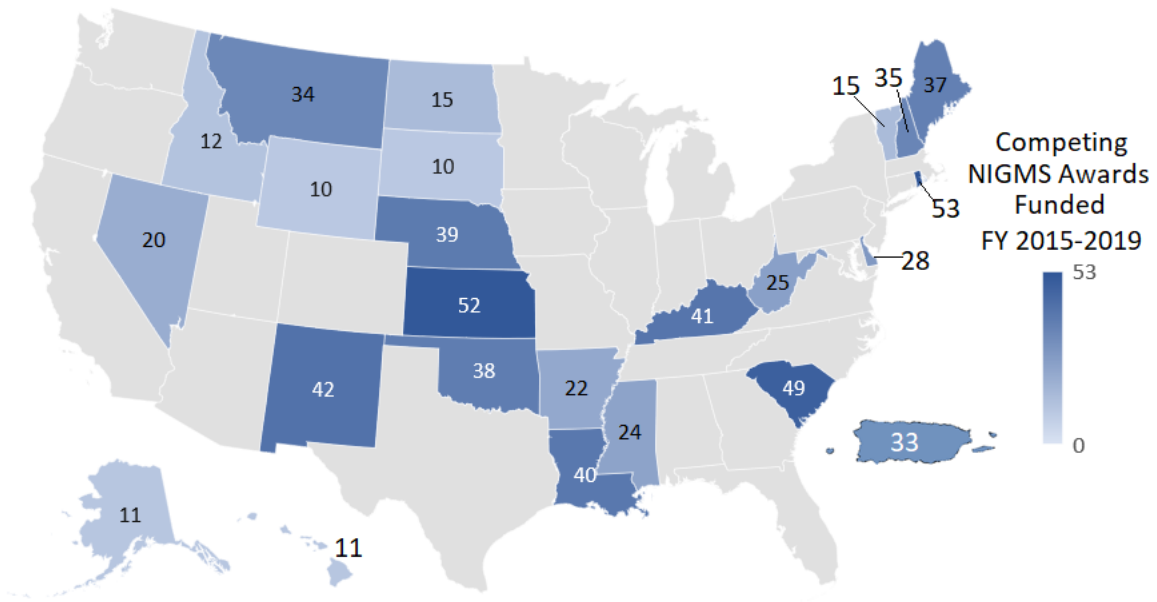


Figure 8

<u>Implementation Strategy:</u> Enhance the research and training environment at institutions by supporting faculty development through NIGMS capacity building programs.

<u>Progress and Key Outcomes</u>

IDeA Networks of Biomedical Research Excellence (INBRE) foster the development, coordination, and sharing of research resources and expertise that expand research opportunities and increase the number of competitive investigators in IDeA-eligible states. This important program enables training and mentorship not only for faculty and principal investigators at network-affiliated institutions, but also for their students, trainees, and postdoctoral fellows, thus broadening pools of expertise. Since 2015, the number of INBRE supported persons—students, investigators, technicians, and trainees—increased by more than 350% (Figure 9), meaning a bolstered capacity and an enhanced research and training environment in each of the INBRE partner centers.

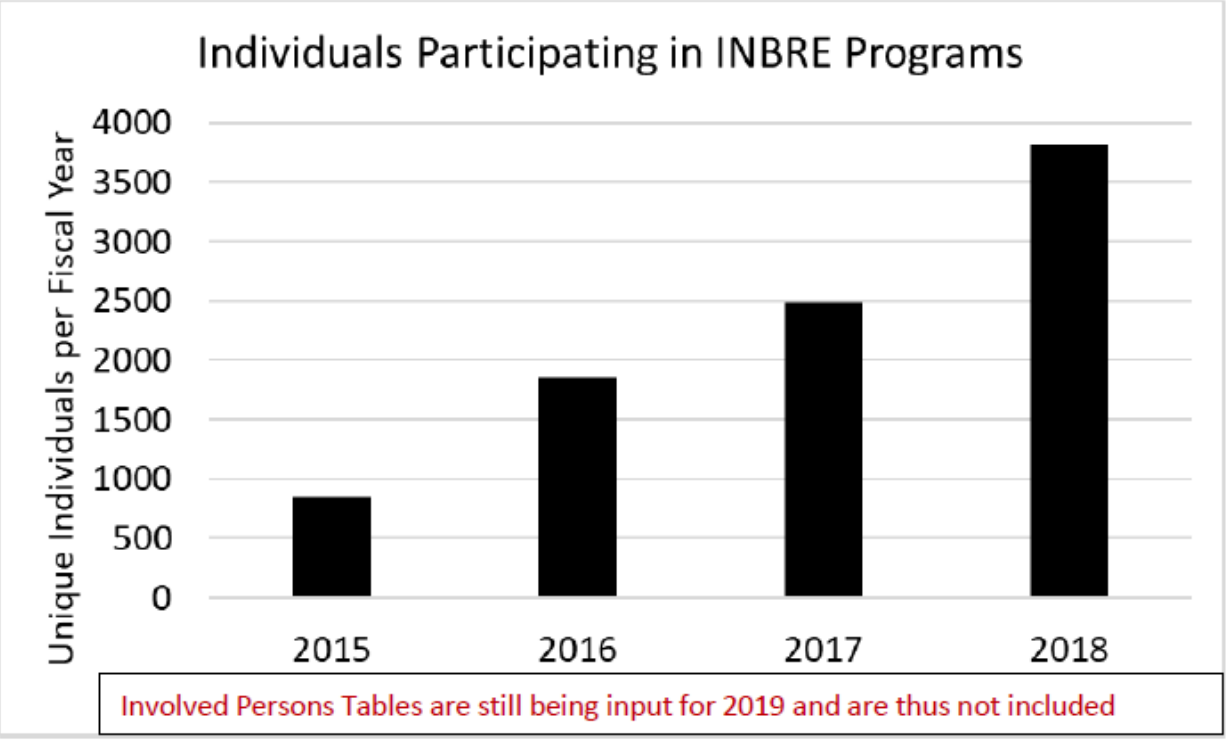


Figure 9

In addition to its IDeA investments, NIGMS manages the Support of Competitive Research (SCORE) program, which provides capacity building support to under-resourced institutions with an explicitly stated mission or a historical track record of training students from groups nationally underrepresented in the biomedical sciences. In 2019, NIGMS conducted an evaluation of the SCORE program to assess its programmatic objectives and whether these objectives were effectively met. A working group of the National Advisory General Medical Sciences Council was formed to provide recommendations about the SCORE program, which were presented at the January 2020 Council session (Videocast – timestamp 58:00). NIGMS is currently working to implement the recommendations of the panel and incorporate them into the next iteration of the SCORE program.

GOAL 4: ADVANCE UNDERSTANDING OF FUNDAMENTAL BIOMEDICAL RESEARCH AND THE NIGMS ROLE IN SUPPORTING IT.

Objective 4-1: Use a broad range of approaches to inform the public about NIGMS goals, activities and results.

Using a variety of communication approaches, channels and partners, NIGMS will develop and distribute information about important scientific findings, the role of basic research and the excitement of careers in science. The Institute will work collaboratively with various organizations to amplify and reinforce these messages.

Implementation Strategy: Communicate with the public about NIGMS-supported research advances and their potential impact on human health.

Progress and Key Outcomes

Commensurate with its transparency function, NIGMS has rapidly expanded its social media outreach through a variety of platforms since 2015. As of 2019, NIGMS has four Twitter handles, two Facebook pages, and accounts on Pinterest, Instagram, and YouTube, all of which disseminate information and spark conversations among students, grantees, and the general public about various topics of interest. These methods of social media outreach also provide an opportunity for program directors within NIGMS to interact directly with the public. NIGMS Twitter accounts cumulatively reach more than 20,000 followers (21,158), an increase of more than 8,000 followers since branching into audience-specific Twitter accounts in 2017. NIGMS also manages two blogs: *Biomedical Beat*, focused on disseminating scientific findings to the general public, and the *NIGMS Feedback Loop*, intended to relay NIH and grant- or program-related information to the scientific community. The *NIGMS Feedback Loop* alone reaches at least 30,000 subscribers with every posted article.

Implementation Strategy: Communicate with educator and student audiences about careers in science.

Progress and Key Outcomes

In 2019, NIGMS announced a collaboration between the Institute and Scholastic, Inc. to develop and distribute a new educational resource about biomedical science and research careers called *Pathways*. This resource is designed for grades 6 through 12 and includes a student magazine, teacher lesson plans, interactives, and videos available through the Scholastic and NIGMS websites.[10] The publication reaches nearly 500,000 students across every state in the U.S. and informs students about careers in basic science so as to inspire the next generation of scientific researchers. As of March 2020, the third and most recent issue on circadian rhythms has garnered nearly 10,000 page views and more than 400,000 social media impressions.

NIGMS also reaches educators and the public through its *Biomedical Beat* blog, which currently has nearly 28,000 email subscribers. Through this blog—as well as through the social media platforms—NIGMS shares its robust collection of science education resources.

Objective 4-2: Continue to engage in an open dialogue with the scientific community and other stakeholders about NIGMS programs, processes, and policies.

NIGMS seeks to communicate Institute programs and policies broadly and effectively and to invite and respond to feedback from its constituents. NIGMS will continue its bidirectional conversation with the scientific community and other stakeholders in a variety of ways. These range from program directors discussing ideas with individual scientists to online forums to meetings with professional societies.

Implementation Strategies: Communicate with the scientific community, including investigators and trainees at all levels, grantee organizations, scientific and professional societies, and relevant industries, about NIGMS programs, processes, and policies; encourage feedback from the scientific community and other stakeholders to ensure open

[10] http://www.scholastic.com/pathways/

dialogue.

Progress and Key Outcomes

NIGMS interacts with the scientific community and stakeholders through formal and informal venues such as the National Advisory General Medical Sciences Council, webinars, requests for information (RFIs), presentations at conferences and meetings, online articles published in the *NIGMS Feedback Loop* blog (see below), and one-on-one conversations with individual applicants or trainees.

One of the critical ways in which the public can comment on various activities such as planning within NIGMS is through the use of RFIs, which are formal mechanisms open to all members of the public for the receipt of comments about a broad range of topics. RFIs routinely garner responses from 1) large professional societies and advocacy groups, 2) groups of physicians and physician-scientists responding together, 3) individual scientists from every career stage, 4) members of the general public, 5) individuals interested in specific research areas or human diseases, and 6) those working directly with patient populations in clinical settings or through social services. Since 2015, NIGMS has issued six RFIs asking for comments on topics such as the direction of sepsis research, challenges in research training, and (in 2020) NIGMS plans to issue an RFI on its new strategic plan framework. In each case, all responses are reviewed, coded, analyzed, and summarized to inform robust decision-making within the Institute, especially as it applies to addressing the needs and perspectives of multiple stakeholders.

Another critical way that NIGMS communicates with the scientific community and stakeholders is through the publication of regular blog posts on the *NIGMS Feedback Loop*. Since 2015, more than 250 posts have been written on topics such as annual funding trends, new grant programs, and diversity initiatives. Within the same timeframe, the blog has received more than 485,000 page views from the scientific community and stakeholders (Figure 10).

The *NIGMS Feedback Loop* is distributed by email to more than 31,000 NIGMS grantees, applicants, and other stakeholders. The data referenced above reflect traffic on the *Feedback Loop* website. Since its launch in 2009, the blog has had 700 posts contributed by NIGMS staff members.

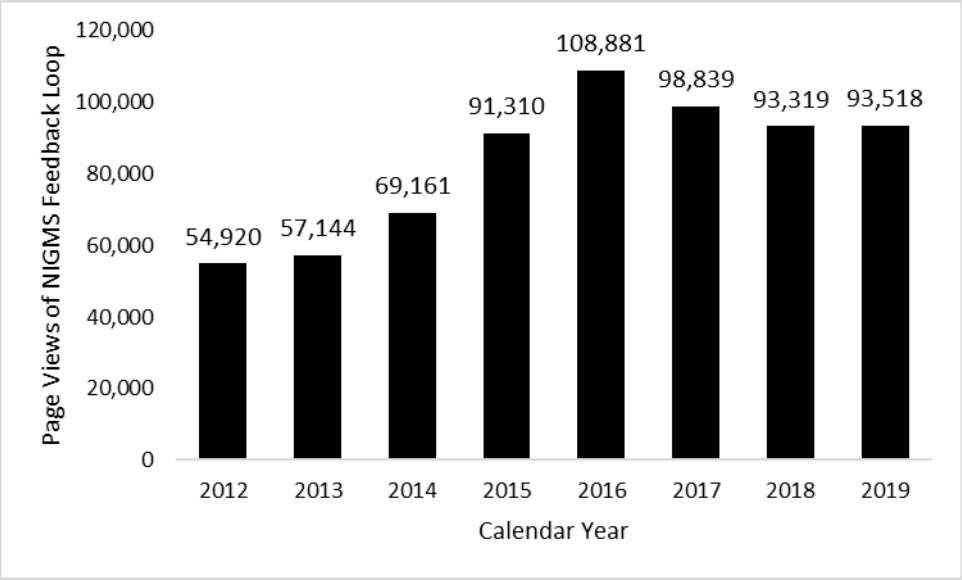


Figure 10

GOAL 5: PROMOTE THE EFFICIENT USE OF HUMAN RESOURCES AND BUSINESS PRACTICES TO ADVANCE THE NIGMS MISSION.

Introduction

In a typical fiscal year, NIGMS awards and manages more than 4,500 grants and reviews nearly 1,000 grant applications (in addition to those reviewed by NIH's Center for Scientific Review), relying on the efforts of its dedicated staff to accomplish these core activities. NIGMS is committed to deepening the capabilities of its staff and embracing an inclusive and ever-changing workforce. The Institute will continue to administer ongoing staff training, encourage participation in professional development activities, and pursue organizational agility to ensure optimal work performance. Also, as federal regulations, NIH policies, and NIGMS procedures change, the Institute will review business practices to ensure efficient operations.

Objective 5-1: Foster a proficient, diverse, and collegial NIGMS workforce.

In order to build a knowledgeable, skilled, and inclusive workforce that is aligned with the Institute's mission and the breadth of science that NIGMS supports, ongoing training of staff and organizational agility are necessary to ensure optimal work performance.

Implementation Strategy: Optimize staffing to meet the needs of the Institute.

Progress and Key Outcomes

Employee recruitment and turnover are natural parts of a healthy organization but benefit from active management. Although extenuating circumstances such as budget uncertainty or hiring freezes can impact staffing needs, maintaining appropriate staffing levels for efficient and effective operations is a top priority for NIGMS leadership and management. From 2015 to 2020, NIGMS has monitored employee turnover as an important metric for the health of the NIGMS workforce and the ability of the Institute to deliver on its mission.

Implementation Strategy: Ensure continued professional development.

Progress and Key Outcomes

There are numerous opportunities for professional development within NIGMS in both formal (e.g., professional development coursework) and informal (e.g., career mentoring) settings. NIGMS has nominated employees to participate in cross-institute professional training activities such as the NIH Management Seminar Series, the Mid-Level Leadership program, and the Senior Leadership Program. Each of these programs incorporate elements of professional development, education, and training from workforce experts who are either internal or external to NIH. NIGMS prides itself on having a strong record of employee nominations and an active applicant pool for each of these programs. From 2015 to 2020, for instance, NIGMS has maintained a strong record of nomination and support for the participation of NIGMS staff in these training opportunities tailored for different stages of work experience, nominating *all* interested staff members who submit applications to these professional development programs.

Objective 5-2: Maximize the efficiency of NIGMS operations by continuously assessing, identifying, and applying the most effective business practices.

For NIGMS to function most effectively, the efficiency of its business practices must be optimized to provide staff with an open and collaborative environment, up-to-date information-technology tools and services, flexible approaches to manage changing workloads, and robust data collection and analysis methods to guide data-driven decision-making.

Implementation Strategy: Enhance internal operating procedures to maximize the efficiency of NIGMS business practices.

Progress and Key Outcomes

Cutting-edge technology can improve operational efficiency when applied thoughtfully. Every year, NIGMS must process, on average, more than 7,300 grant applications submitted to the Institute to decide the appropriate location for any given grant to be reviewed and administered. This challenging classification task (known as receipt and referral) occupies an inordinate amount of staff hours but is necessary to ensure that grant proposals are considered for funding appropriately.

To streamline this labor-intensive assignment process, an internal working group of data scientists and IT professionals from NIGMS worked together to develop and implement a machine learning/natural language processing algorithm—a type of artificial intelligence—to scan and classify grant applications in an automated fashion. Testing of this methodology demonstrated that it was as reliable as the manual, human-based classification currently in use within the Institute. In 2019, this machine learning algorithm was used to make initial assignments for NIGMS' entire R01 research portfolio, leading to significant savings in administrative time and burden—up to 240 labor hours per year—for program personnel, thus freeing staff to dedicate more time more substantive activities (e.g., interfacing with the scientific community and advising applicants on potential awards). Currently, NIGMS is coordinating with the Office of Extramural Research within NIH to test the feasibility of expanding this method NIH-wide, thereby significantly increasing the efficiency of business

processes for multiple institutes and centers (ICs).

Within NIGMS, the Office of Program Planning, Analysis, and Evaluation (OPAE) has grown from a single full-time employee to a vibrant analytical and evaluative community of more than a dozen full-time federal employees and contractors working to meet the data needs of the Institute, NIH, HHS, and the public. With this growth in investment and personnel, there has been a marked increase in analytical and evaluation activities, including multiple year-long program evaluations incorporating internal and external expert panel input and leading to the development and enactment of program recommendations, the development of strategic planning and program-level dashboards, and modifications to improve programmatic impact and function, as showcased on the NIGMS evaluations page. In addition, OPAE has also embarked on business process improvement activities such as the piloting and subsequent scaling of automated receipt and referral mechanisms within the Institute that reduce both labor costs and administrative burden. To align with the functions that OPAE performed, in 2020, its name was changed to the Division of Data Integration, Modeling, and Analytics and the office was changed to a division within the Institute.

NIGMS has worked to integrate or shift many of its business processes and tools with NIH enterprise-wide systems. Most notably, NIGMS has migrated much of its paylist process for approving the award of grants to the enterprise-wide PayPlan module. This has resulted in a number of benefits, including streamlined workflows between program staff, grants management, and budget offices; greater accuracy of initial budget recommendations; and higher consistency overall in the process. NIGMS also shifted its funding opportunity announcement approval process to an enterprise-wide management module, leading to better transparency and higher fidelity than the previous paper-based process. Finally, NIGMS moved from an internal system for managing council activities to the enterprise-wide Electronic Council Book, leading to improved security for council proceedings as well as less burden for NIGMS staff in maintaining existing systems.

Implementation Strategy: Ensure up-to-date information technology infrastructure platforms that facilitate workflow.

Progress and Key Outcomes

Figure 11

In 2018, NIGMS embarked on a process to update its web resources and information technology infrastructure. The information technology teams within NIGMS focused on cloud integration; infrastructure, operations, and maintenance; application development; and business support and process improvements (Figure 11).

Externally, the entirety of the NIGMS website, including blogs, image and video gallery, and staff directories, was redesigned to improve accessibility and information flow, as well as to reflect updates within the NIGMS organizational structure and mission (e.g., those described at the beginning of this report). In addition, external collaborations were migrated to the cloud using Box, and the secure council website was replaced with an Electronic Council Book. The figures below show the old (12a) and updated (12b) publicly facing NIGMS homepage.

Figure 12a

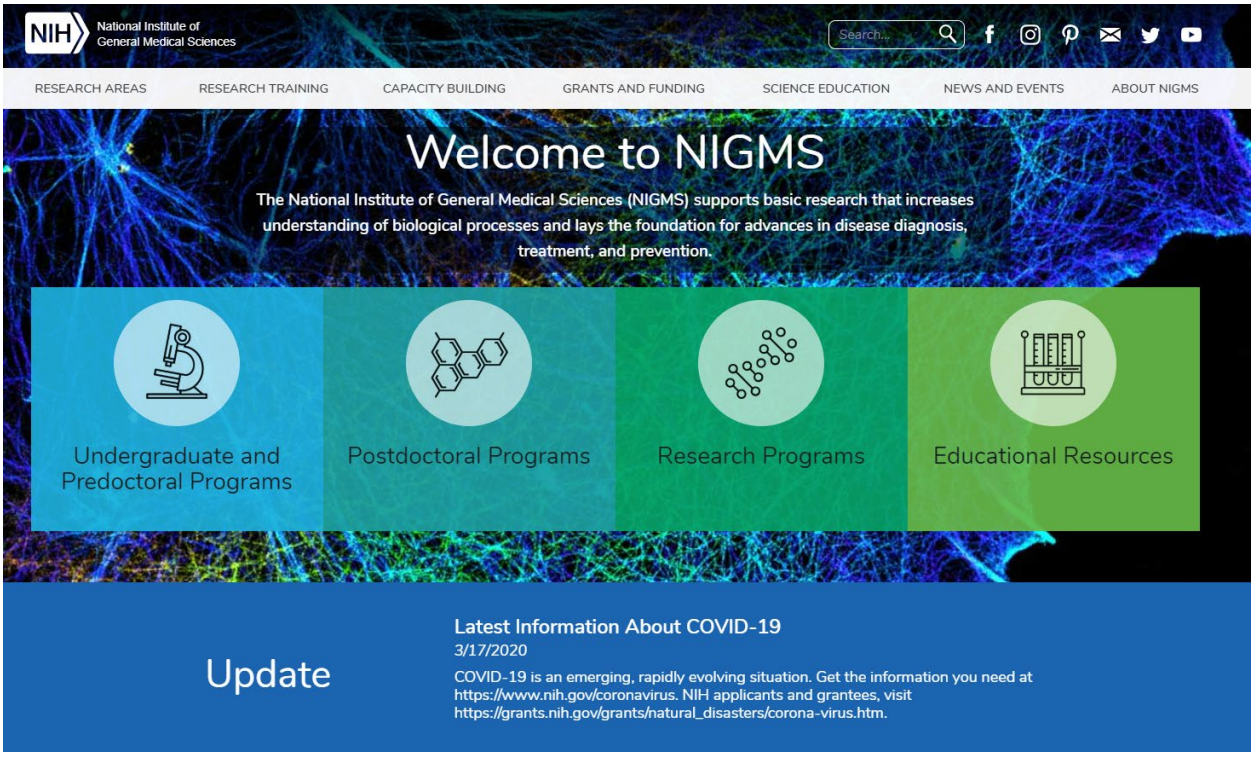


Figure 12b

Internally, information and data resources have been updated to maintain a maximally secure data system, enable staff access to needed technological and data resources, and improve the physical infrastructure of information technology within the Institute. Specific examples of these types of improvements include 1) integration of natural language processing into our extramural support system, 2) automation of the NIGMS awards submission process, 3) implementation of the Division for Research Capacity Building Scientific Information Reporting System, 4) migration and updating of software systems and data hosting, 5) implementation of business objects reporting suite for internal tracking, and 6) full integration of SAS analytics software. Since 2015, the Information Resources Management Branch reduced its time to respond to help tickets by more than 40%, improving Institute functionality.

Objective 5-3: Develop and maintain cooperative and synergistic partnerships with other NIH institutes and centers, other federal agencies and other organizations.

Implementation Strategy: Identify areas of common interest in which partnering would increase the efficiency of funding and/or the accomplishment of the NIGMS mission.

Progress and Key Outcomes

NIGMS supports collaboration and the leveraging of common interests across institutes and centers within NIH and with other federal agencies through a variety of mechanisms. Recently, NIGMS issued two funding opportunity announcements (RFA-19-009, RFA-19-010) for cryo-electron tomography service centers and an associated hub as part of the Common Fund Transformative Cryo-EM Initiative, co-led by NIGMS and the National Eye Institute, and has representation from 10 other NIH institutes and offices. In addition, NIGMS also co-leads the Common Fund Glycosciences initiative and the Diversity Program Consortium (see Goal 2.2).

In February 2019, NIGMS announced a new joint initiative with the National Science Foundation (NSF) to support research focused on strengthening the scientific basis of science and innovation policy, with a focus on the biomedical sciences. The partnership allows for coordination of efforts between both agencies, leverages their resources, and taps into a network of investigators dedicated to this area of research. The SCISIPBIO program joins other long-standing NIGMS/NSF collaborations such as the Mathematical Biology program and the Ecology and Evolution of Infectious Diseases program, as well as joint support for resources such as synchrotron beamlines and the Protein Data Bank.

In addition to these research funding collaborations, NIGMS interacts regularly with academic institutions, professional societies, other federal agencies, and multiple components of HHS, the federal department of which NIH is a part. These interactions take the form of working groups on scientific and administrative topics, service on coordinating committees, and analytical contributions to large-scale initiatives such as department-wide reorganization efforts encapsulated by Re-Imagine HHS.