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on
The President's Fiscal Year 2018 Budget Request
for the National Science Foundation

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Chairman Culberson, Ranking Member Serrano and Members of the Subcommittee, it is my privilege to be here with you today to discuss the National Science Foundation's (NSF) fiscal year (FY) 2018 Budget Request.

On May 10, NSF celebrated its 67th birthday. As we reflect on the enormous impact the agency has had on every facet of society, we can say with certainty that the results of frontier research funded by NSF have a long record of improving lives and meeting national needs. They are a key contributor to economic growth; the path to sustainability in energy, agricultural, and environmental domains; the seeds of the next technology revolution; and the foundation for advances in medicine and national security.

The cornerstone of NSF is the merit-based, competitive process that fosters the highest standards of excellence and accountability. The merit review process is one of NSF's critical business functions. Effective merit review recognizes high-quality research, including high-risk, high-reward or potentially transformative ideas; empowers NSF to support such proposals; and retains the confidence and trust of NSF's external stakeholders. NSF has the latitude to support emerging fields, high-risk ideas, interdisciplinary collaborations and research that pushes – and even creates – the frontiers of knowledge. The programs and practices which the hard-working and dedicated staff at NSF have created have been emulated around the world. NSF support has nurtured the creative talents of hundreds of thousands of scientists, engineers, students and educators in every part of the United States. NSF has supported the discoveries of some 223 American Nobel Prize winners. This represents about 70 percent of all the U.S. Nobel Prize winners since 1950.

As the nation's agency dedicated to funding fundamental research, NSF is unique. Our mission is as broad as science itself. We support all fields of fundamental science and engineering (S&E), as well as science, technology, engineering and mathematics (STEM) education, keeping our nation's scientific enterprise focused on the frontiers of research and education. We recognize and nurture emerging fields, encourage the most insightful ideas, and prepare future generations of scientists and engineers.

The foundation’s annual budget represents 27 percent of the total federal support for basic research conducted at U.S. colleges and universities, and this share increases to 60 percent when medical research supported by the National Institutes of Health is excluded. In many fields, like computer science for example, NSF is the primary source of federal academic support.

NSF is vital to our nation because we invest in the fundamental research and the talented people who make the discoveries that transform our future. These discoveries are a major driver of the U.S. economy, enhance our nation’s security and give the country the competitive edge to remain a global leader. Transforming the future is about looking ahead, and that is why NSF has come up with “10 Big Ideas” on the cusp of breakthroughs. NSF’s 10 Big Ideas focus on: (1) pushing the existing boundaries of knowledge; (2) pinpointing new opportunities to seize; and (3) closing gaps – enabling these and more big ideas to move us to the next levels needed to keep pace with other competitive nations. They are briefly described below.

THE NSF FY 2018 BUDGET REQUEST

The President's FY 2018 Budget Request for NSF continues the nation's longstanding commitment to support basic research and education across all fields of S&E. NSF funds basic research that pushes the boundaries of innovation and lays the groundwork for scientific breakthroughs that advance our nation's economy, security and global leadership. Also critical are NSF's education investments in STEM fields which help to prepare future generations of scientists and engineers.

In January 2017, the President signed into law the American Innovation and Competitiveness Act (P.L. 114-329), abbreviated AICA, a bipartisan bill that affirms NSF’s longstanding, world-renowned merit review process. AICA also addresses NSF’s implementation of particular issues of importance such as increased transparency and accountability; management of multiuser facilities and mid-scale projects; and increased oversight of major research equipment and facilities. While maximizing research and education opportunities that help create the innovations that fuel our economy and create jobs, AICA also provides the foundation’s commitment to diversity in STEM fields, incentivizes NSF’s programs that encourage private-sector involvement, and re-affirms NSF’s continued commitment to entrepreneurship and commercialization.

NSF's FY 2018 Budget Request is $6.65 billion, a decrease of $819 million (-11 percent) from the FY 2017 Enacted level. This funding will support approximately 8,000 new research grants, with an estimated funding rate of 19 percent for research grant proposals submitted to NSF. For comparison, in FY 2016, NSF funded 8,800 new research grants, with a funding rate of 21 percent.

The FY 2018 Budget Request reflects NSF's commitment to establishing clear priorities in areas of national importance, as well as to identifying innovative and promising research ideas, in order to yield high return on investment for the nation.

In 2016, NSF unveiled a set of "Big Ideas" —10 bold, long-term ideas that identify areas for future investment at the frontiers of S&E. With its broad portfolio of investments, NSF is uniquely suited for this set of cutting-edge research agendas and processes that will require collaborations with industry, private foundations, other agencies, S&E academies and societies, and universities. The Big Ideas represent unique opportunities to position our nation at the cutting edge—indeed to define that cutting edge—of global S&E leadership and to invest in basic research that advances the United States' prosperity, security, health and well-being.

NSF remains firmly committed to the Big Ideas, which are at different levels of readiness. The FY 2018 Budget Request to Congress details a variety of activities related to the Big Ideas that (1) continue the investment in developing the research foundations, including piloting select new programs; (2) invest in building capacity in the research community; and (3) invest in the community-wide visioning and planning that will be crucial for effective implementation in the future. Together, these FY 2018 activities position NSF--and the nation's research community--to move toward realizing the vision and potential of the Big Ideas.

NSF's BIG IDEAS

Six of the Big Ideas are research ideas, which build on a foundation made possible by earlier investments in fundamental research.

- Harnessing the Data Revolution—Engaging NSF's research community in the pursuit of fundamental research in data S&E, the development of a cohesive, federated, national-scale approach to research data infrastructure, and the development of a 21st-century, data-capable workforce.
- The Human Technology Frontier: Shaping the Future of Work—Understanding how constantly evolving technologies like artificial intelligence and robotics are actively shaping the lives of workers, and how people in turn can shape those technologies for societal benefit.
- Windows on the Universe: The Era of Multi-Messenger Astrophysics—Using powerful new syntheses of observational approaches to provide unique insights into the nature and behavior of matter and energy, and help address profound questions about the origin and evolution of the cosmos.
- The Quantum Leap: Leading the Next Quantum Revolution—Exploiting the exotic properties of quantum mechanics to observe, manipulate and control the behavior of particles and energy at atomic and subatomic scales, resulting in next-generation technologies for sensing, computing, modeling and communicating.
- Understanding the Rules of Life—Elucidating the set rules of nature that predict an organism's observable characteristics--its phenotype.
- Navigating the New Arctic—Establishing an observing network of mobile and fixed platforms and tools across the Arctic to document and understand the Arctic's rapid biological, physical, chemical and environmental changes, which affect global patterns of change.

Four of the Big Ideas are process ideas, which address NSF practices that could be altered or enhanced to capture the best research and to welcome new members of the science community.

- Mid-scale Research Infrastructure—Developing an agile process for funding experimental research capabilities in the mid-scale range.
- NSF 2026: Seeding Innovation—Investing in bold foundational research questions that are large in scope, innovative in character, originate outside of any particular directorate and require a long-term commitment.
- NSF INCLUDES (Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science):—Transforming education and career pathways to broaden participation in S&E.
- Growing Convergence Research at NSF—Framing challenging, complex research questions at inception and fostering the interdisciplinary collaborations needed for successful inquiry.

FY 2018 NSF-WIDE INVESTMENTS

NSF continues to bring together researchers from all fields of S&E to address today's cross-disciplinary questions and challenges through foundation-wide activities. In FY 2018, NSF will support seven continuing cross-foundation investments.

Understanding the Brain (UtB) ($134.46 million) encompasses ongoing cognitive science and neuroscience research and NSF's contributions to Brain Research through Advancing Innovation and Neurotechnologies Initiative. The goal of UtB is to enable scientific understanding of the full complexity of the brain, in action and in context. There remains much to discover to attain a comprehensive understanding of the general principles underlying how cognition and behavior relate to the brain's structural organization and dynamic activities; how the brain, behavior and environment interact; and how the brain can recover from lost functionality.

Risk and Resilience ($31.15 million) investments aim to improve predictability and risk assessment, and increase preparedness for extreme natural and man-made events in order to reduce their impact on the quality of life, society and the economy. In FY 2018, Prediction of and Resilience against Extreme Events (PREEVENTS) and the Critical Resilient Interdependent Infrastructure Systems and Processes (CRISP) programs will continue, along with other contributing activities. PREEVENTS is a focused research effort that will help to better understand and mitigate the risks posed to the U.S. by natural hazards. CRISP will promote research on interdependent critical infrastructures systems and processes and educate the next generation of scientists and engineers on how to best improve the resilience of our infrastructure in the face of changing and increasing risks. The projects supported will make these infrastructure services more effective, efficient, dependable, adaptable, resilient, safe and secure.

Innovations at the Nexus of Food, Energy, and Water Systems (INFEWS) ($24.40 million) aims to understand, design and model the interconnected food, energy and water system through an interdisciplinary research effort that incorporates all areas of S&E, and addresses the involvement of natural, social and human-built factors. INFEWS is the first program to study the interconnected food-energy-water nexus. This program is driven by pressing needs and challenges, such as growing U.S. and global populations, changes in land use and increasing geographic and seasonal variability in precipitation patterns, all of which are placing an ever-increasing stress on these critical resources. Through this program, NSF is uniquely poised to focus not only on the fundamental S&E questions at this nexus, but to train the next generation of researchers in this interdisciplinary area.

NSF INCLUDES (Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science) ($14.88 million) is an integrated, national initiative to increase the preparation, participation, advancement and potential contributions of those who have been traditionally underserved or underrepresented in the STEM enterprise. Providing opportunities and support for members of all communities and sectors across the U.S. is necessary for the nation's economic welfare and as part of NSF's commitment to equity. Investments aim to produce measurable, sustainable progress at the national level and to scale effective approaches to diversity and inclusion in STEM. NSF INCLUDES is one of NSF's 10 Big Ideas.

Cyber-Enabled Materials, Manufacturing, and Smart Systems (CEMMSS) ($222.43 million) aims to integrate S&E activities across NSF, including breakthrough materials, advanced manufacturing and smart systems, which includes robotics and cyber-physical systems. Research has led to discoveries of materials with unique properties and functionality that can be developed more reliably and efficiently via the integration of theory, modeling and simulation; data analytics; and experimentation. The integration of advanced materials with capabilities of intelligence is transforming static systems, processes and

edifices into adaptive, pervasive and smart systems. These smart systems will be able to act independently and intelligently in dynamic, uncertain and unanticipated environments. They will contribute to advanced manufacturing and have the potential to accelerate scientific and engineering discoveries to address key national and societal challenges critical to U.S. security and competitiveness. In FY 2018, CEMMSS will focus on increasing integration of the highest priority areas such as those related to materials and manufacturing, and the developing smart systems.

NSF Innovation Corps (I-Corps™) ($26.15 million) improves NSF-funded researchers' access to resources that can assist in bridging the gap between discoveries and technologies, helping to transfer knowledge to downstream technological applications and use at scale. In FY 2018, NSF will continue to support I-Corps™ Nodes and I-Corps Sites to further build, utilize and sustain a national innovation ecosystem that helps researchers effectively identify viable market opportunities and augments the development of technologies, products and processes that benefit the nation.

The Secure and Trustworthy Cyberspace (SaTC) ($113.75 million) investment aims to build the knowledge base in cybersecurity that enables discovery, learning and innovation, and leads to a more secure and trustworthy cyberspace. Through focus on long-term, foundational research, this program will develop the scientific foundations for cybersecurity research for years to come. SaTC also focuses on the training of the next-generation cybersecurity workforce, especially for government, and aligns NSF's cybersecurity investments with the national cybersecurity strategy.

ADDITIONAL HIGHLIGHTS

- NSF fully funds the construction of three **major research equipment and facilities projects** ($182.8 million). Funding these projects is an essential part of the S&E enterprise that enables science to advance in ways that would not otherwise be possible. These three projects are: The Daniel K. Inouye Solar Telescope, which will be the world's most powerful ground-based solar telescope and will enable astronomers to gain new insights into solar phenomena; the Large Synoptic Survey Telescope, which will produce the deepest, widest image of the universe; and the Regional Class Research Vessels, a major component in the plan for modernizing the U.S. Academic Research Fleet.

- NSF is responsible for the management of **polar facilities and logistics** ($285 million). Operational support in the Arctic and the Antarctic plays an indispensable role in allowing the nation’s scientists and the international research community to work in these regions. The U.S. is a leading nation in polar science; its research results have global significance.

- The **National Strategic Computing Initiative** (NSCI) was established to advance national leadership in high performance computing (HPC) and maximize the benefits of HPC for scientific discovery and economic competitiveness. Under NSCI, NSF will support research advances in new computing technologies, architectures and platforms for the future, as well as the development and deployment of advanced HPC systems, including maximizing their benefits through deep integration of HPC cyberinfrastructure with S&E research. NSF is one of three lead agencies for NSCI, along with the Department of Defense and the Department of Energy.

- In FY 2018, NSF will continue investments to extend the frontiers of **high-performance computing** ($60 million). This investment will support the acquisition and deployment of a new HPC system that will serve as a national resource for providing predictable and sustained long-term capabilities for S&E to push the frontiers of knowledge and ultimately promote the health, prosperity and welfare of the nation.

EDUCATION AND STEM WORKFORCE

NSF's education and STEM workforce investment, centered in the Directorate for Education and Human Resources (EHR), funds activities that support students, teachers, researchers and the public. The EHR investment in core STEM education research is critical to building the nation's knowledge base for improving STEM learning. NSF's investments for FY 2018 focus on the following priorities:

- **The CyberCorps®: Scholarship for Service (SFS)** program ($40.0 million) supports cybersecurity education and research at higher education institutions. SFS also focuses on workforce development by increasing the number of qualified students entering the fields of information assurance and cybersecurity, which enhances the capacity of the U.S. higher education enterprise to continue to produce professionals in these fields to secure the nation's cyberinfrastructure. FY 2018 activities will include engaging first- and second-year undergraduate students, especially veterans.

- **Computer Science for All (CS for All)** ($20.0 million) will build on ongoing efforts to enable rigorous and engaging computer science education in schools across the nation. Funds will support the development and assessment of prototype instructional materials, scalable and sustainable professional development models, approaches to preservice preparation for computer science teachers, and teacher resources. This activity aims to provide high school teachers with the preparation, professional development and ongoing support that they need to teach rigorous computer science courses and to give preK-8 teachers the instructional materials and preparation they need to integrate computer science and computational thinking into their teaching.

- **The Improving Undergraduate STEM Education (IUSE)** ($96.5 million) initiative supports the development of a STEM and STEM-capable workforce by investing in the improvement of undergraduate STEM education, with focus on attracting and retaining students and on degree completion. In FY 2018, $15.0 million is included for IUSE: Hispanic Serving Institutions (HSI). The primary goals of the IUSE: HSI activity are to promote research on engaged student learning at HSIs, to incentivize institutional and community transformation, to engage HSIs that have not received significant NSF funding, and to promote fundamental research about what it takes to diversify and increase participation in STEM effectively, including research that improves the understanding of how to build institutional capacity at HSIs.

- **Through the Advanced Technological Education (ATE)** ($59.0 million) program, NSF educates technicians in undergraduate programs, preparing for the high-technology fields that drive our nation's economy. ATE is actively engaged in connecting community college educators funded by the program to the Institutes for Manufacturing Innovation within the National Network for Manufacturing Innovation**.**

- **The Graduate Research Fellowships (GRF)** ($246.54 million) program recognizes students with high potential in STEM research and innovation, and provides support for them to pursue multidisciplinary research. GRF fellows may participate in Graduate Research Opportunities Worldwide (GROW), which provides opportunities to conduct research with international partner countries and organizations, and the Graduate Research Internship Program (GRIP), which provides professional development through research internships at federal agencies. In FY 2018, NSF will support 1,000 new fellows, equal to the number supported a decade ago, a reduction from the 2,000 new fellows NSF has supported annually since 2011.

- **The NSF Research Traineeship (NRT)** ($40.10 million) program invests directly in the development of the STEM workforce, and in the improvement of the education of tomorrow's STEM workforce. 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. The FY 2018 request will support approximately 11 NRT Traineeship awards and six Innovations in Education awards.

MAJOR RESEARCH EQUIPMENT AND FACILITIES CONSTRUCTION

In FY 2018, NSF requests funding to continue construction on three projects: the Daniel K. Inouye Solar Telescope (DKIST), the Large Synoptic Survey Telescope (LSST), and Regional Class Research Vessels (RCRV).

- **The Daniel K. Inouye Solar Telescope (DKIST)** ($20.0 million) will enable the study of magneto-hydrodynamic phenomena in the solar photosphere, chromosphere and corona at unprecedented spatial, temporal and wavelength resolution to gain information on the creation, interaction and ultimate annihilation of solar magnetic fields. Determining the role of magnetic fields in the outer regions of the sun is crucial to understanding the solar dynamo, solar variability and solar activity, including flares and coronal mass ejections. These can affect civil life on Earth through the phenomena generally described as "space weather" and may have an impact on the terrestrial climate. FY 2018 is year 10 of an 11-year construction process. In FY 2018, installation of the telescope mount assembly (TMA) will be completed, and commission and acceptance testing of TMA will be underway. By the end of FY 2018, the installation of the Ml main mirror will be underway and the alignment of the mirror with the laser metrology system will have begun. The first of the five, first-light instruments, the visible broadband imager (VBI), will be delivered to the site, assembled and will begin initial checkout.

- **The Large Synoptic Survey Telescope (LSST)** ($57.80 million) will be an 8-meter-class, wide-field optical telescope designed to carry out surveys of the entire sky, available from its site. LSST will collect nearly 40 terabytes of multi-color imaging data every night and will produce the deepest, widest-field sky image ever. It will image the entire sky visible from Chile twice per week, as well as issue alerts for moving and transient objects within 60 seconds of their discovery. LSST surveys will result in a comprehensive dataset that will enable hundreds of other fundamental astrophysical studies by the entire research community. FY 2018 is year five of a nine-year construction process.

- **The Regional Class Research Vessel (RCRV)** ($105.0 million) project will help satisfy the anticipated ocean science requirements for the U.S. East Coast, West Coast and Gulf of Mexico through the construction of three new research vessels. This project is a major component in the plan for modernizing the U.S. Academic Research Fleet.[1] RCRVs are important to the national interest in terms of increasing understanding on many subjects including: the potential impacts of geohazards, such as storm surges and tsunamis; transportation; natural resource identification and extraction; and fisheries and aquaculture. These vessels will also support the maintenance of coastal observing systems, such as those of the Ocean Observatory Initiative and many other

[1] National Ocean Council. (2013). *Federal oceanographic fleet status report.*
Retrieved from https://obamawhitehouse.archives.gov/sites/default/files/federal_oceanographic_fleet_status_report.pdf

moorings and platforms. This project will help ensure U.S. researchers have access to the ships required to meet scientific demands in the coming decades, and replace aging vessels with much newer, technologically capable ships.

ORGANIZATIONAL EXCELLENCE

NSF seeks to integrate mission, vision and core values to efficiently and effectively execute NSF's activities and provide the flexibility and agility required for all aspects of its operations. This goal incorporates a culture of continuous improvement to ensure effective, inclusive and accountable programs and merit review processes that provide the greatest value for taxpayer dollars. The portfolio of activities included in Organizational Excellence addresses the agency's operations and administrative functions, which underpin NSF's programmatic activities.

Staffing

In FY 2018, NSF will work towards full utilization of its established allocations of 1,443 FTE for federal staff and 199 FTE for staff hired under the Intergovernmental Personnel Act (IPAs). The foundation recognizes that maintaining staffing levels is vital to effectively and efficiently achieving its mission. NSF operates with only 7 percent overhead.

FY 2018 Priorities

In FY 2018, the primary driver of the decrease for the Agency Operations and Award Management (AOAM) account is the completion of the headquarters relocation to Alexandria, Virginia. Accompanying this is a reduction in the annual rent and utilities for the new headquarters building. Underlying the FY 2018 request is NSF's ongoing commitment to increase agency efficiency, while constraining administrative costs. This is consistent with the administration's commitment to manage programs and deliver critical services more effectively, to devote a greater percentage of taxpayer dollars to mission achievement, and to be more effective and efficient in supporting program outcomes—all while improving performance, maintaining staffing levels and providing for the 1.9 percent cost-of-living adjustment.

Concluding Remarks

Mr. Chairman, I have touched on some aspects of NSF's diverse and continually evolving portfolio; a portfolio that is responsive to the evolution of science, which changes with new discoveries and new technological capabilities.

As I continue to emphasize, robust NSF investments in discovery research have returned exceptional dividends to the American people, expanding knowledge, improving lives and strengthening our security. To keep those benefits flowing, we need to constantly replenish the wellspring of new ideas and train new talent, while serving as good stewards of the public trust. That is the fundamental and continuing mission of NSF.

In FY 2018, NSF expects to evaluate approximately 50,500 proposals through a competitive merit review process and make approximately 10,800 new competitive awards, including 8,000 new research grants. The number of new research grants decreases by roughly 11 percent from previous levels, in keeping with the overall change in total NSF funding. The process typically involves approximately 225,000 proposal reviews, engaging on the order of 34,000 members of the S&E community participating as panelists and proposal reviewers. In a given year, NSF awards reach over 1,800 colleges, universities, and other public and private institutions in 50 states, the District of Columbia and Puerto Rico. In FY 2018, NSF support is expected to reach approximately 292,000 researchers, postdoctoral fellows, trainees, teachers, and students.

I believe that the United States can continue to be on the leading edge of ideas and research. Through strong federal leadership, we can maintain the standing of our businesses and universities. We must not only maintain our position, we must actively seek to increase our strengths: leadership in fundamental discovery, including high-risk, high-reward transformational research; state-of-the-art facilities and scientific research infrastructure; and a world-class S&E workforce. With a firm commitment to these fundamental building blocks of our high-tech economy, we can solidify the role of the United States as the world leader in innovation.

NSF maintains its longstanding commitment to supporting research that drives scientific discovery, maintains America's global competitiveness, and builds the modern workforce that is critical for addressing the complex challenges that face the nation. NSF's broad portfolio positions the agency to contribute productively and rapidly to important national challenges.

With the continued support of this committee, the community, and outside experts, NSF will continue to thrive in its mission to "promote the progress of science."

This concludes my testimony. I thank you for your leadership. I will be pleased to answer any questions the Members may have.