NATIONAL SCIENCE FOUNDATION CENTERS

NSF supports a variety of centers programs that contribute to the Foundation's mission and vision. Centers exploit opportunities in science, engineering, and technology in which the complexity of the research program or the resources needed to solve the problem require the advantages of scope, scale, duration, equipment, facilities, and students. Centers are a principal means by which NSF fosters interdisciplinary research.

NSF Centers
(Dollars in Millions)

	FY 2018 Actual	FY 2019 (TBD)	FY 2020 Request	Change over FY 2018 Actual Amount	Change over FY 2018 Actual Percent
Centers for Analysis & Synthesis	$6.00	-	$4.80	-$1.20	-20.0%
Centers for Chemical Innovation	22.01	-	19.00	-3.01	-13.7%
Engineering Research Centers	68.49	-	54.66	-13.83	-20.2%
Materials Centers	46.40	-	54.00	7.60	16.4%
Science & Technology Centers	60.24	-	42.05	-18.19	-30.2%
Total	**$203.14**	**-**	**$174.51**	**-$28.63**	**-14.1%**

Description of Major Changes

Centers for Analysis and Synthesis - BIO
The FY 2020 Request of $4.80 million funds one Center for Analysis and Synthesis—the National Social-Environmental Synthesis Center (SESYNC).

SESYNC, located at the University of Maryland, is dedicated to accelerating scientific discovery at the interface of human and ecological systems. This center allows scientists from diverse disciplines to transform approaches for identifying solutions to society's most challenging and complex environmental problems. Workshops sponsored by this Center engage philosophers, sociologists, political scientists, psychologists, anthropologists, and environmental biologists (together with policy makers) to integrate broad disciplines from the outset and to set precedence for all subsequent activities. FY 2020 is the final year of the five-year renewal award and funding will provide continued support for staff and core research activities.

Centers for Chemical Innovation (CCI) - MPS
The FY 2020 Request of $19.0 million is expected to fund up to six Phase II CCIs, three continuing, one potential renewal, and up to two new centers.

CCIs accelerate the solution of fundamental chemical research challenges, produce transformative research that leads to innovation, and attract broad scientific and public interest. CCIs respond rapidly to emerging opportunities through enhanced collaborations as well as initiate high risk / high reward projects. CCIs integrate research, innovation, education, broadening participation, and informal science communication. Each CCI is focused on a chemistry challenge and assembles a multidisciplinary, multi-sector collaborative team. CCIs encompass synthesis, characterization, theory, modeling, data science and computation, along with training for students at all levels. CCIs are also actively engaged in knowledge transfer to industry and commercialization of their discoveries and new technologies.

Each year, CCIs include nearly 100 participating academic institutions, 65 non-academic partner institutions, and over 175 Senior Personnel, 100 Postdoctoral Associates, 255 Graduate Students, and 62

Undergraduate Students.

The CCI program makes awards at two levels: smaller Phase I (three-year awards) for center development, and larger Phase II for full centers (five-year awards with the potential for renewal for up to a total of ten years). In FY 2020 three continuing Phase II CCIs and one potential renewal will be funded. Five Phase I CCIs started in FY 2017 will also be eligible to compete for Phase II in FY 2020, out of which up to two new Phase II CCIs may be funded. A Phase I CCI competition will be held in FY 2020, supporting up to three new developmental awards. Phase I awards are considered part of the NSF Division of Chemistry's core research program investments as they fall under the threshold for formal NSF center awards; thus, their funding is not captured here. The themes of the new Phase I CCI are varied and include the QL, URoL, and HDR Big Ideas, as well as sustainable chemical technologies, and other topics in advanced manufacturing.

An independent CCI evaluation was funded in FY 2017 and is expected to be completed in late calendar year 2019. This evaluation is intended to inform both internal management and external stakeholders about the effectiveness of the CCI program in meeting its core mission. The CCI Program is unique within NSF in that it offers a Phase I on ramp to the larger Phase II competition. Evaluation of this on-ramp is expected within the overall CCI evaluation.

Engineering Research Centers (ERC) - ENG

The FY 2020 Request is $54.66 million. This funding levels supports 17 NSF Engineering Research Centers. The total includes initial funding for three 4th-generation Engineering Research Centers that will advance convergent engineering research to tackle high-impact challenges and benefit U.S. security, prosperity, health and society. The new ERCs will implement new strategies for effective team formation and engagement with stakeholder communities to maximize their impacts.

All NSF ERCs enable innovation, combining the energy and intellectual curiosity of university research focused on discovery with real-world engineered systems and technology opportunities through partnerships with industry. Since the program began in 1985, ERC products of innovation include more than 2,400 inventions disclosures, 2,000 patent applications filed, 800 patents awarded, and 1,300 licenses. The centers also have a successful track record for educating a technology-enabled workforce with hands-on, real-world experience. Together, the NSF ERCs have graduated 4,284 Bachelor's, 4,159 Master's, and 4,790 Doctoral degree students and impacted a total of 68,000 K–12 teachers and students. The NSF ERCs are effective at broadening participation from underrepresented groups. For example, across currently active ERCs, women comprise approximately 32 percent of those involved in center activities, in comparison to the national average of 16 percent across engineering. In addition, the percentage of underrepresented minorities participating is more than double that of engineering's national average.

The ERC program periodically commissions studies by external evaluators to examine aspects of the program, such as the effectiveness of ERC graduates in industry and the benefits of ERC membership to industry. In FY 2015, NSF funded the National Academies of Sciences, Engineering, and Medicine to study the future of center-based, multidisciplinary engineering research. The study report, delivered May 2, 2017, articulates a vision for the future of NSF-supported center-scale, multidisciplinary engineering research. After careful consideration, in FY 2018 ENG sparked new convergent engineering research collaborations through planning grants, providing 60 awards to build capacity for a new generation of engineering research centers. In October 2018 (NSF 19-503) ENG released a solicitation for the 4th generation of ERCs and anticipates awards in 2020.

The report[1] "Post-Graduation Status of Engineering Research Centers—2010" (SciTech Communications),

[1] http://erc-assoc.org/sites/default/files/topics/Grad_ERC_Report-Final.pdf

augmented by a recent update, found that 29 of the 35 centers (83 percent) that graduated after 10 years of NSF support are self-sustaining, with most NSF ERC features in place and strong financial support from other government sources and industry partners.

Materials Centers - MPS

This long-standing, flagship program will complete its triennial competition in FY 2020 and will fund up to nine new centers.

MRSECs exist as hubs to solve complex grand challenge materials problems requiring broad complementary multidisciplinary expertise within the physical sciences and engineering to understand materials phenomena, exploit materials behavior, and to create and discover new materials. Through collaborative efforts involving academics, industry, national laboratories experts, and international and educational partners, MRSECs are a primary example of what is known as transdisciplinary convergent research which typically includes synthesis, theory, characterization, evaluation, and application in interactive feedback loops.

MRSECs have five major components: (1) interdisciplinary research thrusts, (2) education and outreach, (3) industrial outreach/partnerships, (4) the materials research facilities network—providing access to more than 1,250 state-of-the art equipment instrumentation to materials researchers across the Nation—and (5) the SEED program which enables MRSECs to rapidly react/move into new high risk and potentially transformative areas not yet fully explored. Each year, MRSECs produce over 200 PhDs in STEM fields, mentor nearly 500 research experiences for undergraduate students and nearly 70 research experiences for teachers, and impact over 1 million students and parents through outreach activities such as summer camps, K-12 science curriculum development, K-12 in-school science demonstrations, development and deployment of science kits, and partnering with the Nation's top museums to create STEM-related exhibits that impact the public. Since 1994, the program has created over 161 startups and annually produces about 50 awarded patents and 30 patent licensures. MRSECs engage and assist about 250 industrial partners per year in advancing fundamental materials research that can be translated into the market place.

The FY 2020 Request of $54.0 million is expected to fund 17-18 Materials Research Science and Engineering Centers (MRSECs). FY 2019 will be spent preparing for the next MRSEC competition in FY 2020. This includes stimulating the seeding efforts built within each MRSEC to start addressing emerging research areas relevant to the Division of Materials Research. These areas include NSF's Big Ideas QL, FW-HTF, URoL, GCR, and HDR, as well as Materials Sustainable Development research. Informational sessions will take place at several university campuses across the country; potential university applicants will be attending these sessions.

Science and Technology Centers: Integrative Partnerships (STC) - multi-directorate

The FY 2020 Request of $42.05 million will support twelve existing STCs ($41.50 million) and the costs of STC program management and oversight ($550,000). The twelve existing STCs are continuing awards from the FY 2010, FY 2013, and FY 2016 cohorts. FY 2020 is the last year for providing ramped down funding for the five centers in the 2010 cohort. The competition for the FY 2021 cohort begins in FY 2019. Currently, full STC awards are for five years, with possible renewal for an additional five years, or 10 years total. The award sizes of the existing STCs are approximately $5.0 million per year with ramp down in years nine and ten.

The STC program advances interdisciplinary discovery and innovation in science and engineering through the integration of cutting-edge research, excellence in education, targeted knowledge transfer, and the development of a diverse workforce. The STC portfolio reflects NSF-supported disciplines. Examples include: engineering biological systems; energy-efficient electronics; new ways of handling the extraction, manipulation, and exchange of information; and new atomic scale imaging modalities. STCs engage the

Nation's intellectual talent and collaborate with partners in academia, industry, national laboratories, and government. STCs strengthen the caliber of the Nation's science, technology, engineering, and mathematics workforce through intellectually challenging research experiences for students, postdoctoral fellows, researchers, and educators; they advance public scientific understanding through partnerships with K-12 and informal education communities. The knowledge transfer activities focus on engaging stakeholders with the intention of supporting innovation, providing key information to public policy-makers, and disseminating knowledge from one field of science to another. To inform NSF about the progress of individual centers and the program as a whole, the STC program has developed a network of evaluators working with the centers to share information and lessons learned about the most effective way to measure progress.

Estimates for Centers Participation in 2018

	Number of Participating Institutions	Number of Partners	Total FY 2018 NSF Support ($ in millions)	Total Leveraged Support ($ in millions)	Number of Participants
Centers for Analysis & Synthesis	397	133	$6.00	$0.74	877
Centers for Chemical Innovation	85	65	22.01	7.54	809
Engineering Research Centers	534	38	68.49	2.10	4,224
Materials Centers	326	253	46.40	51.40	4,410
Science & Technology Centers	190	221	60.24	27.60	2,650

Number of Participating Institutions: All academic institutions participating in activities at the centers.

Number of Partners: The total number of non-academic participants, including industry, states, and other federal agencies at the centers.

Total Leveraged Support: Funding for centers from sources other than NSF.

Centers Supported by NSF in FY 2018

Center	Institution	State
Centers for Analysis and Synthesis		
National Institute for Mathematical & Biological Synthesis	U of Tennessee	TN
CyVERSE (formerly iPlant)	U of Arizona	AZ
Socio-Environmental Synthesis Center	U of Maryland	MD
Centers for Chemical Innovation (Phase II awards only)[2]		
Center for Chemical Evolution	Georgia Institute of Tech	GA
Center for Chemical Innovation in Solar Fuels	California Institute of Tech	CA
Center for Chemistry at the Space-Time Limit	U of California-Irvine	CA
Center for Enabling New Technologies through Catalysis	U of Washington	WA
Center for Sustainable Materials Chemistry	Oregon State	OR
Center for Sustainable Nanotechnology	U of Wisconsin	WI
Center for Sustainable Polymers	U of Minnesota	MN
NSF Center for Aerosol Impacts on Chemistry and the Environment	U of California-San Diego	CA
NSF Center for Selective C-H Functionalization	Emory	GA
Engineering Research Centers		
Advanced Self-Powered Systems of Integrated Sensors and Technologies (ASSIST)	North Carolina State	NC
Bio-mediated and Bio-inspired Geotechnics (CBBG)	Arizona State	AZ
Biorenewable Chemicals	Iowa State	IA
Center for Ultra-wide-area Resilient Electric Energy	U of Tennessee	TN

[2] Smaller, developmental Phase I awards do not meet the criteria as formal NSF Centers and so are not captured here.

Transmission Network (CURENT)		
Engineering Research Center for Innovative and Strategic Transformation of Alkane Resources (CISTAR)	Purdue	IN
Engineering Research Center for Precise Advanced Technologies and Health Systems for Underserved Populations (PATHS-UP)	Texas A&M	TX
Future Renewable Electric Energy Delivery and Management Systems (FREEDM)	North Carolina State	NC
Integrated Access Networks (CIAN)	U of Arizona	AZ
Nanomanufacturing Systems for Mobile Computing and Mobile Energy Technologies (NASCENT)	U of Texas	TX
Nanosystems Engineering Research Center for Directed Multiscale Assembly of Cellular Metamaterials with Nanoscale Precision (CELL-MET)	Boston College	MA
Nanotechnology Enabled-Water Treatment Systems (NEWT)	Rice University	TX
NSF Engineering Research Center for Cell Manufacturing Technologies (CMaT)	Georgia Institute of Tech	GA
Optimization for Electro-thermal Systems (POETS)	U of Illinois	IL
Quantum Energy and Sustainable Solar Technologies (QESST)	Arizona State	AZ
Re-inventing the Nation's Urban Water Infrastructure (ReNuWit)	Stanford	CA
Revolutionizing Metallic Biomaterials (RMB)	North Carolina A&T U	NC
Sensorimotor Neural Engineering (CSNE)	U of Washington	WA
Smart Lighting	Rensselaer Polytechnic Institute	NY
Translational Applications of Nanoscale Multiferroic Systems (TANMS)	U of California-Los Angeles	CA
Materials Centers		
Brandeis Bioinspired Soft Materials Center	Brandeis	MA
Center for Dynamics and Control of Materials	U of Texas at Austin	TX
Center for Emergent Materials	Ohio State	OH
Center for Multifunctional Materials	Northwestern	IL
Center for Nanoscale Science	Pennsylvania State	PA
Center for Polarization and Spin Phenomena in Nanoferroic Structures	U of Nebraska	NE
Chicago Materials Research Centers	U of Chicago	IL
Columbia Center for Precision Assembly of Superstratic and Superatomic Solids	Columbia	NY
Cornell Center for Materials Research	Cornell	NY
Harvard Materials Research Center	Harvard	MA
Illinois Materials Research Center	U of Illinois at Urbana-Champaign	IL
Laboratory for Research on the Structure of Matter	U of Pennsylvania	PA
Materials Research Science and Engineering Center at UCSB	U of California-Santa Barbara	CA
Materials Research Science and Engineering Center	U of Minnesota	MN
MIT Center for Materials Science and Engineering	Massachusetts Institute of Tech	MA
NYU Materials Research Science and Engineering Center	New York U	NY
Princeton Center for Complex Materials	Princeton	NJ
Soft Materials Research Center	U of Colorado	CO
UW Molecular Engineering Materials Center	U of Washington	WA
Wisconsin Materials Research Center	U of Wisconsin	WI
Nanoscale Science and Engineering Centers		
Center for the Environmental Implications of Nanotechnology (CEINT)	Duke	NC
Predictive Toxicology Assessment & Safe Implementation of Nanotechnology in the Environment (CEIN)	U of California-Los Angeles	CA
Science and Technology Centers		
BEACON: An NSF Center for the Study of Evolution in Action	Michigan State	MI

Biology with X-Ray Free Electron Lasers	SUNY Buffalo	NY
Center for Brains, Minds, and Machines: The Science and the Technology of Intelligence	Massachusetts Institute of Tech	MA
Center for Bright Beams	Cornell	NY
Center for Cellular Construction	U of California-San Francisco	CA
Center for Dark Energy Biosphere Investigations	U of Southern California	CA
Center for Emergent Behaviors of Integrated Cellular Systems	Massachusetts Institute of Tech	MA
Center for Energy Efficient Electronics Science	U of California-Berkeley	CA
Center for Engineering MechanoBiology	U of Pennsylvania	PA
Center for Integrated Quantum Materials	Harvard	MA
Science and Technology Center on Real-Time Functional Imaging	University of Colorado	CO
Center for Science of Information	Purdue	IN