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 is also funding AI and Quantum center-like institutes in FY 2021. See the NSF-Wide Investments chapter for more information on these two efforts.

NSF Centers
(Dollars in Millions)

	FY 2019 Actual	FY 2020 (TBD)	FY 2021 Request	Change over FY 2019 Actual Amount	Change over FY 2019 Actual Percent
Centers for Analysis & Synthesis	$0.05		-	-$0.05	-100.0%
Centers for Chemical Innovation	19.10		21.00	1.90	9.9%
Engineering Research Centers	58.95		50.92	-8.03	-13.6%
Materials Centers	52.51		52.51	-	-
Science & Technology Centers	53.58		57.95	4.37	8.2%
Total	**$184.19**	**-**	**$182.38**	**-$1.81**	**-1.0%**

Description of Major Changes

Centers for Analysis and Synthesis (BIO)
There is no funding for the FY 2021 Request for Centers for Analysis and Synthesis as the National Social-Environmental Synthesis Center (SESYNC) has sunset as planned. Preparation for a new competition is underway.

Centers for Chemical Innovation (MPS)
The FY 2021 Request of $21.0 million is expected to fund up to six Phase II Centers for Chemical Innovation (CCI). This includes up to five continuing centers and one new center.

The CCI program makes awards at two levels: smaller Phase I awards (three-year) for center development, and larger Phase II awards (five-year awards with potential for renewal up to a total of ten years) for full centers. In FY 2021, up to five continuing Phase II CCIs will be funded. In addition, two FY 2018 Phase I CCIs will be eligible to compete for Phase II in FY 2021; up to one new Phase II CCI is anticipated. A Phase I CCI competition will be held in FY 2021, supporting up to three new developmental awards.

The themes of the new Phase I and II CCIs are varied and include Artificial Intelligence (AI); the Big Ideas: QL, URoL, and HDR; and sustainable chemistry, synthetic biology, clean energy technologies, and other topics in Advanced Manufacturing. The CCI Program supports research centers focused on major, long-term fundamental chemical research challenges. CCIs address these challenges by producing transformative research leading to innovation and attracting broad scientific and public interest that lead to better lives for all Americans. For example, the Center for Sustainable Polymers initiated an exploratory project that uses complex molecules formed from sugars to remove trace impurities and emerging contaminants from water, which affects drinking water systems used by about 15 million people in 27 states in the United States.

CCIs are agile, collaborative entities that respond rapidly to emerging opportunities by integrating research with innovation, higher education, broadening participation, and informal science communication. A broad range of chemical research is currently represented at CCIs advancing fundamental understanding in:

chemical synthesis and catalysis; characterization, theory, computation, and modeling; data science, machine learning, and AI for molecular synthesis; and advanced manufacturing of nanomaterials; along with training for students at all levels. CCIs are also actively engaged in knowledge transfer to industry and the commercialization of their discoveries and new technologies.

Each year, CCIs include nearly 100 participating academic institutions, 74 non-academic partner institutions, and over 175 Senior Personnel, 100 Postdoctoral Associates, 255 Graduate Students, and 60 Undergraduate Students.

Engineering Research Centers (ENG)

The FY 2021 Request is $50.92 million. This funding level supports 13 NSF Engineering Research Centers (ERC). The total includes funding for three 4th-generation ERCs, funded as part of the Class of 2020 that will advance convergent engineering research to tackle high-impact challenges that have the potential to 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. Four centers from the Class of 2010 received final year NSF funding in FY 2020 as planned.

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, products of ERC innovation include more than 2,440 inventions disclosures, approximately 2,100 patent applications filed, 850 patents awarded, and 1,360 licenses. ERCs also have a successful track record for educating a technology-enabled workforce with hands-on, real-world experience. Together, NSF ERC's have graduated annually, on average, 134 Bachelor's, 128 Master's, and 150 Doctoral degree students for the past 33 years. Over that time, they have also impacted, on average, over 2,120 K-12 teachers and students annually. NSF ERCs are also effective at broadening participation from underrepresented groups. For example, across currently active ERCs, women comprise approximately 35 percent of those involved in center activities, in comparison to the national average of 24 percent across engineering. Also, the percentage of people from underrepresented groups 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.[1] 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 ERCs. In October 2018, ENG released a solicitation (NSF 19-503)[2] for the 4th-generation of ERCs and anticipates awards in FY 2020.

The program also commissioned a study on the sustainability of ERCs once NSF funding has ended. The 2010 report[3] "Post-Graduation Status of National Science Foundation Engineering Research Centers" (SciTech Communications), augmented by a 2015 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. NSF plans to commission a new study in FY 2020 that is expected to be completed in late FY 2021.

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[1] www.nap.edu/catalog/24767/a-new-vision-for-center-based-engineering-research

[2] www.nsf.gov/pubs/2019/nsf19503/nsf19503.htm

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

Materials Centers (MPS)
The FY 2021 Request of $52.51 million is expected to support 17 to 18 continuing Materials Research Science and Engineering Centers (MRSEC). A MRSEC competition is not planned for FY 2021 as this long-standing, flagship program will complete its triennial competition in FY 2020, funding up to nine new centers.

MRSECs function as hubs to solve complex grand challenge materials problems requiring broad multidisciplinary expertise within the physical sciences and engineering to understand materials phenomena, exploit materials behavior, and to create and discover new materials. Research in materials science is inherently interdisciplinary and the MRSEC program is a prime example of convergent research encompassing physics, chemistry, mathematics, biology, and engineering. Through collaborative efforts involving academics, industry, national laboratories experts, and international and educational partners, MRSECs advance materials research and education in the U.S., and in many cases are international leaders.

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. FY 2019 seeding efforts were 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, and HDR, as well as recyclable plastics and alternative materials for sustainable development, synthetic materials biology, structural materials under extreme conditions, and the use of machine learning to accelerate materials discovery.

Each year, MRSECs produce over 200 Ph.Ds. in STEM fields, mentor nearly 500 Research Experiences for Undergraduate students and 70 Research Experiences for Teachers participants, 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 172 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 marketplace.

Science and Technology Centers: Integrative Partnerships (multi-directorate)
The FY 2021 Request of $57.95 million will support a total of 12 Science and Technology Centers (STC) and the administrative costs associated with program management and oversight. Of the twelve centers, seven are continuing STCs from the FY 2013 and FY 2016 cohorts, and five will be new centers starting in FY 2021. In FY 2019, a solicitation for a new STC class was issued to replace the sunsetting 2010 cohort. The program received 188 preliminary proposals with the expectation of making five new awards in FY 2021 for a total of $25.0 million. 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: creation of atomic-scale devices and systems based on quantum materials; elucidating the mechanisms and architecture of intelligence in the human brain; studying mechanical forces in molecules, cells, and tissues of plants and animals; and developing atomic scale imaging. 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 intent of supporting innovation, providing information to policy-makers, and disseminating knowledge across scientific disciplines. For example, the Sustainability of semi-Arid Hydrology and Riparian Areas (SAHRA) STC disseminated knowledge to the community of water professionals and elected officials to help them make more scientifically informed decisions on water policy and management. The STC program also uses 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 2019

	Number of Participating Institutions[1]	Number of Partners[2]	Total FY 2019 NSF Support ($ in millions)	Total Leveraged Support ($ in millions)[3]	Number of Participants[4]
Centers for Analysis & Synthesis	239	127	$0.05	$1.37	955
Centers for Chemical Innovation	82	74	19.10	4.17	696
Engineering Research Centers	640	215	58.95	3.00	2,953
Materials Centers	291	236	52.51	53.00	4,556
Science & Technology Centers	164	212	53.58	30.40	2,230

[1] All academic institutions participating in activities at the centers.

[2] The total number of non-academic participants, including industry, states, and other federal agencies at the centers.

[3] Funding for centers from sources other than NSF.

[4] The total number of people who use center facilities, not just persons directly support by NSF.

Centers Supported by NSF in FY 2019

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)[4]		
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 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
Center for Ultra-wide-area Resilient Electric Energy Transmission Network (CURENT)	U of Tennessee	TN
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	Boston College	MA

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

Nanoscale Precision (CELL-MET)		
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
Sensorimotor Neural Engineering (CSNE)	U of Washington	WA
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)[5]	Duke	NC
Predictive Toxicology Assessment & Safe Implementation of Nanotechnology in the Environment (CEIN)[5]	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

[5] CEINT and CEIN are operating on no-cost extensions. No funds were obligated for the centers in FY 2019.