NATIONAL SCIENCE FOUNDATION CENTERS

NSF supports a variety of individual Centers and Centers programs that contribute to the Foundation's investment in *Ideas*. Centers exploit opportunities in science, engineering, and technology in which the complexity of the research problem or the resources needed to solve the problem require the advantages of scope, scale, change, duration, equipment, facilities, and students that can only be provided by an academic research center.

Centers Funding
(Dollars in Millions)

	Program Initiation (year)	FY 2005 Number of Centers	FY 2005 Actual	FY 2006 Current Plan	FY 2007 Request	Change over FY 2006 Amount	Change over FY 2006 Percent
Centers for Analysis and Synthesis	1995	2	7.07	6.39	6.46	0.07	1.1%
Chemistry Centers	1998	6	3.00	1.48	3.00	1.52	102.7%
Earthquake Engineering Research Centers	1988	3	6.00	6.00	-	-6.00	-100.0%
Engineering Research Centers	1985	19	62.31	63.42	62.79	-0.63	-1.0%
Materials Centers	1994	29	52.41	53.66	55.70	2.04	3.8%
Nanoscale Science and Engineering Centers	2001	15	36.40	37.21	37.35	0.14	0.4%
Science and Technology Centers	1987	13	49.65	62.38	67.48	5.10	8.2%
Science of Learning Centers	2003	4	19.83	22.71	27.00	4.29	18.9%
Total, Centers		91	$236.67	$253.25	$259.78	$6.53	2.6%

Totals may not add due to rounding.

In 2005, NSF's senior management updated principles that govern investments in Centers. This review reaffirmed the Foundation's commitment to Centers funding and the objective that Centers must push towards research frontiers not normally attainable through individual investigations.

As part of this analysis, all directorates were asked to review programs reported as Centers against the updated principles. Those that did not meet the stated principles were recharacterized and funding was moved to the Fundamental Science and Engineering investment category. The outcome was presented to and accepted by the National Science Board during their August 2005 meeting.

Centers Recharacterization
(Dollars in Millions)

	FY 2005 Current Plan	Percent of 2005 Total Budget	Percent of 2005 R&RA Budget
Pre-Centers assessment	$351	6.4%	8.3%
Amount recharacterized	$119	2.2%	2.8%
Post-Centers assessment	$232	4.2%	5.5%
Percent change in Centers-identified programs	-34%		

Some of the major categories of research no longer characterized as Centers include Long Term Ecological Research (LTER) projects, Plant Genome research, Math Research Institutes, and Children's Research Initiative programs. Among the key elements of the updated principles are that NSF Centers are merit-reviewed, with one of the review criteria being the added value of supporting frontier research using the center mode of support versus the individual investigator mode, and that NSF's support for Centers is of limited duration – a maximum of 10 years, with a built-in phase-out period.

CENTERS DESCRIPTIONS

Centers for Analysis and Synthesis (BIO)
The National Center for Ecological Analysis and Synthesis (NCEAS) at the University of California at Santa Barbara promotes integrative studies of complex ecological questions and serves as a locus for the synthesis of large data sets. The goals of the center are to advance the state of ecological knowledge through the search for universal patterns and principles and to organize and synthesize ecological information so that it will be useful to researchers, policy makers, and resource managers addressing important environmental issues. The Center supports in-house working groups, post-doctoral associates, and sabbatical visits by senior scientists, all on a competitive basis. A Science Advisory Board serves to screen proposals annually.

The National Evolutionary Synthesis Center (NESCent) at Duke University, North Carolina State University, and the University of North Carolina at Chapel Hill provides mechanisms to foster synthetic, collaborative, cross-disciplinary studies in evolutionary biology. This plays a pivotal role in the further unification of the biological sciences as it draws together knowledge from disparate biological fields and increases our general understanding of biological design and function. The Center has a critical role in organizing and synthesizing evolutionary knowledge that is useful to policy makers, government agencies, educators, and society. The established Center will continue to develop new tools and cross-disciplinary standards for management of biological information and meta-information, support data analysis capabilities with broad utility across the biological sciences, host workshops bringing together scientists from a variety of disciplines to integrate various approaches to the field, and begin to host and curate databases important to evolutionary synthesis.

Chemistry Centers (MPS)
The Chemical Bonding Centers (CBCs) are designed to support major, long-term "big questions" in basic chemical research. Problems to be addressed are high-risk but with potentially high scientific and societal impact. CBCs are expected to be agile, responding to scientific opportunities as they arise, and to take advantage of cyberinfrastructure. These centers provide diverse ways for groups of researchers in the chemical sciences to work collaboratively on challenging problems of fundamental and strategic importance. These problems include the activation of strong bonds as a means to decrease energy requirements in chemical processing, the design of self-replicating biological molecules with the capability of evolving enhanced function, and the rational synthesis of "smart materials". Additional centers are fabricating molecular machines that are powered by chemical bond formation, investigating the efficient storage of solar energy in synthetic molecules, and probing the inner workings of molecular events with unprecedented spatial and temporal resolution.

Earthquake Engineering Research Centers (ENG)
Earthquake Engineering Research Centers focus on reducing earthquake losses, integrating research and education, and developing partnerships with industry and public agencies responsible for earthquake hazard mitigation. Funding for these Centers will sunset as planned in FY 2006.

Engineering Research Centers (ENG)
The Engineering Research Centers (ERC) program stands as a landmark in federal support for university research and education in partnership with industry. These centers provide an environment where academe and industry focus together on advances in the complex engineered systems that transform industrial processing systems and product lines most important for the Nation's future. ERCs bring diverse engineering and scientific disciplines together to address fundamental research issues at the interface between the discovery-driven culture of science and the innovation-driven culture of engineering. They provide the intellectual foundation for industry collaboration with faculty and students to resolve generic, long-range challenges, producing the knowledge needed to ensure steady advances in technology, speed their transition to the marketplace, and train graduates who are effective in applying them in industry.

ERCs are also devoted to the integration of research and education by creating collaborative environments for learning and research and producing curricula and course materials for bioengineering, multimedia information systems, manufacturing, electronic packaging, and particle science and technology, among others. In addition, all ERCs have active programs to stimulate interest in engineering among pre-college students and their teachers; several have sites at local museums to educate the general public about engineering and technology.

Materials Centers (MPS)
Materials Research Science and Engineering Centers (MRSECs) support interdisciplinary materials research addressing fundamental problems of intellectual and strategic importance. They support shared experimental facilities, place strong emphasis on the integration of research and education at all levels, and provide support to stimulate emerging areas of materials research. The MRSECs feature cutting-edge materials research in areas such as polymers, biomimetic and biomolecular materials, magnetic and ferroelectric materials, nanoscale materials, electronic and photonic materials, structural materials, and organic systems and colloids.

The MRSECs have strong links to industry and other sectors. MRSECs also involve research and educational partnerships among academic institutions in the U.S. as well as international partnerships. The 2005 MRSEC competition yielded two new centers devoted to biotechnology and materials interfaces, respectively. Three existing centers will be phased out.

Nanoscale Science and Engineering Centers (multi-directorate)
As part of the multi-agency National Nanotechnology Initiative, NSF first funded these Centers in FY 2001; additional Centers have been added since that time. Research at the nanoscale aims to advance the development of the ultra-small technology that will transform electronics, materials, medicine, environmental science and many other fields. Each center has a long-term vision for research. Together they provide coherence and a long-term outlook to U.S. nanotechnology research and education. Support will be provided for education and outreach programs from K-12 to the graduate level, designed to develop a highly skilled workforce, advance pre-college training, and advance the public understanding of nanoscale science and engineering. The Centers have strong partnerships with industry, national laboratories, and international centers of excellence.

Science and Technology Centers (multi-directorate)
NSF's Science and Technology Centers (STC) Integrative Partnerships Program supports discovery and innovation in the integrated conduct of research, education, and knowledge transfer in fields of basic science, mathematics, and engineering. STCs foster partnerships that build a new collaborative culture among researchers and educators at all levels in academia, industry, government laboratories, and other

public and private organizations. The Centers provide opportunities to explore challenging and complex research problems that often require interdisciplinary expertise and high-risk approaches, access to state-of-the-art instrumentation and facilities, and a commitment of high levels of support for sustained periods.

STCs have an impressive record of research accomplishments, research training, contributions to K-12 education, and timely transfer of knowledge and technology from the laboratory to industry and other sectors. Traditional barriers among disciplines and among university, governmental, and industrial laboratories have been reduced, creating a new mode of leadership and management in research and education. STCs have engaged the nation's intellectual talent, robustly drawn from its full human diversity, in the conduct of research and education activities; enabled the training of undergraduate students, graduate students, and postdoctoral fellows; involved scores of industrial researchers in basic research; and spawned new companies, products, and jobs. STCs also create partnerships and programs that transfer knowledge in service to society with respect to new research areas, promising new instrumentation, and potential new technologies.

Science of Learning Centers (multi-directorate)
NSF's investment builds on the Foundation's support for multidisciplinary research that advances fundamental knowledge about the science of learning. Science of Learning Centers (SLC) are built around a unifying research focus and incorporate a diverse, multidisciplinary environment involving appropriate partnerships with academia, industry, international partners, all levels of education, and other public and private entities. Funding is designed to support a diverse portfolio of research, providing leadership across a broad range of science and engineering approaches to the science of learning research.

FY 2005 Estimates for Selected Centers

(Dollars in Millions)

	Number of Participating Institutions	Number of Partners	Total NSF Support	Total Leveraged Support	Number of Participants
Centers for Analysis and Synthesis	4	20	$7	$2	736
Chemistry Centers	53	19	$3	$4	269
Earthquake Engineering Research Centers	65	155	$6	$10	1,130
Engineering Research Centers and Groups	280	482	$62	$72	8,310
Materials Centers	103	325	$52	$42	5,274
Nanoscale Science and Engineering Centers	130	269	$36	$16	1,630
Science and Technology Centers[1]	94	306	$50	$28	2,118
Science of Learning Centers	20	11	$20	$8	366

[1] Statistics reported for STCs are for 2004 only. Information is not yet available for new Centers funded at the end in FY 2005.

Number of Participating Institutions: all academic institutions that participate in activities at the centers.

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

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

Number of Participants: the total number of people who use center facilities, not just persons directly supported by NSF.

Centers Supported by NSF in FY 2005

Center	Institution	State
Centers for Analysis and Synthesis		
National Center for Ecological Analysis and Synthesis (NCEAS)	U of California-Santa Barbara	CA
National Evolutionary Synthesis Center (NESCent)	Duke, NC State, U of N. Carolina	NC
Chemistry Centers		
Activation and Transformation of Strong Bonds	U of Washington	WA
Chemical Design of Materials	U of California-Santa Barbara	CA
Chemistry at the Space:Time Limit: Time Resolved Nonlinear Spectroscopy of Elementary Chemical Events	U of California-Irvine	CA
Center for Molecular Cybernetics	Columbia	NY
Darwinian Chemical Systems	Mass. General Hospital	MA
Powering the Planet: A Chemical Bonding Center for the Direct Conversion of Sunlight into Chemical Fuel	California Institute of Tech	CA
Earthquake Engineering Research Centers		
Mid-America Earthquake Center	U of Illinois-Champaign-Urbana	IL
Multidisciplinary Center for Earthquake Engineering Research	State U of NY-Buffalo	NY
Pacific Earthquake Engineering Research Center	U of California-Berkeley	CA
Engineering Research Centers		
Advanced Engineering Fibers and Films	Clemson	SC
Bioengineering Educational Technology	Vanderbilt	TN
Biomimetic Microelectronic Systems	U of Southern California	CA
Biotechnology Process Engineering	Mass Institute of Tech	MA
Collaborative Adaptive Sensing of the Atmosphere	U of Mass-Amherst	MA
Computer-Integrated Surgical Systems and Technologies	Johns Hopkins	MD
Engineered Biomaterials	U of Washington	WA
Engineering of Living Tissue	Georgia Institute of Tech	GA
Environmentally Beneficial Catalysis	U of Kansas	KS
Environmentally Benign Semiconductor Manufacturing	U of Arizona	AZ
Extreme Ultraviolet Science and Technology	Colorado State	CO
Integrated Media Systems	U of Southern California	CA
Low Cost Electronic Packaging	Georgia Institute of Tech	GA
Neuromorphic Systems Engineering	California Institute of Tech	CA
Particle Science & Technology	U of Florida	FL
Power Electronic Systems	Virginia Tech	VA
Reconfigurable Machining Systems	U of Michigan	MI
Subsurface Sensing and Imaging Systems	Northeastern	MA
Wireless Integrated MicroSystems	U of Michigan	MI
Materials Centers		
Center for Complex Materials	Princeton	NJ
Center for Materials for Information Science	U of Alabama	AL
Center for Materials Research	Cornell	NY
Center for Materials Science and Engineering	Mass Institute of Tech	MA
Center for Micro- and Nanomechanics of Materials	Brown	RI
Center for Multifunctional Nanoscale Materials Structures	Northwestern	IL
Center for Nanoscopic Materials Design	U of Virginia	VA
Center for Nanomagnetic Structures	U of Nebraska	NE
Center for Nanoscale Science	Pennsylvania State	PA
Center for Nanostructured Interfaces	U of Wisconsin	WI
Center for Polymer Science and Engineering	U of Massachusetts	MA
Center for Polymers at Engineered Interfaces	SUNY-Stony Brook, CUNY, Polytech	NY

Center for Polymer Interfaces and Macromolecular Assemblies	Stanford, UC-Davis, IBM	CA
Center for Research on Interface Structures and Phenomena	Yale	CT
Center for Response-Driven Polymeric Films	U of Southern Mississippi	MS
Center for Science and Engineering of Materials	California Institute of Tech	CA
Center for Semiconductor Physics in Nanostructures	U of Oklahoma, U of Arkansas	OK, AR
Center for Thermal Spray Research	SUNY-Stony Brook	NY
Center on the Science and Engineering of Magnetoelectronics	Johns Hopkins	MD
Ferroelectric Liquid Crystals Materials Research Center	U of Colorado-Boulder	CO
Genetically Engineered Materials Science and Engineering Center	U of Washington	WA
Laboratory for Research on the Structure of Matter	U of Pennsylvania	PA
Materials Research Center	U of Chicago	IL
Materials Research Center	Harvard	MA
Materials Research Science and Engineering Center	U of California-Santa Barbara	CA
Materials Research Science and Engineering Center	U of Maryland	MD
Materials Research Science and Engineering Center	U of Minnesota	MN
Materials Research Science and Engineering Center	Carnegie Mellon	PA
Materials Research Science and Engineering Center	Columbia	NY
Nanoscale Science and Engineering Centers		
Affordable Nanoengineering of Polymer Biomedical Devices	Ohio State	OH
High Rate Nanomanufacturing	Northeastern, U of New Hampshire, U of Mass-Lowell	MA
Integrated Nanomechanical Systems	U of Calif-Berkeley, Cal Tech, Stanford, U of Calif-Merced	CA
Molecular Function at the Nano/Bio Interface	U of Pennsylvania	PA
Integrated Nanopatterning and Detection Technologies	Northwestern	IL
Probing the Nanoscale	Stanford, IBM	CA
Nanoscale Systems in Information Technologies	Cornell	NY
Science of Nanoscale Systems and their Device Applications	Harvard	MA
Templated Synthesis and Assembly at the Nanoscale	U of Wisconsin-Madison	WI
Electronic Transport in Molecular Nanostructures	Columbia	NY
Nanoscience in Biological and Environmental Engineering	Rice	TX
Directed Assembly of Nanostructures	Rensselaer Polytechnic Inst	NY
Center for Integrated and Scalable Nanomanufacturing	U of California-Los Angeles	CA
Nanoscale Chemical-Electrical-Mechanical Manufacturing Systems	U of Illinois-Champaign-Urbana	IL
Nanotechnology in Society Network	Ariz St, U of Calif-Berkeley, U of Southern Calif, Harvard	AZ, CA, MA
Science and Technology Centers		
Adaptive Optics	U of California-Santa Cruz	CA
Advanced Materials for Water Purification	U of Illinois	IL
Behavioral Neuroscience	Georgia State	GA
Biophotonics Science and Technology	U of California-Davis	CA
Center for Remote Sensing of Ice Sheets	U of Kansas	KS
Earth Surface Dynamics	U of Minnesota	MN
Embedded Networked Sensing	U of California-Los Angeles	CA
Environmentally Responsible Solvents and Processes	U of North Carolina	NC
Integrated Space Weather Modeling	Boston U	MA
Materials and Devices for Information Technology Research	U of Washington	WA
Nanobiotechnology	Cornell	NY
Sustainability of Semi-Arid Hydrology and Riparian Areas	U of Arizona	AZ
Ubiquitous Secure Technology	U of California-Berkeley	CA

Science of Learning Centers

C-CEN - Center for Cognitive and Educational Neuroscience	Dartmouth College	NH
CELEST - A Center for Learning in Education, Science, & Tech.	Boston U	MA
The LIFE Center - Learning in Formal and Informal Environments	U of Washington	WA
Pittsburgh Science of Learning Center - Studying Robust Learning with Learning Experiments in Real Classrooms	Carnegie Mellon	PA

Recent Research Highlights

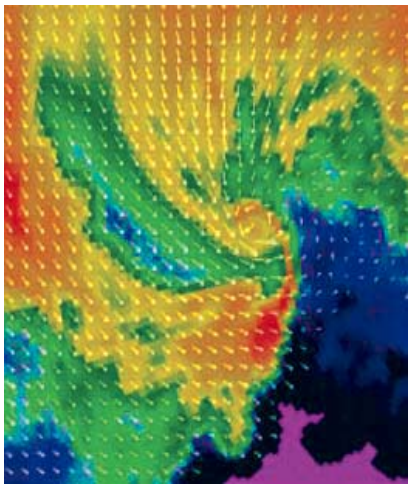
Aplysia califonica. *Photo courtesy of Columbia University.*

► **Sea Slug Mixes Ingredients to Produce a Chemical Defense with Antimicrobial Properties:** A team of researchers from the NSF-supported Center for Behavioral Neuroscience (CBN) has found that when the sea slug *Aplysia* is threatened by predators, it defends itself by drawing on a hidden stash of two ingredients that combine to create a potent ink. The slug stores the normally inert chemicals separately in two glands and then releases them simultaneously into its mantle cavity at the precise time when they are needed. One component of the ink also has strong antibacterial properties and is being studied for its potential applications by the healthcare and marine industries. CBN is a consortium of eight metro Atlanta colleges and universities, led by Georgia State University, that focuses on increasing our understanding of the neurobiology of complex social behaviors.

Other CBN studies have led to breakthrough treatments for anxiety-related disorders and a new understanding of the role neurochemicals play in the formation of social bonds between animals. In addition to research, CBN has a comprehensive education program designed to improve science literacy and attract more women and underrepresented minorities to neuroscience programs.

► **Radar Algorithms for Automatically Detecting Tornadoes:** Using data from networks of low-power Doppler weather radars, researchers have developed the first algorithms for dynamically detecting tornadoes. The Engineering Research Center (ERC) for Collaborative Adaptive Sensing of the Atmosphere (CASA), headquartered at the University of Massachusetts-Amherst, designed the algorithms to distinguish tornadoes from transient but intense low-altitude shear regions within severe storms. For the first time, CASA's radars can now see close to the ground, thus locating a tornado and determining its intensity.

The algorithms reconstruct a three-dimensional wind field based on estimates from multiple Doppler radars. Because real data are not yet available from new CASA radars soon to be deployed in Oklahoma, high-resolution computer simulations of storms and their associated tornadoes are being used in the interim. This image shows one such simulated data set processed by the algorithm, with the tornado located in the region of swirling flow in the right-center portion of the image.



Simulated data processed by an algorithm. *Credit: ERC for Collaborative Adaptive Sensing of the Atmosphere.*