ENGINEERING $764,520,000
+$71,180,000 / 10.3%

Engineering Funding
(Dollars in Millions)

	FY 2008 Actual	FY 2009 Current Plan	FY 2009 ARRA Estimate	FY 2010 Request	Change Over FY 2009 Plan Amount	Change Over FY 2009 Plan Percent
Chemical, Bioengineering, and Transport Systems (CBET)	$132.81	$146.02	$60.40	$160.11	$14.09	9.6%
Civil, Mechanical, and Manufacturing Innovation (CMMI)	161.11	174.84	57.76	191.66	16.82	9.6%
Electrical, Communications, and Cyber Systems (ECCS)	83.60	87.35	45.84	95.75	8.40	9.6%
Industrial Innovation and Partnerships (IIP)[1/]	130.72	141.23	55.00	156.00	14.77	10.5%
SBIR/STTR	*109.07*	*119.21*	*50.00*	*132.52*	*13.31*	*11.2%*
Engineering Education and Centers (EEC)[2/]	116.02	117.45	32.00	132.00	14.55	12.4%
Emerging Frontiers in Research and Innovation (EFRI)	25.23	26.45	14.00	29.00	2.55	9.6%
Total, ENG	**$649.49**	**$693.34**	**$265.00**	**$764.52**	**$71.18**	**10.3%**
Major Components:						
Research and Education Grants	528.36	568.86	234.00	629.71	60.85	10.7%
Centers Programs	92.07	92.06	21.00	102.00	9.94	10.8%
Facilities O&M	29.06	32.42	10.00	32.81	0.39	1.2%

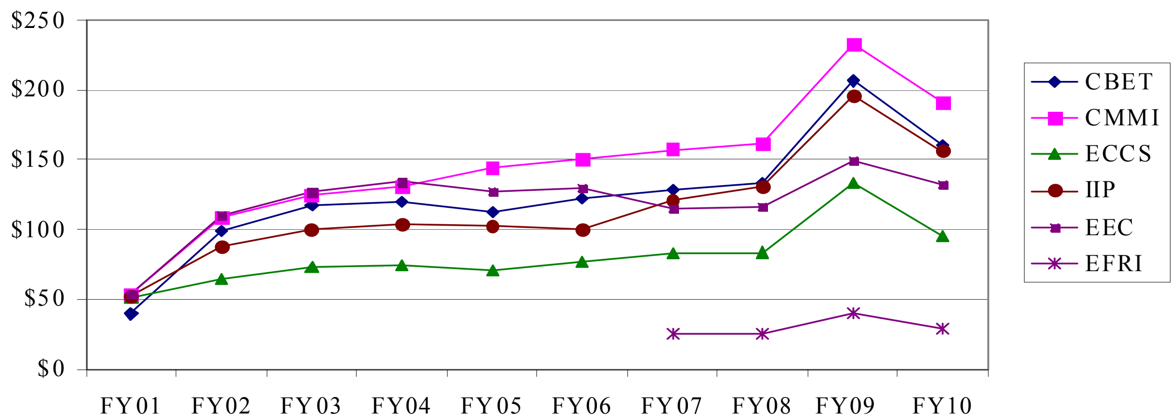
Totals may not add due to rounding.

[1/] Funding for Partnerships for Innovation (PFI) will be transferred in FY 2010 from Integrative Activities (IA) to the Directorate for Engineering, which manages the program. Funding for PFI is shown for all years for comparability.

[2/] Funding for the Science of Learning Center (SLC) within the Division for Engineering Education and Centers is included for all years for comparability. SLC will be cofunded with the Directorate for Social, Behavioral and Economic Sciences beginning in FY 2010.

The NSF Directorate for Engineering (ENG) provides critical support for the Nation's engineering research activities and is a driving force behind the training and development of the U.S. engineering workforce. ENG supports fundamental research, the creation of cutting-edge facilities and tools, and broad interdisciplinary collaborations. ENG also enhances the competitiveness of U.S. companies through its centers, partnerships, and small business programs.

ENG Subactivity Funding
(Dollars in Millions)



Engineering in Context

ENG provides approximately 45 percent of the total federal support for university-based, fundamental engineering research. The directorate's work impacts students and the research community, the business community, and the Nation as a whole. By making education an essential element of its grants and centers, and by supporting research experiences for teachers, undergraduates, graduate students, and new faculty, ENG helps prepare the future engineering workforce to innovate and compete in the global economy. By emphasizing interdisciplinary, high-risk, and potentially transformative engineering research, the directorate encourages the research community to advance the frontiers of knowledge and tackle increasingly complex problems. Through its centers and the Small Business Innovation Research program, the directorate speeds the translation of promising fundamental research into innovations that can be commercialized.

ENG has supported a wide range of critical breakthroughs essential to the Nation's prosperity, security, quality of life, and economic competitiveness. These include creative ways to make the Nation's physical infrastructure more sustainable and resilient; revolutionary advances in sensor technologies; catalytic methods for creating biofuels; new techniques for medical diagnostics and treatments; commercial-scale production of high-quality nanomaterials; novel methods for monitoring and treating drinking water supplies; and a host of others in a portfolio generated by thousands of grantees.

To identify new opportunities and challenges for transformative engineering research, the directorate supports workshops and projects each year. Examples of past workshops are:

- the annual Frontiers of Engineering Symposia (National Academy of Engineering, www.nae.edu/frontiers),
- the Simulation-Based Engineering and Science Workshop (World Technology Evaluation Center, www.wtec.org or www.wtec.org/sbes/workshop/FinalWS-20080425/SBES-allpresentations-30Apr08-lowres.pdf),
- Grand Challenges for Engineering (National Academy of Engineering, www.engineeringchallenges.org).

The FY 2010 Request for ENG includes $35.0 million to leverage activities across the directorate aimed at increasing support for transformative research. Examples of potential foci for these investments include innovative processes for identifying potentially transformative research, special solicitations and competitions, and increased use of specialized funding mechanisms, notably NSF's EAGER (EArly-concept Grants for Exploratory Research).

Directorate-wide Changes and Priorities

Disciplinary and Interdisciplinary Research (+$39.05 million, to a total of $369.64 million).

ENG will continue to build on its strong system of merit review and investigator-initiated proposals, which advance the frontiers of knowledge and innovation by working across traditional boundaries and encouraging multidisciplinary, cutting-edge, and high-impact research. ENG represents a broad and synergistic convergence of fields, disciplines, and frontier opportunities. This supports both newly emerging fields and long-standing challenges that are poised for major advancement. The Office of Emerging Frontiers in Research and Innovation will continue to identify, prioritize, and fund emerging areas in engineering research, innovation, and education.

Engineering Research Centers (ERC) (+$9.65 million, to a total of $63.20 million).
Increased funding will support three new Generation-3 centers and the planned growth of the FY 2008 class of ERCs.

Small Business Innovation Research/Small Business Technology Transfer (SBIR/STTR) (+$13.31 million, to a total of $132.52 million).
This funding increase meets the mandated agency spending target of 2.8 percent of the agency's extramural research budget.

Science and Engineering Beyond Moore's Law (+$7.0 million, to a total of $10.00 million).
Engineering contributions are fundamental to advances in this area. For example, research in nanomanufacturing, photonics, and micro- and nanoelectronics will result in the new materials and devices—such as silicon microelectronics that exploit properties at the quantum level—required to realize computing capacity beyond the limits suggested by Moore's Law.

CAREER (+$4.85 million, to a total of $50.70 million).
The CAREER program remains the primary mechanism for jump-starting junior faculty toward independent careers in research and education. ENG provides a portion of its research investment each year towards CAREER. The increased funding in FY 2010 will fund at least twelve additional CAREER grants.

Cyber-enabled Discovery and Innovation (CDI) (+$3.00 million, to a total of $14.00 million).
Investment in CDI seeks to infuse computational thinking into all areas of engineering, bringing computational capabilities into the traditional experimentation-observation-analysis-theory research paradigm. ENG supports CDI with contributions from the CBET, CMMI, and EEC divisions. The ENG investment in CDI will focus on the development of the next generation of computationally-based discovery concepts and tools to deal with data-rich and interacting systems.

Industry/University Cooperative Research Centers (+$750,000, to a total of $7.85 million).
Engineering support provided to each center will increase by approximately $10,000 per center. The NSF investment in this program leverages investment of approximately $65.0 million annually from industry, university, state, and other federal partners.

Program Evaluation and Performance Improvement

The Performance Information chapter describes the Foundation's performance evaluation framework, which is built upon the four strategic outcome goals in NSF's Strategic Plan: *Discovery, Learning, Research Infrastructure*, and *Stewardship*. Performance evaluation is conducted at all levels within the Foundation, using both qualitative and quantitative measures—including an agency-wide annual review of research and education outcomes by an external expert committee and periodic reviews of programs and portfolios of programs by external Committees of Visitors and directorate Advisory Committees. Other performance indicators, such as funding rates, award size and duration, and numbers of people supported on research and education grants, are also factored into the performance assessment process.

ENG convenes Committees of Visitors, composed of qualified external evaluators, to review each division every three years. These experts assess the integrity and efficiency of the processes for proposal review and provide a retrospective assessment of the quality of results of NSF's investments. The Chemical, Bioengineering, Environmental, and Transport Systems (CBET) and Civil, Mechanical, and Manufacturing Innovation (CMMI) division will be reviewed in FY 2009, and the Industrial Innovation and Partnerships (IIP) division and the Office of Emerging Frontiers in Research and Innovation (EFRI) will be reviewed in FY 2010.

Number of People Involved in ENG Activities

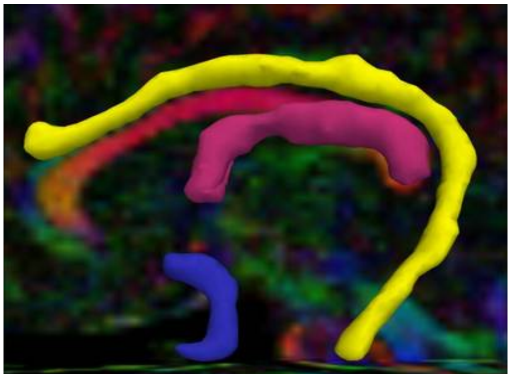
	FY 2008 Estimate	FY 2009 Estimate	FY 2009 ARRA Estimate	FY 2010 Estimate
Senior Researchers	6,809	7,252	2,860	7,868
Other Professionals	1,337	1,424	548	1,545
Postdoctorates	331	353	136	383
Graduate Students	6,327	6,738	2,594	7,310
Undergraduate Students	2,819	3,002	1,156	3,257
Total Number of People	17,623	18,769	7,294	20,363

ENG Funding Profile

	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate
Statistics for Competitive Awards:			
Number of Proposals	9,644	10,770	11,170
Number of New Awards	1,967	2,789	2,470
Regular Appropriation	1,967	2,040	2,470
ARRA	-	749	-
Funding Rate	20%	26%	22%
Statistics for Research Grants:			
Number of Research Grant Proposals	7,220	8,303	8,610
Number of Research Grants	1,159	1,775	1,540
Regular Appropriation	1,159	1,300	1,540
ARRA	-	475	-
Funding Rate	16%	21%	18%
Median Annualized Award Size	$100,000	$101,000	$101,500
Average Annualized Award Size	$112,540	$113,500	$114,000
Average Award Duration, in years	3.1	3.0	3.0

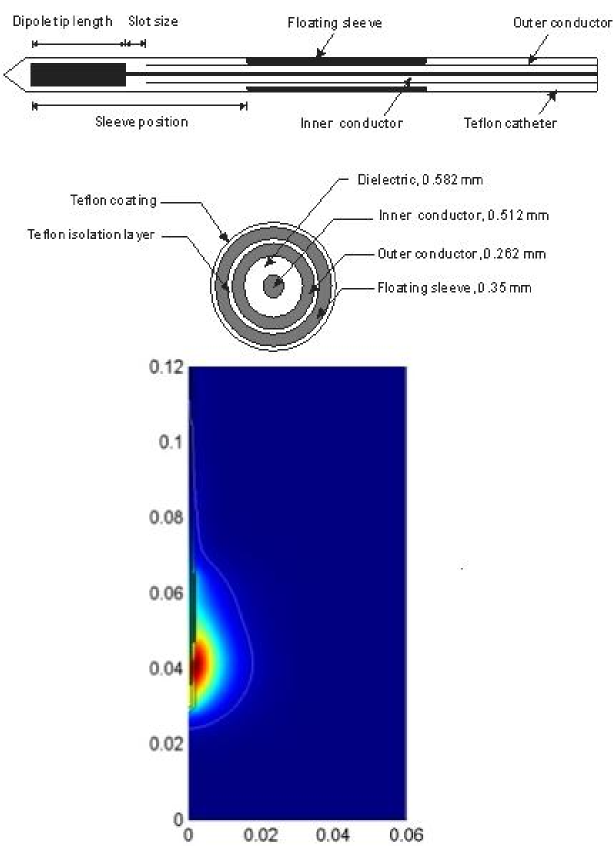
Recent Research Highlights

► **Medical Images Benefit from Algorithm:** A new technique to improve the usefulness of brain scans could be a boon to medicine. The approach combines systems and control, computer vision, and image processing to track objects in dynamically changing environments. For the first time, the technique allows researchers to robustly and efficiently extract key brain structures, such as major neural connections known as "fiber tracts," which impact just about every aspect of brain imaging. This technique can aid image-guided therapy, assist image-guided surgery and treatment, and detect diseases such as schizophrenia. The same technique can be applied to novel virtual colonoscopy as a minimally invasive method to identify suspicious polyps in screening for colon cancer.



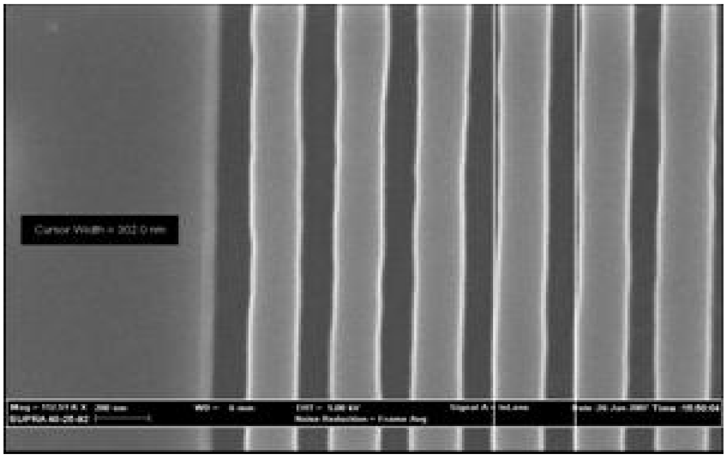
Three key neural fiber bundles are located in a human brain using the shape-based tractography technique on diffusion tensor magnetic resonance imagery. *Credit: Georgia Institute of Technology.*

► **Simulation Techniques That Improve Cancer Treatment:** What do microwave antennas have to do with cancer treatment? By inserting a thin coaxial cable into cancerous tissue to transmit the microwave power, the heat from microwaves can be used to shrink or eliminate tumors. Designing the antenna's radiation pattern is critical to achieving a heating pattern that removes only the cancerous tissue. To assess and design new antennas for treatment, researchers at the University of Wisconsin and Georgia Institute of Technology combined clinical knowledge with state-of-the-art computer simulation models. Their new designs will ablate the cancerous tissue without seriously damaging the healthy tissue and will limit radiation exposure. Using their modeling scheme, the researchers determined that the resulting antenna would provide a 27 percent improvement over the standard design used in clinical treatment. They also developed a modeling scheme that considers individual tissue variation so that treatment can be tailored to each patient's needs.



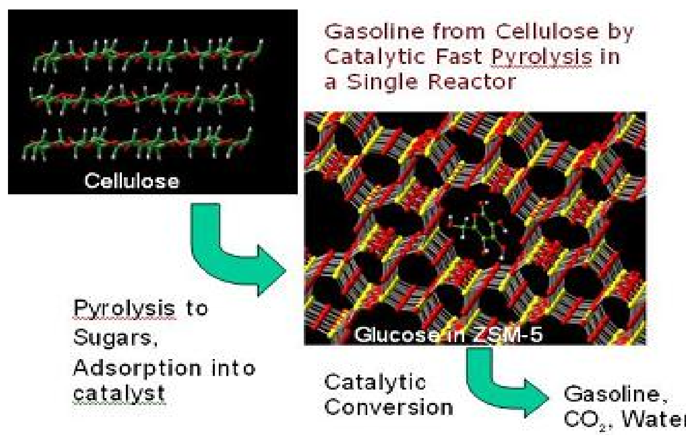
By optimizing microwave antenna design, University of Wisconsin researchers demonstrated it is possible to ablate cancerous tumors without causing severe damage to surrounding noncancerous tissue. *Credit: Michael Ferris, Univ. of Wisconsin.*

► **A Better Light Trap Improves Efficiency of Solar Cells:** Development of a thin film with almost complete light absorption will make it possible to create solar cells with unprecedented efficiency. To achieve high efficiency, it is essential to trap light in a way that increases the absorption path length in the thin film. A research team at the Massachusetts Institute of Technology has developed a new light-trapping scheme using a novel photonic crystal backside reflector. The reflector increases the optical path length more than 104 times the thin film's thickness for almost complete light absorption. This optimized back reflector will significantly increase thin film Si solar cell efficiency; for a 2-mm thick (silicon) thin-film solar cell, the relative efficiency enhancement is expected to be as high as 53 percent. The researchers fabricated the design at the University of New Mexico node of the National Nanotechnology Infrastructure Network using a process that can be scaled up at low cost.



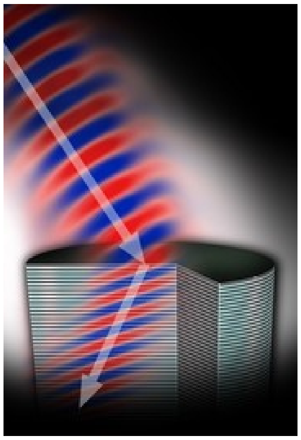
Scanning electron microscope image of a thin film patterned with interference lithography tool. *Credit: University of New Mexico.*

► **A One-Step Process to Convert Cellulose into Gasoline:** Biofuels from plant sources such as switchgrass and forest waste are becoming vital as our society moves away from petroleum-derived resources. The current roadblock to producing these new biofuels is the lack of economical processes to convert the plant matter into liquids. The ideal process would selectively produce a liquid biofuel from solid biomass in a single, small reactor. A group of researchers at the University of Massachusetts at Amherst recently demonstrated that gasoline range aromatics and olefins can be produced from solid biomass quickly and in high yields in a single reactor over zeolite-based catalysts. The process, named "catalytic fast pyrolysis," addresses the needs of the recently passed Energy Independence and Security Act of 2007, which mandates increased production of renewable fuels.



In one reactor, cellulose is broken up into sugar fragments that interact with a catalyst to become aromatic compounds used for gasoline. *Credit: George Huber, University of Massachusetts at Amherst.*

► **Bending Light Backwards:** In nature, light waves and other forms of electromagnetic radiation bend when they pass from one medium into another, but they continue to move forward. Using alternating layers of different semiconductors, Princeton University researchers have created a new optical "metamaterial" that causes light to bend backwards. This behavior has significant potential for optical components such as lenses for magnification and imaging. Princeton's invention is the first three-dimensional metamaterial that bends light backwards and is composed of semiconductors for ease in manufacturing. The metamaterial has relatively low optical loss and functions over a very wide range of mid-infrared wavelengths. With these features, the metamaterial has tremendous potential to be used in devices such as chemical threat sensors, communications equipment, and medical diagnostics tools. For science fiction fans, it means cloaking devices like those featured in Star Trek and Harry Potter are one step closer to reality.



Light bends backwards in a new optical metamaterial with a negative index of refraction. The material is crafted from alternating layers of semiconductors (indium-gallium-arsenic and aluminum-indium-arsenic). *Credit: Claire Gmachl.*

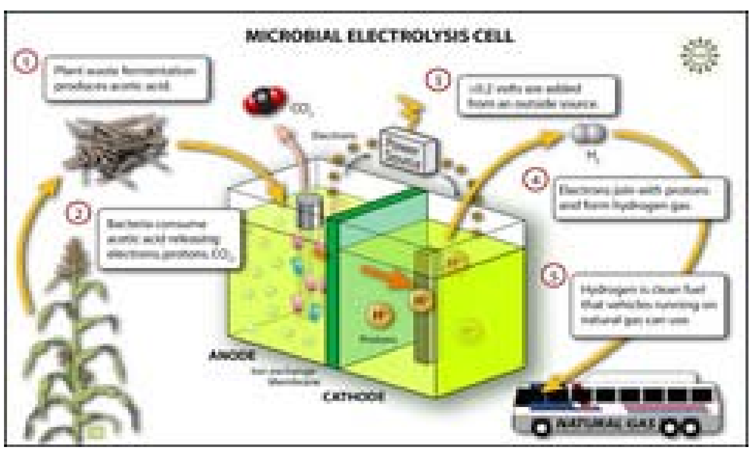
► **Bridges Get All Shook Up:** Researchers at the University of Nevada-Reno are testing the performance of entire four-span bridges and individual bridge components by subjecting them to simulated earthquake ground motion. This is the first system that can examine the interactions between components and assess the performance of the entire bridge system. In light of recent events such as the Minneapolis Interstate 35W bridge collapse and earthquake-related failures, such research to ensure a strong and resilient national infrastructure is critical. In the laboratory in Reno, researchers are building and testing large-scale models of existing bridges and innovative infrastructure with seismic-resistant design. Researchers from the University of California at San Diego and Florida International University, as well as Japan's Tokyo Institute of Technology, are collaborating in the testing. This project, which uses the George E. Brown, Jr., Network for Earthquake Engineering Simulation (NEES) infrastructure, will advance fundamental understanding and will help to improve the design criteria and seismic codes to ensure better bridge performance in future earthquakes.

Model bridge tested at the University of Nevada at Reno. *Credit: M. Saiidi, University of Nevada, Reno.*

► **Touch Robot Mimics Human Arm:** NSF-funded research by Western Robotics of Kirtland, Ohio, has created a Touch Robot with low inertia links, low friction joints, and totally smooth actuation – in short, a robot with dynamics similar to the human arm. This breakthrough means it can be made to work the way humans do, by using force and tension, rather than by repeating positions like conventional robots. When a robot interacts compliantly with its environment, just like a person, it can sense, react, and adjust to variations and imprecision. NSF-funded work at the University of Michigan combines the Touch Robot technology with Michigan's noncontact precision inspection technology. The goal is to close the loop between inspection and product manufacture, making manufacturing equipment that works intelligently and ensures every part is made correctly. The work is initially focused on smoothing and shaping jet engine turbine blades, a difficult, injurious manufacturing process that has resisted automation. Ultimately, this technology may allow robots to perform a variety of strenuous and hazardous tasks in manufacturing.

Mockup of integrated inspection and robotic turbine blade finishing system. *Credit: Western Robotics.*

► **Microbes Churn out Hydrogen at Record Rate:** Starting from raw materials that can include waste streams, a team of researchers at Pennsylvania State University reports progress toward practical generation of electric power or hydrogen by microbial fuel cells. The team recently announced they have increased hydrogen yield to a new record for this type of system, with the addition of a small jolt of electricity. Yields as high as 91 percent from vinegar and 68 percent from cellulose were achieved. Incorporating all energy inputs and outputs, the overall efficiency of the vinegar-fueled system is better than 80 percent, far better than the efficiency for generating ethanol. The researchers note that microbial fuel cells can be used to generate electric power if the objective is not to produce hydrogen.



Researchers designed a microbial electrolysis cell in which bacteria break up acetic acid (a product of plant waste fermentation) to produce hydrogen gas with a very small electric input from an outside source. Hydrogen can then be used for fuel cells or as a fuel additive in vehicles that now run on natural gas. *Credit: Zina Deretsky, National Science Foundation.*

CHEMICAL, BIOENGINEERING, ENVIRONMENTAL, AND TRANSPORT SYSTEMS $160,110,000 +$14,090,000 / 9.6%

Chemical, Bioengineering, Environmental, and Transport Systems Funding

(Dollars in Millions)

	FY 2008 Actual	FY 2009 Current Plan	FY 2009 ARRA Estimate	FY 2010 Request	Change Over FY 2009 Plan Amount	Percent
Total, CBET	**$132.81**	**$146.02**	**$60.40**	**$160.11**	**$14.09**	**9.6%**
Major Components:						
Research and Education Grants	119.88	132.37	57.00	146.46	14.09	10.6%
Centers	9.63	9.95	-	9.95	-	-
Nanoscale Science and Engineering Centers	*5.63*	*5.95*	-	*5.95*	-	-
STC: Ctr. for Advanced Materials for Water Purification	*4.00*	*4.00*	-	*4.00*	-	-
Facilities	3.30	3.70	3.40	3.70	-	-
National Nanotechnology Infrastructure Network	*3.30*	*3.70*	*3.40*	*3.70*	-	-

The Chemical, Bioengineering, Environmental, and Transport Systems division (CBET) supports research to enhance and protect U.S. national health, energy, environment, and security. Through CBET, the physical, life, and social sciences are merged in engineering research and education, resulting in advances in the rapidly evolving fields of bioengineering and environmental engineering, and in areas that involve the transformation and/or transport of matter and energy by chemical, thermal, or mechanical means. CBET investments contribute significantly to the knowledge base and to the development of the workforce for major components of the U.S. economy, including chemicals, pharmaceuticals, medical devices, forest products, metals, petroleum, food, textiles, utilities, and microelectronics. CBET supports research in biotechnology and the chemical, environmental, biomedical, mechanical, civil, and aerospace engineering disciplines.

To achieve synergy across disciplinary boundaries, CBET is organized into four program clusters: Chemical, Biochemical, and Biotechnology Systems; Biomedical Engineering and Engineering Healthcare; Environmental Engineering and Sustainability; and Transport and Thermal Fluids Phenomena.

In general, 65 percent of the CBET portfolio is available for new research grants. The remaining 35 percent is used primarily to fund continuing grants made in previous years.

FY 2010 Funding

CBET will continue to allocate the majority of its budget to research and education grants. The current balance emphasizing new over continuing grants provides the division with the opportunity to support the most cutting-edge research and educational programs. In addition, CBET will continue to participate in major NSF-wide investments, such as Cyber-enabled Discovery and Innovation (CDI), Science and Engineering Beyond Moore’s Law (SEBML), and to support Nanoscale Science and Engineering Centers (NSEC), the National Nanotechnology Infrastructure Network (NNIN), and a Science and Technology Center (STC) in the area of water purification.

Funding for research and education grants supports work in areas at the intersection of engineering and the physical, life, and social sciences, such as catalysis, chemical process design, environmental engineering, advanced materials, fuel cells, fluid flow, combustion, heat transfer, and particulate processes. These investments contribute to advances that are important for energy, the environment, transportation, information technologies, health-related products, and other national priorities that both impact our daily lives and sustain and enhance U.S. competitiveness.

Current high-emphasis areas include multi-disciplinary research funded through programs across the division and with support from outside the division. This cross-disciplinary research leads to improved biosensors, biomaterials, controlled drug release, improved medical devices and instrumentation, artificial organs, therapeutic agent bioprocessing, bioremediation, water and waste treatment, and food engineering.

Changes by Activity/Cluster

CBET Research and Education Grants (+$14.09 million, to a total of $146.46 million).
Research and Education Grants from CBET's programs support interdisciplinary, frontier research in many national priority areas. CBET will increase funding for these grants in order to raise the division's funding rate, particularly in the areas of energy, environment, and sustainability; nanoscale science and engineering; and complex engineered and natural systems. Within this larger investment, funding will also support the following cross-Foundation investments:

- *Science and Engineering Beyond Moore's Law (+$2.0 million, to a total of $2.70 million).* This increase from CMMI reflects the priority this research takes within the division and the engineering community, and the importance of the innovations that will come from these investigations. Support will focus on research exploiting quantum states and interactions, new connection architectures, and new algorithms that will significantly advance computations ability. Frontier research areas included: new materials, new control principles, massive parallelism and designed asynchronicity and interdeterminacy.

- *Cyber-enabled Discovery and Innovation (CDI) (+$1.10 million, to a total of $5.23 million).* The academic communities funded by CBET rely on high-performance computing for multi-scale modeling of biomedical, biological, and behavioral systems. Investment in CDI builds capacity for high-performance computing. To advance efforts in multi-scale modeling and encourage its connections with experimental efforts, in FY 2010 CBET will increase funding of projects involving CDI through its disciplinary programs.

CIVIL, MECHANICAL, AND MANUFACTURING INNOVATION

$191,660,000
+$16,820,000 / 9.6%

Civil, Mechanical, and Manufacturing Innovation Funding
(Dollars in Millions)

	FY 2008 Actual	FY 2009 Current Plan	FY 2009 ARRA Estimate	FY 2010 Request	Change Over FY 2009 Plan Amount	Change Over FY 2009 Plan Percent
Total, CMMI	**$161.11**	**$174.84**	**$57.76**	**$191.66**	**$16.82**	**9.6%**
Major Components:						
Research and Education Grants	134.28	144.01	56.00	160.65	16.64	11.6%
Centers	5.93	7.11	-	7.11	-	-
Nanoscale Science and Engineering Centers	*5.13*	*6.31*	-	*6.31*	-	-
National Institute for Science Education	*0.55*	*0.55*	-	*0.55*	-	-
National Center for Learning and Teaching	*0.25*	*0.25*	-	*0.25*	-	-
Facilities	20.90	23.72	1.76	23.90	0.18	0.8%
Network for Earthquake Engineering Simulation	*19.20*	*21.82*	-	*22.00*	*0.18*	*0.8%*
National Nanotechnology Infrastructure Network	*1.70*	*1.90*	*1.76*	*1.90*	-	-

The Civil, Mechanical, and Manufacturing Innovation division (CMMI) supports fundamental research leading to advances that promote the global competitiveness of the nation's manufacturing sector; enhance the sustainability and resiliency of the nation's civil infrastructure; help protect the nation from extreme natural events; and economically improve the nation's health care systems. Approximately 69 percent of the funding allocated to the division is available for new research grants, with the remaining 31 percent applied primarily to fund continuing awards made in previous years.

CMMI programs are organized into four clusters: Advanced Manufacturing; Mechanics and Engineering Materials; Resilient and Sustainable Infrastructures; and Systems Engineering and Design. The **Advanced Manufacturing** Cluster is comprised of the Nanomanufacturing, Materials Processing and Manufacturing, Manufacturing and Construction Machines and Equipment, and Manufacturing Enterprise Systems programs. The research and education projects funded by these programs are concerned with every stage of the manufacturing process. The **Mechanics and Engineering Materials** Cluster includes the Materials and Surface Engineering, Structural Materials and Mechanics, Mechanics of Materials, Geomechanics and Geotechnical Systems, and Nano and Biomechanics programs. The **Resilient and Sustainable Infrastructures** Cluster includes the Geotechnical Engineering, Hazard Mitigation and Structural Engineering, Infrastructure Management and Extreme Events, Civil Infrastructure Systems, and the George E. Brown, Jr. Network for Earthquake Engineering Simulation Research (NEESR) programs. The Network for Earthquake Engineering Simulation (NEES) is a system of 15 experimental facilities located at universities across the United States that work together via cyberinfrastructure. This distributed research facility addresses important challenges in earthquake and tsunami engineering research that previously could not be addressed, such as testing structures at near to full scale. The **Systems Engineering and Design** Cluster consists of the Operations Research, Engineering Design and Innovation, Control Systems, Service Enterprise Systems, Sensors and Sensing Systems, and Dynamical Systems programs.

CMMI also promotes the funding of multidisciplinary research and cross-divisional activities through the Interdisciplinary and Cross-divisional Activities program.

FY 2010 Funding

High-emphasis areas for FY 2010 will include civil infrastructure protection, resilience and sustainability; energy manufacturing; megaquakes/megacities; and competitive manufacturing and service enterprises. Funding for research in **civil infrastructure protection, resilience, and sustainability** will enable accelerated progress in understanding the interactions between different elements of civil infrastructure and between people and infrastructure during times of extreme events, leading to knowledge that enables the development of a more resilient and sustainable complex of infrastructure and to more appropriate and effective approaches to recovery from attacks and natural disasters. Funding for research in **energy manufacturing** will enable the manufacturing sector to provide crucial solutions to the Nation's energy problems, enable scale-up of promising energy technologies, and revitalize the manufacturing sector of the U.S. economy. This research focus will include technologies that enhance the availability of energy to the Nation and promote a cleaner, safer environment. Research supported in the area of **megaquakes/megacities** will focus on providing new information to enable better regulation and construction for withstanding extreme events, such as earthquakes and tsunamis, and to mitigate the hazards that these threats impose on people. Funding for **competitive manufacturing and service enterprises** will enable research that provides new technologies for improving the nation's manufacturing and service enterprises. Health care and transportation systems in particular can benefit from the implementation of advanced engineering approaches to manufacturing, including scheduling, resource allocation, and quality control.

Changes by Activity/Cluster

CMMI Research and Education Grants (+$16.64 million, to a total of $160.65 million).

Funds will be allocated to high-quality proposals across CMMI programs to enable the division to raise its success rate in support of the NSF strategic plan. Within this larger investment, funding will also support the following cross-Foundation investments:

- *Science and Engineering Beyond Moore's Law (+$2.0 million, to a total of $2.70 million).* This increase from CMMI reflects the priority this research takes within the division and the engineering community, and the importance of the innovations that will come from these investigations. Efforts in CMMI will concentrate on advanced manufacturing methods for nanoscale circuitry.

- *Cyber-enabled Discovery and Innovation (CDI) (+$900,000, to a total of $4.34 million).* CMMI will increase funding of projects involving CDI through its disciplinary programs. CMMI will support research to model both manufacturing and civil infrastructure systems as interacting networks of communicating system elements, the behaviors of which evolve with time. Such an approach has broad application to intelligent transportation systems, built structures and their attendant utilities and supporting services, and manufacturing supply chains and the accompanying codes and regulations, business relationships, and economic environments in which they all operate.

CMMI Facilities (+$180,000, to a total of $23.90 million).

Additional funding for operations and maintenance costs of George E. Brown, Jr. Network for Earthquake Engineering Simulation provides for inflationary increases within the headquarters function of the 15-site national network.

ELECTRICAL, COMMUNICATIONS, AND CYBER SYSTEMS $95,750,000 +$8,400,000 / 9.6%

Electrical, Communications, and Cyber Systems Funding

(Dollars in Millions)

	FY 2008 Actual	FY 2009 Current Plan	FY 2009 ARRA Estimate	FY 2010 Request	Change Over FY 2009 Plan Amount	Percent
Total, ECCS	**$83.60**	**$87.35**	**$45.84**	**$95.75**	**$8.40**	**9.6%**
Major Components:						
Research and Education Grants	75.69	79.46	41.00	90.52	11.06	13.9%
Centers	3.36	2.66	-	-	-2.66	-100.0%
STC: The NanoBiotechnology Center	*3.36*	*2.66*	-	-	*-2.66*	*-100.0%*
Nanoscale Science and Engineering Centers	*3.25*	*3.40*	-	*3.40*	-	-
Facilities	4.55	5.23	4.84	5.23	-	-
National Nanotechnology Infrastructure Network	*4.55*	*5.23*	*4.84*	*5.23*	-	-

The Division of Electrical, Communications, and Cyber Systems (ECCS) will address fundamental research issues at the nano, micro, and macro scales underlying device and component technologies, power and energy, controls, networks, communications, computation, and cyber technologies. ECCS will support integration of systems principles in complex engineering systems and networks for a variety of applications areas, including health care, environment, energy, communications, disaster mitigation, homeland security, transportation, and manufacturing. ECCS envisions a research community that will address major technological challenges for the next generation of devices and systems due to convergence of technologies and increased emphasis on interdisciplinary research. ECCS will integrate education into its research programs to ensure preparation of a diverse workforce to meet the technological challenges of a 21st century global economy. In general, 65 percent of ECCS funds are available for new research grants; the remaining 35 percent of funds are in continuing grants made in prior years.

ECCS organizes its research and education activities into three programs: Electronics, Photonics and Device Technologies; Power, Controls and Adaptive Networks; and Integrative, Hybrid and Complex Systems. ECCS supports instrument acquisition through NSF's Major Research Instrumentation program. ECCS has lead oversight and provides funding for a Science and Technology Center in the area of Nano-Biotechnology, which receives its final year of NSF support in FY 2009. The division provides partial funding for several Nanoscale Science and Engineering Centers. ECCS also has lead oversight for the National Nanotechnology Infrastructure Network, an integrated national network of user facilities for research and education in nanoscale science, engineering, and technology, which has been renewed for an additional five-year award period with funding by all NSF research and education directorates and the Office of International Science and Engineering.

FY 2010 Funding

The **Electronics, Photonics and Device Technologies** (EPDT) program will invest in research and education to advance innovation and fundamental understanding of devices and component technologies based on the principles of electronics, photonics, magnetics, organics, electromechanics, and related physical phenomena at the micro- and nanoscale. The program's investments in nanotechnology research are significant and span the areas of nanoelectronics, nanophotonics, and nanomagnetics.

The **Power, Controls and Adaptive Networks** (PCAN) program will invest in research and education in the design and analysis of adaptive and complex engineering systems and networks, including sensing, imaging, controls, and computational technologies for a variety of application domains.

The **Integrative, Hybrid and Complex Systems** (IHCS) program is intended to spur visionary systems-oriented activities in collaborative research and education environments for multidisciplinary integrative activities. The program will focus on innovative research in micro- and nanosystems, communications systems, and cyber systems that integrate physical devices and components with controls, computational intelligence, and networks.

ECCS will support education and workforce development through foundation-wide and Engineering programs, such as CAREER, Increasing the Participation and Advancement of Women in Academic Science and Engineering Careers (ADVANCE), and through Research Experiences for Undergraduates (REU), Research Experiences for Teachers (RET), and Graduate Research Supplements programs.

Changes by Activity/Cluster

Research and Education Grants (+$11.06 million, to a total of $90.52 million).

ECCS will increase funding for highly meritorious research and education activities. Research from investigator-initiated proposals expands the body of knowledge and has the potential for transformative advances in areas of national priority such as energy, infrastructure, health care, security, and economic competitiveness. This increase will enable ECCS to both increase the number and size of its awards. Within this larger investment for research and education grants, funding will also support the following investments.

- *Cyber-Physical Systems (+$4.51 million, to a total of $7.01 million).* Cyber-physical systems deeply integrate computation, communications, and control into physical systems. They can transform how we interact with the physical world and how engineered systems can be realized. ECCS and the Directorate for Computer and Information Science and Engineering (CISE) are collaborating on this important topic and plan to reissue a joint solicitation in FY 2010. ECCS is increasing support for this collaboration, because the engineering community has strongly responded to the opportunity for ground-breaking research supported by this solicitation.

- *Science and Engineering Beyond Moore's Law (+$3.0 million, to a total of $4.60 million).* This NSF-wide investment area is central to ECCS's support of research on nanoelectronics and spin electronics device technologies that focus on concepts beyond the scaling limits of silicon technology. This additional contribution from ECCS reflects the priority this research takes within the division and the engineering community, and the importance of the innovations that will come from these investigations.

- *Cyber-enabled Discovery and Innovation (CDI) (+$1.0 million, to a total of $4.44 million).* Investment in CDI builds capacity for high-performance computing. To advance efforts in multi-scale modeling and encourage its connections with experimental efforts, in FY 2010 ECCS will increase funding of projects involving CDI through its disciplinary programs.

INDUSTRIAL INNOVATION AND PARTNERSHIPS $156,000,000 +$14,770,000 / 10.5%

Industrial Innovation and Partnerships Funding

(Dollars in Millions)

	FY 2008 Actual	FY 2009 Current Plan	FY 2009 ARRA Estimate	FY 2010 Request	Change Over FY 2009 Plan Amount	Change Over FY 2009 Plan Percent
Total, IIP	**$130.72**	**$141.23**	**$55.00**	**$156.00**	**$14.77**	**10.5%**
Major Components:						
Small Business Innovation Research (SBIR)	97.51	106.59	44.70	118.49	11.90	11.2%
Small Business Technology Transfer (STTR)	11.56	12.62	5.30	14.03	1.41	11.2%
Grant Opportunities for Academic Liaison w/ Industry (GOALI)	5.79	5.73	2.50	6.44	0.71	12.4%
Industry/University Cooperative Research Centers (I/UCRC)	6.67	7.10	2.50	7.85	0.75	10.6%
Partnerships for Innovation (PFI)[1/]	9.19	9.19	-	9.19	-	-

[1/] Funding for Partnerships for Innovation (PFI) will be transferred in FY 2010 from Integrative Activities (IA) to the Directorate for Engineering, which manages the program. Funding for PFI is shown for all years for comparability.

The Division of Industrial Innovation and Partnerships (IIP) serves the entire foundation by fostering partnerships to transform discoveries into technological innovations with societal benefits. IIP is home to two NSF small business research programs, the Small Business Innovation Research (SBIR) program and the Small Business Technology Transfer (STTR) program. Additionally, IIP leverages industrial support through three research programs, the Industry/University Cooperative Research Centers (I/UCRC) program, the Grant Opportunities for Academic Liaison with Industry (GOALI) program, and the Partnerships for Innovation (PFI) program.

FY 2010 Funding

Each year, the NSF SBIR and STTR programs (mandated by Public Law 106-554 and 107-50, respectively) support ground-breaking research by U.S. small businesses on topics that span the breadth of NSF scientific and engineering research and reflect national and societal priorities. The SBIR and STTR programs target research that is too risky for even early-stage corporate investment, but that, if successful, has the potential for further development and commercialization with investment from capital markets and strategic partners. Although SBIR and STTR are two distinct NSF programs, until recently they both invited proposals from one common solicitation that reflected broad topics. To manage the business community's increasing interest in STTR grants, IIP has begun issuing a separate STTR solicitation. The program's current focus is on multifunctional materials, an area of significant NSF fundamental research with strong innovation potential. This program offers an excellent opportunity to translate academic research into commercial innovations in bio-inspired materials and systems, materials for sustainability, and smart materials and structures by partnering with the small business community.

The SBIR program is aligned into four technology clusters: biotech and chemical technologies; education applications; information and communication technologies; and nanotechnology, advanced materials, and manufacturing. These topics are well positioned to attract research proposals from the small business community; moreover, they are of interest to large corporations that see the potential for strategic partnerships with small businesses, as well as to investors who seek to support and grow new businesses.

The I/UCRCs work closely with industry to develop the enabling technologies needed for national priorities, such as managing the electrical power system, improving manufacturing and biological processes, and improving information and telecommunications technologies. The I/UCRC program provides modest seed funds and management expertise to highly leveraged centers, with states joining in many partnerships to expand the impact of center activities on local economic development. The program also supports a supplemental activity to advance the fundamental science and engineering research underlying the center technologies. The I/UCRC program, in collaboration with the NSF SBIR/STTR programs, recently began supporting academic-small business partnerships as a means to accelerate the innovation process through synergistic opportunities. To further expand the range of businesses involved in the centers, the program is examining additional options for industry participation besides the traditional center memberships and SBIR/STTR partnerships. Due to interest from centers, the I/UCRC program is exploring ways to maintain NSF involvement in graduating centers and to encourage international collaborations.

The GOALI program seeks to increase partnerships between the academic and industrial communities. The program leverages its budget with support from other NSF academic research programs by a factor of four to one. In FY 2010, the GOALI program will continue to seek opportunities to accelerate innovation by strengthening the discovery knowledge base for a quicker translation of discovery to societal benefit.

The PFI program connects knowledge created in the discovery process to learning and innovation. Goals are to: stimulate knowledge transformation created by the national research and education enterprise into innovations that create new wealth, build strong economies, and improve the national well-being; broaden participation to more fully meet the range of workforce needs of the national innovation enterprise; and enhance infrastructure necessary to foster and sustain innovation in the long-term. Partnerships must include a U.S. academic institution as lead and a private sector partner; state/local government partners are also encouraged. In FY 2010, PFI will continue to support partnerships that foster learning and innovation. Funding for Partnerships for Innovation (PFI) will be transferred in FY 2010 from Integrative Activities (IA) to the Directorate for Engineering, which manages the program.

Changes by Activity/Cluster

Small Business Innovation Research (+$11.90 million, to a total of $118.49 million). The increase for the Small Business Innovation Research program (SBIR) will support the anticipated significant increase in Phase I proposals. The interest level for research funding from the small business community has already been very high, which is a reflection of the 2009 economic climate. Further, to help sustain ongoing research by Phase II grantees, some funding will be used for additional supplements.

Small Business Technology Transfer (+$1.41 million, to a total of $14.03 million). NSF received significantly more proposals in response to the FY 2009 STTR solicitation on multifunctional materials. IIP will use the requested FY 2010 increase for the STTR program to raise the funding rate.

Industry/University Cooperative Research Centers (+$750,000, to a total of $7.85 million). The funding increase for the I/UCRC program will be used to support 8 additional centers. The recently expanded partnerships between I/UCRC and SBIR/STTR to graduated awardees will be supported by the increase in funding.

Grant Opportunities for Academic Liaison with Industry (+$710,000 to a total of $6.44 million). The increase for the GOALI program will be used to target growing interest from industry members for supporting post-doctoral fellows in industry. Such an effort will provide future faculty members with experience in an industrial innovation ecosystem and thereby strengthen their ability to educate and train future entrepreneurs and innovators.

ENGINEERING EDUCATION AND CENTERS $132,000,000 +$14,550,000 / 12.4%

Engineering Education and Centers Funding
(Dollars in Millions)

	FY 2008 Actual	FY 2009 Current Plan	FY 2009 ARRA Estimate	FY 2010 Request	Change Over FY 2009 Plan Amount	Change Over FY 2009 Plan Percent
Total, EEC	**$116.02**	**$117.45**	**$32.00**	**$132.00**	**$14.55**	**12.4%**
Major Components:						
Research and Education Grants	52.60	53.90	13.50	60.25	8.55	15.9%
Centers	63.42	63.55	18.50	71.75	8.20	12.9%
Engineering Research Centers	*53.42*	*53.55*	*18.50*	*59.55*	*6.00*	*11.2%*
Nanoscale Science and Engineering	*10.00*	*10.00*	-	*10.00*	-	-
Science of Learning Center [1/]	-	-	-	*2.20*	*2.20*	*N/A*

[1/] Funding for the Science of Learning Center (SLC) is added for all years for comparability. SLC will be cofunded with the Directorate for Social, Behavioral and Economic Sciences (SBE) beginning in FY 2010.

The Engineering Education and Centers (EEC) Division promotes and facilitates university interdisciplinary research and curricula by supporting innovative programs that integrate research and education, improve the quality of the engineering workforce, cut across disciplines, develop partnerships with industry, and enable a breadth of investigation that spans the inception of an idea to proof of concept.

The division's programs are divided into three major categories: (1) Major Centers (Engineering Research Centers and Nanoscale Science and Engineering Centers), for the support of interdisciplinary research that fosters partnerships among academe, government, and industry; (2) Engineering Education Research, for advancing the quality and productivity of both undergraduate and graduate engineering pedagogy; and (3) Human Resources, for the development of a diverse and capable engineering workforce. EEC programs address issues that are critical to all fields of engineering and complement the research and education portfolios of the other divisions of the Directorate for Engineering. In general, 15 percent of the EEC portfolio is available for new grants each year, while 85 percent is used primarily to fund grants made in previous years for centers, graduate fellowships, and undergraduate programs.

FY 2010 Funding

In FY 2010, EEC will continue to support Engineering Research Centers, Nanoscale Science and Engineering Centers, engineering education research, and engineering workforce development.

In FY 2010, 15 ERCs will receive funding to support research that includes: biomaterials for implants, power electronics, detection and warning systems for severe storms, and systems for delivery and management of renewable electric energy. ERCs initiated in FY 2008 or later, known as Generation-3 ERCs, place increased emphasis on innovation and entrepreneurship, partnerships with small research firms, and international collaboration and cultural exchange. These added dimensions speed the translation of fundamental research to innovations in U.S. industry and prepare engineering graduates to succeed in a global economy.

The ongoing NSECs, fully or partially supported by EEC, perform research to advance the development of the ultra-small technology that will transform electronics, materials, medicine, and many other fields.

They involve key partnerships with industry, national laboratories, and other sectors; NSECs also support education programs from the graduate to the pre-college levels designed to develop a highly skilled workforce. Funds are also provided to smaller interdisciplinary teams and to the Network for Computational Nanotechnology (www.nanoHub.org), a web-accessible repository of simulations of nanoscale phenomena for research and education.

Research programs for engineering education are aimed at transforming engineering education to produce an engineering workforce that is diverse and creative, understands the impacts of its solutions on both technical and social systems, and possesses the ability to adapt to the rapidly evolving technical environment in industry, academe, and society.

A second focus for engineering education in FY 2010 will be to encourage engineering schools to recruit and serve veterans, particularly those who receive education benefits under the new GI Bill. Effective August 1, 2009, the Post-9/11 GI bill will provide veterans, service members, and members of the National Guard and Selected Reserve with support in reaching their educational goals.

EEC offers grants to develop the engineering workforce through two human resources programs: the Research Experiences for Undergraduates (REU) program and the Research Experiences for Teachers (RET) program. The REU program supports undergraduate engineering students in summer research internships under the tutelage of a senior engineering professor; in FY 2008, about 1,500 undergraduates participated in the program.

Changes by Activity/Cluster

Centers (+$6.0 million, to a total of $69.55 million).

The FY 2010 increase will enable the addition of three new Generation-3 ERCs as part of the Class of 2010 and will also provide for the planned growth of recently awarded centers in line with the phased funding approach. The increase will enhance the ability of the ERC program to further impact competitiveness and stimulate job creation in two ways: by initiating collaborative research partnerships to translate ERC research advances into innovative new products; and by increasing the involvement of pre-college teachers to bring engineering to pre-college classrooms and stimulate student interest in engineering careers.

Human Resources (+$700,000, to a total of $14.70 million).

Additional FY 2010 funds will be used to expand two successful EEC programs that focus on the engineering workforce. The first program that EEC seeks to expand is the Research Experiences for Undergraduates (REU) program; $500,000 is requested to support two additional REU sites at U.S. universities to diversify the regions and topics involved in the program. The second program that EEC seeks to expand is the Research Experiences for Teachers (RET) program; EEC requests an additional $200,000 to support two additional site awards for this successful program.

Engineering Education (+$700,000, to a total of $12.85 million).

The requested increase will be used to address and bolster the project on personalized learning in engineering education, and the project on encouraging engineering schools to recruit and serve veterans, which EEC will accomplish by providing planning grants and disseminating the plans.

EMERGING FRONTIERS IN RESEARCH AND INNOVATION $29,000,000

+$2,550,000 / 9.6%

Emerging Frontiers in Research and Innovation Funding

(Dollars in Millions)

	FY 2008 Actual	FY 2009 Current Plan	FY 2009 ARRA Estimate	FY 2010 Request	Change Over FY 2009 Plan Amount	Change Over FY 2009 Plan Percent
Total, EFRI	**$25.23**	**$26.45**	**$14.00**	**$29.00**	**$2.55**	**9.6%**
Major Components:						
Research and Education Grants	25.23	26.45	14.00	29.00	2.55	9.6%

The Office of Emerging Frontiers in Research and Innovation (EFRI) resides within the Office of the Assistant Director for Engineering and was established in FY 2007 to fulfill the critical role of helping ENG focus on important emerging areas in a timely manner. Each year EFRI recommends, prioritizes, and funds interdisciplinary topics at the emerging frontiers of engineering research and education. These emerging frontiers are frequently found in transformative interdisciplinary areas. EFRI enables the Directorate for Engineering (ENG) to strategically pursue such research and allows the engineering community to come forward with new and paradigm-shifting proposals at the interface of disciplines and fields.

Technological innovations have given rise to new industries, expanded access to quality healthcare, and fueled national prosperity even as global competition has grown. To help ensure the nation's continued success, EFRI will provide critical, strategic support of fundamental discovery, particularly in areas that may lead to breakthrough technologies and strengthen the economy's technical underpinnings.

EFRI investments represent transformative opportunities, potentially leading to: new research areas for NSF and other agencies; new industries or capabilities that result in a leadership position for the country; and/or significant progress on a recognized national need or grand challenge. These challenges may include areas such as sustainable energy resources; safe, clean water; technologies to overcome physical limitations from disease or injury; and integrated systems designed to thwart attacks on U.S. infrastructures and interests throughout the world. EFRI will have the necessary flexibility to target long-term challenges, while retaining the ability and agility to adapt as new challenges demand.

In general, 95 percent of the EFRI portfolio is available for new research grants while 5 percent is used primarily to fund grants made in previous years.

FY 2010 Funding

The role of EFRI is to invest in research opportunities that would be difficult to fund with other mechanisms, such as Early-concept Grants for Exploratory Research, typical awards, or large research center solicitations. Successful projects usually require small- to medium-sized interdisciplinary teams of researchers and significant funding for several years in order to make substantial progress and to provide evidence for additional follow-on funding through other established mechanisms.

Potential EFRI topics can arise from input from a number of sources: the research community, advisory committees, workshops, professional societies, academies, proposals and awards, and NSF committees of visitors. In addition, EFRI has issued a Dear Colleague Letter and provided the opportunity for direct submission of topic ideas for the FY 2010 competition by the research community through the Web.

Examples of topic areas that EFRI has pursued based on the above sources are Autonomously Reconfigurable Engineered Systems (ARES), Cellular and Biomolecular Engineering (CBE), Cognitive Optimization (COPN), and Resilient and Sustainable Infrastructures (RESIN), Biosensing and Bioactuation: Interface of Engineering and Living Systems (BSBA), and Hydrocarbon from Biomass (HyBi). In ARES, researchers are paving new research frontiers for engineering systems that can modify themselves when subject to *unplanned* events. In CBE, methods and technologies are being developed to regenerate some of the body's most complex tissues. COPN projects are building new dynamic optimization algorithms and robotic systems by studying the way systems of neurons do such complex tasks. RESIN projects are developing the theoretical foundation, methods, and technologies for making interdependent critical infrastructures both resilient and sustainable. BSBA will fund projects that lead to the development of intelligent systems to address a number of national needs including protection of critical and aging infrastructures, early detection and treatment of currently incurable diseases, and mitigation of environmental hazards and pollution. HyBi will fund projects to develop non-ethanol "green gasoline," an area of critical need that will help reduce U.S. dependence on foreign oil while producing fuel through an environmentally-friendly green process.

EFRI research in FY 2010 will better enable ENG to meet its strategic goal of fostering frontier and transformative research. Topics for EFRI support will typically relate to the five ENG research themes as well as consider the grand challenges identified by National Academy of Engineering (www.engineeringchallenges.org). When appropriate, EFRI will partner with other programs within NSF and other agencies.

Changes by Activity/Cluster

Emerging Frontiers in Research and Innovation (+$2.55 million, to a total of $29.0 million).

The additional $2.55 million will allow for the support of 14 awards, rather than 12, to strengthen the impact of this important office.