BIOLOGICAL SCIENCES $675,060,000

The FY 2009 Budget Request for the Directorate for Biological Sciences (BIO) is $675.06 million, an increase of $63.04 million, or 10.3 percent, over the FY 2008 Estimate of $612.02 million.

Biological Sciences Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Molecular and Cellular Biosciences (MCB)	$111.50	$112.51	$126.10	$13.59	12.1%
Integrative Organismal Systems (IOS)	202.31	199.86	216.27	16.41	8.2%
Environmental Biology (EB)	109.60	110.86	125.64	14.78	13.3%
Biological Infrastructure (BI)	80.23	86.94	86.99	0.05	0.1%
Emerging Frontiers (EF)	104.90	101.85	120.06	18.21	17.9%
Total, BIO	$608.54	$612.02	$675.06	$63.04	10.3%

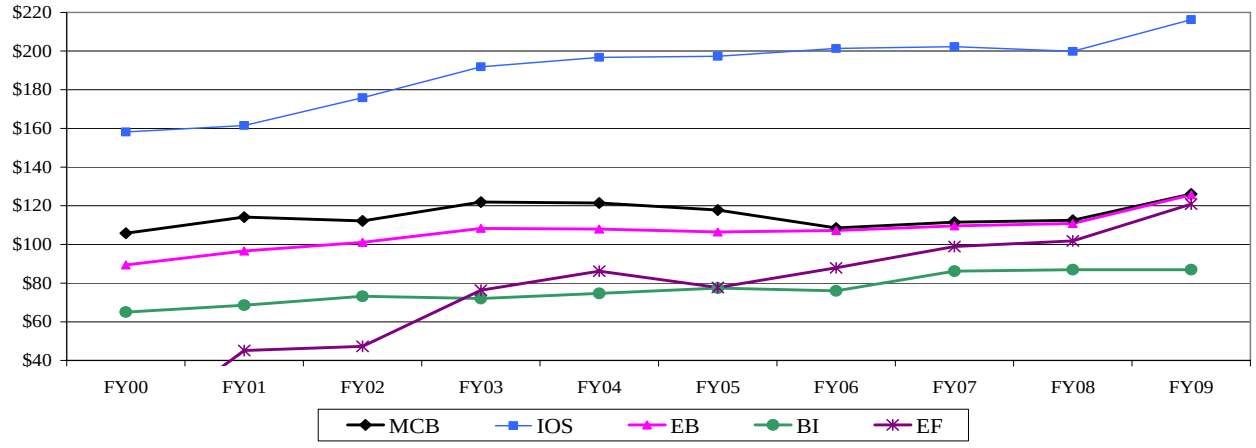
Totals may not add due to rounding.

The Plant Genome Research program has been assigned as a program element within the IOS Subactivity. Further details are provided in the restructuring cross-walk table.

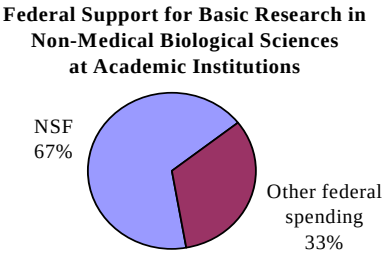
The mission of the BIO Directorate is to enable discoveries for understanding life. Through its investments in innovative and transformative research, BIO advances the frontiers of knowledge in the life sciences, increases our understanding of complex living systems, and provides the theoretical basis for advances in other sciences and engineering.

Biological research leading to the development of novel technologies to generate, store, and analyze molecular, genetic, cellular, organismal, evolutionary, and ecological data is stimulating innovation in the physical sciences, engineering, and computer science, a primary goal of the Administration's American Competitiveness Initiative (ACI).

BIO Subactivity Funding
(Dollars in Millions)



RELEVANCE



NSF is the major source of federal funding for non-medical, fundamental life sciences research at academic institutions, providing 67 percent of this support. Issues of national importance related to the environment, economy, agriculture, and human welfare require an understanding of how complex living systems function and interact with non-living systems. Research supported by BIO enhances this understanding. As the physical, computational, mathematical, and engineering fields increasingly use living systems to address major questions in their areas, it is essential to maintain a robust investment in the non-medical biological sciences. Biological research uncovers the principles that form the foundation for the interdisciplinary grand challenge questions.

Living organisms have evolved mechanisms for efficiently using energy, producing an endless array of novel compounds, and storing information in a highly compact, adaptable format. Fundamental biological research is working to make this 3.5 billion years of biological innovation available to inform the next generation of nano-, bio-, and information technologies. Basic research to understand how genomic information is encoded and specifically expressed will provide new and important opportunities to improve existing computational tools, and develop new computational technologies with broad application in the life and physical sciences and engineering.

The explosion of heterogeneous data about complex biological systems is providing rich opportunities for developing innovative cyberinfrastructure to integrate knowledge. Integrating knowledge about individual biological units into networks, from the molecular level to the ecosystem scale, is a leading challenge in biology. Connecting individual networks to understand complex biological webs will require the collaborative effort of all biological sub-disciplines working with other fields of science and engineering. The focus on multiple scales of biological organization builds on the current vigor of biological inquiry, but envisions a stronger conceptual and theoretical basis as researchers strive to uncover basic principles of organization, form, and function. This will enable breakthroughs in nanotechnology and biotechnology.

BIO is uniquely suited to advance our understanding of complex biological systems, in keeping with the Administration's FY 2009 R&D priorities, through its ability to integrate research across the entire range of biological systems and scales. Biological concepts are integral to wide-ranging areas of science, including national priorities such as nanotechnology, biotechnology, bioengineering, climate change science, and water. Mathematical modeling and computational simulations have become critical to leading edge biology by advancing our understanding of non-linear systems such as invasive species dynamics and gene regulation.

BIO has made significant contributions to understanding the changing dynamics of the biosphere through investment in interdisciplinary research. Continued investment will improve the capabilities for predicting a changing biosphere, and will foster development of broadly-testable theories that link the biosphere, geosphere, and atmosphere in a project like the National Ecological Observatory Network (NEON).

Summary of Major Changes by Division ***(Dollars in Millions)***

FY 2008 Estimate, BIO.....……..$612.02

Enhanced support for disciplinary and interdisciplinary research across BIO's core programs is the highest priority in FY 2009. The FY 2009 requested increase for core programs will help to restore funding rates and numbers of research awards to FY 2007 levels following a projected decrease of 5% across the board along with a decrease in funding rates to 15% in FY 2008. Included will be support for a new activity, Life in Transition. The role of the living world in adapting to and shaping a changing Earth is found in the fundamental questions at the junction of the life and physical sciences. NSF is the best positioned agency to lead a comprehensive, trans-disciplinary approach to understanding the changing biosphere.

Molecular and Cellular Biosciences (MCB) +$13.59

Disciplinary and interdisciplinary research in the MCB core will increase to enhance support for projects that incorporate metagenomics, theoretical and mathematical modeling, synthetic biology, small RNA biology, and the role of the intracellular environment on the dynamic structure and function of complex biomolecules. MCB investments in the new Life in Transitions activity will contribute to advancing our understanding of the origin of life through synthetic biology research; and the new Adaptive Systems Technology activity brings biological and physical systems into convergence, to enable revolutionary advances in the development of novel adaptive systems by translating advances in neuroscience into engineered systems.

Integrative Organismal Systems (IOS) +$16.41

Disciplinary and interdisciplinary research in the IOS core will increase to emphasize integrative research, with special attention to new activities in Adaptive Systems Technology, Life in Transition, and Dynamics of Water Processes in the Environment. IOS will support innovative studies that promise to provide a deeper understanding of the properties emerging from the interactions of the myriad of processes and structures of living systems. In addition, enhanced support for the Plant Genome Research Program will build on the prior ten years of investment as part of the National Plant Genome Initiative (NPGI). Continued support for genome-enabled plant biology research will build on the knowledge and research resources and tools accumulated to date, including continued support for collaborations between U.S. scientists and scientists in developing countries that focus on plant genomics and plant biotechnology.

Environmental Biology (DEB) +$14.78

Disciplinary and interdisciplinary research in the DEB core will emphasize support for biodiversity research with increased emphasis on resolving uncertainties regarding the ancestry of microbial life forms. The explosion of genomics-level information about living organisms has opened up new avenues of inquiry that relate the adaptability and dynamics of populations to their genetic makeup. DEB will continue to play a major role in emphasizing research to reduce uncertainties in global climate projections. Special attention will be placed on the new activities for Dynamics of Water Processes in the Environment and Life in Transition.

Biological Infrastructure (DBI) +$0.05

Funding for DBI remains flat for FY 2009, except for an increase for Stewardship activities. Programmatic evaluations for all DBI programs will continue in FY 2009 with the goal to identify those research and human resources that are most effective and essential to advancing the frontiers in the biological sciences.

Emerging Frontiers (EF) +$18.21

Programmatic funding in EF provides seed funds for new transformational research activities at the leading edge of biology and science. EF also provides support and oversight for biological centers and facilities. In FY 2009, EF will provide venture funding for the Life in Transition activity, and will contribute to the NSF-wide investment, Dynamics of Water Processes in the Environment. In addition, significant investment will be made to support Centers and facilities, including: establishment of the Center for Research at the Interface of the Mathematical and Biological Sciences, enhanced support for the Plant Science Cyberinfrastructure Collaborative, and enhanced support for the Center for Environmental Implications of Nanotechnology begun in FY 2008. Support for NEON will increase for continued project development to prepare for final design reviews in FY 2009.

Subtotal, Changes +$63.04

FY 2009 Request, BIO……...……..$675.06

Summary of Major Changes in Directorate-wide Investments ***(Dollars in Millions)***

FY 2008 Estimate, BIO…….....$612.02

Discovery +$54.80

Core BIO Investments (+$33.44 million).

Increasing support for basic research in biology will yield insights that can be used innovatively to produce the next generation of nano-, bio-, and information technologies. Support of fundamental scientific discovery in areas such as these will have major impacts on quality of life, technological innovation, economic competitiveness, and new job growth – high priorities of the ACI. Support will focus on: unlocking the genetic code; network and cross-scale analysis from cells to societies; theoretical and conceptual basis of biology; and changing dynamics of the biosphere.

Life in Transition (+$10.0 million).

Funding will support research on the indispensable properties of living systems; the fundamental characteristics of biological energy systems and their potential utility; and the mechanisms and principles of resilience and sustainability that enable some life forms to survive, adapt to, and transform their environment. In partnership with the National Aeronautics and Space Administration (NASA), Life in Transition research will also determine the biogeochemical conditions that enabled molecules to cross the barrier between non-living organic chemistry and life, findings that can define and direct the search for life or proto-life elsewhere in our solar system.

Adaptive Systems Technology (AST) (+3.49 million).

BIO will contribute to this cross-Foundation activity by supporting research to determine how living systems solve problems of form and function. This research will enable new generations of innovative machines to explore and expand human abilities using systems that interface with or mimic living neural networks. Research will be supported on neurosystems design characteristics and principles that can lead to the development of new materials and technologies such as neural networks and mechano-responsive biomaterials that mimic natural systems in intelligence, adaptability, resilience, and robustness. Living and engineered systems

will reciprocally inform fundamental understanding in areas such as movement control, and sensing and adaptation to changing environments. This research will enable new generations of biologically-inspired innovative technologies with great potential impact on U.S. competitiveness.

Dynamics of Water Processes in the Environment (+$4.21 million).
Coordinated research on fresh water is critical to human health and economic prosperity. BIO's investments focus largely on research to understand the resilience that the presence of living organisms confers to freshwater ecological systems. A major emphasis will be on ecological forecasting to understand the impacts and feedbacks between climate and ecological change.

Centers (+$3.66 million).

- *Centers for Analysis and Synthesis (+$4.80 million).* The Plant Science Cyberinfrastructure Collaborative established in FY 2008 will receive enhanced support to use advanced computational and cyberinfrastructure capabilities and expertise to craft solutions to an evolving array of grand challenges in plant science (+$2.48 million). The Center for Research at the Interface of the Mathematical and Biological Sciences (CIMBS) will be established in FY 2009 to stimulate research and education at the interface of the mathematical and biological sciences (+$3.10 million). CIMBS will play a critical role in addressing national needs, particularly in the area of modeling infectious diseases of animals and plants, providing useful knowledge to policy makers, government agencies, and society. A total investment of $16 million over 5 years in this center includes partnership contributions from the Mathematical & Physical Sciences Directorate, Department of Homeland Security and United States Department of Agriculture. Initiation of CIMBS was deferred from FY 2008. Other centers for analysis and synthesis will see decreasing out-year adjustments. (-$780,000)

- *Behavioral Neuroscience Science and Technology Center (-$1.19 million).* Established in FY 2000, this center will receive a final year of funding in FY 2009.

- *Center for Environmental Implications of Nanotechnology (CEIN) (+$50,000).* CEIN will receive a small increase as it ramps up to full year operations to conduct fundamental research on the interactions between nano-particles, materials, and the living world at all scales. Total investment of $5.0 million in this important center includes partnership contributions from across NSF and the Environmental Protection Agency.

Research Infrastructure +$6.0

NEON (+$6.0 million). Increased investment in the National Ecological Observatory Network (NEON) will sustain project design and development activities until completion of the preliminary and final design reviews, expected in FY 2008 and FY 2009, and certification for construction readiness.

Stewardship +$2.24

A number of activities are funded directly from NSF's programs to advance NSF's Stewardship goal. These include Intergovernmental Personnel Act appointments, NSF-wide studies and evaluations, and mission-related information technology investments. As is discussed further in the Stewardship chapter of this Request, in FY 2009 NSF has realigned IT investments to tie mission-related activities more directly to NSF's programs.

Subtotal, Changes +$63.04

FY 2009 Request, BIO……..……..……..….$675.06

NSF-WIDE INVESTMENTS

In FY 2009, the Directorate for Biological Sciences will support research and education efforts related to broad, Foundation-wide investments in a number of areas including NSF's multidisciplinary priority areas and the Administration's interagency R&D priorities.

BIO NSF-wide Investments
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Adaptive Systems Technology			$3.49	$3.49	N/A
Biocomplexity in the Environment	9.43	-	-	-	N/A
Climate Change Science Program	15.10	15.10	15.10	-	-
Cyber-enabled Discovery & Innovation	-	1.00	2.65	1.65	165.0%
Cyberinfrastructure	90.50	97.13	99.78	2.65	2.7%
Dynamics of Water Processes in the Environment	-	-	4.21	4.21	N/A
Human and Social Dynamics	0.50	0.50	-	-0.50	-100.0%
International Polar Year	2.00	2.00	-	-2.00	-100.0%
Mathematical Sciences	1.11	-	-	-	N/A
National Nanotechnology Initiative	52.55	55.55	56.60	1.05	1.9%
Networking and Information Technology R&D	83.50	83.50	86.15	2.65	3.2%

Adaptive Systems Technology (AST): A total of $3.49 million will support research to determine how living systems solve problems of form and function, aiding the development of innovative technologies that mimic natural systems in intelligence, adaptability, resilience, and robustness, including neural networks and mechano-responsive biomaterials.

Biocomplexity in the Environment, Human and Social Dynamics, International Polar Year, Mathematical Sciences: With the conclusion of these NSF-wide investments, components of each have been transferred to core programs for continued support.

Climate Change Science Program (CCSP): CCSP was established to respond to the challenge of understanding climate and climate variability. A total of $15.1 million will continue support for research to address ecological rates of change and related impacts on species diversity. This includes support for programs that specifically address terrestrial ecosystem responses to climate change through experimental modeling and laboratory studies, including research through the Long Term Ecological Research (LTER) program.

Cyber-enabled Discovery & Innovation (CDI): CDI capitalizes on the discovery potential of fundamental scientific research to inform and expand today's computational capabilities. BIO's investment in the Plant Science Cyberinfrastructure Collaborative will enable new conceptual advances in biology through integrative, computational thinking. The collaborative will create intellectual synergy among biologists, computer and information scientists, mathematicians, engineers, and others to drive

discovery and address the grand challenges in plant science. An investment of $2.65 million in BIO will contribute to the agency's strategic goals of advancing the frontier of knowledge by creating new computational concepts, methods, and tools, and will also contribute to the preparation of a workforce with the computational competencies critical to continued U.S. competitiveness.

Cyberinfrastructure (CI): Improving high-end computing capability is an important objective of ACI and is expected to increase our understanding of complexity across biological systems by accelerating the pace and nature of biological discovery in the 21st century. A total of $99.78 million (+$2.65 million) will support databases and informatics tools within BIO, including the Protein Data Bank (PDB), the international repository and primary source for information about the structure of biological macromolecules, and The Arabidopsis Information Resource (TAIR). FY 2009 funds will enhance support for the Plant Science Cyberinfrastructure Collaborative that will enable new conceptual advances in biology through integrative, computational thinking. The collaborative will create intellectual synergy among biologists, computer and information scientists, mathematicians, engineers, social scientists and others to drive discovery and address grand challenges in plant science.

Dynamics of Water Processes in the Environment (WATER): A total of $4.21 million will support research on the resilience that is conferred by the presence of living organisms in freshwater ecological systems. A major emphasis will be on the ecological forecasting necessary to understand impacts and feedbacks associated with climate and environmental change.

National Nanotechnology Initiative (NNI): A total of $56.60 million (+$1.05 million) will continue support for research on biosystems at the nanoscale that exhibit novel properties. Potential applications of findings include exploiting functions of cellular organelles and nanoscale sensory systems, and the development of nano- devices for research in genomics, proteomics, and cell biology. BIO will enhance support for the Center for Environmental Implications of Nanotechnology.

Networking and Information Technology Research and Development (NITRD): A total of $86.15 million (+$3.0 million) will continue support for Human-Computer Interaction and Information Management (HCI&IM) to increase the benefit of computer technologies for biology; and for Software Design and Productivity (SDP) research leading to fundamental advances in concepts, methods, techniques, and tools for software design. These efforts are critical to the future of research technologies relevant to a broad range of scientific disciplines and related to ACI priorities.

QUALITY

BIO maximizes the quality of the R&D it supports through the use of a competitive, merit-based review process. The percent of research funds allocated to projects that undergo external merit review was 97 percent in FY 2007, the last year for which complete data exist.

To ensure the highest quality in processing and recommending proposals for awards, BIO convenes Committees of Visitors (COV), which are composed of qualified external evaluators who review each program 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 NSF's investments. In June 2008, BIO will convene COVs for both the Division of Molecular and Cellular Biosciences and Integrative Organismal Systems.

The Directorate for Biological Sciences also receives advice from the Advisory Committee for Biological Sciences (BIOAC) on such issues as: the mission, programs, and goals that can best serve the scientific

community; how BIO can promote quality graduate and undergraduate education in the biological sciences; and priority investment areas in biological research. The BIOAC meets twice a year. Members from academic institutions and industry represent a cross section of biology. The Committee is balanced with respect to gender, underrepresented minorities, and geographic regions.

PERFORMANCE

The FY 2009 Budget Request is aligned to reflect funding levels associated with the Foundation's four goals stated in the FY 2006-2011 Strategic Plan. These goals provide a framework for progress in fundamental research and education and facilitate budget and performance integration.

Biological Sciences
By Strategic Outcome Goal
(Dollars in Millions)

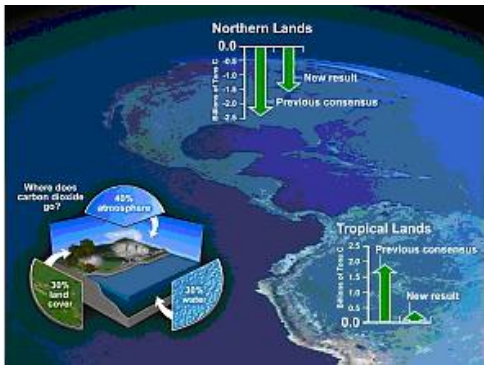
	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Discovery	$443.42	$435.86	$490.66	$54.80	12.6%
Learning	47.17	43.14	43.14	-	-
Research Infrastructure	112.38	127.02	133.02	6.00	4.7%
Stewardship	5.57	6.00	8.24	2.24	37.3%
Total, BIO	$608.54	$612.02	$675.06	$63.04	10.3%

Totals may not add due to rounding.

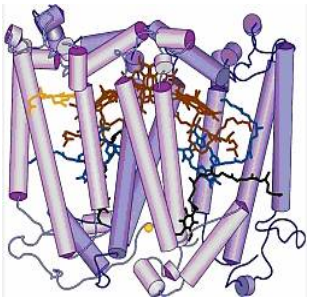
BIO will continue its commitment to education, training, and increasing diversity while emphasizing 21st Century Biology within all of its divisions and subactivities. The FY 2009 Request will slightly increase award size and success rates. It will also continue to focus on interdisciplinary research and interagency partnerships and activities, with special attention given to broadening participation at all levels.

Recent Research Highlights

► **Northern Forests Less Effective Than Tropical Forests in Reducing Global Warming:** To help determine what happens to carbon emitted as carbon dioxide from industrial sources, researchers analyzed flasks of air that had been collected for decades by research aircraft over various global locations. Results show that computer models of carbon had overestimated the amount of carbon absorbed by northern forests and the amount of carbon released by tropical ecosystems, and underestimated net carbon emissions from northern forests. This means that northern forests are doing significantly less and tropical forests are doing significantly more to offset global warming than predicted by computer models. Computer models were incorrect because they had relied on ground-level measurements and so had failed to accurately account for the vertical movement of carbon dioxide in the atmosphere. (DEB)



Northern forests play a smaller role in offsetting global warming than previously thought. *Credit: NCAR.*



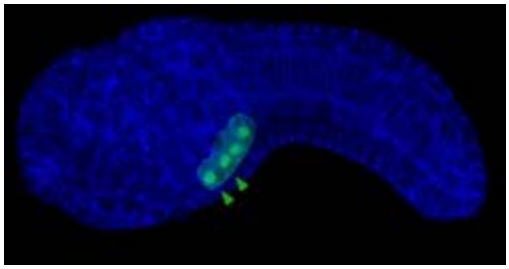
Biologists have discovered that a split-second, highly orchestrated process drives photosynthesis. *Credit: ASU.*

► **Scientists Offer New View of Photosynthesis:** To help determine how plants efficiently scavenge nearly every photon of available light during photosynthesis, researchers studied the reaction center of a photosynthetic bacterium, where light energy is funneled into specialized chlorophyll-binding proteins. By using an ultra-fast laser that acts like a high-speed motion picture camera capturing lightning-fast reactions, the researchers analyzed the orchestrated movements of proteins that occur on a timescale of a millionth of a millionth of a second. This analysis revealed that during photosynthesis, proteins move in the reaction center in ways that promote electron transfer and maximize the harnessing of light energy even when conditions are not optimal. Such insights may support the development of organic solar cells that use the same chemistry as living organisms to harvest the sun's energy. (MCB)

► **Biologists Develop Large Gene Dataset for Rice Plant:** The largest gene sequence database ever amassed for a plant species was created for rice. These data will advance our understanding of how genes work in rice, which is the major food crop for much of the world's population. Researchers will also use the database to examine the role of small ribonucleic acids (small RNAs) in gene expression in all plants. Though once considered biologically unimportant, small RNAs are now known to play important roles in gene regulation. In this study, advanced gene sequencing technologies and high-powered computer technologies were used to examine both normal gene expression as well as small RNAs. The dataset was based on gene sequences representing nearly 47 million mRNA molecules and three million small RNAs. (PGR)

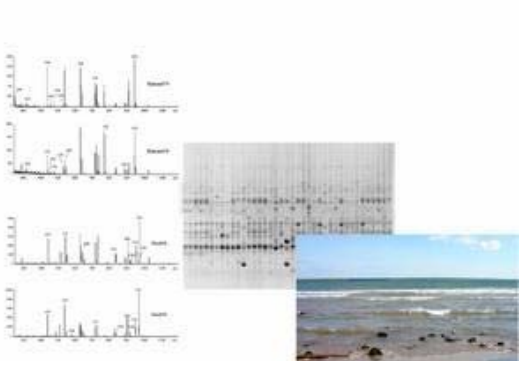
Plant biologists have reported a new understanding of how genes work in rice. *Credit: Fangming Xie, IRRI.*

► **Heart to Heart: Evolution of the multi-chambered heart:** Researchers found that changing the activity of a single gene, named *ets1/2*, doubled the number of cells in the developing sea squirt heart, which is single-chambered. But instead of leading to a heart that was simply twice as big, this doubling led to the formation of a functional two-chambered heart. These results show that small genetic changes can generate new, more complex organs and structures. They provide clues about how the heart evolved from an ancestral one-chambered organ into the multi-chambered structure present today in humans and other vertebrates. They also demonstrate that studies of a single gene, in a non-mammalian species like the sea squirt, can improve our understanding of human heart cells and congenital heart defects. (IOS)



A transgenic Ciona embryo with expanded *ets* gene activity makes twice as many heart precursors. Normally only the anterior two cells (arrowheads) will form the heart. Two additional heart precursors are formed when *ets* gene activity is expanded and this can result in an additional heart chamber in the adult. *Credit: This research was conducted by Brad Davidson in the laboratory of Michael Levine.*

► **A New Way of Identifying Bacteria in the Environment:** NSF funding enabled researchers at the University of Wisconsin to develop a new method of identifying strains of bacteria in environmental samples, such as lake or irrigation water. They invented a special type of mass spectrometer to distinguish between bacterial strains based on analysis of proteins in the cells. This method of protein profiling is more rapid and less costly than DNA fingerprinting, the traditional means of strain identification. Faster identification of bacterial strains allows for a quicker response to possible health threats, such as the contamination of California spinach with a dangerous *E. coli* strain that sickened several hundred people in 2006. (DBI)



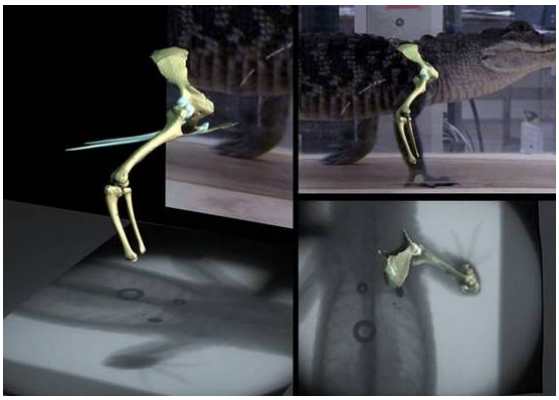
Protein fingerprint from mass spectrometer (left), DNA fingerprint (center), recreational waters in Door County, Wisconsin (right). *Credit: University of Wisconsin at Oshkosh.*

► **Forming Groups Stabilizes Populations of Predators and Prey:** Breaking with 80 years of ecological theory, scientists have found that the best way to spot a sustainable relationship between social predators and prey is to count not the animals, but the groups they form. Social grouping was more strongly correlated with the long-term stability, or sustainability, of the Serengeti ecosystem suggesting that even if an ecosystem has lots of carnivores and their herbivores, the two populations may be in trouble if the animals are social but cannot readily form groups. Ecologists have long modeled interactions between predators and prey by taking head counts of each species, ignoring the fact that many predators and their prey both form social groups. But the number and distribution of groups, rather than individuals, is most important in determining how often and how long the two species will interact. Results suggest that road building and other human disruptions that spread

Scientists have found that being social and forming groups is a protection against prey extinction. *Credit: Craig Packer, University of Minnesota.*

wildlife out and keep them from grouping have important implications for sustainably managing large ecosystems like North American national parks. (DEB)

► **X-Ray vision: Science Fiction to Science Fact:** Imagine being able to see inside an animal and watch its bones move. Imagine if scientists had a better way to study moving skeletons and doctors had a better way to diagnose and study skeletal injuries. This capability may no longer be out of reach. Researchers at Brown University have developed a method of clearly observing the movement of skeletons of living animals. Using a novel technique called scientific rotoscoping, the researchers simultaneously record standard video of moving animals and X-ray images of their moving skeletons. Seeing the movement of bones from shoulder joints to wrists and legs, which this technology provides, has many potential applications. It could transform both applied work and basic research in comparative biology and medicine. It could allow for clearly observing bone movements, testing theories about the mechanics of animal locomotion, and planning orthopedic surgeries, diagnosing injuries, and observing the effectiveness of different clinical treatment techniques. (IOS)



Scientific Rotoscoping of a walking alligator (left). 3-D computer models of shoulder and forelimb bones are aligned to X-ray (lower right) and standard (upper right) video frames. The resulting animations and data accurately capture motion at each joint. *Credit: David Baier.*

► **MorphoBank: New Software to Facilitate Virtual Collaborations:** Researchers designed a new Web application, called MorphoBank, which is revolutionizing morphological biology, the branch of biology that addresses the form and structure of organisms. MorphoBank is a secure virtual workspace that provides powerful visual software for comparing the morphology of organisms. This application currently houses more than 3,000 images that range from insects to fossils of humans, and its capabilities include zoom and label features. By providing these features, MorphoBank supports more archiving than was previously possible and enables scientists to collaborate across large distances to reach agreement on the descriptions and categorizations of biological specimens, which is required to classify organisms. Applications such as MorphoBank are becoming increasingly important as large international collaborative efforts become more common. (DBI)

Screen shot from MorphoBank 2.0 showing image zoom and labeling capabilities. *Credit: The MorphoBank Project.*

Other Performance Indicators

The tables below show the number of people benefiting from BIO funding, along with trends in the award size, duration, and number of awards.

Number of People Involved in BIO Activities

	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate
Senior Researchers	4,106	4,010	4,290
Other Professionals	1,559	1,520	1,630
Postdoctorates	1,267	1,240	1,330
Graduate Students	2,641	2,580	2,760
Undergraduate Students	3,365	3,285	3,520
K-12 Teachers	58	58	58
Total Number of People	12,996	12,693	13,588

BIO Funding Profile

	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate
Statistics for Competitive Awards:			
Number	1,303	1,250	1,310
Funding Rate	19%	18%	19%
Statistics for Research Grants:			
Number of Research Grants	970	930	975
Funding Rate	17%	15%	16%
Median Annualized Award Size	$141,929	$149,000	$156,500
Average Annualized Award Size	$182,246	$191,000	$200,600
Average Award Duration, in years	3	3	3

Biological Science Directorate Reorganization

In FY 2009, the Biological Sciences Directorate is requesting a realignment of two activities. The first will move Plant Genome Research (PGR) as a new program line under the Integrative Organismal Systems (IOS) subactivity. The future activities of PGR will be facilitated by the pioneering systems biology approaches and research projects emphasized and supported within IOS, and will provide an integrated approach to funding plant genome research and the plant sciences. The second move will transfer management and oversight of NEON to the Emerging Frontiers (EF) subactivity. This move will

ensure strong management oversight and integrate NEON into the transformational and frontier science supported by this subactivity at a critical time in its development.

BIO Reorganization Crosswalk – FY 2009

(Dollars in Millions)

New Structure	Current Structure						Total New Structure
	MCB	IOS	DEB	DBI	EF	PGR	
Molecular and Cellular Biosciences (MCB)	$126.10						$126.10
Integrative Organismal Systems (IOS)		$115.05				$101.22	216.27
Research Project Support		115.05					115.05
Plant Genome Research Program						101.22	101.22
Environmental Biology (DEB)			$0.64				125.64
Biological Infrastructure (DBI)				$86.99			86.99
Emerging Frontiers (EF)				10.00	$110.06		120.06
Research Project Support					94.06		94.06
National Ecological Network Observatory (NEON)				10.00	16.00		26.00
Plant Genome Research Program (PGR)						0.00	0.00
Total Current Structure	$126.10	$115.05	$125.64	$96.99	$110.06	$101.22	$675.06

Restructuring of IOS/PGR Organization:

The Plant Genome Research (PGR) subactivity was initiated in FY 1998 as part of the National Plant Genome Initiative (NPGI). PGR is part of BIO's Plant Biology portfolio that also includes the Plant Cyberinfrastructure Collaborative established in FY 2008 and funded through EF, the 2010 program supported separately from PGR by all the BIO divisions, and additional projects funded by core programs via unsolicited proposals. These investments have established the U.S. as the world leader in fundamental research in plant biology, transformed plant biology into a 21st century science, revitalized plant sciences at U.S. colleges and universities, attracted a new generation of students to plant biology research, and catalyzed large multinational collaborative plant genome research projects. The FY 2009 budget will take the next steps to ensure US preeminence in plant biology research.

National and international reviews of the future of plant science research make the point that the future improvement of economically important crops will come from integrating functional genomics, systems biology, and novel genes from a diversity of plant species. To achieve this vision in FY 2009 PGR will become a distinct program element in the Division of Integrative Organismal Systems (IOS). In FY 2008 the IOS subactivity was realigned to focus on understanding emergent properties of living systems such as complexity, sustainability, resilience, robustness, and adaptability. Understanding these properties translates to practical plant characters like improved yield, drought tolerance, and adaptation to a changing climate by integrating genetic, developmental, physiological, and structural systems. Placing PGR in the IOS research activity is a way to readily translate basic knowledge about how plants function as systems into the improvement of economically important crops.

In FY 2009, the restructured subactivity will have two distinct program elements with separate budgets: research project support aligned with established IOS programs and the plant genome research program. While separate support will be maintained for each, there will be an increased emphasis on interaction and integration of the science from both research communities to the benefit of both.

Restructuring of DBI/EF Subactivities:

The National Ecological Observatory Network (NEON) was funded as a new start MREFC project in FY 2007. Restructuring the NEON project oversight from the Biological Infrastructure subactivity to the Emerging Frontiers subactivity will allow for stronger management and oversight of the project at a critical time in its development. In addition, the emerging frontier science expected as a result of the NEON facility will complement other EF programs.

MOLECULAR AND CELLULAR BIOSCIENCES $126,100,000

The FY 2009 Budget Request for the Division of Molecular and Cellular Biosciences (MCB) is $126.10 million, an increase of $13.59 million, or 12.1 percent, over the FY 2008 Estimate of $112.51 million.

Molecular and Cellular Biosciences Funding

(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
Molecular and Cellular Biology	**$111.50**	**$112.51**	**$126.10**	**$13.59**	**12.1%**
Major Components:					
Research & Education Projects	111.50	112.51	126.10	13.59	12.1%

About MCB:

The Molecular and Cellular Biosciences Division supports research aimed at illuminating the molecular underpinnings and defining the indispensable properties of complex living systems. Creative ideas and insights from MCB-supported investigators transform our understanding of the natural world and the molecular basis for the emergence of life on Earth. This research will lead to a better understanding of form and function in multi-scale, complex, biological systems, and of the dynamic interactions of living systems with the physical world. These advances contribute to our economy through discoveries pointing to new products and processes with applications in biotechnology, nanotechnology, and agriculture and contribute to our ability to detect and defend against biological threats.

Key biological questions in MCB-supported projects address the fundamental principles that determine the structural, functional, and dynamic properties of the complex molecular machinery involved in genetic, cellular, and signaling processes in all organisms, with a particular emphasis on microbial and plant systems. Answering such major biological questions increasingly requires the tools of genomics, the physical sciences, mathematics, computer and information science, and engineering, as well as integration of theoretical and experimental approaches.

MCB continues to forge partnerships to support research at the interfaces of these complementary disciplines, to introduce new analytical and conceptual tools for biological research, and to provide unique education and training opportunities for the next generation of researchers, scientific educators, and scientifically literate citizens. Leading edge cyberinfrastructure is indispensable in MCB-supported research for capturing, storing, manipulating, and analyzing large volumes of diverse data.

MCB supports multidisciplinary research through three scientifically-focused clusters. Within the **Biomolecular Systems** cluster, the use of cutting-edge technologies is a priority to integrate theoretical and experimental approaches to study the dynamic properties of biological molecules and their complexes (paradigms for nanomachines). Nanoscale studies of the structure, function, and assembly of cellular elements are a priority for the **Cellular Systems** cluster. The **Genes and Genome Systems** cluster emphasizes genome dynamics, genetic circuitry, and genetic mechanisms used by living systems to express and regulate the information encoded in the genome.

In general, 34 percent of the MCB portfolio is available for new research grants. The remaining 66 percent is used primarily to fund continuing grants made in previous years.

MCB priorities for FY 2009:

MCB will place the highest priority on innovative, creative, and potentially transformative projects that advance our understanding of the molecular underpinnings of complex living systems. The transfer of energy and information among a heterogeneous group of individual units (molecules, cells, organisms, and/or populations) is critical for orchestrating many of the unique properties of life such as robustness and resilience. Furthermore, it is now realized that the DNA sequence encodes far more information than what is used to determine protein sequences, and that biomolecules contain much more heritable information than what is encoded in the sequence of nucleotides. Research that deepens our understanding of the networks and interactions that govern the flow of energy and information in living systems, and the myriad ways in which information is encoded within biomolecules, cells, and organisms, will be highlighted.

Building connections with the physical sciences is instrumental in enhancing the theoretical, computational, mathematical, and simulation approaches that are critical for studies of biological complexity at the molecular and cellular level. Thus, MCB will also give priority to opportunities that benefit research at the interface and in the intersection between the physical sciences and biology, as investments in interdisciplinary research are likely to lead to transformative breakthroughs in these critical areas.

MCB will continue to place a high priority on efforts to integrate research and education and to broaden participation by infusing these values throughout all of the core activities, and also by supporting awards made through the NSF-wide CAREER and Research at Undergraduate Institutions programs.

Changes from FY 2008:

Guided by the priorities described above, research and education supported in the **MCB core** will increase by $13.59 million. Following a reduction in research awards (-5%) and decrease of 12% in success rates (from 17% to 15%) in FY 2008, this increase will focus on improving average award sizes to enable transformative research and provide for the integration of research and education—endeavors that have significantly increased the cost of research.

- Emphasis areas of research (+11.59M): Projects that incorporate metagenomics, theoretical and mathematical modeling, synthetic biology, small RNA biology, protein folding and modifications, and the role of the intracellular environment in the dynamic structure and function of complex biomolecules will be emphasized, as will those that address critical questions in microbial and plant systems.
- Interface of the Physical and Life Sciences (+2.0M): The new Life in Transition activity will contribute to advancing our understanding of the origin of life through synthetic biology research, and the flow of energy through natural systems. MCB-supported research at the interface of the physical sciences is well-positioned to address how the building blocks and heritable units of life, and life processes, evolved under the physical and chemical conditions that existed on the early, prebiotic Earth.

INTEGRATIVE ORGANISMAL SYSTEMS $216,270,000

The FY 2009 Budget Request for the Division of Integrative Organismal Systems (IOS) is $216.27 million, an increase of $16.41 million, or 8.2 percent, over the FY 2008 Estimate of $199.86 million.

Integrative Organismal Systems Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Integrative Organismal Systems	**$202.31**	**$199.86**	**$216.27**	**$16.41**	**8.2%**
IOS Project Support	$101.50	$101.99	$115.05	$13.06	12.8%
Plant Genome Research Program	100.81	97.87	101.22	3.36	3.4%

About IOS:

Biology, in the context of the organism, addresses questions that cannot be answered by focusing on the extremes of molecules or ecosystems. Innovations in genomics, molecular biology, and computer science are now enabling advancement of the frontiers of knowledge on an array of complex questions. The goal of IOS-funded research is to predict why organisms are structured the way they are and function as they do with a particular emphasis on emergent properties of organisms (including complexity, robustness, communication, cooperation, and adaptability). Understanding these emergent systems properties of organisms requires integrative, interdisciplinary approaches and innovative integration of information across levels of analysis and stages of development, across phyla, environments, and evolutionary time. It can also require computational techniques and interdisciplinary perspectives from other areas of biology, the physical sciences, mathematics, engineering, social sciences, and computer science.

Advancing understanding of living systems cannot be achieved merely by enumerating and describing their individual components. IOS researchers are now advancing the frontier of understanding complex, dynamic organismal systems in their natural environments by building on investments in genome sequencing and projects that have accumulated in-depth knowledge of the molecular nature of biological systems. New knowledge and insights gained from plant genomics, for example, are leading to unexpected discoveries and conceptual advances in our understanding of the biology of plants.

Innovative studies offer potential solutions to many critical national problems such as energy production, carbon sequestration, improved crop yields, environmental clean up, improved diagnosis and treatment of disease, as well as better protection of people from environmental hazards. For example, organisms could be modified to serve as sensitive detectors for dangerous pathogens and toxins, or to create novel materials, catalysts, and drugs. Finally, advancing our understanding of how emergent properties arise in organisms may ultimately lead to a paradigm shift in the design, engineering, and production of biomimetic materials and machines, such as highly maneuverable, advanced aircraft.

The IOS portfolio has two interactive and integrative programmatic areas of support:

- **IOS Project Support** includes support for studies of behavioral, developmental, neural, physiological, and structural systems and how they are integrated in living organisms.
- **The Plant Genome Research Program (PGR)** supports genome-enabled plant biology research that takes full advantage of cyberinfrastructure and the latest systems biology approaches in studies using model systems and plants and plant processes of economic importance.

In general, 40 percent of the IOS portfolio is available for new research grants. The remaining 60 percent is used primarily to fund continuing grants made in previous years.

IOS Priorities for FY 2009:

IOS will place highest priority on highly creative, integrative, and transformative studies that lead to a deeper understanding of the emergent properties of organisms. Studies that cross previously disparate scientific areas and that cross scales of organization from molecules to ecosystems involving a variety of levels of analysis will be highlighted.

Changes from FY 2008:

Guided by the priorities described above, research and education supported in the **IOS** will increase by $16.41 million -- +$3.36 M for Plant Genome Research program and +$13.06 M for IOS project support. Following a reduction in research awards (-5%) and decrease of 12% in success rates (from 17% to 15%) in FY 2008, this increase will focus on improving average award sizes to enable transformative research and provide for the integration of research and education—endeavors that have significantly increased the cost of research. It will also focus on returning the Plant Genome Research program to FY 2007 levels of funding.

- The **Plant Genome Research Program** (+$3.36 million), building on the ten years of investment in this program as part of the National Plant Genome Initiative (NPGI), will provide continued support for genome-enabled plant biology research, including continued support of collaborations between U.S. scientists and scientists in developing countries. PGR forms part of BIO's Plant Biology portfolio that also includes: the Plant Cyberinfrastructure Collaborative established in FY 2008 and funded through EF, the 2010 program supported separately from PGR by all the BIO divisions, and additional projects funded by core programs via unsolicited proposals.

- Disciplinary and interdisciplinary research in the **IOS core** will increase by $13.06 million to support innovative studies to provide a deeper understanding of the properties emerging from the interactions of the myriad of processes and structures of living systems. IOS will continue to give the highest priority to projects that integrate research and education while broadening participation. Included in this increase is support for:

  - Applying neuroscience theory and concepts is at the heart of the new **Adaptive Systems Technology** activity (+$3.49). Knowledge of the structure and function of nervous systems and the mechanisms underlying behavior provides a blueprint for advancing transformational research with the aim of discovering innovative design principles and new technologies based on nature's varied solutions for survival.

  - Investments in the new **Life in Transition** activity (+$2.0) will focus on understanding bio-centered energy technology systems and their potential utility. IOS will invest in projects aimed at discovering the mechanisms and principles of resilience and sustainability that enable some life forms to survive, adapt to, and transform their environment.

ENVIRONMENTAL BIOLOGY $125,640,000

The FY 2009 Budget Request for the Division of Environmental Biology (DEB) is $125.64 million, an increase of $14.78 million, or 13.3 percent, over the FY 2008 Estimate of $110.86 million.

Environmental Biology Funding

(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
Environmental Biology	**$109.60**	**$110.86**	**$125.64**	**$14.78**	**13.3%**
Major Components:					
Research & Education Projects	109.60	110.86	125.64	14.78	13.3%

About DEB:

Fundamental research on complex ecological and evolutionary dynamics is crucial to maintaining a vital economy while insuring a healthy environment. It improves our ability to forecast and mitigate environmental change and illuminates options for sustaining and improving ecological systems and related goods and services. The Division of Environmental Biology supports catalytic and transformative research into the diversity of life on earth to discover its origins and evolutionary history and to understand its dynamics within ecological systems at many scales. Biodiversity and evolutionary studies concern all life on earth, including the oceans, while ecological studies emphasize terrestrial and aquatic (non-oceanic) ecosystems. Study systems include pristine as well as intensively managed habitats, including a network of long-term ecological research sites. DEB-funded research informs our ability to live sustainably on earth because ecological systems provide the goods and services upon which human health, wealth and welfare depend (e.g., clean water, food and fiber, crop pollination, disease control).

DEB is the primary source of federal research funding addressing fundamental questions in ecology and evolution, including how terrestrial and aquatic environments fit into global carbon cycling. DEB will continue to foster synthesis and education in environmental biology while promoting full participation of all groups. Scientific foci in DEB address the processes of evolution; describe the genealogical relationships of all life; elucidate the spatial and temporal dynamics of species interactions that govern the assembly of functional communities; and determine the flux of energy and materials through ecosystems. This theoretical and empirical research in ecology, evolution and biodiversity is continually transformed as it incorporates new tools from genomics, computer, and mathematical sciences. In turn, study of ecological and evolutionary dynamics has inspired breakthroughs in mathematics, such as chaos theory.

Biodiversity research is time-critical due to extinctions and global homogenization of flora and fauna. This research serves sister fields such as physiology, neuroscience, conservation, ecological restoration, and disease ecology. Phylogenetic approaches provide a framework for predicting genetic potential and risk and aid in the discovery of economically-important processes and products.

DEB supports the Long-Term Ecological Research (LTER) program, a network of 26 research sites representative of the range of natural, agricultural, and urban ecosystems in the U.S. A Network Office coordinates cross-site communication, education, outreach, and international activities, while promoting

synthesis via an open access data policy. All LTER projects share common research themes that facilitate multi-site and interdisciplinary activities. A decadal planning exercise has highlighted opportunities for leveraging the existing network to further our understanding of integrated natural and social systems.

In general, 48 percent of the DEB portfolio is available for new research grants. The remaining 52 percent is used primarily to fund continuing grants made in previous years.

DEB priorities for FY 2009:

- Characterizing the diversity of life on earth continues to be a key, time-sensitive objective. DEB will continue to support biodiversity research with increased emphasis on resolving uncertainties regarding the ancestry of microbial life forms. The explosion of genomics-level information about living organisms has opened up new avenues of inquiry that relate the adaptability and dynamics of populations to their genetic makeup. Foci include: how populations respond to climate and other anthropogenic forcing; how evolutionary processes relate to ecological patterns; and discovering the properties of resilience and robustness that enable some life forms to survive, adapt and often transform their environment. Freshwater and terrestrial ecosystems are major components of earth's global carbon cycle and thereby enter strongly into future climate scenarios. DEB will continue to play a major role in funding research to reduce uncertainties in global climate projections, as well as to improve understanding of the adaptability and malleability of these systems. Dynamic interactions of coupled social and natural systems are another high research priority.

- DEB will continue to support integrated education and research experiences that involve experiential, hands-on exposure to science. Students and teachers in these programs will contribute to a diverse citizenry well-prepared to understand and apply information about the biological world in their daily lives. DEB supports CAREER grants, Doctoral Dissertation Improvement Grants, Research Experiences for Teachers and Research Experiences for Undergraduates. It funds the LTER Schoolyard Science activity.

Changes from FY 2008:

Guided by the priorities listed above, disciplinary and interdisciplinary research in the DEB core will increase by $14.78 million. Following a reduction in research awards (-5%) and decrease of 12% in success rates (from 17% to 15%) in FY 2008, this increase will focus on improving average award sizes to enable transformative research and provide for the integration of research and education—endeavors that have significantly increased the cost of research. Included in this increase is support for:

- Interface of the Physical and Life Sciences (+$1.0M): DEB investments in the **Life in Transition** activity will focus on the role of the living world in adapting to and shaping a changing Earth, particularly focusing on fundamental questions at the junction of the life and physical sciences.

- **Dynamics of Water Processes in the Environment** (+$4.21M): This new NSF activity will be supported within DEB core activities. It will address society's need for improved knowledge to face conflicting demands on limited freshwater resources. Research in DEB is fundamental to our understanding of the vulnerability and resilience of freshwater systems to climate and environmental change. Research will focus on complex system properties such as thresholds and tipping points, maintenance of freshwater biodiversity, hydrological drivers of aquatic ecological systems, and effects of climate change on freshwater species.

BIOLOGICAL INFRASTRUCTURE $86,990,000

The FY 2009 Budget Request for the Division of Biological Infrastructure (DBI) is $86.99 million, an increase of $50,000 or 0.1 percent, over the FY 2008 Estimate of $86.94 million.

Biological Infrastructure Funding

(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Biological Infrastructure	**$80.23**	**$86.94**	**$86.99**	**0.05**	**0.000575**
Research Resources	48.22	55.61	55.66	0.05	0.1%
Human Resources	32.01	31.33	31.33	-	-

About DBI:

DBI's responsibility is to provide innovative scientific infrastructure that empowers the biological research community to advance all sub-disciplines of biology. The division funds a number of infrastructure projects that are large, inter- and multi-disciplinary. Through DBI, BIO has been able to support projects responding to the ACI priority for "Federal investment in the tools of science—facilities and instruments that enable discovery and development—particularly unique, expensive, or large-scale tools beyond the means of a single organization." DBI supports the development of a range of infrastructures, including instrumentation, informatics resources, biological collections, field stations and marine laboratories - elements critical to the operation and success of the larger biological enterprise. DBI is uniquely positioned to contribute to the increased need for interdisciplinary training for biologists in math, physical, and information sciences and greater opportunities for undergraduate research.

DBI is organized into two clusters. The **Research Resources** cluster supports development of research tools and resources The **Human Resources** cluster focuses on integration of research and education, and works closely with the Education and Human Resources Directorate.

The DBI portfolio includes fellowships, instrumentation, infrastructure improvements, and research grants. Approximately 37% is available for all new awards each year while approximately 15% of the DBI portfolio is available for new research grants. The remainder is distributed through grants for various DBI priorities and continuing funding for grants made in previous years.

DBI Priorities for FY 2009:

Research Resources

- Cyberinfrastructure ($) has been an integral part of all DBI activities and will continue to be a high priority for FY 2009. Biological Informatics supports the design, development, implementation, and use of information resources and cyberinfrastructure tools needed across biology for analysis and integration of data, informatics tools to provide the power to mine all available information and data/biological research resources to be utilized for new insights and discoveries.
- Instrumentation Resources ($) provides access to the latest instrumentation with new capabilities; and the development of new instruments for transformative research in areas such as Life in Transition. Supporting the ACI in funding the development of biological instrumentation ensures that the next generation of scientists and engineers can maintain our competitive edge. Improving field research

facilities increases America's capability for transformative research, contributes to NEON, and supports Life in Transition and the Dynamics of Water Processes in the Environment activities through access to different environments. BIO's participation in Major Research Instrumentation is managed within this subactivity.

- The Adaptive Systems Technology area will be supported by funding collaborative teams of biologists, engineers, and physical scientists to develop the next generation of adaptive tools based on biological models.
- Improvements to natural history collections archived at museums, botanical gardens, field stations, and academic institutions that are widely used for biological research and education ensures that the nation's scientific collections will continue to play a major role in the analysis of environmental change, national security, and economic development and emphasizes new strategies to further collections research. Support for repositories of live research organisms, genetic stocks, seeds, cell lines, and DNA clones that are associated with whole organisms in a collection provides access for researchers to these tools necessary for interdisciplinary research.

Human Resources

Broadening participation and integration of research and education are priorities. To provide scientists at all stages of their careers with a conceptual framework that embraces new technologies, techniques, and tools and applies this infrastructure broadly across the sciences is critical for human resource development.

- Provide year-round research mentoring in Biology ($5.0 million) for undergraduate students, especially those from underrepresented groups to train a new generation of scientists open to new approaches across scientific boundaries.
- Support increasingly interdisciplinary Research Experiences for Undergraduates site awards through partnering with MPS, ENG, and SBE.
- Support postdoctoral fellowships with solicitations that allow flexibility to address emerging resource needs throughout biology and also focus on broadening participation.
- Increase the participation of individuals from groups underrepresented in the scientific enterprise, especially beginning investigators or those new to obtaining research support ($9.99M).
- This cluster manages BIO participation of the NSF-wide human resource activities including GK-12 ($1.14M), Advance ($2.50M) and IGERT ($6.50M).

Changes from FY 2008:

Guided by BIO priorities to sustain and enable core research, including support for the new Life in Transition activity, and to support NSF-wide activities for Adaptive Systems Technology and Dynamics for Water Processes in the Environment, all programs supported within the Biological Infrastructure subactivity will be significantly impacted. Programmatic evaluations will be continuing in FY 2009 to identify the research and human resource programs most effective and essential for advancing the frontiers of the biological sciences.

- Research Resources: In order to sustain funding levels and enable research through appropriate award sizes, some programs were deferred in FY 2008 and will be put on alternate year funding cycles, including support for field stations and marine laboratories; instrumentation; biological collections; and informatics resources.
- Human Resources: In order to focus support for programs where BIO can make a difference, particular attention will be given to evaluating the effectiveness of programs in broadening participation and mentoring in biology.

EMERGING FRONTIERS $120,890,000

The FY 2009 Budget Request for the Emerging Frontiers (EF) Subactivity is $120.89 million, an increase of $19.04 million, or 18.7 percent, over the FY 2008 Estimate of $101.85 million.

(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Emerging Frontiers	**$104.90**	**$101.85**	**$120.06**	**$18.21**	**17.9%**
Major Components:					
Research & Education Projects	78.40	58.29	66.84	8.55	14.7%
Centers Programs					
National Evolutionary Synthesis Center	2.99	2.89	2.29	-0.60	-20.7%
National Center for Ecological Analysis and Synthesis[1]	3.68	3.89	3.71	-0.18	-4.7%
Plant Science Cyberinfrastructure Collaborative	-	6.63	9.11	2.48	37.4%
Center for the Environmental Implications of Nanotechnology (CEIN)	-	3.00	3.05	0.05	1.7%
Center for Research at the Interface of the Mathematical Mathematical and Biological Sciences (CIMBS)	-		3.10	3.10	N/A
Center for Behavioral Neuroscience[2]	3.85	3.15	1.96	-1.19	-37.8%
Center for Microbial Oceanography	4.00	4.00	4.00	-	-
Facilities					
National Ecological Observatories Network	11.98	20.00	26.00	6.00	30.0%

About EF:

Emerging Frontiers supports innovative research, education, and networking activities that are built upon and integrate advances in disciplinary research. EF encourages synergy among disciplines using project, network, center, and infrastructure grants that cross disciplinary boundaries.

In general, 50 percent of the EF portfolio is available for new research grants. The remaining 50 percent is used primarily to fund continuing grants made in previous years.

EF priorities for FY 2009:

Interdisciplinary Research: Support continues for multidisciplinary teams to address major biological and transdisciplinary questions through the Theoretical Advances in Biology, Assembling the Tree of Life, and Coupled Natural and Human Systems programs. EF supports an integrated portfolio of microbial activities ranging from genomics to the ecology of infectious disease. Being inherently interdisciplinary, Dynamics of Water Processes in the Environment and Life in Transition are also supported by EF.

Centers conduct long-term scientific research, explore more effective ways to educate students, partner with industry and develop mechanisms to ensure the timely transition of research and education advances of benefit to society. Centralization of all BIO centers in EF fosters collaboration and integration of research themes and facilitates the sharing of best practices. Enhanced or new centers in FY 2009 are:

- **Plant Science Cyberinfrastructure Collaborative:** Established in FY 2008, this center enables new conceptual advances by bringing together new computer, computational science, and cyberinfrastructure solutions and teams of plant biologists, computer and information scientists, and experts from other fields to address an evolving array of major questions in plant science.
- **Center for Environmental Implications of Nanotechnology:** Established in FY 2008, this center conducts multidisciplinary fundamental research on the interactions between nanoparticles and materials and the living world at all scales. Examples of topics being addressed include interactions of nanomaterials with cellular constituents, bioaccumulation, and the impacts of nanostructures dispersed in the environment on living organisms. Research on methods for nanoparticle detection is also supported.
- **Center for Research at the Interface of the Mathematical and Biological Sciences:** Being established in FY 2009, this center will conduct research and education at the interface of the mathematical and biological sciences. The Center will address national needs, particularly the modeling of infectious diseases of animals and plants, and will provide knowledge useful to policy makers, government agencies, and society.

National Ecological Observatory Network (NEON): As the first research tool designed to enable regional to continental scale ecological research, constructing NEON, now in its final design and development stage, remains the highest priority for BIO

Changes from FY 2008:

Guided by the priorities described above, research supported in EF will increase by $18.22 million. Enabling innovative research, education, networking, and facilities activities that integrate advances in the life sciences will be the focus of FY 2009 increases:

- Life in Transition (+$5.0 million): Funding will support research on the indispensable properties of living systems;
- Transformative research (+$1.2 million): Venture funding for transformative research will increase.
- Centers (+$3.66 million):
  - The Center for Research at the Interface of the Mathematical and Biological Sciences ($3.1 million), deferred in FY 2008, will be supported in FY 2009;
  - Support will be enhanced for the Plant Science Cyberinfrastructure Collaborative (+2.48 million) which is BIO's contribution to the CDI activity; and
  - Support will be enhanced for the Center for Environmental Implications of Nanotechnology (+$50,000).
  - Other centers have small out-year adjustments. (-$1.97 million)
- NEON (+$6.0 million): Support for NEON will increase by $6.0 million to complete pre-construction activities.