BIOLOGICAL SCIENCES

BIOLOGICAL SCIENCES $562,220,000

The FY 2004 Request for the Biological Sciences Activity is $562.22 million, an increase of $36.60 million, or 7.0 percent, above the FY 2003 Request of $525.62 million.

BIO Funding
(Dollars in Millions)

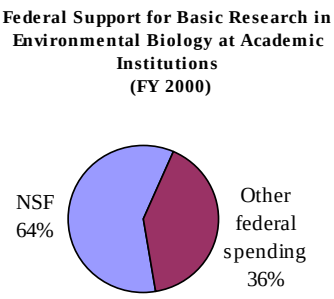
	FY 2002 Actual	FY 2003 Request	FY 2004 Request	Change Amount	Change Percent
Molecular and Cellular Biosciences	112.17	111.56	116.86	5.30	4.8%
Integrative Biology and Neuroscience	100.86	98.73	103.38	4.65	4.7%
Environmental Biology	101.11	99.77	104.77	5.00	5.0%
Biological Infrastructure	73.21	72.32	79.96	7.64	10.6%
Emerging Frontiers	47.30	68.25	82.25	14.00	20.5%
Plant Genome Research	75.00	75.00	75.00	0.00	0.0%
Total, BIO	$509.65	$525.62	$562.22	$36.60	7.0%

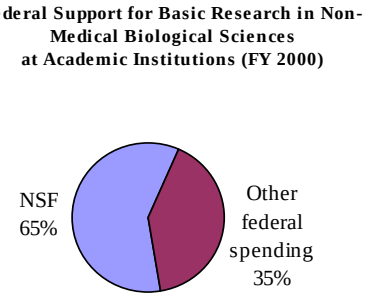
Totals may not add due to rounding

The mission of the Biological Sciences Activity (BIO) is to support the vitality of the biological sciences at U.S. colleges and universities, especially in those areas where NSF has major responsibility. BIO supports research, infrastructure, and education.

RELEVANCE

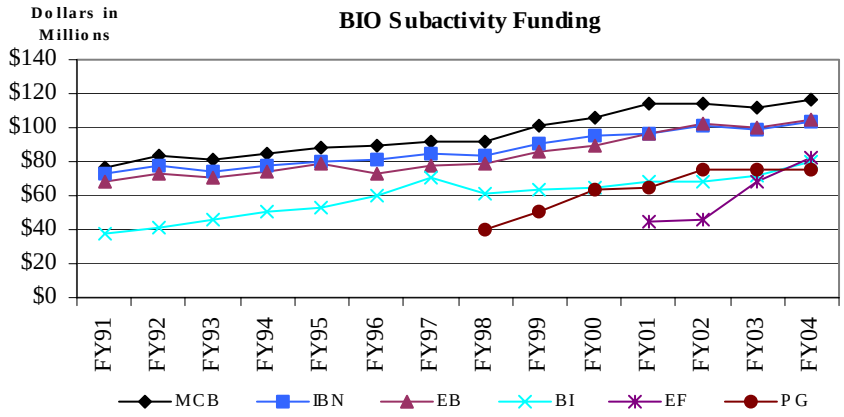
BIO is the dominant federal supporter of basic research in non-medical aspects of the biological sciences at academic institutions – providing over 65 percent of the support for these activities. Because most federal support for the life sciences – over 85 percent – goes to health-related research funded by the National Institutes of Health, NSF's contribution to the broader array of the biological sciences is significant and strategically-focused – particularly in such areas as environmental biology and plant sciences.





Fundamental research on understanding all aspects of "life" from the cell to whole ecosystems is supported within NSF – where the ability to integrate the range of biological sub-disciplines is unique. BIO support represents 64 percent of all federal funding for basic research in environmental biology and an estimated 55 percent of support in plant biology. Additionally, NSF plays a unique role in

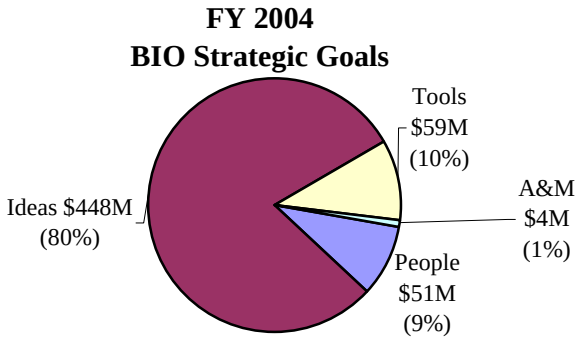
interdisciplinary biological research, since collaborations among disciplines represented by the various R&RA Activities are possible. Issues of national importance related to the environment, economy and human welfare require understanding how living organisms function and interact with the non-living systems they sustain and that sustain them. BIO supported research enhances this understanding.



Fundamental research about living organisms and their interactions with non-living systems is by nature complex and risky. Research outcomes are often surprising and unpredictable. These attributes call for the type of sustained support best provided by federal investments. NSF has taken the lead in supporting fundamental research across all levels of biological organization and especially in the areas noted above because increasing our fundamental understanding about life requires interdisciplinary approaches, which NSF is uniquely designed to provide.

STRATEGIC GOALS

Three aims guide BIO's activities:



- PEOPLE: BIO will support improvement of the quality of biological sciences education and training and enhancement of diversity in all the fields of biology. BIO will advance education and training for current biological scientists, increase the diversity of the biological sciences community, facilitate education and training for future generations of biological scientists, and enhance the general public's knowledge about biology. In FY 2004, BIO will support increases in stipends for graduate students and postdoctoral fellows and enhancement of training experiences for K-12 teachers and their students.

- IDEAS: BIO will support advancement of knowledge about major biological questions from a multidisciplinary view, including both maintaining adequate base support across all biological fields and identifying opportunities where more focused support can play a catalytic role in advancing scientific progress. 21st Century Biology is multidimensional, multidisciplinary, integrative, data-

driven, education-oriented and global, encompassing conceptual and experimental approaches much different from those of the last century. Advances in areas such as genomics, information technology, high throughput instrumentation, imaging and wireless technologies, sensors and Geographic Information Systems (GIS) now enable novel and integrative approaches to major challenges in biology. As a result, biological research has become increasingly integrative and interdisciplinary. An activity, Frontiers in Biological Research (FIBR), invites high-risk proposals for new ideas or approaches to address fundamental questions in biology that do not fit within the boundaries of traditional disciplinary or subdisciplinary areas.

- TOOLS: BIO will support enhancement of the infrastructure for the conduct of biological research. BIO will invest in instrumentation and facilities, including operational support costs for the National Ecological Observatory Network (NEON); mid-size facilities; biological research resources; and nano-sensor development.

Summary of BIO Funding by Strategic Goal
(Dollars in Millions)

	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	Change Amount	Change Percent
People	51.68	50.24	50.78	0.54	1.1%
Ideas	402.66	419.39	447.90	28.51	6.8%
Tools	50.81	52.04	59.14	7.10	13.6%
Administration & Management	4.49	3.95	4.40	0.45	11.4%
Total, BIO	$509.64	$525.62	$562.22	$36.60	7.0%

Totals may not add due to rounding.

People (+$540,000, for a total of $50.78 million)

BIO places a high priority on programs to develop a diverse, internationally competitive workforce of scientists, engineers and well-prepared citizens. These programs seek to achieve a participation in biology that reflects the diversity of the U.S. population. This emphasis ensures that the next generation of scientists will be adequately prepared for a scientific future that increasingly blurs borders between scientific disciplines, and that is increasingly dependent on technology and on the sharing and analysis of information from distributed resources. These efforts also aid in the development of a scientifically and technologically literate populace.

BIO People Investments
(Dollars in Millions)

	FY 2003 Estimate	FY 2004 Estimate	Change Amount	Change Percent
K-12	0.04	1.04	1.00	2500.0%
Undergraduate	14.07	12.07	-2.00	-14.2%
Graduate & Professional	36.13	37.67	1.54	4.3%
Total, People	$50.24	$50.78	$0.54	1.1%

Totals may not add due to rounding.

Support for People programs will increase by $540,000, or 1.1 percent, over the FY 2003 Request.

- A total of $1.04 million, an increase of $1.0 million, reflects enhanced investment in the Research Experiences for Teachers (RET) program, an activity designed to provide hands-on research experiences to K-12 science teachers and their students.
- A total of $12.07 million, a decrease of $2.0 million from the FY 2003 Request, will be used to support undergraduate activities to broaden participation in science. Examples of some of the programs supported include Research Experiences for Undergraduates (REU); Undergraduate Mentorships in Environmental Biology (UMEB), begun in FY 1995 specifically to encourage participation of underrepresented groups within environmental biology; and Collaborative Research at Undergraduate Institutions (C-RUI), which supports new multidisciplinary collaborative research groups at primarily undergraduate institutions. Each group is composed of faculty members representing at least two disciplinary areas and includes up to 10 undergraduates. Funding for C-RUI and UMEB will be provided in alternate years resulting in the decrease in funding of $2.0 million in FY 2004.

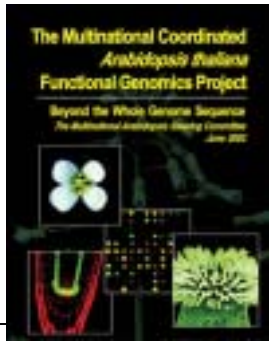
- A total of $37.67 million, an increase of $1.54 million over the FY 2003 Request of $36.13 million, will be used to support graduate, postdoctoral, and professional-level programs, including the NSF Graduate Teaching Fellows in K-12 Education (GK-12) program. BIO increases its contribution to the Integrative Graduate Education and Research Training program in FY 2004 by $2.03 for a total of $11.20 million to allow for an increase in stipends. Support for the ADVANCE program, designed to increase the participation and advancement of women in academic science and engineering careers, program will continue at $2.43 million. Decreased support for postdoctoral fellowships within BIO to a level of $4.90 million, a reduction of $710,000 or seven postdoctoral fellows, reflects a shift in priorities in FY 2004 towards support for Research Resources (Tools).

Ideas (+$28.51 million, for a total of $447.90 million)

The Biological Sciences Activity provides support for research to advance understanding of the underlying principles and mechanisms governing life. BIO's support for discovery spans all the biological disciplines. BIO-supported research effectively builds the knowledge base for resolution of societal concerns in areas as diverse as food, nutrition, agriculture, the environment, and education.

Disciplinary Research: Through all programs BIO will provide priority support to areas of emerging importance, such as integrative research focused on complex biological systems; research that integrates rapidly accumulating, massive amounts of disparate data into understanding biological processes; genome sequencing and the assembly of primary sequence databases especially for microbes and plants; and functional analyses, also known as "functional genomics".

Functional genomics has revolutionized biological research. This multidisciplinary area provides a new paradigm in biology by linking sequence data to the biological functions at the cellular, organismal, ecological, and evolutionary levels. Functional genomics tools allow researchers to conduct sequence comparisons among several different species to determine which genes are common to all life forms and which genes are unique to specific species. Identifying the function of genes has many practical applications, for example, in developing improved or novel crop plants of added value.



To capture the unprecedented opportunities offered by functional genomics, in FY 2001 BIO began the next phase of the *Arabidopsis* project, a major program in functional genomics, the **"2010 Project."** The goal is to determine the functions of the approximately 26,000 genes of the flowering plant, *Arabidopsis* by 2010.

Projects include applying the latest bioinformatic software tools to fill a publicly accessible web database cataloguing gene functions related to nitrogen metabolism. Because nitrogen is a key element in the biosphere and essential for the growth of all plants, this research will have a broad impact on the understanding of plant growth and reproduction.

In FY 2004, support for the "2010 Project" will be maintained at a total of $25.0 million. Scientists anticipate that the "2010 Project" will lead to construction of an integrated database of a "virtual plant" that will allow predictive approaches to the science of plant biology. The transfer of knowledge from research supported in this area to the private sector is almost instantaneous, as biotechnology companies seek to transform this information into better products for society, from food to pharmaceuticals to environmentally benign products. Continued support at this level will permit achievement of the goal of the project by the year 2010.

Modern biological science increasingly involves teams of scientists and students at all levels of education, and requires increasing access to supplies, equipment, and data, the latter often requiring the ability to access, analyze, and visualize remote databases. For these reasons, the cost of modern biological research is increasing sharply. BIO will continue to increase award size.

BIO Investments in Priority Areas
(Dollars in Millions)

	FY 2002 Actual	FY 2003 Request	FY 2004 Request	Change Amount	Change Percent
Biocomplexity in the Environment	16.90	35.86	39.86	4.00	11.2%
Information Technology Research	6.08	6.80	7.50	0.70	10.3%
Nanoscale Science & Engineering	2.50	2.98	4.98	2.00	67.1%
Mathematical Sciences	N/A	0.91	2.21	1.30	142.9%
Human and Social Dynamics	N/A	N/A	0.5	0.50	N/A

Priority Areas

The NSF priority areas of Biocomplexity in the Environment (BE), Information Technology Research (ITR), Nanoscale Science and Engineering (NSE), Mathematical Sciences, and Human and Social Dynamics (HSD) represent important areas of scientific inquiry.

Biocomplexity in the Environment (BE) research on the dynamics that occur within biological systems and between these systems and the physical environment will be increased by $4.0 million for a total of $39.86 million in FY 2004. This will increase support for the NSF-wide competition as well as for the Tree of Life Project. Two special competitions, the Ecology of Infectious Disease and Microbial Sequencing, will be continued.

- Ecology of Infectious Diseases ($6.0 million) activity continues an interagency partnership between NSF and NIH. The goal of the effort is to encourage the development of predictive models and discovery of the principles for relationships between environmental factors and the transmission of infectious agents. Funded research will focus on understanding the ecological determinants of transmission by vectors or abiotic agents, the population dynamics of reservoir species, and transmission to humans or other hosts. The potential benefits of interdisciplinary research in this area include: development of disease transmission models, improved understanding of unintended health effects of environmental changes, increased capacity to forecast outbreaks, and improved understanding of how diseases (re) emerge.

- The Microbial Sequencing ($15.0 million) activity will fund projects for high-throughput sequencing of the genomes of selected microorganisms including viruses, bacteria, archaea, fungi, and protozoa. The microorganisms are chosen based on their fundamental biological interest, importance to the productivity and sustainability of agriculture and forestry, and relevance to the safety and quality of the nation's food or water supply. Genome sequence information provides the foundation for understanding how organisms function and live, and how organisms interact with the environment and with other organisms. This knowledge can be used to detect unknown microorganisms and to understand their properties, e.g. why an organism may be pathogenic or beneficial to a plant or animal, or how its properties might be exploited industrially.

- BIO will increase support for the Tree of Life (ToL) Project**.** Capitalizing on new and powerful computational and genomic technologies, biologists plan to construct a universal genealogy for all 1.7 million named species of living organisms on earth. The goal is to complete the Tree within 10 years. The "family tree" will elucidate the relationships of all species of life, providing the infrastructure to guide research in many biological sub-disciplines. Inter-disciplinary, inter-agency, and international collaborations will be required. Conceptual challenges in integrating genomic data in comparisons of thousands of species will attract biologists, mathematicians, software engineers, and natural resource managers.

Information Technology Research (ITR) in FY 2004 will increase by $700,000 to $7.50 million over the FY 2003 Request of $6.80 million for the NSF-wide ITR competition, and especially for database development and management and information networking. Examples of BIO relevant areas include: algorithms for designing, managing, and linking primary biological databases, development of new tools for microbial genomics, development of innovative database structures (both hardware and software) that support distributed storage of very dense files of genetic sequence and genomic data; development of relational authority files (databases) and development of real time information networks linking researchers worldwide engaged in Tree of Life research.

Nanoscale Science and Engineering (NSE) research, focused on studying the structure and regulation of macromolecular machines and macromolecular complexes that are capable of self-replication and self-assembly, will increase by $2.0 million to $4.98 million in FY 2004. The increase will specifically support research on nanoscale biosensors and information processors, which could provide new tools for understanding cellular communication and detection of environmentally important signals.

Mathematical Sciences support within BIO, as part of the NSF-wide priority area, will be increased by $1.30 million for a total of $2.21 million, to support interdisciplinary research involving mathematics and biology with a focus on mathematical and statistical challenges posed by large biological data sets, managing and modeling uncertainty, and modeling complex, non-linear systems.

Human and Social Dynamics (HSD) support within BIO, as part of the NSF-wide priority area, will be supported for a total of $500,000. One of HSD's long-term goals is to exploit the convergence of biology, engineering and information technology to advance understanding of human cognition. This emphasis, in line with the emergence of 21st Century Biology, will support research on behavior, cognition, development and neuroscience.

BIO-supported centers are another important component in its portfolio of activities. The BIO centers facilitate the development of new knowledge and techniques and include Science and Technology Centers (STCs), Long Term Ecological Research (LTER) sites, the Center for Ecological Analysis and Synthesis (CEAS), and Plant Genome Virtual Centers. In FY 2004, BIO will continue support for all centers.

BIO Centers
(Dollars in Millions)

	FY 2003 Estimate	FY 2004 Estimate	Change Amount	Change Percent
Science and Technology Centers	4.00	4.00	0.00	0.0%
Center for Ecological Analysis and Synthesis	2.86	3.15	0.29	10.1%
Long Term Ecological Research Program	15.35	15.70	0.35	2.3%
Plant Genome Virtual Centers	31.00	31.70	0.70	2.3%
Total, BIO Centers	$53.21	$54.55	$1.34	2.5%

Totals may not add due to rounding.

The **Science and Technology Center** for Behavioral Neuroscience at Emory University was established in FY 2000. Now in its third year, this Center will move to Georgia State University where it will continue to meet the scientific goals of understanding how neural processes regulate and are regulated by complex social behaviors across animal species. Collaborating institutions include Emory University, Georgia Institute of Technology, Morehouse School of Medicine, and Atlanta University Center. The Center provides a unique opportunity to integrate research with education for a broadly diverse set of students in the Atlanta metropolitan area.

The **Center for Ecological Analysis and Synthesis** (CEAS), established in FY 1995 and recompeted in FY 1999, promotes integrative studies of complex ecological questions and serves as a locus for synthesis of large data sets. The goals of the Center are to advance the state of ecological knowledge through the search for universal patterns and principles and to organize and synthesize ecological information. Increases in support reflect the enhancement of IT capabilities.

In FY 2004, NSF will continue support for 24 **Long Term Ecological Research** (LTER) sites, which are representative of major ecosystems. Four sites are located in coastal ecosystems, two are in human-dominated, urban ecosystems, and the remaining 18 sites cover a broad range of ecosystems including the Arctic tundra of Alaska, the deserts of New Mexico, the rainforests of Puerto Rico, and the Dry Valleys of Antarctica. BIO provides full support for 16 of these sites, and partial support for 6 sites; OPP, GEO and SBE provide additional support.

Plant Genome Virtual Centers (centers without walls) are collaboratories where coordinated, multi-investigator teams pursue comprehensive plant genome research programs relevant to economically important plants or plant processes. Currently active centers range in size and scope, some with a focus on functional genomics and others with a focus on developing tools and resources for plant genomics studies for the scientific community. One award will develop a protein interaction database for rice protein kinases. Rice is a major food crop worldwide but productivity is seriously limited by environmental stresses such as drought. Kinases are part of the signaling pathways involved in plant response to stress. The outcomes of this project, which builds on the recently released rice genome sequence as well as prior projects studying kinases in the model plant Arabidopsis, should yield insights into how plants tolerate stress.

Tools (+$7.10 million, for a total of $59.14 million)

Support for Tools in BIO will increase by $7.1 million over the FY 2003 Request of $52.04 million for a total of $59.14 million. In FY 2004, BIO will increase support for research resources by $4.00 million for a total of $51.94 million to expand support for operations, maintenance and sustainability of mid-size scientific facilities and resources unique to biological research. The BIO Activity supports research resources for the biological sciences that include databases, multi-user instrumentation, development of instrumentation and new techniques, living stock centers, marine laboratories, and terrestrial field stations. Support for infrastructure ranging from databases and the informatics tools and techniques needed to manage them to instrumentation development are essential for all areas of research, including the priority areas.

BIO Investments in Tools
(Dollars in Millions)

	FY 2003 Estimate	FY 2004 Estimate	Change Amount	Change Percent
Research Resources	47.94	51.94	4.00	8.3%
NEON	3.00	6.00	3.00	100.0%
NNIN	0.30	0.40	0.10	33.3%
CHESS	0.80	0.80	0.00	0.0%
Total, BIO	$52.04	$59.14	$7.10	13.6%

Totals may not add due to rounding.

FY 2004 proposes the second year of support for the National Ecological Observatory Network (NEON). Operational support for two NEON observatories is planned. In addition, strategic planning and coordination activities will continue. NEON IT infrastructure and systems integration will be designed and evaluated using the observatories established in FY 2003 and 2004. Construction funding for the NEON observatories is discussed in the Major Research Equipment and Facilities Construction (MREFC) section.

Administration and Management

Administration and Management provides for administrative activities necessary to enable NSF to achieve its strategic goals. This includes the cost of Intergovernmental Personnel Act appointments and contractors performing administrative functions.

QUALITY

BIO maximizes the quality of the R&D it supports through the use of a competitive, merit-based review process. In FY 2002, 98 percent of basic and applied research funds were allocated to projects that underwent merit review.

To ensure the highest quality in processing and recommending proposals for awards, BIO convenes Committees of Visitors, composed of qualified external evaluators, to 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 results of NSF's investments.

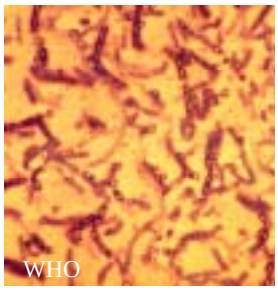
The Directorate also receives advice from the Advisory Committee for Biological Sciences (BIOAC) on such issues as: the mission, programs, and goals that can best serve the scientific community; how BIO

can promote quality graduate and undergraduate education in the biological sciences; and priority investment areas in biological research. The BIOAC meets twice a year and members represent a cross section of biology with representatives from many different sub-disciplines within the field; a cross section of institutions including small colleges, large universities, and industry representatives; broad geographic representation; and balanced representation of women and under-represented minorities.

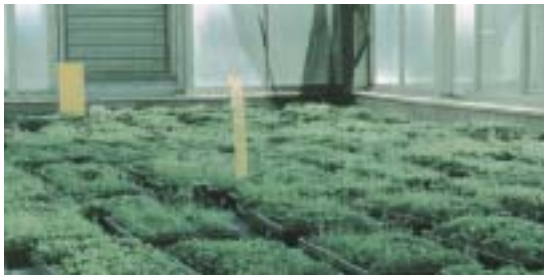
PERFORMANCE

Biological Sciences Research Highlights for FY 2002

- In a BIO supported study, researchers have discovered that signals serving as "mental pointers" are produced in the brains of zebra finches while they sing, and also while they dream about, or "rehearse," their song during sleep. This long-term, fundamental neural research is helping scientists understand brain mechanisms and, specifically, how the brain produces signals for motor control and learning. By studying how songbirds learn their songs, scientists hope to understand how humans learn to speak.



- With NSF funding, the genome of the bacterium from the Florida anthrax victim was sequenced and compared to the sequence of a standard anthrax "type" strain. The project revealed important information about the relatedness of the Florida strain to the type strain and generated an innovative and powerful technique for comparing and distinguishing closely related bacterial strains. This technology will be invaluable for studying genetic variability and tracking the sources of disease-causing bacteria.



- A recent research project is building a sequence-indexed library of mutations in the Arabidopsis genome. The library consists of approximately 140,000 Arabidopsis mutants, with each mutation tagged with insertion of a molecular tag called T-DNA. The insertion sites are sequenced and aligned with the Arabidopsis genome sequence completed in December 2000. All the data and mutant seeds are immediately made available for the community's use without restriction. The creation of a searchable database containing the insertion site information and the availability of the corresponding mutant lines in public stock centers are providing researchers with ready access to mutants in their genes of interest, allowing the testing of hypotheses about gene function at an unprecedented rate.

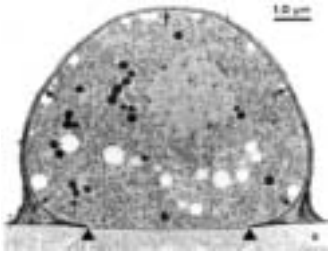
- The newly discovered remains in China of the oldest, most complete flowering plant show it probably lived underwater nearly 125 million years ago, which challenges assumptions about the origins of flowering plants. The discovery is important because it provides clues about how these now-extinct ancestors evolved

into modern living flowering plants, which comprise today's major agricultural crops.

- Colorado's Green Lakes were studied under NSF's Long-Term Ecological Research (LTER) program and it was found that atmospheric nitrogen from auto emissions and agriculture on the heavily populated Front Range of the Colorado Rockies was a possible cause of increased algal growth in high alpine lakes, which supply 40 percent of Boulder's water.

Plant diseases are a major threat to food security worldwide. Currently, there is no way to rapidly track the spread of any pathogen, naturally occurring or otherwise. Our current ability to counteract disease is limited and is mainly based on using potentially toxic chemicals that may breed resistant varieties. These age old practices while often effective in the short term are putting excessive strain on the environment and on the economy of some nations. An alternative strategy for safeguarding our well being and our food supply is to obtain a complete genetic blue print – the DNA sequence – of these noxious pathogens. Two examples of these efforts are:

- Researchers are studying the rice blast fungal pathogen, the most devastating disease of rice. The data will be available for the research community to help understand the molecular basis of plant disease as well as provide the foundation for designing novel environmentally sound strategies to more effectively manage this and other fungal diseases. The figure shows a cross section of the infectious stage of the fungus.



- A multi-disciplinary team of researchers from several universities and colleges have identified and sequenced potato genes responsible for late potato blight resistance. Late potato blight has reemerged in the United States as a serious threat to the nation's potato industry.

Awards to BIO Researchers

Duke scientist Eric Jarvis was chosen for the prestigious NSF Waterman Award in April 2002. A performing artist turned scientist, Eric overcame economic disadvantage as a child growing up in New York City's Harlem to become a top young researcher at Duke University--one of only 52 African American men out of more than 4,300 biologists who received Ph.D.s. in 1995. Jarvis was chosen for his individual achievements and leadership in studying the brain system of how birds vocalize. While conducting his groundbreaking research into how birds learn their songs, he discovered "how little scientists know about the language-fostering structures in our own brains."

President Bush named 15 individuals to receive the National Medal of Science in May 2002. BIO supported three of those named that have made lasting contributions to a burgeoning list of discoveries

and technology breakthroughs in the biological sciences. Ann M. Graybiel of M.I.T. did pioneering work on the functional anatomy and physiology of the brain systems involved in disorders such as Parkinson's and Huntington's diseases and obsessive-compulsive disorder. Francisco J. Ayala of the University of California, Irvine revolutionized molecular biology in the study of the origins of species. Gene E. Likens of the Institute of Ecosystem Studies in Millbrook, N.Y., documented for the first time in North America the environmental consequences of the phenomenon known as acid rain.

Other Performance Indicators

The tables below show the growth in the number of people benefiting from BIO's funding, and trends in growth of award size, duration and number.

Number of People Involved in BIO Activities

	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate
Senior Researchers	2,911	2,910	3,025
Other Professionals	1,651	1,650	1,715
Postdoctorates	1,355	1,355	1,410
Graduate Students	2,292	2,300	2,390
Undergraduate Students	2,246	2,250	2,340
K-12 Teachers	51	5	125
Total Number of People	10,506	10,470	11,005

BIO Funding Profile

	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate
Number of Requests for Funding	7,303	7,303	7,303
Dollars Requested (in thousands)	$4,506,000	$4,506,000	$4,506,000
Total Number of Awards	3,494	3,494	3,494
Statistics for Competitive Awards:			
Number	1,400	1,345	1,300
Funding Rate	27%	26%	25%
Statistics for Research Grants:			
Number of Research Grants	974	935	900
Median Annualized Award Size	$110,000	$117,600	$130,124
Average Annualized Award Size	$136,517	$164,569	$165,200
Average Award Duration, in yrs	3.1	3.1	3.1
Percent of Competitive Research Grants to New Investigators	33%	33%	33%

MOLECULAR AND CELLULAR BIOSCIENCES $116,860,000

The FY 2004 Request for the Molecular and Cellular Biosciences (MCB) Subactivity is $116.86 million, an increase of $5.30 million, or 4.8 percent, from the FY 2003 Request of $111.56 million.

Molecular and Cellular Biosciences Funding
(Dollars in Millions)

	FY 2002 Actual	FY 2003 Request	FY 2004 Request	Change Amount	Change Percent
Molecular & Cellular Biosciences Research Projects	112.17	111.56	116.86	5.30	4.8%
Total, Molecular & Cellular Biosciences	$112.17	$111.56	$116.86	$5.30	4.8%

MCB supports research on the fundamental properties and dynamics of the molecular and cellular components of living organisms. This research provides the foundation and framework for understanding multi-scale, complex biological systems and their interactions with the physical world. Study of complex biological questions increasingly requires the tools of genomics, information science, the physical sciences, and mathematics to achieve insights into the mechanisms by which genetic information is transmitted and expressed and the processes by which living cells are organized, communicate, and respond to environmental signals.

Such challenging questions require collaborations of biological scientists with those in the physical sciences, mathematics, computer science, and engineering. MCB is forging partnerships with these disciplines, with the goals of introducing new analytical and conceptual tools to the biological scientist, as well as providing unique training environments for the biologists of the future. This approach is consistent with the overarching goal of **21st Century Biology,** which is to understand life at both its most fundamental level and in all its complexity. Exciting progress and integration of advances in genomics, informatics, computer science, mathematics, physics, chemistry, and engineering offer the promise of realizing these ambitious goals.

In FY 2004, core activities in the MCB Subactivity are increased by $5.30 million to enhance support for multidimensional, multidisciplinary, integrative and data-driven **21st Century biological research** on the fundamental properties and dynamics of the molecular and cellular components of living organisms. From such knowledge can emerge the innovative ideas and insights that transform our understanding of the natural world, contribute to our economy through new applications in biotechnology, agriculture and the environment, and provide new knowledge that will contribute to our ability to detect and defend against biological threats.

Highlights of areas supported:

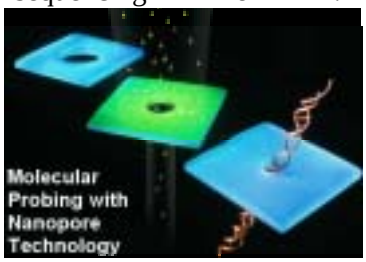
Microbial Biology: MCB, through its core activities and through the Microbial Observatories effort, encourages research on microbes at all levels of biological organization. New **genome-enabled** and biochemical approaches are being used to identify and characterize attributes of microbes, most of which have never before been described. Analysis of microbial genomes is leading to discovery of new organisms and to appreciation of the diversity of their metabolic functions that enable them to occupy diverse habitats and to interact in complex communities. These efforts are consistent with priorities of the interagency effort, "The Microbe Project."

Little is known about wetland bacteria that turn organic matter into the greenhouse gas methane. Now, for the first time, scientists are collecting methane-generating bacteria (called methanogens) from oxygen-poor wetlands, and bringing them to a lab alive. No one has ever cultured and grown methanogens from acidic wetlands in a lab. If the researchers succeed in duplicating the carbon-rich, anaerobic, acidic conditions where methanogens thrive, the organisms may have a future in bioengineering – perhaps in bioremediation of contaminated sites or in the controlled production of methane.

"2010 Project:" Unsolicited research initially funded in MCB led to the discovery of the value of *Arabidopsis thaliana* as a model flowering plant. The MCB Subactivity will continue to support research enabled by the availability of the complete genome sequence of *Arabidopsis* to determine the functions of all the genes of this model flowering plant by the year 2010.

Natural nanomachines: MCB core activities support research on the structure, mechanisms of action, and control of the molecules that represent the machinery of the living cell. These natural nanomachines provide models and paradigms for science and technology at the nanoscale.

Capitalizing on the potential of nanotechnology, researchers proposed a new method for rapidly sequencing DNA or RNA. They hypothesized that if single-stranded DNA or RNA could be drawn through a nano-pore in a membrane then changes in the ionic current of the membrane would reflect the properties of the DNA (length, nucleotide composition, etc.). A MCB Small Grants for Exploratory Research award allowed the researchers to successfully test their hypothesis. This method has fewer steps than currently used methods and depends on rapid, molecular events. This can reduce the time and cost of DNA/RNA sequencing by several orders of magnitude. This is being heralded as an extraordinarily important advance. Several publications and patents have resulted and the technology is being tested for commercial application.



Living Networks: Theoretical, computational, and mathematical modeling approaches are playing increasingly critical roles in all areas of the molecular and cellular biosciences - in formulating and testing physical and mathematical models of the structure and function of complex molecules and cellular processes; in analysis of genome data; and in addressing one of the greatest computational challenges facing 21st Century Biology, creating multi-scale models that can integrate our understanding of biological structure, function, and interactions at all levels into a predictive whole.

INTEGRATIVE BIOLOGY AND NEUROSCIENCE $103,380,000

The FY 2004 Budget Request for the Integrative Biology and Neuroscience (IBN) Subactivity is $103.38 million, an increase of $4.65 million, or 4.7%, from the FY 2003 Request of $98.73 million.

Integrative Biology and Neuroscience Funding
(Dollars in Millions)

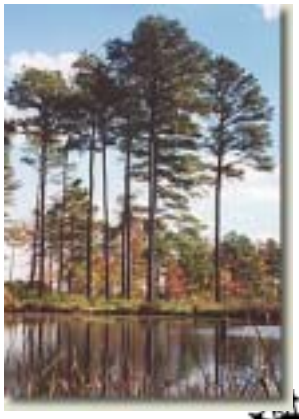
	FY 2002 Actual	FY 2003 Request	FY 2004 Request	Change Amount	Change Percent
Integrative Biology & Neuroscience Research Projects	100.86	98.73	103.38	4.65	4.7%
Total, IBN	$100.86	$98.73	$103.38	$4.65	4.7%

Research supported by the Integrative Biology and Neuroscience Subactivity seeks to understand how complex living organisms, such as plants, animals, and microbes, work. IBN researchers study the mechanisms by which organisms develop, grow, reproduce, regulate their physiological activity, and respond to their environment. The integration of molecular, subcellular, cellular, and functional genomics approaches provides insight into the development, functioning, and behavior of organisms in both laboratory and natural settings. In addition, the development and use of a wide diversity of organisms as biological models contributes to identifying unifying principles common to all organisms and documents the variety of mechanisms that have evolved in specific organisms.

IBN supports research whose goal is to understand life at both its most fundamental level and in all its complexity. Such research requires an integrated approach that utilizes exciting advances in genomics, proteomics, informatics, computer science, mathematics, physics, chemistry, and engineering. In FY 2004, core activities in the IBN Subactivity are increased by $4.65 million. IBN will emphasize 21st Century Biology projects that are multidimensional, multidisciplinary, integrative and data-driven, to understand the development, physiology, neurobiology, and behavior of living organisms.

Highlights of areas supported:

Characterization of biological systems has reached an unparalleled level of detail. To organize quantities of data and achieve integrative understanding of fundamental life processes, it is imperative that powerful computational approaches be applied. IBN supports research that utilizes advanced computational approaches and tools to understand biological systems in all their complexity. Computational biology deals with two pressing needs – the management and the analysis and interpretation of biological information. Computational biology is an important component of 21st Century biological research.

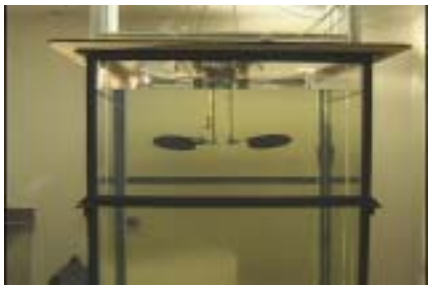


Biologists collaborating with computer scientists are using advanced information technology to determine the genetic basis of drought stress in loblolly pine and Arabidopsis. A software system has been designed that stores, mines, and analyzes microarray data. This system is being expanded to process other types of data thereby providing an automated means for merging new and existing data and identifying patterns of responses. A new method for determining relationships in multidimensional data, Inductive Logic Programming, will be used to find associations between gene expression

patterns and responses to stressful stimuli. The software will also support statistical methods for clustering gene expression data.

One benefit of having the Arabidopsis genome completely sequenced is that researchers can now study the multiple ways that flowering plants and their pollinators interact. One well-known mechanism for long- and mid-range attraction of pollinators to plants is floral scent. Research enabled by Arabidopsis genome data is revealing the complexity of the floral scent system, including the genes that control scent compound synthesis, the interactions of the flowers with the pollinating insects, and how scent and pollination systems evolve over time. Since many important crop plants are insect pollinated, results from these studies that lead to improvements in crop management can have important economic benefit.

Although the science of aeronautics is used to design airliners, space shuttles and stealth fighters, scientists are only just beginning to understand the aerodynamic mechanisms that enable tiny insects to fly and maneuver. Recent discoveries used a variety of experimental and theoretical techniques to construct a comprehensive theory of animal flight. The techniques include three-dimensional high-speed videography to capture the complex wing motions of tiny fruit flies as they actively steer and maneuver. The research also employs a giant robotic model of flapping insect wings, immersed in a 3-ton tank of mineral oil. By 'replaying' the wing and body motion of real insects on the large robot, the researchers directly measure the flows and forces created by flapping wings. This makes it possible to determine not simply how insects manage to stay in the air, but how they carefully manipulate aerodynamic forces to actively steer and maneuver.



Robot-wing in tank

By providing experimental verification of the solutions to complicated flow problems, this research will help mathematicians around the world improve the accuracy of their computer models. Also, knowledge gathered in this study on the aerodynamics of flapping wings will provide new and creative design concepts for the aeronautics industry.

ENVIRONMENTAL BIOLOGY $104,770,000

The FY 2004 Request for the Environmental Biology (DEB) Subactivity is $104.77 million, an increase of $5.0 million, or 5.0 percent, from the FY 2003 Request of $99.77 million.

Environmental Biology Funding
(Dollars in Millions)

	FY 2002 Actual	FY 2003 Request	FY 2004 Request	Change Amount	Change Percent
Environmental Biology Research Projects	101.11	99.77	104.77	5.00	5.0%
Total, Environmental Biology	$101.11	$99.77	$104.77	$5.00	5.0%

The Environmental Biology Subactivity supports fundamental research on the origins, functions, relationships, and evolutionary history of populations, species, and higher taxa, and on the interactions within and dynamics of biological communities and ecosystems. Studies can be conducted in any natural or human-impacted biotic system of the world, and can address the species of or genealogical relationships among plants, animals, and microbes; the flux of energy and materials in ecosystems; and the principles or rules by which species function in communities and evolve through time.

In FY 2004, core activities in the DEB Subactivity are increased by $5.0 million to enhance support for multidimensional, multidisciplinary, integrative and data-driven research focused on understanding ecological and evolutionary patterns and processes. Such research seeks to achieve the overarching goal of **21st Century Biology:** to understand life at both its most fundamental level and in all its complexity. Exciting progress and integration of advances in genomics, informatics, computer science, sensors, GIS and satellite imagery, mathematics, physics, chemistry, and engineering offer the promise of realizing this ambitious goal as DEB supported researchers collaborate in multidisciplinary teams.

Highlights of areas supported:

Multidisciplinary research on complex systems. Recent advances in computation, mathematics and modeling techniques support studies of the functioning of complex ecosystems. In the world's first large-scale rainfall manipulation experiment, researchers studying the Amazon are using empirical and modeling approaches over a five-year period to establish the level of drought stress that this rainforest can tolerate before large trees begin to die. These results are invaluable for understanding climate change since rainforests contribute substantially to the carbon dioxide dynamics of the atmosphere and worldwide they are experiencing stronger droughts as El Niño episodes become more frequent and severe.

Living Networks research involves fundamental analytical and synthetic studies on interactions between and among organisms, humans and their abiotic settings. During the summer of 2002, western North America experienced one of the largest forest fires in recorded history. The Biscuit Fire burned nearly one

half million acres of mostly pristine habitats in Oregon and California. One project is using burned and unburned sites left by this fire to address questions in community ecology. At replicated sites, researchers will exclude ants, a major seed dispersal agent, and test for effects on plant community composition and growth. This work will significantly extend our knowledge of ant-plant community interactions and re-establishment after catastrophic fire.

Population-level **genome-enabled** research incorporates new methods and tools from genomics, computer science and mathematics to study the properties and processes that lead to variation within and between populations, both in the present and through evolutionary time. Fragmentation of populations, reproductive isolation, and population declines jeopardize the survival of many species. A representative project is examining the evolutionary dynamics of gene flow and its landscape scale conservation and restoration consequences using California Valley oak (Quercus lobata), a threatened species experiencing habitat loss from residential and agricultural development. The project will develop novel experimental approaches to generate data that can be integrated into spatially explicit simulation models of landscape changes, which will be useful for future species management and policy decisions.

Recent **genome-enabled** science and information technologies also underpin DEB support for exploration of the diversity and history of life on earth. Madagascar is home to some of the most rare and endangered organisms on Earth. A DEB supported study of the evolutionary history of Malagasy vertebrates using genomic tools will help us understand the consequences of environmental change for vertebrate speciation and human impact on genetic diversity of forest-dependent species. This research can inform conservation policy for one of earth's most ecologically diverse and threatened environments.

Ring-Tail Lemurs

BIOLOGICAL INFRASTRUCTURE $79,960,000

The FY 2004 Budget Request for the Biological Infrastructure (DBI) Subactivity is $79.96 million, an increase of $7.64 million, or 10.6 percent, from the FY 2003 Request of $72.32 million.

Biological Infrastructure Funding
(Dollars in Millions)

	FY 2002 Actual	FY 2003 Request	FY 2004 Request	Change Amount	Change Percent
Research Resources	48.22	47.94	54.99	7.05	14.7%
Human Resources	24.99	24.38	24.97	0.59	2.4%
Total, Biological Infrastructure	$73.21	$72.32	$79.96	$7.64	10.6%

Totals may not add due to rounding.

The goal of the Biological Infrastructure Subactivity is to ensure that essential infrastructure for contemporary research is available to scientists in all areas of biological science, from the molecular to the ecosystem level, for both disciplinary and interdisciplinary efforts. Innovations in infrastructure support are vital to the advancement of 21st Century Biology across the BIO Activity. Resources supported range from physical infrastructure, such as multi-user instrumentation, to training in biological research for students at undergraduate and postdoctoral levels. In addition, teams of scientists including biologists, mathematicians, physicists, chemists, computer scientists, and engineers are supported to develop new research tools. Development of research resources, such as genome sequence databases and improvement of natural history collections and biological field stations, is also supported.

Research Resources supports a range of activities including operation and management of the National Ecological Observatories Network (NEON), multi-user instrumentation; the development of instruments with new capabilities, improved resolution or sensitivity; upgrades to biological field stations and marine laboratories; support of living stock collections ranging from microbes to plants and animals; development of biological databases and informatics tools; and research collections in biological sciences. These various research resources provide the essential platforms and tools for effective research in modern biology.

Research Resources will provide infrastructure support of $54.99 million, an increase of $7.05 million, for:

- Support for Mid-Size Facilities increased by $4.05 million over FY 2003. BIO will expand support for operations, maintenance and sustainability of mid-size scientific facilities, such as field stations, marine labs, natural history collections and living stock centers, all resources unique to biological research; and

- Support for NEON, totaling $6.0 million, an increase of $3.0 million in FY 2004. Funding will be used for operational support for and coordination of two National Ecological Observatory Network (NEON) sites. Construction and instrumentation costs for NEON are discussed in the Major Research Equipment and Facilities Construction section.

Highlights of areas supported:

Research Resources provided support to the Santa Margarita Ecological Reserve field station to develop a wireless communication system and install an array of sensing devices. These improvements to a remote field station will feed into major collaborations with other NSF-funded projects, such as ROADNet (Real-time Observatories, Applications, and Data Management Network) and HPWREN (High Performance Wireless Research and Education Network). With improved data collection and distribution, scientists and field station staff will be able to better inform policy makers, natural resource managers, and the general public on how to address critical questions about the environment and to teach students about environmental research.

Human Resources supports a range of activities centered on ensuring adequately and appropriately trained scientists for the future, broadening participation, and fostering the integration of research and education. Increasingly, emphasis is being placed on training a new generation of scientists who are well equipped to advance biology of the 21st Century. **Human Resources** will provide support of $24.97 million for programs that broaden participation while fostering the integration of research and education. This includes: NSF-wide activities such as Integrative Graduate Education and Research Training (IGERT) program, Graduate Teaching Fellows in K-12 Education (GK-12), and ADVANCE; increased stipends for students on IGERT and GK-12 awards; Research Experiences for Undergraduates (REU) Sites projects, the Undergraduate Mentorship in Environmental Biology (UMEB), and the Collaborative Research at Undergraduate Institutions (C-RUI) programs, designed to encourage interdisciplinary research experiences for faculty and students at predominantly undergraduate institutions. Beginning in FY 2004, C-RUI and UMEB will be funded in alternate years. Support will increase for Research Experience for Teachers (RET).

A specific example of the impact of the DBI investment in the human resources program is the Research Experiences for Undergraduate (REU) Sites program. Broadening participation has been emphasized in BIO-supported REU sites. As a result, 10 REU sites are now based at minority-serving institutions. In addition, several sites successfully recruited 100% of their participants from underrepresented groups, including the University of Montana (Native American students), Northern Arizona University (Native American students), Massachusetts Bay Community College (African American, Hispanic and non-traditional students), University of Missouri at Columbia (primarily African American students), Emory University (African American students) and Michigan State University (African American and Hispanic students).

EMERGING FRONTIERS $82,250,000

The FY 2004 Budget Request for the Emerging Frontiers (EF) Subactivity is $82.25 million, an increase of $14.0 million, or 20.5 percent, from the FY 2003 Request of $68.25 million.

Emerging Frontiers Funding
(Dollars in Millions)

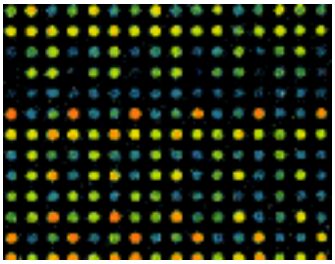
	FY 2002 Actual	FY 2003 Request	FY 2004 Request	Change Amount	Change Percent
Emerging Frontiers	47.30	68.25	82.25	14.00	20.5%
Total, Emerging Frontiers	$47.30	$68.25	$82.25	$14.00	20.5%

The Emerging Frontiers Subactivity was proposed in FY 2003 to serve as an incubator for 21st Century Biology. EF supports evolving multidisciplinary research opportunities and networking activities that arise from advances in disciplinary research. By encouraging synergy between disciplines, Emerging Frontiers provides a mechanism by which new initiatives will be fostered and subsequently integrated into core programs.

In FY 2004 BIO will increase support for **Frontiers in Integrated Biological Research (FIBR),** an activity proposed to begin in FY 2003. FIBR invites new ideas for integrative research on major biological questions from a multidisciplinary point of view. Relevant scientific questions will be those recognized both as major challenges in biology and as beyond the scope of traditional single-investigator or small-team approaches.

BIO continues support for **Research Coordination Networks (RCN)**, which seeks to encourage and foster communications and collaborations among scientists with common goals and interests. RCN provides support for groups of investigators to communicate and coordinate their research efforts across disciplinary, organizational, institutional and geographical boundaries. Networks are formed around a focal theme and can involve a broad research question, group of organisms, or particular technologies or approaches.

One Research Coordination Network was designed to develop, evaluate, and disseminate methods for the analysis of gene expression using microarrays. The network involves an interdisciplinary, inter-institutional group of scientists and students with varying backgrounds but common interests in microarrays. As a result of these interactions, a subgroup of participating investigators has developed a collaborative research project with plant biologists. This research will contribute novel statistical techniques to the analysis of plant gene expression using microarray technologies.


microarray

NSF-wide Priority Areas will be supported out of EF in order to introduce new ideas into these model 21st Century Biology activities and to provide a mechanism through which the priority areas can be integrated with disciplinary activities. Support includes:

Biocomplexity in the Environment (BE) research on the dynamics that occur within biological systems and between these systems and the physical environment. Support will be increased by $4.0 million over

the FY 2003 level of $35.86 million for a total of $39.86 million in FY 2004. The increase will enhance support for the NSF-wide competition as well as for the Tree of Life Project. Two special competitions, the Ecology of Infectious Disease and Microbial Genome Sequencing, that were initiated in FY 2003, will be continued.

Microorganisms capable of using hydrogen as an energy source and carbon dioxide as an electron acceptor for the production of methane are well known but generally rare in microbial communities. Recently, researchers found an environment in a geothermal spring in Idaho where the hydrogen and inorganic carbon levels were high enough to sustain bacteria, but the organic carbon was too low to be the primary energy source. In this environment, the dominant species were a number of novel microbes. The fact that organisms can adapt to this extreme environment, that may be representative of extraterrestrial environments, bolsters the possibility of extraterrestrial life.

Information Technology Research (ITR) in FY 2004 will increase by $700,000 to $7.50 million for the NSF-wide ITR competition, and for database development and management and information networking. Examples of BIO relevant areas include: algorithms for designing, managing, and linking primary biological databases, development of new tools for microbial genomics, development of innovative database structures (both hardware and software) that support distributed storage of very dense files of genetic sequence and genomic data; and development of real time information networks linking researchers worldwide engaged in Tree of Life research.

Nanoscale Science and Engineering (NSE) research, focused on studying the structure and regulation of macromolecular machines and macromolecular complexes that are capable of self-replication and self-assembly, will increase by $2.0 million to $4.98 million in FY 2004. The increase will specifically support research on nanoscale biosensors and information processors that could provide new tools for understanding cellular communication and detection of environmentally important signals.

A new method for creating bioelectronic circuits that allows electrically interfacing specific molecules on the membrane of living cells and then incorporate the cells into larger electrical circuits is being developed. This method is based on a new technique that allows the assembly of long, electrically conductive micro wires directly from suspensions of metallic nanoparticles. The Principal Investigators will devise techniques for controlled growth of micro wires in thin chambers and micro fluidic channels, and will develop experimental and theoretical tools for cell and wire manipulation in the electrical field leading to cell interfacing. The success of this project could lead to development of new sensors for detecting biological or chemical.


Nano-wires (~3nm)

Mathematical Sciences (MSI) will increase by $1.30 million in FY 2004 to a total of $2.21 million to support interdisciplinary research involving mathematics, science and engineering, and focus on mathematical and statistical challenges posed by large data sets, managing and modeling uncertainty, and modeling complex, non-linear systems.

Human and Social Dynamics (HSD) will be supported for a total of $500,000 in FY 2004 and will focus on research in behavior, cognition, development and neuroscience.

PLANT GENOME RESEARCH $75,000,000

The FY 2004 Budget Request for the Plant Genome Research (PGR) Subactivity is $75.0 million, equal to the FY 2003 Request.

Plant Genome Research Funding
(Dollars in Millions)

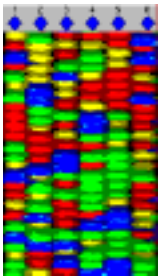
	FY 2002 Actual	FY 2003 Request	FY 2004 Request	Change Amount	Change Percent
Plant Genome Research Projects	75.00	75.00	75.00	0.00	0.0%
Total, Plant Genome Research	$75.00	$75.00	$75.00	$0.00	0.0%

The Plant Genome Research Subactivity was initiated in FY 1998, building upon an existing base of genome research supported throughout the BIO activity. PGR supports projects that make significant contributions to our understanding of plant genome structure and function. Emphasis is placed on plants of economic importance, as well as plant processes of potential economic value. Long-term benefits of this research include fundamental breakthroughs in our understanding of plant biology and practical applications to crop improvement, and the development of novel, plant-based products.

The program was established as part of the National Plant Genome Initiative (NPGI). NSF plays a major role in the NPGI. Other participating agencies are USDA, DOE, and NIH. The NSF program is managed according to the guidelines and objectives of the NPGI, and it works closely with the other agencies in coordinating funding activities.

Significant progress toward the NPGI goals has been made. Research resources and research tools have been developed that now make it possible for scientists located anywhere in the U.S. to participate in plant genome research. For example, in 1998, only 50,000 plant Expressed Sequence Tags (ESTs) were publicly available. By 2002, PGR-supported projects had produced and deposited over 2 million ESTs in public databases. These resources are now being used by thousands of plant biologists to identify genes and conduct research on many different species. In FY 2002, efforts to sequence gene-rich regions of the maize genome began. Maize is the most economically important crop in the US and knowledge of its genome sequence can help improve crop yield and nutritional quality, and expand its uses. The maize sequencing effort is also pioneering a novel method to sequence large genomes more efficiently.

PGR has supported large-scale genome projects that address major biological questions in plants, such as plant responses to environmental and biological stresses. Many of the projects are conducted by virtual centers each of which involves scientists from multiple institutions and disciplines. NSF's investment in plant genome research has stimulated international collaboration, including the international wheat genome research group, the international rice functional genomics consortium, and the international *Medicago trancatula* (a model legume) research consortium.



A new method, massively parallel signature sequencing (MPSS), is being used to identify expressed genes and determine the level of expression. This method has the advantage of being very sensitive compared to other current approaches and is likely to detect sequences that would otherwise be missed. The outcomes of this project will allow a far more complete and accurate understanding of the Arabidopsis genome and will also provide a valuable database of which genes are expressed during different stages of plant development and under a wide range of stress conditions.

The National Plant Genome Initiative has issued its new five-year plan for 2003-2008. The FY 2004 Budget Request will support activities to meet the goals of the new NPGI plan, including:

- **Functional Genomics including Rice Functional Genomics**: Taking advantage of the recently completed sequence of the rice genome by an international consortium, PGR will support efforts to identify the function of all the rice genes and to develop functional genomics tools for rice. These efforts will be coordinated internationally. Functional genomics research in other plant systems will continue to be supported utilizing the large amounts of data and resources accumulated over the last five years as a result of PGR supported projects.

- **Young Investigator Awards in Plant Genome Research:** This activity is designed to increase participation of new investigators in plant genome research. Young investigators are encouraged to submit individual or small collaborative projects to establish themselves as active members of the plant genome research community and become tomorrow's leaders.

- **Large-scale Sequencing of Genomes of Economically Important Plants**: The recent success in using new methods to concentrate gene-rich regions of large genome species, like maize, for sequencing will likely lead to increased efforts to sequence gene-rich regions of several other economically important plant species.

- **Individual and Small Group Awards in Plant Genome Research**: Plant genome research by individual or small group of scientists will be supported in order to increase participation of a broader segment of the scientific community.

- **Plant Genome Virtual Centers:** These are "centers without walls" or collaboratories where coordinated, multi-investigator teams pursue comprehensive plant genome research programs relevant to economically important plants or plant processes. Currently active centers range in size and scope, some with a focus on functional genomics and others with a focus on developing tools and resources for plant genomics studies for the scientific community.