

**DIRECTORATE FOR BIOLOGICAL SCIENCES (BIO)****\$747,920,000**  
**+\$16,890,000 / 2.3%****BIO Funding**

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate	
				Amount	Percent
Molecular & Cellular Biosciences (MCB)	\$129.32	\$134.16	\$136.21	\$2.05	1.5%
Integrative Organismal Systems (IOS)	215.21	213.71	215.40	1.69	0.8%
Environmental Biology (DEB)	138.70	143.49	144.76	1.27	0.9%
Biological Infrastructure (DBI)	131.81	142.60	145.41	2.81	2.0%
Emerging Frontiers (EF)	105.79	97.06	106.14	9.08	9.4%
<b>Total, BIO</b>	<b>\$720.84</b>	<b>\$731.03</b>	<b>\$747.92</b>	<b>\$16.89</b>	<b>2.3%</b>

Totals may not add due to rounding.

**About BIO**

The Directorate for Biological Sciences (BIO) increasingly supports more projects that address comprehensive questions involving multiple types of data acquisition and levels of analysis and many of these projects are becoming larger and more collaborative both within the biological sciences and with other fundamental disciplines. NSF is one of the few agencies where support for such integration across disciplines is possible, but achieving this requires new funding strategies and portfolio realignment within BIO. These new strategies are reflected in the FY 2016 budget.

**Opportunities and Directions:**

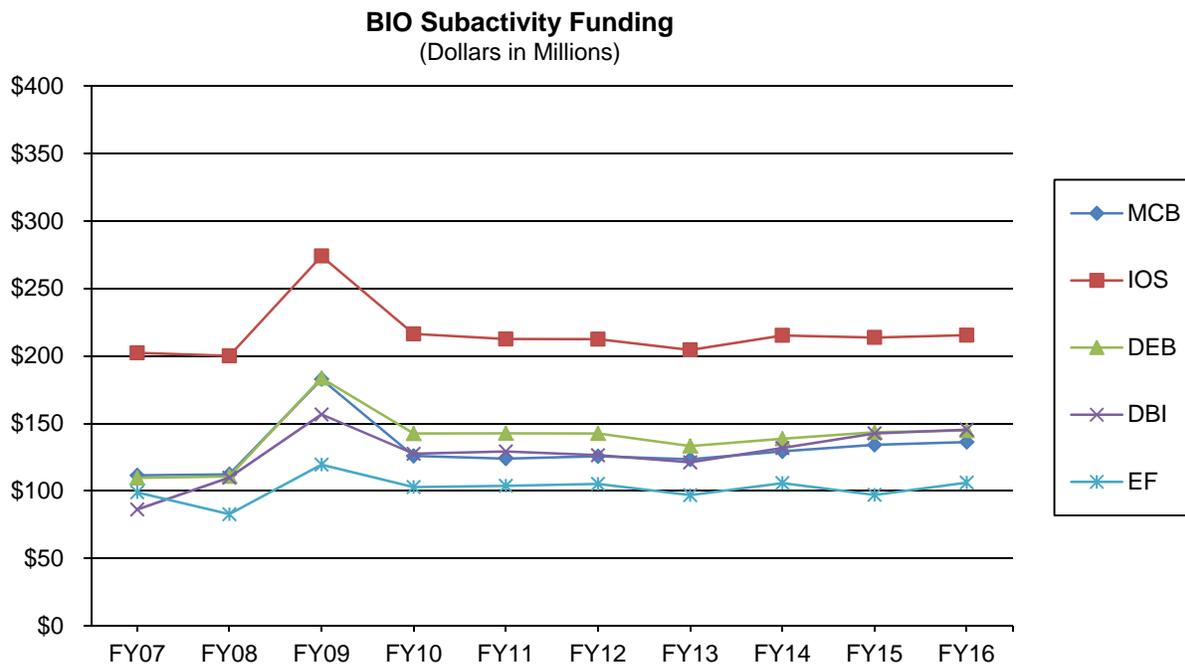
1. Systems approaches and synthetic biology (including its ecological applications and implications) are producing and employing new, widely applicable techniques and tools (e.g., Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR), a DNA editing technology) to advance the fundamental understanding of living systems, the interrelationship of genotype and phenotype, and the simultaneous drivers of ecology and evolution. This emerging area has broad scientific, economic, and societal implications and is reflected in the Research at the Interface of Biological Sciences, Mathematical and Physical Sciences (BioMaPS) investment strategy, in enhanced support for synthetic biology, and also includes opportunities in science, technology, education, and mathematics (STEM) education and broadening participation.
2. BIO participates in the Brain Research through Advancing Innovative Neurotechnologies (BRAIN) Initiative, an Administration priority, which aims to expand fundamental cognitive science and neuroscience research. With other NSF directorates (Social, Behavioral, and Economic Sciences (SBE), Mathematical and Physical Sciences (MPS), Computer & Information Science & Engineering (CISE), and Engineering (ENG)), BIO has initiated a unique program for fundamental research in neural circuits and neurotechnology development that complements BRAIN Initiative research supported by other participating agencies (National Institutes of Health (NIH) and the Defense Advanced Research Projects Agency (DARPA)). BIO's support for the BRAIN Initiative is reflected in the NSF-wide priority investment, Understanding the Brain (UtB).
3. The National Ecological Observatory Network (NEON) is a major BIO facility that will continuously stream terabytes of environmental data of regional and national significance on all scales, from organismal to continental. The MacroSystems Biology program will fund research that uses NEON

data to address macroscale research questions by supporting collaborative teams with larger awards than are possible in other core programs. As NEON construction completes and full operations begin, collaborations with other environmental facilities such as the Long Term Ecological Research (LTER) Network, Critical Zone Observatories (CZO), and the Ocean Observatories Initiative (OOI) will be actively explored. NEON will be an essential observatory for anticipating and adapting to large-scale planetary change. In FY 2016, NEON is projected to complete construction and significant components of operations will be commissioned, including STREON – the stream ecology experiment – and aquatics sites across the country. NEON operations will represent a major change to the BIO portfolio, with up to 5.9 percent of BIO’s total funding dedicated to operations and maintenance of the facility. It is expected that NEON science – through macrosystems and other core programs – will be an important investment strategy for the NSF-wide priority Innovations at the Nexus of Food, Energy, and Water Systems (INFEWS).

4. BIO invests in diverse cyberinfrastructure activities for the biological sciences, including: Synthesis Centers, iPlant, iDigBio, NEON, GoLife, and the BRAIN Initiative. In addition, the Division of Biological Infrastructure (DBI) focuses specifically on software, databases, and the creation of virtual communities to enable diverse types of biological research. DBI awards emphasize research areas that complement ongoing activities and infrastructure supported in other BIO divisions and other NSF directorates, such as the investment in BioData (BIO’s contribution to the Cyberinfrastructure Framework for 21st Century Science, Engineering, and Education (CIF21)), which will network biological research facilities and related collaborative activities with other relevant legacy and new extant data sources and biological resources. This will enable the synthesis of fundamental research data and new knowledge from a wide spectrum of activities including large-scale molecular, phylogenetic, environmental, and behavioral databases, as well as digitized collections of biological specimens.
5. BIO has been a consistent innovator within NSF in the approach to merit review and in new ways to advance science. BIO has developed such signature programs as Research Collaboration Networks (RCN) – virtual communities of investigators who share ideas, results, and best practices; Synthesis Centers; Ideas Labs for high risk multidisciplinary research projects; and the creative application of Early-concept Grants for Exploratory Research (EAGER) awards to emerging research areas (e.g., neurotechnology and neural circuits and the Basic Research to Enable Agricultural Development (BREAD) program). These strategies will be important components of BIO’s investments to broaden participation through the RCN-Undergraduate Biology Education (UBE) program and to support the BRAIN Initiative.
6. BIO continues to emphasize investments in the Five Grand Challenges in Biology: 1) synthesizing life-like systems; 2) understanding the brain; 3) predicting organisms’ characteristics from their DNA sequences; 4) elucidating interactions between the earth, its climate, and its biosphere; and 5) understanding biological diversity. These challenges are supported by the divisions for Molecular and Cellular Biosciences (through the Molecular Biophysics, Cellular Dynamics and Function, Genetic Mechanisms, and Systems and Synthetic Biology clusters), Environmental Biology (through the Ecosystem Science, Evolutionary Processes, Population and Community Ecology, and Systematics and Biodiversity Science clusters), and Integrative Organismal Systems (through the Behavioral Systems, Developmental Systems, Neural Systems, and Physiological and Structural Systems clusters), as well as through NEON and cross-NSF activities such as BioMaPS, the BRAIN Initiative, and UtB.

BIO provides about 66 percent of the federal funding for non-medical, basic research at academic institutions in the life sciences, including environmental biology, a research area critical for addressing

questions related to climate science.



FY 2009 funding reflects both the FY 2009 omnibus appropriation and funding provided through the American Recovery and Reinvestment Act of 2009 (P.L. 111-5).

### FY 2016 Summary by Division

- MCB’s FY 2016 Request (\$136.21 million) will focus support for research at the interface of biology with the quantitative and predictive sciences to enhance understanding into the fundamental molecular and cellular principles of life representing the heart of all grand challenges and bioeconomy. MCB will also fund advanced manufacturing through the NSF-wide investment priorities BioMaPS and Cyber-enabled Materials, Manufacturing, and Smart Systems (CEMMSS). MCB will support research on computational design of biomaterials, and the development of tools and standards in synthetic biology as an approach to the rapid development of biomanufacturing platforms. MCB’s contributions include research such as computational mining of the biological data from diverse biological systems to identify inspirations for the design and synthesis of new materials with defined properties and capabilities, and predictive synthetic biology to design new nanomaterials, particularly based on photosynthesis and other biological processes.
- IOS’s FY 2016 Request (\$215.40 million) will focus on basic neuroscience research directed towards understanding the development, modification, and activity of the healthy brain during complex natural behaviors. A significant proportion (\$13.50 million) of BIO’s BRAIN Initiative activities are funded through the Emerging Frontiers division, but support and complement IOS’ investment in neuroscience in collaboration with other partners across NSF. In FY 2016, the enhanced BRAIN activities will focus on opportunities for large-scale data integration, data re-use and synthesis, extending theory, and leveraging the investments in BRAIN EAGERS made in FY 2014 and FY 2015. IOS core programs will continue to support research related to the Five Grand Challenges. All IOS programs, but especially the Plant Genome Research Program (PGRP), will encourage use of synthetic biology approaches to alter and manipulate the complex interactions of components of cells and organisms to reveal systems dynamics and emergent properties. IOS programs will emphasize

multi-scale integration through mathematical, computational, experimental, and theoretical approaches to understand how characteristics of individual organisms and their emergent properties arise from their DNA sequences.

- DEB's FY 2016 request (\$144.76 million) will emphasize fundamental research on complex ecological and evolutionary processes and on how their relationships and feedbacks shape biodiversity and explain the dynamics of populations, species, communities, and ecosystems across broad spatial, temporal, and phylogenetic scales. This research will improve our ability to understand the reciprocal interactions between living systems and a changing environment, and inform essential considerations of environmental sustainability. A proportion (\$15.0 million) of NEON research activities are funded through the Emerging Frontiers division, but will support and complement research through DEB core programs with an emphasis on expanding the community of researchers addressing macro-scale environmental questions. DEB will expand research in synthetic biology to support new capabilities that provide an unprecedented opportunity to advance understanding in evolutionary ecology and the processes linking genome with phenome, and to enable the responsible development of this biotechnology. DEB will sustain support for the Dimensions of Biodiversity and the Dynamics of Coupled Natural and Human Systems (CNH) programs, and will continue to invest in coordinated efforts to link legacy and current data streams to enable integrative synthesis.
- DBI's FY 2016 Request (\$145.41 million) empowers biological discovery by supporting the development and enhancement of biological research resources, human capital, and centers. It includes sustaining support for the Advanced Digitization of Biodiversity Collections (ADBC) program and continued support for centers including the most recently BIO-funded Science and Technology Center (STC), Center for Biology with X-Ray Lasers (XFEL). In addition, support will be enhanced for biological research resources in CIF21 through increased funding for the BioData activity. Support also will be enhanced for human capital focused activities through active research participation by undergraduate students through the Research Experiences for Undergraduates (REU) Sites program.
- EF's FY 2016 Request (\$106.14 million) supports a number of limited-term activities, thus allowing for repurposing of funds towards new emphases including support for facilities. NSF-wide activities supported within EF include: UtB, BioMaPS, and the new INFEWS activity. EF also will maintain investment in Dimensions of Biodiversity, as the last BIO program within SEES as this activity continues to phase-down. In addition, enhanced support for research related to synthetic biology (within MCB, IOS, and DEB) will be leveraged via additional funds for this activity centered in EF. In FY 2016, NEON Operations and Maintenance (O&M) increases to a total of \$44.04 million, as construction is completed and NEON ramps up operations. Support for the MSB program and first NEON science (\$15.0 million) will be enhanced as NEON continues to phase into operations and standardized cross-continental data is available for research.

**Major Investments**

**BIO Major Investments**

(Dollars in Millions)

Area of Investment	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate	
				Amount	Percent
BioMaPS	\$14.31	\$14.31	\$16.81	\$2.50	17.5%
CAREER	38.56	36.43	38.25	1.82	5.0%
CEMMSS	4.75	4.99	5.48	0.49	9.8%
<i>Advanced Manufacturing</i>	2.60	2.84	3.33	0.49	17.3%
Clean Energy Technology	46.00	47.20	48.39	1.19	2.5%
CIF21	6.16	3.75	8.39	4.64	123.7%
I-Corps™	0.95	1.00	1.00	-	-
NSF INCLUDES	-	-	1.40	1.40	N/A
INFEWS	-	-	7.50	7.50	N/A
INSPIRE	0.32	1.00	1.00	-	-
IUSE	1.82	2.50	2.50	-	-
NRT <sup>1</sup>	3.12	3.39	2.33	-1.06	-31.3%
SEES	31.00	21.00	17.50	-3.50	-16.7%
Understanding the Brain	33.60	37.77	43.40	5.63	14.9%

Major investments may have funding overlap and thus should not be summed.

<sup>1</sup> Outyear commitments for Integrative Graduate Education and Research Traineeship (IGERT) are included in the NRT line and are \$3.12 million in FY 2014, \$2.0 million in FY 2015, and \$1.62 million in FY 2016.

- **BioMaPS (\$16.81 million):** This NSF-wide investment seeks to discover fundamental new knowledge to enable innovation in national priorities such as clean energy, climate science, and advanced manufacturing. In FY 2016, BIO will increase support for this activity (+\$2.50 million over the FY 2015 Estimate) by enhancing and broadening its research investment. One area of emphasis will be synthetic biology, which is a convergent area at the intersection of biology, engineering, and physical sciences that informs our ability to design and build novel biological functions and systems using engineering principles. Synthetic biology promises to develop a wide range of economically viable agricultural, industrial, environmental, energy, and health applications. Because many synthetic biology products, such as food additives, biofuels, drugs, and applications to prevent insect borne diseases are now close to commercialization, it is becoming increasingly essential and urgent that we understand environmental, evolutionary, and societal contexts of synthetic biology products and organisms. In addition, synthetic biology is also opening up new avenues of enquiry and experimental approach that promise to advance fundamental knowledge about biological processes linking genome to phenome.
- **CAREER (\$38.25 million):** BIO’s CAREER awards support young investigators who exemplify the role of teacher-scholars through outstanding research, excellent education, and the integration of education and research within the context of the mission of their organizations. In FY 2016, BIO will increase support for CAREER by \$1.82 million over the FY 2015 Estimate.

- CEMMSS (\$5.48 million): BIO's support (+\$490,000 over the FY 2015 Estimate) will enable breakthrough materials through research on topics such as computational mining of genomic data from diverse biological systems to identify inspirations for design of new materials, or predictive synthetic biology to design new nanomaterials, particularly based on photosynthesis and other biological processes. In FY 2016, BIO will continue its interagency collaborations in the area of engineering biology related to advanced biomanufacturing. ENG and BIO will continue to collaborate in funding a new Industry/University Cooperative Research Center (I/UCRC) in the area. A National Academies study on the Industrialization of Biology, co-funded by ENG and BIO, will be completed in FY 2015.
- Advanced Manufacturing (\$3.33 million): BIO will support advanced manufacturing research through BioMaPS and CEMMSS. In collaboration with ENG, BIO supports advances in standards in synthetic biology and the development of tools that will advance biomanufacturing and the development of novel biomaterials that will support the development of a thriving bioeconomy.
- Clean Energy Technology (\$48.39 million): BIO support for clean energy technology increases by \$1.19 million over the FY 2015 Estimate for fundamental research in areas such as systems and synthetic biology to streamline and scale the metabolic and energetic potential of living organisms (e.g., microbes, fungi, algae, and plants) to produce non-petroleum based sources of important chemicals/materials, feed stocks, and fuels. Investigations to assess the impact of fuel and/or bio-renewable chemical production on genome stability, fitness, and phenotype of the production organisms are of interest, as are studies to assess the potential environmental impacts of these technologies. A Dear Colleague Letter was released in FY 2015 to encourage the submission of proposals in the area of clean energy research.
- CIF21 (\$8.39 million): BIO support, an increase of \$4.64 million over the FY 2015 Estimate, will be partnered with the CISE programs Software Infrastructure for Sustained Innovation (SI<sup>2</sup>) and Data Infrastructure Building Blocks (DIBBS). In FY 2016, SI<sup>2</sup> will begin to focus on software infrastructure for major projects and awards including STCs, iPlant, and Major Research Facilities and Construction (MREFC) projects such as NEON. The DIBBS program's expanded scope includes: data reproducibility; interoperability of specific research data; sustainability plans; and exploration of innovative economic/operating models for archiving and curation.
- I-Corps (\$1.0 million): BIO will sustain support for I-Corps nodes and grants that test the feasibility of commercial prototypes developed from NSF/BIO-supported research.
- NSF INCLUDES (\$1.40 million): In FY 2016, BIO will participate in this NSF-wide effort to increase the preparation, participation, advancement, and potential contributions of those who have been traditionally underserved and/or underrepresented in STEM fields.
- Innovations at the Nexus of Food, Energy, and Water Systems (INFEWS) (\$7.50 million): The food-energy-water emphasis will be stressed in NSF-wide and BIO specific programs, such as CNH, and MSB. NEON includes both a stream ecology experiment (STREON) and aquatics sites as part of the observatory design. As NEON continues to phase into operations as construction funding is completed in FY 2016, research findings as part of the embedded NEON STREON experiment and support for research proposals utilizing data streaming from the observatory related to aquatics will inform this NSF-wide activity.
- INSPIRE (\$1.0 million): In FY 2016, BIO will continue to invest in INSPIRE awards that address complicated scientific problems at the interface between disciplines.

- IUSE (\$2.50 million): In FY 2016, support will transfer from EF to DBI to continue to support activities related to undergraduate biology education including continuation of The Partnership for Undergraduate Life Sciences Education (PULSE), RCN-UBE.
- NRT (\$2.33 million): BIO will participate in the NSF-wide program, NSF Research Traineeship (NRT), which is a modernization of the Integrative Education and Research Traineeship (IGERT) program. For more information regarding NRT, see the Major Investments in Science, Technology, Engineering, and Mathematics (STEM) Graduate Education narrative in the NSF-Wide Investments chapter.
- Science, Engineering, and Education for Sustainability (SEES) (\$17.50 million): BIO will sustain support for the Dimensions of Biodiversity while phasing down support (-\$3.50 million below the FY 2015 Estimate) for other SEES programs.
- Understanding the Brain (UtB) (\$43.40 million): BIO increases support, +\$5.63 million above the FY 2015 Estimate, for this cross-foundation activity that draws together under one management framework ongoing activities and NSF's contributions to the Administration's BRAIN Initiative. The increase, focused in Emerging Frontiers (EF), supports research on mapping circuits that drive behavior in a variety of organisms. Support will be included for activities related to integrative and transdisciplinary team-based brain research; data science, infrastructure, tool development for understanding the brain, and specialized training and professional development in multi-disciplinary and international research and large-scale data management and analysis.

## BIO Funding for Centers Programs and Facilities

### BIO Funding for Centers Programs

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate	
				Amount	Percent
<b>Total, Centers Programs</b>	<b>\$42.75</b>	<b>\$38.92</b>	<b>\$34.73</b>	<b>-\$4.19</b>	<b>-10.8%</b>
Centers for Analysis & Synthesis (DBI)	21.35	20.80	18.40	-2.40	-11.5%
Nanoscale Science & Engineering Centers (DBI)	6.33	6.33	6.33	-	-
Science & Technology Centers (DBI)	13.32	10.16	10.00	-0.16	-1.5%
Science of Learning Centers (DBI)	1.75	1.63	-	-1.63	-100.0%

Totals may not add due to rounding.

For detailed information on individual centers, please see the NSF-Wide Investments chapter.

- Centers for Analysis and Synthesis: Funding decreases by \$2.40 million below the FY 2015 Estimate, to a total of \$18.40 million. The program will support three centers in FY 2016. The decreased support represents the planned phase-down for two centers: the Plant Science Cyberinfrastructure Collaborative (iPlant) and the National Institute for Mathematical and Biological Synthesis (NIMBioS).
- Nanoscale Science and Engineering Centers (NSEC): Support will be continued for the Centers for Environmental Implications of Nanotechnology (CEIN).

- Science and Technology Centers (STCs): BIO will maintain support for two STCs in FY 2016 for a total of \$10.0 million. The Bio/computational Evolution in Action CONSortium (BEACON) increases to a total of \$5.0 million. Support is sustained for the Center for Biology with X-Ray Lasers (X-Fel) at \$5.0 million.

**BIO Funding for Facilities**

(Dollars in Millions)

	FY 2014	FY 2015	FY 2016	Change Over	
	Actual	Estimate	Request	FY 2015 Estimate Amount	Percent
<b>Total, Facilities</b>	<b>\$27.24</b>	<b>\$43.35</b>	<b>\$49.39</b>	<b>\$6.04</b>	<b>13.9%</b>
National Nanotechnology Coordinated Infrastructure (NNCI)	-	0.35	0.35	-	-
National Nanotechnology Infrastructure Network (NNIN)	0.35	-	-	-	N/A
Cornell High Energy Synchrotron Source (CHESS)	5.00	5.00	5.00	-	-
National Ecological Observatory Network (NEON)	21.89	38.00	44.04	6.04	15.9%

Totals may not add due to rounding.

For detailed information on individual facilities, please see the Facilities chapter.

- Funding for NEON O&M ramps up in FY 2016 (+\$6.04 million over the FY 2015 Estimate, to a total of \$44.04 million) as sites are commissioned and validated for delivery of science data through a central cyberinfrastructure portal. NEON is in its sixth and final year of construction and is building a series of 106 sites over twenty domains across the U.S. The research community began early science using NEON with the initiation of operations in FY 2015 and the availability of NEON soils and remote sensing data. The NEON web portal (active since FY 2015) is providing data to researchers from NEON sensors and citizen scientists. Release of a NEON data products catalog, NEON protocols, and publications is ushering in a new paradigm for ecological research. The NEON Citizen Science Academy is providing accredited training for educators and professional development for federal agency staff.
- NNIN/NNCI: BIO investment for the National Nanotechnology Infrastructure Network (NNIN) transitions in FY 2015 to the National Nanotechnology Coordinated Infrastructure (NNCI), the successor to NNIN.
- Cornell High Energy Synchrotron Source (CHESS): BIO support for CHESS will be sustained since it is an important synchrotron facility for studying biological molecules, training beam-line scientists, and providing outreach activities, including a program targeting Native American students.

**BIO Funding Profile**

	FY 2014 Actual Estimate	FY 2015 Estimate	FY 2016 Estimate
<b>Statistics for Competitive Awards:</b>			
Number of Proposals	4,788	5,000	5,300
Number of New Awards	1,276	1,250	1,300
Funding Rate	27%	25%	25%
<b>Statistics for Research Grants:</b>			
Number of Research Grant Proposal	3,829	4,000	4,200
Number of Research Grants	945	920	970
Funding Rate	25%	23%	23%
Median Annualized Award Size	\$177,930	\$182,300	\$186,900
Average Annualized Award Size	\$216,855	\$222,300	\$227,900
Average Award Duration, in years	3.2	3.2	3.2

**Summary and Funding Profile**

In FY 2016, the number of full research grant proposals is projected to increase slightly compared to FY 2015 estimated submissions. BIO will continue with the current proposal submission process: a preliminary proposal step was implemented in two of four divisions in BIO in FY 2012, and three divisions moved to annual full proposal cycles in FY 2013. Pre-proposals are not counted in the numbers cited in the funding profile above. In FY 2014, BIO received approximately 4,000 pre-proposals. When pre-proposals are included in the funding profile, funding rates are significantly lower, with some program areas below 10 percent. BIO expects to award about 970 research grants. Average annual award size will slightly increase to reflect increasing costs of research; duration will remain constant.

In FY 2016, BIO will invest \$34.73 million in centers, accounting for 4.6 percent of the BIO budget. In FY 2016, total centers funding will decrease \$4.19 million from the FY 2015 Estimate. The phase-down for two centers, iPlant and NIMBioS, continues along with the sunseting of C-MORE and the BIO-supported Science of Learning Center.

Operations and maintenance funding for NEON, the only BIO-managed facility, comprises 5.9 percent of BIO’s FY 2016 Request.

**Program Monitoring and Evaluation**

- BIO developed a Transparency and Accountability Plan in May 2014. This plan includes several steps that build on prior best practices that have been implemented across the directorate. First, every program holds a post-panel briefing that includes the program directors, the division director, and the science advisor (if the division has one) to discuss proposed awards and declinations. The briefing includes an analysis of the current portfolio and proposed awards for scientific and demographic information.
- Since FY 2014, the divisions submit narrative annual reports to BIO’s Office of the Assistant Director (OAD) that provide information on the whole division’s activities. These are then summarized in the form of a directorate-wide report.

## *Directorate for Biological Sciences*

- BIO has established a standing BIO Portfolio Analysis Working Group (BPAWG), which is charged with carrying out an annual portfolio analysis at the directorate level as well as retrospective analyses as needed.
- BIO held two directorate-wide portfolio discussions in FY 2014. The first focused on the emerging scientific gaps, opportunities, and synergies across the directorate. The second discussion focused on the types of tools available and the kind of queries that are possible. The result was a summary of scientific opportunities across divisions and the decision to obtain an enhanced IT tool for better portfolio analysis through text mining. The outputs to be analyzed across FY 2015 – FY 2016 will inform the FY 2017 budget request.

### Committee of Visitors (COV):

- In FY 2014, BIO held three COVs: MCB, IOS, and a third reviewed two programs in Emerging Frontiers (EF):
  - The MCB COV recommended that BIO increase oversight on the use of the EAGER mechanism, including requiring recommendations from two or more program directors to ensure that funding is used for early stage, exploratory, potentially transformative projects.
  - In June 2014, IOS convened a COV to evaluate IOS core programs and processes over the period of FY 2011-2013. The COV commended the division on the implementation of the preliminary proposal process and new data analytic tools that are in part aimed at portfolio analysis. Among other recommendations, the COV recommended increased staffing to mitigate rising workloads; increased documentation of processes; increasing participation of smaller, primarily undergraduate institutions and of members of underrepresented groups; continued funding to support mid-career awards; and an evaluation of the impacts of IOS awards over time.
  - The EF COV presented a favorable evaluation of the operations and management of the MSB and the ADBC programs. The COV recommendations included: establishing a long-term home for integrative, highly collaborative science, e.g. MSB; encouraging interagency collaboration relating to collections; and developing a long-term strategic look at data infrastructure needs and plans.
- In FY 2015, a COV will review DEB.
- In FY 2016, a COV will review DBI.

### Workshops and Reports:

- Division of Molecular and Cellular Biosciences:
  - In collaboration with the Division of Chemical, Bioengineering, Environmental, and Transport Systems (CBET) within the Directorate for Engineering (ENG), jointly supported an award in FY 2013 for a preliminary study on “Industrialization of Biology: A Roadmap to Accelerate Advanced Manufacturing of Chemicals.” The National Research Council of the National Academy of Sciences, through its Board on Chemical Sciences and Technology and its Board on Life Sciences, will identify key gaps in knowledge, tools, techniques and systems needed to realize the potential for advanced manufacturing via biological systems, using manufacturing of chemicals as the case study. A report will be available in the fourth quarter of FY 2015.
  - MCB, CBET, and the Division of Chemistry (CHE) within the Directorate for Mathematical and Physical Sciences (MPS) jointly funded a workshop entitled “Design, engineering and selection of novel proteins,” held in May 2014, that supports CEMMSS. The workshop brought together scientists and engineers from diverse fields to address advances in protein (material) design. The report is expected in the fourth quarter of FY 2015.
  - Partnered with the Industrial Innovation and Partnerships Division (IIP) within ENG to work with other funding and regulatory agencies and representatives from Office of Science and Technology Policy (OSTP) to convene a workshop in July 2014 addressing case studies in synthetic biology

- to enable horizon scanning and proactive conversations about the coordinated regulatory framework that governs products of synthetic biology.
- MCB, CBET, and the Division of Social and Economic Sciences (SES) within SBE jointly supported an award titled “Workshop on Research Agendas in the Societal Aspects of Synthetic Biology”. The workshop was conducted in November 2014 and a final report will be delivered in the second quarter of FY 2015. The workshop and report formulated recommendations for the conduct of social science, risk assessment, and economic research that will facilitate the responsible practice of the science and technology associated with synthetic biology.
  - MCB and the Division of Mathematical Sciences (DMS) in MPS jointly funded an award late in FY 2014 for 5 years entitled “Building a Community to Pursue Quantitative Cell Biology”. The goal of the project is to bring together researchers in a series of workshops and focused meetings to advance the use of quantitative and theory driven, predictive approaches to the study of cell biology. Graduate and undergraduate students will be included in workshops as well as laboratory exchanges to ensure education and training of the next generation of scientists at the interface of mathematical and biological sciences. A first report is due in May 2015.
  - Division of Integrative Organismal Systems:
    - Held a workshop during the summer of 2014 on the future of Animal Behavior programmatic areas focused on multiscale integration. A final report was received in early FY 2015. The report recognized the need for integration of neural, genetic, physiological, ecological, and evolutionary studies in integrative animal behavior research. Among other recommendations, the report recommended development of field-compatible technological advances that allow the measurement of physiological (e.g. hormones, heart rates) or neural changes (e.g. neurotransmitter release) in real time in non-tethered animals.
    - Organized and supported a BRAIN EAGER awardees meeting in early FY 2015. The meeting was a venue for these principal investigators (PIs) to discuss recent outcomes from their high risk/high reward research on emergent properties of neural circuit activity, to network with other investigators, and to potentially establish new collaborations.
    - A workshop is planned for the summer of FY 2015 to facilitate discussions among faculty from Primarily Undergraduate Institutions (PUI) on identifying aspects of the BRAIN Initiative that may be particularly relevant to conducting research and engaging undergraduate researchers at PUIs, to identify barriers that could prevent PUI faculty and students from contributing to this effort, and to propose solutions to such impediments.
    - In collaboration with MCB and DMS, IOS is planning one or two workshops later in FY 2015 on multi-scale integration in organisms. The workshops will be aimed at identifying opportunities where mathematical modeling approaches would enhance our understanding of multi-scale integration and emergent properties of organisms.
  - Division of Environmental Biology:
    - Funded a series of workshops in 2012 and 2013 through an award titled “Frontiers in Ecosystem Science: Energizing the Research Agenda,” to catalyze the Ecosystem Science community to develop an agenda of major directions for future research with a focus on interdisciplinary topics. A final report is expected in the fourth quarter of FY 2015.
    - The Long Term Ecological Research (LTER) program in DEB funded a “Task Force to re-envision the network office of the Long Term Ecological Research Program.” In FY 2013, this award supported a team of researchers to engage diverse environmental science communities in discussions about, and to gather input on, the future structure and function of the LTER Network Office. A preliminary report was submitted in 2014, and the group’s final report was accepted by NSF early in calendar year 2015. The report will help to inform future directions of the network office and the LTER network.
    - DEB, MCB, and CBET jointly supported an award in FY 2013 titled “Creating a Research Agenda for the Ecological Implications of Synthetic Biology,” which supports workshops to set a

national research agenda for environmental implications of synthetic biology. The workshops were conducted in January-February 2014 and a final report was published in 2014.<sup>1</sup>

- Funded a workshop in June 2014 to advance the use of genetic information in classifying fungi. This workshop will consider the technical, analytical, and taxonomic/nomenclatural challenges and opportunities presented by methods that use sequence data to recognize and identify fungi, either from fungal cultures, fruiting bodies, or directly the environment. A report is expected in early calendar year 2015.
- Funded an international workshop in FY 2014 to take place in the first half of calendar year 2015 to advance the theory and practice of meta-analysis of ecological data from the international literature for understanding sustainable development, biodiversity, and ecosystem function. A review paper examining best practices is expected to be produced.
- DEB is funding a workshop to be held in the fall of 2015 on "what works" in broadening participation. It will occur in the Washington, DC area, involve diverse stakeholders, establish an online community, and help focus priorities within DEB for a potential new solicitation on broadening participation.
- DEB funded a three-year series of workshops in FY 2014 titled "The future of comparative biology in a phylogenetic age: Enabling the power and potential of the genealogy of life" which will bring together diverse experts in phylogenetics, data visualization, and computational sciences to identify the major challenges in generating, storing, serving and visualizing the genealogy of life. Numerous products are expected over the course of the workshops being held in calendar years 2015 and 2016, and will be maintained on a central web presence to be launched in early 2015.

The Performance chapter provides details regarding the periodic reviews of programs and portfolios of programs by external Committees of Visitors and directorate Advisory Committees. Please see this chapter for additional information.

**Number of People Involved in BIO Activities**

	FY 2014		
	Actual Estimate	FY 2015 Estimate	FY 2016 Estimate
Senior Researchers	4,194	4,300	4,400
Other Professionals	1,619	1,600	1,600
Postdoctorates	1,467	1,500	1,500
Graduate Students	2,886	2,900	3,000
Undergraduate Students	4,360	4,400	4,500
<b>Total Number of People</b>	<b>14,526</b>	<b>14,700</b>	<b>15,000</b>

<sup>1</sup> [www.wilsoncenter.org/article/ecological-risk-research-agenda-for-synthetic-biology](http://www.wilsoncenter.org/article/ecological-risk-research-agenda-for-synthetic-biology)

**DIVISION OF MOLECULAR AND  
CELLULAR BIOSCIENCES (MCB)**

**\$136,210,000**  
**+\$2,050,000 / 1.5%**

**MCB Funding**  
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate	
				Amount	Percent
<b>Total, MCB</b>	<b>\$129.32</b>	<b>\$134.16</b>	<b>\$136.21</b>	<b>\$2.05</b>	<b>1.5%</b>
<b>Research</b>	<b>127.72</b>	<b>132.55</b>	<b>134.37</b>	<b>1.82</b>	<b>1.4%</b>
CAREER	15.79	14.96	15.76	0.80	5.3%
<b>Education</b>	<b>1.61</b>	<b>1.61</b>	<b>1.84</b>	<b>0.23</b>	<b>14.3%</b>

Totals may not add due to rounding.

MCB supports fundamental research and related activities that promote quantitative, predictive, and theory-driven understanding of complex living systems at the molecular, subcellular, and cellular levels. MCB gives high priority to interdisciplinary research projects that integrate theory, methods, and technologies at the interface with physical sciences, mathematics, computational sciences, and engineering to address major biological questions. Using this approach, MCB seeks to support research that addresses important questions in fundamental cell and molecular biology, including the emerging areas of synthetic biology, multi-scale integration, molecular and cellular evolution, and quantitative prediction of phenome from genomic information.

The division also supports development of methods and resources that will be used to tackle major biological questions, such as how non-living systems converge to create emergent properties of living systems, and the molecular correlates of environmental changes. MCB funds research that employs a range of experimental approaches – including *in vivo*, *in vitro* and *in silico* strategies – and a broad spectrum of model and non-model organisms, especially microbes and plants.

MCB is one of the major supporters of synthetic biology in the Foundation, and collaborates with Divisions of Physics (PHY), Chemistry (CHE), Mathematics (DMS), and Materials Science (DMR) in the Directorate for Mathematical and Physical Sciences (MPS) and the Directorate for Computer and Information Science and Engineering (CISE) to develop and utilize tools from systems and synthetic biology to address basic questions including the origins of life, minimal life forms, molecular and cellular evolution, pattern formation, and robustness and stability in biological systems. In collaboration with the Directorate for Engineering (ENG), MCB supports advances in standards in synthetic biology and the development of tools that will advance biomanufacturing and development of novel biomaterials that will support the development of a thriving bioeconomy.

MCB continues to forge partnerships (including international partnerships) to support fundamental research in the cellular and molecular sciences and to provide unique educational and training opportunities for the next generation of researchers, science educators, and scientifically literate citizens.

In general, 42 percent of the MCB portfolio is available for new research grants and the remaining 58 percent funds continuing grants made in previous years.

## **FY 2016 Summary**

All funding increases represent change over the FY 2015 Estimate.

### **Research**

- Emphasis in MCB on research at the interface of biology with the quantitative and predictive sciences will yield insights into the fundamental molecular and cellular principles of life that provide the foundation for all of the biological sciences.
- MCB will maintain its strong support (\$4.17 million) for BioMaPS through partnerships with MPS and ENG. This support will foster foundational research activities that employ interdisciplinary, quantitative, and theory-based approaches to understand the function and evolution of living systems.
- MCB will support CEMMSS research via BioMaPS at a total of \$5.48 million, by supporting fundamental research on the components and processes that comprise and control biological systems at the nano to cellular scales. In addition, MCB will contribute to Advanced Manufacturing (\$3.33 million) by supporting research on computational design of biomaterials, the development of tools and standards in synthetic biology as an approach to the rapid development of biomanufacturing platforms, and the foundational molecular scale research that will produce the next generation of nano-, bio-, and information technologies.
- MCB will increase its investment in synthetic biology by \$1.0 million. Synthetic biology is an inherently interdisciplinary activity whose funding will complement BioMaPS and CEMMSS activities. Research in synthetic biology will enable greater understanding of the fundamental principles on which living systems operate and can be built, including molecular and cellular evolution, genomes to phenomes, ecological research, and the development of biologically inspired materials. Synthetic biology is also an important tool in developing advanced biomanufacturing capabilities. MCB will invest in partnerships with the United Kingdom Biotechnology and Biological Sciences Research Council and the European Research Agency in support of the U.S. components of joint research projects that engage synthetic biology as a mechanism to leverage international investments in this area.
- Support for early-career researchers is a BIO priority; MCB will increase investment (+ \$800,000 to a total of \$15.76 million) in CAREER grants.

### **Education**

- Along with other BIO divisions, MCB increases support for Research Experiences for Undergraduates (REU) activities (+\$230,000 to a total of \$1.71 million).

**DIVISION OF INTEGRATIVE  
ORGANISMAL SYSTEMS (IOS)**

**\$215,400,000**  
**+\$1,690,000 / 0.8%**

**IOS Funding**  
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate	
				Amount	Percent
<b>Total, IOS</b>	<b>\$215.21</b>	<b>\$213.71</b>	<b>\$215.40</b>	<b>\$1.69</b>	<b>0.8%</b>
<b>Research</b>	<b>183.94</b>	<b>183.54</b>	<b>184.57</b>	<b>1.03</b>	<b>0.6%</b>
CAREER	11.15	9.75	10.19	0.44	4.5%
<b>Education</b>	<b>4.59</b>	<b>5.97</b>	<b>6.63</b>	<b>0.66</b>	<b>11.1%</b>
<b>Infrastructure</b>	<b>26.67</b>	<b>24.20</b>	<b>24.20</b>	-	-
Research Resources	26.67	24.20	24.20	-	-

Totals may not add due to rounding.

IOS supports research and education aimed at understanding the structure and function of plants, animals, and microorganisms as complex systems. Activities supported by IOS focus on neural, developmental, physiological, biomechanical, and behavioral processes that characterize organisms, and how they are integrated to result in the dynamic stability of whole organisms. Achieving such a systems-level understanding of organisms is relevant to, and will help advance, the understanding of genomes to phenomes, one of five grand challenges in biology, and will require a new emphasis on interdisciplinary approaches and development of new tools. These approaches span computational, mathematical, molecular, cellular, and individual organism levels of inquiry and analysis. IOS-supported research yields important new knowledge about functional integration and responsiveness of biological systems, providing valuable insights about the control of stability and dynamics of complex systems. IOS-supported research affords new understanding of how a wide diversity of organisms will respond to environmental change to improve our understanding of the reciprocal interactions between the biological and physical-chemical drivers of global climate change.

Within IOS, support for neuroscience focuses on the basic functions of the nervous system in response to physical, physiological, and social environments using empirical, theoretical, and computational approaches. Supported research includes comparative and evolutionary approaches to expose common patterns of mechanisms underlying how organisms perceive their physical and social environment. Results of IOS-supported neuroscience will provide the information needed to enable multi-scale integration of these dynamic activities to reveal emergent properties of nervous systems.

The Plant Genome Research Program (PGRP) supports genome-scale research to accelerate discoveries of relevance to basic plant biology, as well as downstream applications of potential societal benefit, such as crop improvement, development of new sources of bio-based energy, development of sources of novel bio-based materials, and plant adaptation to global climate change. Genome-enabled technologies developed through PGRP investments are being coupled with synthetic biology approaches to explore engineering of plants as bio-manufacturing sites that produce useful products, such as oils. The Basic Research to Enable Agricultural Development (BREAD) program will continue support for basic research to test innovative, early-concept approaches and technologies for sustainable, science-based solutions to problems of agriculture in developing countries.

IOS will plan for one or two workshops on multi-scale integration in organisms in collaboration with the

Division of Molecular and Cellular Biosciences (MCB) and the Division of Mathematical Sciences (DMS) in the Directorate for Mathematical and Physical Sciences (MPS). In this way community input will be solicited to identify opportunities where mathematical modeling approaches would enhance our understanding of the integration of the vast number of non-linear interactions of components of organisms. This developing cross-disciplinary collaboration is relevant to the BioMaPS activity. Workshop outcomes will be used to develop future plans for support of this important aspect of research in genomes to phenomes.

In general, 53 percent of the IOS portfolio is available for new research grants and the remaining 47 percent funds continuing grants made in previous years.

### **FY 2016 Summary**

All funding increases represent change over the FY 2015 Estimate.

#### **Research**

- IOS supports basic neuroscience research directed towards understanding the development, modification, and activity of the healthy brain during complex natural behaviors. In FY 2016, total funding for Understanding the Brain (UtB) will increase (+\$5.63 million, to a total of \$43.40 million). While a significant proportion of the UtB activities related to the BRAIN initiative will be funded through Emerging Frontiers (\$13.5 million), IOS neuroscience will support the UtB activity in collaboration with other partners across BIO and NSF. In FY 2016 these activities will focus on opportunities for large-scale data integration, data re-use and synthesis, extending theory, and leveraging the investments in BRAIN EAGERS made in FY 2014 and FY 2015.
- IOS core programs will continue to support research related to the Five Grand Challenges.
- All IOS programs, but especially PGRP, will encourage use of synthetic biology (+\$1.0 million in FY 2016) approaches to alter and manipulate the complex interactions of components of cells and organisms to reveal systems dynamics and emergent properties. IOS programs will emphasize multi-scale integration through mathematical, computational, experimental, and theoretical approaches to understand how characteristics of individual organisms and their emergent properties arise from their DNA sequences.
- Support for early-career researchers is a BIO priority; IOS will increase investment (+\$440,000 to a total of \$10.19 million) in CAREER grants.

#### **Education**

- Along with other BIO divisions, IOS increases support for Research Experiences for Undergraduates (REU) activities (+\$660,000 to a total of \$2.14 million).
- The Plant Genome Research Program (PGRP) will continue to provide support for the National Plant Genome Initiative (NPGI) Postdoctoral Research Fellowships Program, which is co-sponsored by NSF, the U.S. Department of Energy (DOE), and the U.S. Department of Agriculture (USDA) – Agricultural Research Service (ARS).

#### **Infrastructure**

- The IOS request maintains investments in research resources essential to PGRP, including tools for high-throughput analysis of agriculturally-important plant phenotypes under field conditions, as well as computational tools for assembly and annotation of complex genomes and their integration with associated genomic data that supports research in all IOS program. Priorities are consistent with the National Plant Genome Initiative (NPGI) 5-year plan goals.

**DIVISION OF ENVIRONMENTAL BIOLOGY (DEB)**

**\$144,760,000**  
**+\$1,270,000 / 0.9%**

**DEB Funding**  
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate	
				Amount	Percent
<b>Total, DEB</b>	<b>\$138.70</b>	<b>\$143.49</b>	<b>\$144.76</b>	<b>\$1.27</b>	<b>0.9%</b>
<b>Research</b>	<b>137.01</b>	<b>141.79</b>	<b>142.74</b>	<b>0.95</b>	<b>0.7%</b>
CAREER	4.86	3.97	4.24	0.27	6.8%
Centers Funding (total)	-	-	-	-	N/A
<b>Education</b>	<b>1.70</b>	<b>1.70</b>	<b>2.02</b>	<b>0.32</b>	<b>18.8%</b>

Totals may not add due to rounding.

DEB supports fundamental research to inventory and document all life on earth; to reveal its evolutionary history and current patterns of speciation and extinction; to understand the origins, maintenance, and consequences of biodiversity; to understand the dynamics of integrated, ecological, and evolutionary processes; and to understand feedbacks between natural and human systems.

DEB encourages research that integrates theoretical, modeling, and empirical approaches and promotes synthesis across spatial, temporal, and phylogenetic scales. Scientific foci in DEB address the processes and patterns of evolution, elucidate the integrated dimensions of biodiversity, address the dynamics of species interactions that govern the assembly of functional communities, and determine the flux of energy and materials through ecosystems. DEB includes support for long term research in evolution, ecology, and ecosystem science. Research supported by DEB is enhanced by interactions with the fields of genomics, organismal biology, computer science, geoscience, synthetic biology, engineering, and mathematics.

In general, 58 percent of the DEB portfolio is available for new research grants. The remaining 42 percent funds continuing grants made in previous years.

**FY 2016 Summary**

All funding increases represent change over the FY 2015 Estimate.

**Research**

- In DEB, total support increases slightly (+\$950,000) for fundamental research on the interactions and feedbacks of ecological and evolutionary processes in the context of changing environmental factors.
- With the completion of NEON construction and onset of full operations, DEB will encourage and support research that uses NEON data and samples to address macro-scale environmental questions, with funding provided through Emerging Frontiers.
- DEB will increase support for synthetic biology (+\$1.0 million), both as an approach to advance understanding of evolutionary ecology processes, and to enable the responsible development of this biotechnology.
- Support for Dimensions of Biodiversity, a SEES program, will continue to be supported in DEB (\$11.0 million). In addition, the Dynamics of Coupled Natural Human Systems (CNH) program will

be sustained in DEB. Research supported by these programs contributes to our understanding of ecosystem services, environmental sustainability, and the nexus of food, energy, and water.

- Support for early-career researchers remains a BIO priority; DEB will increase investment (+\$270,000, to a total of \$4.24 million) in CAREER grants.
- DEB will sustain its FY 2015 investment (\$1.90 million) in activities to promote data integration and accessibility in conjunction with a recent program on the genealogy of life, and in coordination with collections and informatics activities in DBI. This innovative program connects an open access tree of life with planetary biodiversity data, specimen/collections data, and with current data streams coming from biodiversity science, phylogenetics, environmental science, paleontology, and geosciences. This integration will foster synthesis, and enable interdisciplinary research in comparative biology.

### **Education**

- DEB will increase support for Research Experiences for Undergraduates (REU) activities by \$320,000.

**DIVISION OF BIOLOGICAL INFRASTRUCTURE (DBI)**

**\$145,410,000**  
**+\$2,810,000 / 2.0%**

**DBI Funding**  
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate	
				Amount	Percent
<b>DBI Funding</b>	<b>\$131.81</b>	<b>\$142.60</b>	<b>\$145.41</b>	<b>\$2.81</b>	<b>2.0%</b>
<b>Research</b>	<b>49.50</b>	<b>46.43</b>	<b>42.53</b>	<b>-3.90</b>	<b>-8.4%</b>
CAREER	4.92	6.00	6.31	0.31	5.2%
Centers Funding (total)	42.75	38.92	34.73	-4.19	-10.8%
Centers for Analysis & Synthesis	21.35	20.80	18.40	-2.40	-11.5%
Nanoscale Science & Engineering Centers	6.33	6.33	6.33	-	-
STC: Center for Microbial Oceanography (C-MORE)	3.32	2.66	-	-2.66	-100.0%
STC: BEACON	5.00	2.50	5.00	2.50	100.0%
STC: Xfel	5.00	5.00	5.00	-	-
Science of Learning Centers	1.75	1.63	-	-1.63	-100.0%
<b>Education</b>	<b>20.31</b>	<b>18.59</b>	<b>22.40</b>	<b>3.81</b>	<b>20.5%</b>
<b>Infrastructure</b>	<b>62.00</b>	<b>77.59</b>	<b>80.48</b>	<b>2.89</b>	<b>3.7%</b>
CHESS	5.00	5.00	5.00	-	-
NNCI	-	0.35	0.35	-	-
NNIN	0.35	-	-	-	N/A
Research Resources	56.65	72.24	75.13	2.89	4.0%

Totals may not add due to rounding.

DBI empowers biological discovery by supporting the development and enhancement of biological research resources, human capital, centers, and facilities. In particular, DBI supports the development of, or improvements to: research infrastructure, including instruments, software, and databases; and improvements to biological research collections, living stock collections, and field stations and marine labs. In addition, DBI funds the development of human capital through support of undergraduate, graduate, and postdoctoral research experiences. Support of center, center-like activities, and a few small facilities creates opportunities to address targeted but deep biological questions that have major societal impact.

In general, 30 percent of the DBI portfolio is available for new research grants and 70 percent funds continuing grants made in previous years.

**FY 2016 Summary**

All funding decreases/increases represent change over the FY 2015 Estimate.

**Research**

- A significant component of Understanding the Brain (UtB), while supported in EF, focuses on technologies with connections to activities in DBI that include support for student and postdoctoral training in instrumentation, software, and databases.

## *Directorate for Biological Sciences*

- Support for centers will decrease \$4.19 million to a total of \$34.73 million. Support for the Center for Microbial Oceanography: Research and Education (C-MORE) and the Science of Learning Centers ceases in FY 2016; the Plant Science Cyberinfrastructure Collaborative (iPlant) and National Institute for Mathematical and Biological Synthesis (NIMBioS) enter their planned ramp down. Funding for the National Socio-Environmental Synthesis Center (SESync) and funding for the Centers for the Bio/computational Evolution in Action CONSortium (BEACON) are both expected to be renewed.
- Support for early-career researchers is a BIO priority; DBI will increase investment (+\$310,000, to a total of \$6.31 million) in CAREER grants.

### **Education**

- In FY 2016, support for IUSE will be centralized within DBI (\$2.50 million). This activity includes: Partnerships in Undergraduate Learning in Science and Education (PULSE), and Research Collaboration Networks-Undergraduate Biology Education (RCN-UBE).
- The DBI program for Postdoctoral Research Fellowships in Broadening Participation (\$2.50 million) aims to promote the advancement of underrepresented groups in STEM at the postdoctoral level, is eager to engage with other NSF initiatives such as INCLUDES.
- DBI will support the new NSF activity, INCLUDES, for \$1.40 million to promote the advancement of underrepresented groups in STEM.
- Along with other BIO divisions, DBI increases support for Research Experiences for Undergraduates (REU) activities (+\$970,000).
- Support for Postdoctoral Research Fellowships in Biology and Research Coordination Networks will be sustained in FY 2016.

### **Infrastructure**

- Support for biological infrastructure will increase by \$2.89 million for a total of \$80.48 million, which will enhance support for cyberinfrastructure necessary for 21<sup>st</sup> century biology, including the development of tools necessary to address grand challenge questions such as understanding the brain.
- DBI will partner with CISE to invest in research that will focus on improving infrastructure for data integration. This is particularly important for integration of different types of data across spatial and temporal scales.
- BIO will increase support for large data-driven science, and, in particular, for CIF21-BioData activities (+\$4.64 million for a total of \$8.39 million).
- Two facilities will receive sustained funding: the Cornell High Energy Synchrotron Source (CHESS) and the National Nanotechnology Coordinated Infrastructure (NNCI).

**DIVISION OF EMERGING FRONTIERS (EF)**

**\$106,140,000**  
**+\$9,080,000 / 9.4%**

**EF Funding**  
(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate	
				Amount	Percent
<b>Total, EF</b>	<b>\$105.79</b>	<b>\$97.06</b>	<b>\$106.14</b>	<b>\$9.08</b>	<b>9.4%</b>
<b>Research</b>	<b>70.50</b>	<b>56.06</b>	<b>61.60</b>	<b>5.54</b>	<b>9.9%</b>
CAREER	1.84	1.75	1.75	-	-
<b>Education</b>	<b>3.40</b>	<b>2.55</b>	<b>0.05</b>	<b>-2.50</b>	<b>-98.0%</b>
<b>Infrastructure</b>	<b>31.90</b>	<b>38.45</b>	<b>44.49</b>	<b>6.04</b>	<b>15.7%</b>
Research Resources	10.01	0.45	0.45	-	-
National Ecological Observatory Network	21.89	38.00	44.04	6.04	15.9%

Totals may not add due to rounding.

EF identifies, incubates, and supports infrastructure and research areas that transcend scientific disciplines and/or advance the conceptual foundations of biology. It is also responsible for high-risk high-profile projects, such as NEON, that require additional oversight mechanisms. Typically, programs and priority areas begin development in EF and then shift to other BIO divisions to become part of the disciplinary knowledge base. Examples include SEES, which is phasing down, and the Advanced Digitization of Biodiversity Collections (ADBC) program which is transitioning to core divisions. EF also facilitates the development and implementation of new forms of merit review and mechanisms to support transformative research and stimulate creativity. These goals are accomplished by promoting cultural change within and across scientific disciplines to increase and strengthen multidisciplinary collaborations, encourage curiosity and exploration through novel mechanisms and investments, and facilitate support of research areas relevant to all of biology by targeted co-funding throughout the directorate.

In FY 2016, the EF portfolio changes as NEON operations and maintenance (O&M) scales up to support infrastructure following the completion of construction for the observatory, an NSF Major Research Equipment and Facility Construction (MREFC) project. Funds that were previously centralized in EF to support short-term programs will begin to phase down and transition to support this facility as it becomes fully operational. Support for education programs transitioned to DBI core activities in support of undergraduate biology education through IUSE. The research portfolio in EF remains diverse and evolving, as long standing cross-cutting activities transition to core programs (i.e. Dynamics of Coupled Natural and Human Systems (CNH) and ADBC) and new activities are developed. In FY 2016, support will focus on synthetic biology, MacroSystems Biology, early NEON science, and Understanding the Brain (UtB) including the BRAIN Initiative.

In general, 59 percent of the EF portfolio is available for new research grants. The remaining 41 percent funds continuing grants made in previous years.

## **FY 2016 Summary**

All funding increases represent change over the FY 2015 Estimate.

### **Research**

- Research in EF increases by \$5.54 million to a total of \$61.60 million to enhance support for MacroSystems Biology, early NEON science, and UtB including the BRAIN Initiative.
- Support for synthetic biology (+\$2.0 million) will be matched by other BIO divisions (+\$1.0 million each in MCB, IOS and DEB) to encourage a cross-disciplinary focus.
- Support for SEES programs in EF will be reduced by \$3.50 million to a total of \$6.50 million as support for the SEES-CNH focus phases out. Support will continue for Dimensions of Biodiversity.
- CAREER support is maintained at \$1.75 million.
- Support for INSPIRE is sustained at \$1.0 million.
- Support for BioMaPS within EF will be sustained at \$12.64 million and supplemented by support from MCB and IOS as this cross-cutting activity transitions into core programs. In FY 2016, the research focus is expanded to include increasingly essential understanding of environmental impacts, evolutionary consequences, and societal acceptance of synthetic biology products and organisms.
- Support for innovation programs continue with support for new cross-BIO activities, Ideas Labs, and interdisciplinary research.

### **Education**

- In FY 2016, EF will support Career Life Balance (CLB) supplements.

### **Infrastructure**

- Funding for NEON O&M will increase by \$6.04 million, to a total of \$44.04 million. For more detailed information on NEON, see the MREFC chapter.