

DIRECTORATE FOR BIOLOGICAL SCIENCES (BIO)**\$790,520,000**
+\$46,350,000 / 6.2%**BIO Funding**
(Dollars in Millions)

	FY 2015 Actual	FY 2016 Estimate	FY 2017 Request	Change Over FY 2016 Estimate	
				Amount	Percent
Molecular & Cellular Biosciences (MCB)	\$134.95	\$135.53	\$136.77	\$1.24	0.9%
Integrative Organismal Systems (IOS)	215.12	214.32	215.40	1.08	0.5%
Environmental Biology (DEB)	143.76	144.03	145.17	1.14	0.8%
Biological Infrastructure (DBI)	144.14	144.68	135.74	-8.94	-6.2%
Emerging Frontiers (EF)	98.22	105.61	157.44	51.83	49.1%
Total, BIO	\$736.19	\$744.17	\$790.52	\$46.35	6.2%

Totals may not add due to rounding.

About BIO

The FY 2017 Budget Request for the Directorate for Biological Sciences (BIO) is \$790.52 million, of which \$745.73 million is discretionary funding and \$44.79 million is new mandatory funding. The major focus of the mandatory funding is support for core activities and support of early career investigators. Special emphasis will be placed on research that aligns with the new BIO emphasis on Rules of Life that includes areas such as the genotype to phenotype challenge, plant and microbial sciences, including study of the microbiome, synthetic biology, and the origin of life. Support for early investigators is important to ensure adequate numbers of researchers as these research problems will require a long-term investment in tackling difficult and complex questions.

BIO's top priority is core research across biology. Current funding rates have become dangerously low, at or near single digits in most programs (when pre-proposals are counted). U.S. academic research in the biological sciences depends on NSF funding; 68 percent of academic basic research in non-medical biology is supported by NSF. BIO considers this role essential to the health of fundamental biological research at U.S. universities and colleges. Broad support for biology is necessary to produce the knowledge that will address national needs in agriculture, health, environment, and continuing innovation for the bioeconomy, which has already shown progress in areas such as biofuels, biorenewable chemicals, and nanotechnology.

BIO increasingly supports projects that address comprehensive questions involving multiple types of data acquisition and levels of analysis. 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 2017 Budget Request.

In FY 2017, BIO will begin a new emphasis in understanding the "Rules of Life," necessary to inform our collaborations with the Directorates for Engineering (ENG), Mathematical and Physical Sciences (MPS), and Computer and Information Science and Engineering (CISE).

FY 2017 priorities for BIO include:

Rules of Life (+\$13.0 million): Support for this new emphasis includes research areas such as the genotype to phenotype challenge, plant and microbial sciences, including the study of microbiomes, synthetic

biology, origins of life, and developing biological theory as a framework for the rules of life. Quantitative approaches that integrate the mathematical and physical sciences, computer science, and engineering into advancing basic biological understanding underpinning the study of the rules of life will be encouraged. In addition, BIO will emphasize support for early career scientists through enhanced funding for principal investigators, new efforts to train graduate students, and targeted support for postdoctoral fellows.

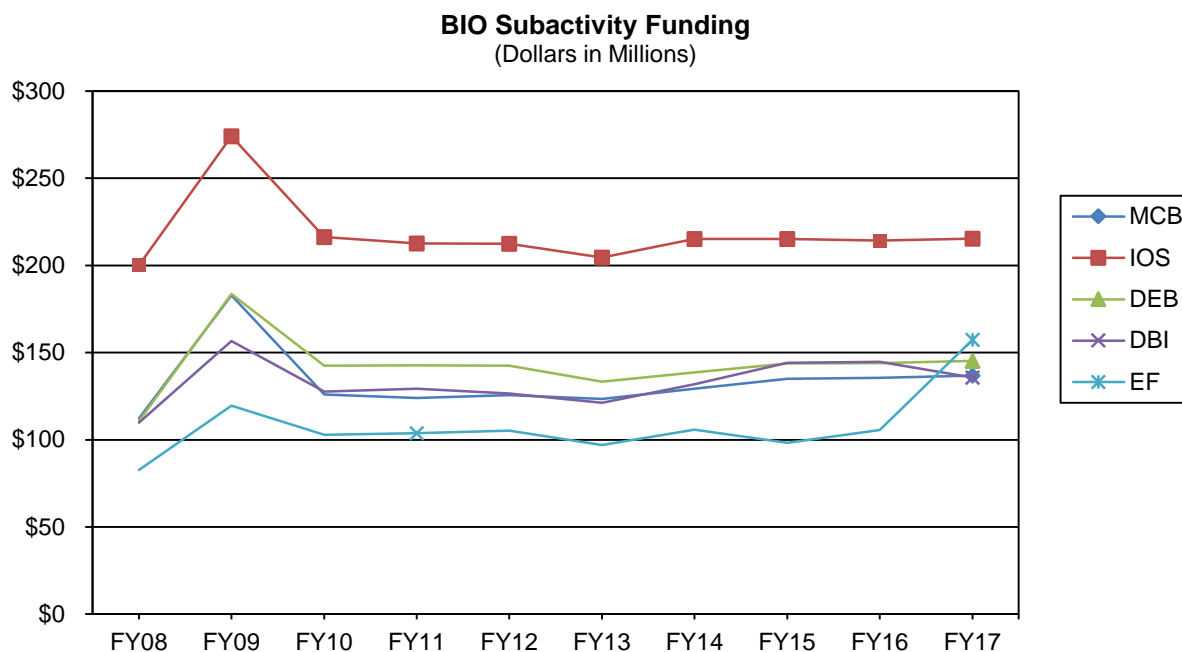
National Ecological Observatory Network (NEON) (+\$20.96 million): In FY 2017, as NEON nears completion, BIO will assume full operations and maintenance funding responsibility for NEON, including increased funding for oversight. With the need for increased oversight, BIO will transfer program management for NEON operations from Emerging Frontiers (EF) into the Division of Biological Infrastructure (DBI), which has long-standing experience managing cooperative agreements and infrastructure, such as Science and Technology Centers (STCs), iPlant, and other BIO Centers for Analysis and Synthesis. Funding for early NEON science, including continuing support for the MacroSystems Biology (MSB) program, remains a priority. NSF is in the process of evaluating new managing organizations for NEON operations and maintenance; until the final organization is selected and costs determined, funds are being retained in EF. For more information on NEON, see the Major Research Equipment and Facilities Construction (MREFC) chapter.

Understanding the Brain (UtB), including the BRAIN Initiative (+\$1.62 million): This cross-agency priority will be enhanced in FY 2017. BIO funding for UtB, including the BRAIN Initiative, increases to support investment strategies designed to enable the transformational research, engineering, infrastructure development, and training required to accomplish the overall multi-year goal. A new solicitation for Neuro-Tech Hubs will be issued to further support the development of a brain observatory. Additional information for UtB is available in the NSF-Wide Investments chapter.

Graduate Students: Graduate student costs on BIO research awards, including reimbursement for tuition, have increased. Within BIO, there is concern about the quality of student training via traditional graduate research experiences (i.e. research assistants on research grants) versus more independent approaches (i.e. fellowships and traineeships). BIO is concerned that graduate training supported on BIO research grants is not responsive to areas of long-term research need, including improved diversity in science and engineering education, nor is it providing essential information about long-term academic and non-academic career opportunities. In FY 2017, BIO proposes limiting the investment in graduate students on research grants. In parallel, BIO will endorse an increased number of Graduate Research Fellowship (GRF) awards for students in biology, will slightly increase its funding for the NSF Research Traineeship (NRT) program, and begin support for a new pilot program, BIO Research Training Grant (RTG), which is expected to integrate with NRT in later years following the initial pilot.

Innovation: Through funding in EF, BIO has invested in Ideas Labs in multiple areas of scientific inquiry, including photosynthesis, nitrogen fixation, and olfaction, this latter activity as part of the President's BRAIN Initiative. In FY 2017, a new Ideas Lab, in collaboration with NASA, is planned on the Origins of Life. NASA and NSF have signed an interagency agreement to encourage and support interaction among NASA and NSF personnel about origin of life research. A joint Ideas Lab is in the planning stages to be funded in FY 2017 as a mechanism for identifying and funding potentially transformative research to address grand challenge questions on the origin of life. The aim of this Ideas Lab is to foster the development of a theoretical framework that encompasses the "metabolism first" and "RNA first" theories for the origin of life by stimulating creative thinking and new research on the earliest events leading to life on Earth. Understanding plausible pathways for the origin of life would contribute directly to our understanding of the indispensable properties of life on Earth and inform our search for life on other worlds. Additional funding for innovation activities will continue with a focus on rules of life.

Early Career Awards and Enhanced Research Investment (+\$44.79 million): Support for early career awardees and research on the rules of life will be enhanced. BIO broadly defines early career investigators as 1) first-time NSF postdoctoral fellows, 2) first-time federal grantees (excluding postdoctoral fellowship awards), and 3) second-time NSF grantees (i.e., NSF awardees who submit a proposal within one year - before or after - the expiration date of their first NSF award (excluding postdoctoral fellowship awards)). Funds will be used to encourage BIO's core programs to support meritorious investigators in these three early career categories. Priority will be placed on the new BIO emphasis Rules of Life.



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 2017 Summary by Division

- MCB's FY 2017 Request (\$136.77 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 the new Rules of Life emphasis as well as the bioeconomy. Funding for graduate students on research grants will be limited allowing those funds to be redirected to other emphasis areas. MCB will fund advanced manufacturing research through the Research at the Interface of Biology, Mathematics, and Physical Sciences (BioMaPS) cross-foundational activity and Engineering Biology, a part of the Advanced Manufacturing initiative in Cyber-Enabled Materials, Manufacturing, and Smart Systems (CEMMSS). MCB will support research on computational design of biological systems (from proteins to communities of organisms) that could be used to produce fuels, chemicals and materials, 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. Research in these areas provides important foundational information towards clean energy technologies.

- IOS's FY 2017 Request (\$215.40 million) provides support for 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, as well as contribute substantively to understanding the rules of life. IOS' investment in neuroscience is supported and complemented by BIO's BRAIN Initiative activities, a significant portion of which (\$16.10 million of \$19.54 million total for BIO) are funded through Emerging Frontiers. All IOS programs, particularly the Plant Genome Research Program (PGRP), will encourage the use of synthetic biology approaches to alter and manipulate the complex interactions of cellular and organismal components to reveal systems dynamics and emergent properties. PGRP also will enhance support for research in areas that will provide important foundational information towards clean energy technologies.
- DEB's FY 2017 Request (\$145.17 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 is central to the new Rules of Life emphasis. 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. DEB's financial investment in graduate students on research awards will be limited allowing those funds to be redirected to other emphasis areas. 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. DEB will enhance support for research in areas that will provide important foundational information towards clean energy technologies.
- DBI's FY 2017 Request (\$135.74 million) empowers biological discovery by supporting the development and enhancement of biological research resources, human capital, and centers. In FY 2017, BIO plans to assess the effectiveness of current DBI programs towards the evolving needs of the biology community, which have become more complex, diverse, and centered on data storage, access, and analysis. Evaluating current programs, assessing where investments can make a difference in the long term resource needs, and developing a robust STEM pipeline will be a priority. BIO will use FY 2017 to reexamine the goals and objectives of many of DBI's longstanding research resource and human resource programs. Emphasis will be placed on evaluation, impact, and scalability, to gauge where support from BIO makes a difference and can be leveraged. Several programs will be put on a biennial competition schedule during their assessment and evaluation. BIO expects this assessment to be complete in time to inform the FY 2018 budget.

In addition, DBI is limiting the financial investment of graduate students supported on research grants. A new BIO Research Training Grant program (+\$6.16 million) is being introduced.

- EF's FY 2017 Request (\$157.44 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: the BRAIN Initiative, BioMaPS, and INFEWS. EF also will maintain investment in Dimensions of Biodiversity, the last BIO program within SEES as this activity continues to phase-down. In FY 2017, NEON Operations and Maintenance (O&M) increases to a total of \$65.0 million, as construction nears completion and NEON moves into full operations. Support for the MSB program and early NEON science (\$10.0 million) will be supported as NEON cross-continental data is available for research. A majority of the increase in EF (+\$44.79 million) will be used to support

additional early career researchers and to fund additional awards across BIO as part of the Rules of Life emphasis.

Major Investments

BIO Major Investments					
(Dollars in Millions)					
Area of Investment	FY 2015	FY 2016	FY 2017	Change Over	
	Actual	Estimate	Request	FY 2016 Estimate	
				Amount	Percent
ADVANCE	\$1.25	\$1.25	\$1.25	-	-
BioMaPS	14.53	16.81	16.81	-	-
CAREER	40.53	34.60	35.07	0.47	1.4%
CEMMSS	4.99	5.48	5.48	-	-
<i>Advanced Manufacturing</i>	2.84	3.33	3.33	-	-
Clean Energy Technology	48.31	48.39	79.22	30.83	63.7%
CIF21	3.75	8.39	8.39	-	-
Microbiome	-	13.64	16.37	2.73	20.0%
NSF I-Corps™	0.85	1.00	1.00	-	-
NSF INCLUDES	-	1.47	1.40	-0.07	-4.8%
INFEWS	-	7.50	10.00	2.50	33.3%
IUSE	1.13	2.50	2.50	-	-
NRT ¹	3.24	2.33	2.82	0.49	21.0%
SEES	21.00	17.50	17.50	-	-
Understanding the Brain	38.48	44.38	46.00	1.62	3.7%
<i>BRAIN Initiative</i>	11.50	18.05	19.54	1.49	8.3%

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

¹ Outyear commitments for Integrative Graduate Education and Research Traineeship (IGERT) are included in the NRT line and are \$1.85 million in FY 2015 and \$1.62 million in FY 2016.

- **ADVANCE (\$1.25 million):** BIO will continue to participate in the NSF-wide program ADVANCE as part of its ongoing commitment to broaden participation to build strategies and models to increase the participation, retention, and advancement of women in all STEM academic careers.
- **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 2017, BIO will sustain support for this activity. 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, and 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 as well as other areas of investigation that encompass the rules of life.

- CAREER (\$35.07 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 2017, BIO will increase support for CAREER by \$470,000 over the FY 2016 Estimate.
- Cyber-Enabled Materials, Manufacturing, and Smart Systems (CEMMSS) (\$5.48 million): BIO's support will enable breakthrough materials through research on topics such as computational mining of genomic data from diverse biological systems to identify inspirations for the design of new materials, or predictive synthetic biology to design new nanomaterials, particularly based on photosynthesis and other biological processes. In FY 2017, 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 an Industry/University Cooperative Research Center (I/UCRC) in the area. For more information on CEMMSS, see the NSF-wide Investments Chapter.
- 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 (\$79.22 million): BIO support for clean energy technology increases by \$30.83 million over the FY 2016 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. Bioinspired design of new proteins and other complex biomaterials that can transform light into energy will also be supported. 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.
- Cyberinfrastructure Framework for 21st Century Science, Engineering, and Education (CIF21) (\$8.39 million): BIO will sustain support for new midscale projects to advance data, software, and collaborative infrastructure in support of several priority areas, such as Rules of Life, Understanding the Brain, and Genotype to Phenotype, through the Advances in Biological Informatics Program, BIO Synthesis Centers, as well as ongoing solicitations, i.e. Software Infrastructure for Sustained Innovation (SI²). In FY 2017, SI² 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. For more information on CIF21, see the NSF-wide Investments Chapter.
- Microbiome (\$16.37 million): In FY 2017, support for microbiome research will increase +\$2.73 million. Microbiomes are the collective microbial partners that live in, on, and around plants and animals. Microbiome investments support research on the role of microbes in plant and animal function, productivity, health, and resilience to environmental change, as well as microbes' role in soil and marine ecosystems. Studies of microbiomes occur on a broad range of scales from metagenomics, which looks at the entirety of collective genomes in microbial communities, to individual community composition and collective metabolic activity. A joint solicitation between BIO IOS and USDA NIFA called Plant Biotic Interactions (PBI) will be issued in FY 2016, with initial awards funded in FY 2017.
- NSF Innovation Corps (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. For more information on NSF I-Corps™, see the NSF-wide Investments Chapter.

- NSF Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science (NSF INCLUDES) (\$1.40 million): In FY 2017, 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. For more information on NSF INCLUDES, see the NSF-wide Investments Chapter.
- Innovations at the Nexus of Food, Energy, and Water Systems (INFEWS) (\$10.0 million): The food-energy-water emphasis will be stressed in NSF-wide and BIO specific programs, such as Dynamics of Coupled Natural and Human Systems (CNH), Macrosystems Biology (MSB), and a phytobiome Dear Colleague Letter. For more information on INFEWS, see the NSF-wide Investments Chapter.
- Improving Undergraduate STEM Education (IUSE) (\$2.50 million): DBI will continue to support activities related to undergraduate biology education through Research Collaboration Networks-Undergraduate Biology Education (RCN-UBE). For more information regarding IUSE, see the NSF-Wide Investments chapter.
- NSF Research Traineeship (NRT) (\$2.82 million): BIO will participate in the NSF-wide program, NRT. 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 for other SEES programs. For more information on SEES, see the NSF-Wide Investments Chapter.
- Understanding the Brain (UtB) (\$46.0 million): BIO continues support for this cross-foundation activity. Investments in research on mapping circuits that drive behavior in a variety of organisms will be sustained. Support also is 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. For more information on UtB, see the NSF-wide Investments Chapter.
- BRAIN Initiative (\$19.54 million): As part of UtB, BIO increases support for the BRAIN Initiative, +\$1.49 million above the FY 2016 Estimate of \$18.05 million. The increase, housed in EF, will support a new solicitation for Neuro-Tech Hubs to be funded in response to the need for a brain observatory, in partnership with MPS and CISE.

BIO Funding for Centers Programs and Facilities

BIO Funding for Centers Programs

(Dollars in Millions)

	FY 2015 Actual	FY 2016 Estimate	FY 2017 Request	Change Over FY 2016 Estimate	
				Amount	Percent
Total, Centers Programs	\$41.42	\$34.73	\$31.13	-\$3.60	-10.4%
Centers for Analysis & Synthesis (DBI)	20.80	18.40	15.80	-2.60	-14.1%
Nanoscale Science & Engineering Centers (DBI)	6.33	6.33	5.33	-1.00	-15.8%
Science & Technology Centers (DBI)	12.66	10.00	10.00	-	-
Science of Learning Centers (DBI)	1.63	-	-	-	N/A

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 \$2.60 million below the FY 2016 Estimate, to a total of \$15.80 million. The program will support three centers in FY 2017. 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 reduced to \$5.33 million for the Centers for Environmental Implications of Nanotechnology (CEIN). Forward funding provided in earlier years resulted in a lower funding requirement for FY 2017.
- Science and Technology Centers (STCs): BIO will maintain support for two STCs in FY 2017 for a total of \$10.0 million. The Bio/computational Evolution in Action CONsortium (BEACON) remains at a total of \$5.0 million. Support is also sustained for the Center for Biology with X-Ray Lasers (X-Fel) at \$5.0 million.

BIO Funding for Facilities

(Dollars in Millions)

	FY 2015 Actual	FY 2016 Estimate	FY 2017 Request	Change Over FY 2016 Estimate	
				Amount	Percent
Total, Facilities	\$5.57	\$49.39	\$70.35	\$20.96	42.4%
National Nanotechnology Coordinated Infrastructure (NNCI)	0.45	0.35	0.35	-	-
Cornell High Energy Synchrotron Source (CHESS)	5.00	5.00	5.00	-	-
National Ecological Observatory Network (NEON)	0.12	44.04	65.00	20.96	47.6%

Totals may not add due to rounding.

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

- BIO's investment for the National Nanotechnology Coordinated Infrastructure (NNCI) will be sustained.
- Cornell High Energy Synchrotron Source (CHESS): BIO support for CHESS will be sustained. CHESS is an important synchrotron facility for studying biological molecules, training beam-line scientists, and providing outreach activities, including a program targeting Native American students.
- Funding for NEON O&M ramps up in FY 2017 to a total of \$65.0 million. This represents the final increment from the original three-year O&M award as well as a partial increment for an anticipated one-year extension. This additional year in prototype O&M will allow time for a more complete

understanding of the services and costs proposed and to prepare for a re-competition for a longer term award. The FY 2017 Request amount includes management and technical support, seasonal biological sampling, analytical and archival costs, and domain facilities costs. Funds also will support the calibration and validation laboratories and headquarters functions, such as maintenance of the data center, Observatory monitoring, quality assurance and control, and O&M of the Airborne Observation Platform. In FY 2017, NSF will explore options for operation and maintenance of the full NEON Observatory after construction. For more information on NEON, see the MREFC chapter.

Summary and Funding Profile

In FY 2017, the number of full research grant proposals is projected to increase above the FY 2016 estimated submissions. To accommodate the increase in proposal submissions, BIO will continue with its current proposal submission process: two of BIO’s five divisions require a preliminary proposal step and the remaining three divisions have an annual full proposal submission window. Pre-proposals are not counted in the numbers cited in the funding profile below. In FY 2015, BIO received approximately 3,500 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 1,600 research grants. Average annual award size will remain flat as BIO moves to limit investment in graduate students on grants; duration will remain constant.

In FY 2017, BIO will invest \$31.13 million in centers, accounting for 3.9 percent of the BIO budget.

Operations and maintenance funding for NEON, the only BIO-managed facility, comprises 8.2 percent of BIO’s FY 2017 Request.

BIO Funding Profile			
	FY 2015	FY 2016	FY 2017
	Actual	Estimate	Estimate
	Estimate	Estimate	Estimate
Statistics for Competitive Awards:			
Number of Proposals	5,122	5,400	6,200
Number of New Awards	1,382	1,400	1,600
Funding Rate	27%	26%	26%
Statistics for Research Grants:			
Number of Research Grant Proposals	4,303	4,500	5,300
Number of Research Grants	1,033	1,100	1,300
Funding Rate	24%	24%	25%
Median Annualized Award Size	\$185,708	\$195,000	\$195,000
Average Annualized Award Size	\$238,573	\$250,500	\$251,000
Average Award Duration, in years	3.1	3.2	3.2

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.

- 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.

Directorate for Biological Sciences

- Since FY 2014, the divisions submit narrative annual reports to BIO's Office of the Assistant Director (OAD) that provide information on the division's activities. These are then summarized in the form of a directorate-wide report. In FY 2015, the directorate-wide report included a portfolio analysis that informed the scientific themes presented in BIO's FY 2017 Congressional Budget Request.
- 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 across FY 2015 – FY 2016 informed the FY 2017 Budget Request.

Committee of Visitors (COV)

- In FY 2015, BIO held one COV in the Division of Environmental Biology (DEB). The COV convened June 17-19 at NSF and reviewed division operations and the programmatic portfolio for FY 2012 to FY 2014. The COV commended the division on the operations and management of a diverse suite of core and special programs that support a broad scientific endeavor. The primary recommendations of the COV centered on implementing additional mechanisms to reduce the variability in proposal reviews written by external experts. The COV also recommended increased staffing to mitigate administrative workloads and continued efforts to increase interactions with the research communities. They strongly endorsed continued internal and external evaluation of the preliminary proposal mechanism.
- In FY 2016 the Division of Biological Infrastructure (DBI) will be holding a COV.
- In FY 2017, BIO is planning to hold COVs for the Division of Molecular and Cellular Biosciences (MCB) and the Division of Integrative Organismal Systems (IOS).

Evaluation

- DEB and IOS are working with the NSF Division of Acquisition and Cooperative Support to award a contract for an external evaluation of the preliminary proposal review mechanism for core programs in the two BIO divisions. The evaluation is expected to address program and research community questions about the outcomes of the preliminary proposal mechanism on the research portfolio and quality of merit review. The contract is expected to be awarded in early CY 2016 and final reporting in early CY 2017.
- DBI will be evaluating its postdoctoral fellowship program across FY 2016 and FY 2017.

Workshops and Reports

- Division of Molecular and Cellular Biosciences:
 - “The Nuts and Bolts of Bioengineered Systems: A workshop on Standards in Synthetic Biology” was held March 2015 in Valencia, Spain and sponsored by MCB, the European Commission (EC), organized by U.S. and European scientists, and attended by representatives from the EC, National Institute of Standards and Technology, Defense Advanced Research Projects Agency, and NSF. Its goal was continued community building and leadership activities around the development of standards for the field of synthetic biology.
 - MCB supported “NIMBioS: National Institute of Mathematical Biosynthesis: A Workshop on Computational Advances in Microbiome Research (CAMR)” in July 2015. It had the goal of bringing together and integrating novel bioinformatics techniques from diverse areas of microbial community research and to identify gaps in computational and statistical techniques not currently addressed in any subfields.

- “Design Principles for Engineering Biology” was held in November 2015 in Virginia, supported by MCB, ENG, and the MPS divisions of Physics (PHY) and Chemistry. This workshop focused on how the convergence of fundamental principles from physics, chemistry, biology, and engineering increasingly provides a quantitative basis for the understanding of biology and enables a rational design of biological systems.
- MCB supports the Computational Modeling in Biology Network (COMBINE) workshops that bring together computer scientists, computational biologists, and engineers to discuss ways to standardize existing computer languages such as System Biology Markup Language (SBML) for mathematical modeling; the Biological Pathways Exchange Language (BioPaX) for describing pathways; the Systems Biology Graphical Notation (SBGN) for visual representations; and the Synthetic Biology Open Language (SBOL). The major goals of the most recent workshop, held October 2015, were to develop synergistic relationships between systems and synthetic biology researchers and to support a coordinated effort to advocate the use of standards in publications and archival databases.
- MCB and the PGRP in IOS jointly funded two workshops on “The Pathway to a Roadmap: Phytobiomes 2015: Designing a New Paradigm for Crop Improvement. The first workshop was held in Washington, D.C. in June 2015. The second is scheduled for March 6, 2016 in Pacific Grove, CA.
- A workshop co-funded by MCB, ENG, and DEB entitled: “Gene Drives: A Deliberative Workshop to Develop Frameworks for Research and Governance” scheduled for Feb 2016, will address the timely and important issue of second generation genetic engineering technologies being developed with the aim of moving synthetic gene constructs into wild animal populations.
- A workshop on Physics of Wear, Tear, Aging and Failure in Living and Nonliving Systems was supported by MCB along with the Physics of Life Systems program in PHY and was held in May 2015 at Tysons Corner in Virginia. Approximately 25 scientists representing physics, material science, and biology discussed the physical principles and processes underlying aging in living and nonliving system, the similarities and differences between living and nonliving systems and their repair and failure.
- MCB supported an award to the American Society for Biochemistry and Molecular Biology for workshop directed at the career development and mentoring program called Interactive Mentoring Activities for Grantsmanship Enhancement (IMAGE). Developing IMAGE will offer annual mentoring workshops and one-on-one structured mentoring to develop tenable strategies to improve the success rates of under-represented minority faculty in securing funding. The first workshop was held in June 2015 in Washington, D.C.
- MCB supports the SUNY Albany conference, held in June 2015, that serves as an important forum for exchange of new research and ideas among scientists working on diverse aspects of macromolecular structure-function, including RNA localization/structure/catalysis, DNA-protein interactions, DNA damage/repair, DNA nanotechnology, protein folding/design/engineering, optogenetics, among others. A defining feature of this meeting was the emphasis on biophysical and computational approaches to these problems. The meeting has a long history of including young scientists from diverse backgrounds, including 40 percent women speakers and representatives from 20 countries.
- MCB supported the 9th Annual q-bio conference at Virginia Polytechnic Institute in August 2015. This meeting focused on bringing investigators, postdoctoral fellows, and students together to discuss quantitative cell biology as a field that needs to attract experimentalists and modelers to overcome the barriers separating the conventional disciplines that impede significant advances in understanding how cells function. The goal of this effort is to train a new generation of interdisciplinary researchers with the abilities to combine experimental and theoretical approaches to cell biology.

- Division of Integrative Organismal Systems:
 - A workshop entitled "Unpacking the Phenotype (UP): Deciphering Genome to Phenome Relationships - Interdisciplinary Research at the Interface of the Biological and Mathematical Sciences" was held on October 2015. This workshop was jointly supported by IOS, MCB, and the Division of Mathematical Sciences (DMS) in MPS. The workshop brought together mathematicians and biologists to identify opportunities where mathematical modeling approaches would enhance our understanding of multi-scale integration and emergent properties of organisms. A preliminary report was received in December 2015. Among the recommendations are the need to develop mechanisms of support and infrastructure that facilitate collaboration between mathematical and biological scientists. In addition the workshop identified the need for tools that can collect phenotypic spatial and temporal data with the resolution needed for developing robust mathematical models.
 - A BRAIN STEM workshop was held in October 2015 that facilitated discussions among faculty from Primarily Undergraduate Institutions (PUI). The workshop's goal was to identify aspects of the BRAIN Initiative that may be particularly relevant to conducting research and engaging undergraduate researchers at PUIs, identify barriers that could prevent PUI faculty and students from contributing to this effort, and to propose solutions to such impediments. A report from this workshop is pending.
 - A workshop is planned for later in FY 2016 to facilitate dialog among investigators on barriers to integration of multi-scale data sets from the sub-cellular to multi-cellular organisms. This workshop will encourage investigators in the cellular and organismal areas to address barriers and propose solutions to multi-scale integration and the problem of so-called dark data, large data sets that are not easily structured for the computational analyses needed.
- Division of Environmental Biology:
 - The DEB supported workshop "Broadening Participation in Environmental Biology-Exploring What Works" was held in October of 2015. This workshop brought together professors, students, and administrators to discuss "what works" with respect to broadening participation in environmental biology. Prior to the workshop, the organizers interviewed dozens of scientists from underrepresented groups and summarized their stories in a book¹ that is now widely available. Also, a wiki was constructed to foster continued collaboration of participants at the workshop and to encourage new partnerships.
 - The DEB-supported workshop "Improving Inference in Evolutionary Biology and Ecology" was held in November of 2015. At this workshop, editors of practically all major journals of ecology and evolution gathered to discuss how they might collaborate to encourage authors to be more transparent about how conclusions are drawn from data, to encourage publication of all results (regardless of novelty), to replicate studies that have had large impacts on their fields, and to establish standards for data archiving and accessibility.
 - DEB also supported "Infrastructure and ecosystem adaptations in the face of global climate change." This workshop, held on August 15, 2015, was focused on looking forward at the next 100 years of life on Earth and at the same time celebrating the 100th Anniversary of the Ecological Society of America (ESA). It resulted in a special issue of *Frontiers in Ecology and the Environment*.² Specific topics include accelerating rates of sea level rise, long-term droughts, increased flooding, species movements towards northern latitudes and higher elevations, and changes in scientific understanding required for tracking and predicting major changes in ecosystems, in the form of both new statistical analyses and integrated models that cross scales from local populations of organisms to continents.

¹ ISBN 9780996477536

² www.esajournals.org/toc/fron/13/9

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 2015	FY 2016	FY 2017
	Actual	Estimate	Estimate
	Estimate	Estimate	Estimate
Senior Researchers	4,081	4,200	4,400
Other Professionals	1,636	1,700	1,800
Postdoctorates	1,527	1,600	1,700
Graduate Students	2,848	2,900	3,100
Undergraduate Students	4,769	4,900	5,200
Total Number of People	14,861	15,300	16,200

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

\$136,770,000
+\$1,240,000 / 0.9%

MCB Funding
(Dollars in Millions)

	FY 2015 Actual	FY 2016 Estimate	FY 2017 Request	Change Over FY 2016 Estimate	
				Amount	Percent
Total, MCB	\$134.95	\$135.53	\$136.77	\$1.24	0.9%
Research	132.47	133.69	134.93	1.24	0.9%
CAREER	13.97	14.26	14.39	0.13	0.9%
Education	2.48	1.84	1.84	-	-

Totals may not add due to rounding.

The FY 2017 Budget Request for MCB is \$136.77 million in discretionary funding.

MCB supports fundamental research and related activities that position the community to address a key question in biology, how cells function and change. This focus aligns well with the Directorate’s emphasis on the Rules of Life. MCB funded efforts include: studies to explore origins of life; determination of the minimum set of protein and nucleic acid sequences and structures that can sustain life; studies that examine mechanisms of adaptation and homeostasis/robustness of biological systems; identifying the repertoire of gene expression that determines the relationship between genotype and phenotype; and the development of new theoretical concepts that describe cellular decision making.

A key element of BIO’s funding priorities include the recognition that acquisition of data alone is insufficient to provide an understanding of rules of life. Therefore MCB prioritizes research that utilize models that are accompanied by experimental systems in which quantitative measures allow theories to be tested, refined, and validated. Committed to fundamental questions in cell and molecular biology, MCB engages traditional approaches but continues to give high priority to interdisciplinary research projects at the interfaces with physical sciences, mathematics, computational sciences, and engineering.

MCB supports systems-level research to uncover emergent biological behaviors that are governed by complex, integrated processes to impart a necessary balance between robustness and plasticity for life on earth. The systems studied range from unicellular to multi-cellular higher life forms, including microbes, microbial communities, fungi, plant systems, and select metazoan model systems. As such MCB is invested in research that focuses on the microbiome as an integral part of our portfolio.

Synthetic biology projects aimed at probing the design principles of biology through the construction of new biological parts, devices and systems, or the re-design of natural systems including regulatory and metabolic networks remain a focus of MCB’s efforts. MCB is one of the major supporters of synthetic biology in the Foundation and collaborates with the other BIO divisions to develop and utilize tools that drive systems and synthetic biology. In collaboration with ENG, MCB supports advances in standards in synthetic biology to advance biomanufacturing and development of novel biomaterials that will support the development of a thriving bioeconomy. MCB is a key partner with ENG in developing Engineering Biology as an advanced manufacturing area.

Clean energy technologies have emerged as an important outcome of research in systems and synthetic biology, as projects supported by MCB streamline and scale the metabolic and energetic potential of living organisms such as microbes, fungi, algae and plants to produce non-petroleum based sources of important chemicals/materials, feedstocks, and fuels. Investigations that probe the molecular mechanisms and limits

of photosynthesis, including understanding the structure and function of photosynthesis reaction centers are also part of the clean energy portfolio, as are approaches to enhance the efficiency of photosynthesis.

The development of methods, tools, 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, continue to be a priority for MCB. Funded research 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.

Priorities for MCB involve cutting edge foundational research at the interface of traditional disciplines. MCB is committed to training the next generation of scientists and will invest in new training paradigms including programs that provide professional development for trainees outside academia. Additionally, MCB continues to forge international partnerships to support fundamental research in the cellular and molecular sciences and remains committed to these collaborations.

In general, 49 percent of the MCB portfolio is available for new research grants and the remaining 51 percent funds continuing grants made in previous years.

FY 2017 Summary

All funding decreases/increases represent change over the FY 2016 Estimate.

Research

Research funding for MCB increases \$1.24 million, to a total of \$134.93 million. Emphases within the research portfolio will:

- Support the Rules of Life emphasis through research at the interface of biology and the quantitative and predictive sciences to yield insights into the fundamental molecular and cellular principles of life that provide the foundation for all of the biological sciences.
- Maintain support 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.
- Continue efforts to understand how cells make decisions using computer simulations, mathematical models, and quantitative measurements.
- Prioritize fundamental questions on how genes work, how genes are maintained and inherited, and how genes and genomes change using emerging technologies and include identification of novel roles for RNA.
- Invest in synthetic biology aimed at supporting and developing new technologies through a foundational understanding of basic biology (i.e. the support of bacterial immunity research that led to the development of the CRISPR/Cas9 genome editing technology) and the use of the tools of synthetic biology to design new kinds of experiments that enable a greater understanding of the rules of life.
- Contribute to Advanced Manufacturing by supporting research on computational design of biological systems from proteins to organisms to microbial communities that can synthesize fuels, chemicals, and materials, 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.
- Invest in research of metabolic systems that will continue to address energy yields and significantly enhance understanding of micro-algal biofuel production.

Education

In FY 2017, MCB's Education investments in Research Experiences for Undergraduates (REU) and Teachers (RET) are maintained at the FY 2016 Estimate of \$1.84 million.

Within MCB, new models of training that transitions support of graduate students from research grants to fellowships and/or targeted training programs will be explored. This includes award supplements for graduate students to explore career options, by (for example) participating in internships (in the public and private sector), attending courses that focus on career development, and/or obtaining additional training in specialized areas (e.g. quantitative/computational skills). The end goal is to develop a body of graduate students across the Nation that reflects workforce needs and research priorities.

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

**\$215,400,000
+\$1,080,000 / 0.5%**

IOS Funding
(Dollars in Millions)

	FY 2015 Actual	FY 2016 Estimate	FY 2017 Request	Change Over FY 2016 Estimate	
				Amount	Percent
Total, IOS	\$215.12	\$214.32	\$215.40	\$1.08	0.5%
Research	186.29	183.49	187.97	4.48	2.4%
CAREER	13.60	9.20	9.25	0.05	0.5%
Education	4.47	6.63	6.63	-	-
Infrastructure	24.36	24.20	20.80	-3.40	-14.0%
Research Resources	24.36	24.20	20.80	-3.40	-14.0%

Totals may not add due to rounding.

The FY 2017 Budget Request for IOS is \$215.40 million in discretionary funding.

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, as well as contribute substantively to understanding the rules of life. IOS seeks to support 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 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 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 clean 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 and bio-fuel sites that produce useful products, such as oils and clean energy.

In general, 56 percent of the IOS portfolio is available for new research grants and the remaining 44 percent funds continuing grants made in previous years.

FY 2017 Summary

All funding decreases/increases represent change over the FY 2016 Estimate.

Research

Research funding for IOS increases \$1.08 million, to a total of \$215.40 million. Support within the IOS research portfolio will be used to:

- Collaborate with the National Institutes of Food and Agriculture (NIFA), of the United States Department of Agriculture (USDA), on supporting research in the area of Plant Biotic Interactions (PBI). IOS and NIFA recognized the potential for integration of activities across the spectrum of basic science supported by IOS and the translational agricultural research supported by NIFA in the areas that include plant microbiomes (phytobiomes), plant pathogens, and plant defenses. PBI development began in FY 2015 for a joint IOS/NIFA PBI solicitation in mid FY 2016, with the first awards being made in FY 2017 (estimated IOS share \$8.50 million in FY 2017).
- Support the Enabling Discovery through Genomic Tools (EDGE) activity at a level of \$10.0 million in FY 2017. Understanding the rules of life will require research on a diversity of organisms, many of which are not sufficiently developed as model organisms to establish cause and effect relationships essential to understanding genomes to phenomes. To address this barrier, the EDGE proposal track was developed in FY 2015, announced in the FY 2016 IOS Core solicitation, with the first awards to be made in FY 2017. Through EDGE, IOS will support research directed towards developing and disseminating tools and methods for enabling emerging model organisms through genomic manipulations that can directly test the relationship of traits (phenomes) with specific genes (genomes).
- Enhance support of clean energy research, via PGRP, by targeting whole genome analysis of plant species valuable for their contributions to bio-fuel development.
- Enhance support for microbiome studies across multiple programs. The Symbiosis, Defense and Self-Recognition (SDS) program supports research in animal-microbiome relationships and the interactions between microbes and protozoa. The PBI program described above will support research on plant-microbe and plant-microbiome (phytobiome) interactions. An increase (+\$2.50 million) will be directed towards phytobiome research related to INFIEWS.
- Support basic neuroscience research directed towards understanding the development, modification, and activity of the healthy brain during complex natural behaviors. While a significant proportion (\$16.10 million of \$19.54 million total for BIO) of the activities related to the BRAIN Initiative will be funded through Emerging Frontiers, IOS' investment in neuroscience will support the Understanding the Brain activity, including the BRAIN Initiative, 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.

Education

- IOS' education investment through the PGRP will continue to provide support (\$4.0 million) 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).
- Investments in REU and RET are maintained at \$2.14 million and \$490,000 respectively.

Infrastructure

Total Research Resource investments decrease \$3.40 million to \$20.80 million.

- Investments in research resources essential to PGRP, including tools for high-throughput analysis of agriculturally important plant phenotypes under field conditions are maintained.

DIVISION OF ENVIRONMENTAL BIOLOGY (DEB)

\$145,170,000
+\$1,140,000 / 0.8%

DEB Funding
(Dollars in Millions)

	FY 2015 Actual	FY 2016 Estimate	FY 2017 Request	Change Over FY 2016 Estimate	
				Amount	Percent
Total, DEB	\$143.76	\$144.03	\$145.17	\$1.14	0.8%
Research	141.62	142.01	143.15	1.14	0.8%
CAREER	6.05	3.84	3.86	0.02	0.5%
Education	2.14	2.02	2.02	-	-

Totals may not add due to rounding.

The FY 2017 Budget Request for DEB is \$145.17 million in discretionary funding.

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, engineering, and mathematics.

In general, 72 percent of the DEB portfolio is available for new research grants. The remaining 28 percent funds continuing grants made in previous years.

FY 2017 Summary

All funding decreases/increases represent change over the FY 2016 Estimate.

Research

In DEB, total support increases (+\$1.14 million, to a total of \$143.15 million) for fundamental research on the interactions and feedbacks of ecological and evolutionary processes in the context of changing environmental factors.

- Research priorities will focus on fundamental science related to rules of life. Within DEB, this includes support for development and testing of new theories that transcend the boundaries between ecology and evolution to understand biological phenomena that cannot be explained by either discipline alone.
- Dimensions of Biodiversity, a SEES program, will continue to be supported at \$11.0 million. Dynamics of Coupled Natural Human Systems (CNH) program funding will be sustained and leverage additional funding for INFEWS provided in Emerging Frontiers. Research supported by these programs contributes to our understanding of ecosystem services, environmental sustainability, renewal, clean energy, and the nexus of food, energy, and water.

Directorate for Biological Sciences

- DEB will contribute to the Administration's clean energy research priority through investments in ecosystem services and biomass production relevant to cellulosic ethanol feedstock production and management, and production of other biofuels.
- With the expected onset of NEON operations, DEB will continue to encourage and support research that uses NEON data and samples to address macro-scale environmental questions, in coordination with funding provided through Emerging Frontiers.
- Consistent with BIO's plan to reorganize its support for graduate students, funding for graduate students on DEB research grants is decreased and will be redirected by BIO to support a new graduate research training program in DBI.

Education

- DEB will maintain FY 2016 support levels for REU (\$1.78 million) and RET (\$240,000).

DIVISION OF BIOLOGICAL INFRASTRUCTURE (DBI)

\$135,740,000
-\$8,940,000 / -6.2%

DBI Funding
(Dollars in Millions)

	FY 2015 Actual	FY 2016 Estimate	FY 2017 Request	Change Over FY 2016 Estimate	
				Amount	Percent
Total, DBI	\$144.14	\$144.68	\$135.74	-\$8.94	-6.2%
Research	47.80	42.01	46.15	4.14	9.9%
CAREER	4.09	5.73	5.81	0.08	1.4%
Centers Funding (total)	41.42	34.73	31.13	-3.60	-10.4%
Centers for Analysis & Nanoscale Science & STC: Center for Microbial STC: BEACON STC: Xfel Science of Learning Centers	20.80 6.33 2.66 5.00 5.00 1.63	18.40 6.33 - 5.00 5.00 -	15.80 5.33 - 5.00 5.00 -	-2.60 -1.00 - - - -	-14.1% -15.8% N/A - - N/A
Education	24.28	22.47	22.89	0.42	1.9%
Infrastructure	72.06	80.20	66.70	-13.50	-16.8%
CHESS	5.00	5.00	5.00	-	-
NNCI	0.35	0.35	0.35	-	-
Research Resources	66.71	74.85	61.35	-13.50	-18.0%

Totals may not add due to rounding.

The FY 2017 Budget Request for DBI is \$135.74 million in discretionary funding.

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 facilities creates opportunities to address targeted but deep biological questions that have major societal impact.

In FY 2017, DBI will assess the effectiveness of current programs towards the evolving needs of the biology community, which have become more complex, diverse, and centered on data storage, access, and analysis. Evaluating current programs, assessing where investments can make a difference in the long term resource needs, and developing a robust STEM pipeline will be a priority. The goals and objectives of many of DBI's longstanding research resource and human resource programs will be reexamined. Emphasis will be placed on evaluation, impact, and scalability, to gauge where support from NSF/BIO makes a difference. Smaller programs with limited long term objectives or scalability will be phased down and potentially terminated. Several programs will be put on a biennial competition schedule during their assessment. BIO expects this assessment to be complete in time to inform the FY 2018 budget.

In general, 31 percent of the DBI portfolio is available for new research grants and 69 percent funds continuing grants made in previous years.

FY 2017 Summary

All funding decreases/increases represent change over the FY 2016 Estimate.

Research

Funding for Research activities in DBI increases \$4.14 million, to a total of \$46.15 million.

- DBI will continue to assess its research-focused programs for the impacts they have on research supported across the directorate.
- Support for centers will decrease \$3.60 million, to a total of \$31.13 million. Support for iPlant and NIMBioS enter their planned phase down. Funding for the STCs SESyNC and BEACON are expected to be renewed at their FY 2016 Estimate levels.
- While the majority of BIO's investment is funded through EF, a significant component of UtB focuses on technologies with connections to activities in DBI that include support for the development of software and databases, as well as student and postdoctoral training in these areas.

Education

- In FY 2017, support for IUSE will continue to be centralized within DBI (\$2.50 million) through BIO's RCN-UBE program.
- Funding for the Postdoctoral Research Fellowships in Biology program is maintained at \$3.80 million. The Broadening Participation track of this program, funded at \$2.50 million, aims to promote the advancement of underrepresented groups in STEM at the postdoctoral level, and will leverage its investment through engagement with other NSF initiatives such as NSF INCLUDES.
- In FY 2017, DBI will contribute \$1.40 million to NSF INCLUDES to promote the advancement of underrepresented groups in STEM.
- Support for NSF Research Traineeship increases \$490,000, to a total of \$2.82 million.
- DBI will maintain support for REU and RET activities at FY 2016 levels (\$11.12 million).
- In FY 2017, BIO proposes a new program, BIO Research Training Grant (BIO RTG), as a way to explore alternative mechanisms to support biology graduate students – moving away from the traditional approach of supporting graduate students on research awards to a more directed approach supporting graduate students in one or more areas of strategic national need. The FY 2017 Request includes \$6.16 million for DBI to initiate a 3-year pilot.

Infrastructure

Support for biological infrastructure in DBI will decrease \$13.50 million, to a level of \$66.70 million. This reduction will be accomplished by reducing specific programs associated with research resources and instrumentation as the effectiveness of these programs is assessed with respect to the evolving needs of the biology community.

- Support will continue for cyberinfrastructure necessary for 21st century biology, including the development of tools necessary to address several priority research initiatives including, genotype to phenotype, understanding the brain, and plant genomics.
- 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.
- Emphases within research resources will be related to the new BIO emphasis Rules of Life to include support for multidisciplinary imaging, digitization of biological specimens, and cyberinfrastructure in support of synthetic biology.
- BIO will continue midscale investments for large data-driven science, and, in particular, for CIF21-BioData activities (\$8.39 million).
- Two facilities will receive sustained funding: CHES and NNCI.

DIVISION OF EMERGING FRONTIERS (EF)

\$157,440,000
+\$51,830,000/ 49.1%

EF Funding
(Dollars in Millions)

	FY 2015 Actual	FY 2016 Estimate	FY 2017 Request	Change Over	
				FY 2016 Estimate Amount	Percent
Total, EF	\$98.22	\$105.61	\$157.44	\$51.83	49.1%
Research	96.96	61.07	91.94	30.87	50.5%
CAREER	2.83	1.57	1.76	0.19	12.1%
Education	1.04	0.05	0.05	-	-
Infrastructure	0.22	44.49	65.45	20.96	47.1%
NEON	0.12	44.04	65.00	20.96	47.6%
NNCI	0.10	-	-	-	N/A
Research Resources	-	0.45	0.45	-	-

Totals may not add due to rounding.

The FY 2017 Budget Request for EF is \$157.44 million, of which \$112.65 million is discretionary funding and \$44.79 million is new mandatory funding. The mandatory funding is within the Research line in the above table.

EF identifies, incubates, and supports infrastructure and research areas that transcend scientific disciplines and/or advance the conceptual foundations of biology. 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 has transitioned into DBI. EF also facilitates the development and implementation of new forms of merit review and mechanisms to support transformative research and stimulate creativity (such as Ideas Labs). 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 2017, the EF portfolio changes as NEON operations and maintenance (O&M) scales up to support infrastructure as construction of the observatory - an NSF MREFC project - nears completion. Funds that were previously centralized in EF to support short-term programs will begin to phase down and transition to support NEON as it becomes fully operational. Given the expected change in managing organizations for NEON, funding for O&M remains in EF until costs are stabilized and predictive; program oversight for the facility has transferred to DBI.

The EF research portfolio will remain diverse in FY 2017 and will evolve, as long standing cross-cutting activities transition to core programs (i.e. BioMaPS and SEES) and new activities are developed such as CNH as a component of INFEWS and the microbiome. In FY 2017, support will continue to focus on MSB and early NEON science, and on Understanding the Brain (UtB) including the BRAIN Initiative.

In general, 71 percent of the EF portfolio is available for new research grants. The remaining 29 percent funds continuing grants made in previous years.

FY 2017 Summary

All funding decreases/increases represent change over the FY 2016 Estimate.

Research

EF Research investments are increased \$30.87 million, to a total of \$91.94 million in FY 2017.

- Though investments in MSB and early NEON science remain a priority for BIO, support for these programs decreases as funding is redirected to NEON O&M.
- Support for the BRAIN Initiative will increase \$1.49 million to \$16.10 million and will continue development of a national brain observatory.
- EF will contribute to INFEWS through continued support of CNH and MSB.
- SEES/Dimensions of Biodiversity is reduced to \$3.25 million with FY 2017 its final year of support.
- Support for BioMaPS within EF is reduced to \$3.25 million but is supplemented by support from MCB and IOS as this cross-cutting activity transitions into core programs.
- Funding for innovation programs continues through investments in new cross-BIO activities, Ideas Labs, and interdisciplinary research.
- Support for early career awardees and research on the rules of life will be enhanced by \$44.79 million.

Education

- FY 2017 support for Career Life Balance (CLB) supplements is maintained at the FY 2016 Estimate level.

Infrastructure

- Funding for NEON O&M increases \$20.96 million, to a total of \$65.0 million. For more detailed information on NEON, see the MREFC chapter.
- Research Resources funding is maintained at the FY 2016 Estimate of \$450,000.