

**DIRECTORATE FOR BIOLOGICAL SCIENCES (BIO)****\$672,110,000**  
**-\$51,670,000 / -7.1%****BIO Funding**  
(Dollars in Millions)

	FY 2016 Actual <sup>1</sup>	FY 2017 (TBD)	FY 2018 Request	Change Over FY 2016 Actual	
				Amount	Percent
Molecular & Cellular Biosciences (MCB)	\$135.46	-	\$123.21	-\$12.25	-9.0%
Integrative Organismal Systems (IOS)	214.21	-	111.20	-103.01	-48.1%
Environmental Biology (DEB)	143.96	-	130.78	-13.18	-9.2%
Biological Infrastructure (DBI)	144.61	-	169.61	25.00	17.3%
Emerging Frontiers (EF)	85.53	-	137.31	51.78	60.5%
<b>Total</b>	<b>\$723.78</b>	<b>-</b>	<b>\$672.11</b>	<b>-\$51.67</b>	<b>-7.1%</b>

<sup>1</sup> In FY 2016, \$20.0 million was transferred from EF to the MREFC account for increased NEON construction costs. Including this transfer, BIO's total funding in FY 2016 was \$743.78 million. FY 2018 Request funding for BIO compared to BIO's initial FY 2016 budget is a decrease of \$71.67 million or 9.6 percent.

**About BIO**

BIO has three overarching goals:

- To support research to advance understanding of the principles and mechanisms governing life;
- To increase our understanding of complex interactions between living systems and their environments; and
- To provide real and theoretical bases for original research in other scientific disciplines and for application of science to improve the quality of life.

The FY 2018 Budget Request for BIO is \$672.11 million. Special emphasis will be placed on research that aligns with the comprehensive BIO framework, Understanding the Rules of Life (URoL) that will address major challenges in biology. These include understanding living systems across scales of size, time and place, and the complex relationships between genotype and phenotype in plants, animals, and microbes. 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. U.S. academic research in the biological sciences depends on NSF funding; 69 percent of academic basic research in non-medical biology is supported by NSF. BIO considers this role essential to the promotion of vibrant and innovative fundamental biological research at U.S. universities and colleges, noting that BIO's programs support the real and theoretical bases for original research in other scientific disciplines as well as downstream applications of potential societal benefit. Broad support for biology is necessary to produce knowledge relevant to national needs in food, health, energy, and environment. Additionally, support for biological research will continue a stream of economic innovations that contribute to American livelihoods, as demonstrated by 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. 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 effective integration requires new

funding strategies and portfolio realignment within BIO. These strategies are reflected in the FY 2018 Budget Request.

FY 2018 priorities for BIO include:

Understanding the Rules of Life (URoL): First introduced in FY 2017, support for URoL will continue in FY 2018 emphasizing research areas such as the genotype to phenotype challenge, plant-organismal interactions, 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 continue to be encouraged.

National Ecological Observatory Network (NEON): Construction of NEON is expected to be complete by the spring of 2018 and BIO will assume full responsibility for operations and maintenance (O&M), including increased funding for oversight. In FY 2018, NEON O&M funding moves from EF to DBI in accordance with the shift in program management and oversight that occurred in FY 2017. Funding for early NEON science, including continuing support for the MacroSystems Biology (MSB) program, remains a priority. For more information on NEON, see the Major Research Equipment and Facilities Construction (MREFC) chapter.

Understanding the Brain (UtB), including the Brain Research through Advancing Innovative Neurotechnologies (BRAIN) Initiative: This cross-agency priority will be continued in FY 2018. BIO funding for UtB, including the BRAIN Initiative, will support investment strategies designed to enable the transformational research, engineering, infrastructure development, and training required to accomplish the overall multi-year goal. Support for neuroscience activities will focus on the Next Generation Networks for Neuroscience (NeuroNex) program. Additional information for UtB is available in the NSF-Wide Investments chapter.

Innovation: In FY 2018, through funding in EF, BIO will continue investments in innovation activities with a focus on URoL. These activities will build on the interagency agreement, signed in FY 2016 by NSF and the National Aeronautics and Space Administration (NASA) that encourages and supports interaction among NASA and NSF personnel on origins of life research and the joint Ideas Lab on the Origins of Life held in FY 2016 and the ensuing research funded in FY 2017.

## Major Investments

### BIO Major Investments

(Dollars in Millions)

Area of Investment	FY 2016	FY 2017	FY 2018	Change Over	
	Actual	(TBD)	Request	FY 2016 Actual Amount	Percent
CAREER	\$45.68	-	\$35.07	-\$10.61	-23.2%
CEMMSS	5.48	-	5.48	-	-
Advanced Manufacturing	3.33	-	3.33	-	-
NSF I-Corps™	1.00	-	1.00	-	-
NSF INCLUDES	1.40	-	1.40	-	-
IUSE	2.74	-	2.50	-0.24	-8.7%
Understanding the Brain	33.51	-	46.00	12.49	37.3%
BRAIN Initiative	9.06	-	19.54	10.48	115.7%

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

All funding decreases/increases represent changes over the FY 2016 Actual.

- Faculty Early Career Development (CAREER) (-\$10.61 million to a total of \$35.07 million): BIO's CAREER awards support young investigators who exemplify the role of teacher-scholar through outstanding research, excellent education, and the integration of education and research within the context of the mission of their organizations.
- Cyber-Enabled Materials, Manufacturing, and Smart Systems (CEMMSS) (no change; total of \$5.48 million): BIO's support will enable development of breakthrough materials through research on topics such as computational mining of genomic data from diverse biological systems to identifying 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 2018, BIO will continue its interagency collaborations in the area of engineering biology related to advanced biomanufacturing. The Directorate for Engineering (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 (no change; total of \$3.33 million): BIO will continue support for advanced manufacturing research. 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.
- NSF Innovation Corps (I-Corps™) (no change; total of \$1.0 million): BIO will sustain support for I-Corps™ nodes and teams 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) (no change; total of \$1.40 million): In FY 2018, BIO will continue to 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.
- Improving Undergraduate Science, Technology, Engineering, and Mathematics (STEM) Education (IUSE) (-\$240,000 to a total of \$2.50 million): BIO 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.
- Understanding the Brain (UtB) (+\$12.49 million to a total of \$46.0 million): BIO will increase 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 (+\$10.48 million to a total of \$19.54 million): As part of UtB, BIO will increase support for the BRAIN Initiative to support the Next Generation Networks for Neuroscience (NeuroNex) program.

## BIO Funding for Centers Programs and Facilities

### BIO Funding for Centers Programs

(Dollars in Millions)

	FY 2016 Actual	FY 2017 (TBD)	FY 2018 Request	Change Over FY 2016 Actual	
				Amount	Percent
<b>Total, Centers Programs</b>	<b>\$33.76</b>	-	<b>\$21.00</b>	<b>-\$12.76</b>	<b>-37.8%</b>
Centers for Analysis & Synthesis (DBI)	18.40	-	6.00	-12.40	-67.4%
Nanoscale Science & Engineering Centers (DBI) <sup>1</sup>	5.36	-	-	-5.36	-100.0%
STC: Bio/computational Evolution in Action CONSortium (BEACON) (DBI)	5.00	-	5.00	-	-
STC: Center for Biology with X-Ray Lasers (XFel) (DBI)	5.00	-	5.00	-	-
STC: Center for Cellular Construction (CCC) (DBI)	-	-	5.00	5.00	N/A

<sup>1</sup> The Nanoscale Centers program will sunset as planned in FY 2017.

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

### BIO Funding for Facilities

(Dollars in Millions)

	FY 2016 Actual	FY 2017 (TBD)	FY 2018 Request	Change Over FY 2016 Actual	
				Amount	Percent
<b>Total, Facilities</b>	<b>\$38.32</b>	-	<b>\$69.35</b>	<b>\$31.03</b>	<b>81.0%</b>
National Nanotechnology Coordinated Infrastructure (NNCI)	0.35	-	0.35	-	-
Cornell High Energy Synchrotron Source (CHESS)	5.00	-	4.00	-1.00	-20.0%
National Ecological Observatory Network (NEON)	32.97	-	65.00	32.03	97.1%

For detailed information on individual facilities, see the Facilities and the Major Research Equipment and Facilities Construction chapters.

## Funding Profile

BIO supports investment in core research and education as well as research infrastructure.

In FY 2018, the number of research grant proposals received is anticipated to remain unchanged from the prior year and BIO expects to award about 900 research grants. The average annual award size and duration are not expected to materially fluctuate in FY 2018.

In FY 2018, BIO will invest \$21.0 million in research centers, accounting for 3.1 percent of the BIO budget. This total is down from FY 2016 Actual as several centers have sunset as planned. BIO's FY 2018 Request funds one Center for Analysis and Synthesis, the National Socio-Environmental Synthesis Center (SESync), and the three Science and Technology Centers (An NSF Center for the Study of Evolution in Action (BEACON), X-Ray Free Election Lasers (XFEL), and Center for Cellular Construction (CCC)).

O&M funding for BIO-supported facilities is 10.3 percent of BIO's FY 2018 Request. Support of facilities operations increases in FY 2018 as NEON construction is expected to complete and BIO assumes full responsibility for O&M, including increased funding for oversight. NEON, the only BIO-managed facility, comprises 9.7 percent of BIO's FY 2018 Request.

**BIO Funding Profile**

	FY 2016 Actual Estimate	FY 2017 (TBD)	FY 2018 Estimate
<b>Statistics for Competitive Awards:</b>			
Number of Proposals	5,211	-	5,200
Number of New Awards	1,335	-	1,200
Funding Rate	26%	-	23%
<b>Statistics for Research Grants:</b>			
Number of Research Grant Proposals	4,328	-	4,400
Number of Research Grants	959	-	900
Funding Rate	22%	-	20%
Median Annualized Award Size	\$200,605	-	\$200,600
Average Annualized Award Size	\$246,358	-	\$246,400
Average Award Duration, in years	3.2	-	3.2

**Program Monitoring and Evaluation**

Since 2014, BIO has followed and maintained a Transparency and Accountability Plan that enables the directorate to build on prior best practices. This plan includes requirements for post-panel briefings to discuss proposed awards and declinations as well as analysis of the programs’ current portfolio of awards for scientific and demographic information; submission of annual prior-year activity reports to BIO’s Office of the Assistant Director by each division which are then summarized into a directorate-wide report; and annual directorate-level portfolio analysis by the BIO Portfolio Analysis Working Group.

**External Program Evaluations and Studies:**

- DEB and IOS, working through the NSF Division of Acquisition and Cooperative Support, awarded a one-year contract in March 2016 to Abt Associates to conduct an external evaluation of the preliminary proposal review mechanism for core programs in the two BIO divisions. The final report was submitted to DEB and IOS in March 2017. The evaluation addressed both program and research community questions about the outcomes of the preliminary proposal mechanism on the research portfolio and the quality of merit review. The report is being reviewed internally and DEB and IOS plan to formulate a response that will be shared with the scientific community within CY 2017.
- Starting in FY 2017, BIO undertook an internal analysis of the programmatic activities of two biological infrastructure programs: Collections in Support of Biological Research and Instrument Development for Biological Research. The outcomes of this analysis will be used to determine the future directions of these two programs and it is anticipated that a summary of the major conclusions will be released in the fourth quarter of FY 2017.

**Workshops and Reports:**

- Division of Molecular and Cellular Biosciences
  - MCB continued its support of workshops on the topic of reproducibility in biological sciences. In February 2017, NSF’s Directorate for Mathematical and Physical Sciences (MPS), Directorate for Computer and Information Science and Engineering (CISE), BIO and the National Institute of Standards and Technology (NIST) convened a workshop titled: “Robustness, Reliability, and Reproducibility in Scientific Research”. The resultant report lays out a strategy to engage the community in developing standards and best practices broadly across science.

- A workshop co-funded by MCB, ENG, and DEB titled: “Gene Drives: A Deliberative Workshop to Develop Frameworks for Research and Governance” held February 2016, addressed 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. This workshop will be important in setting up mechanisms for governance of this powerful but potentially high risk/dual use technology.
  - 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).
  - Two workshops in CY 2016 focused on broadening participation in MCB science: the “Youth Bioinformatics Symposium” in summer 2016, and the “A Strategic Planning Workshop to Explore Quantitative Biology as a Vehicle for Broadening Participation” held at Spelman College in March, 2016. These activities both engage a broader community and provide reports that provide guidance to MCB as it plans its strategic investments.
- Division of Integrative Organismal Systems
    - A workshop titled "Unpacking the Phenotype (UP): Deciphering Genome to Phenome Relationships—Interdisciplinary Research at the Interface of the Biological and Mathematical Sciences" was held in October 2015. This workshop was jointly supported by IOS, MCB, and the Division of Mathematical Sciences (DMS) in MPS to identify opportunities where mathematical modeling approaches would enhance our understanding of multi-scale integration and emergent properties of organisms. A working group formed as a result of this workshop developed recommendations that have led IOS and MCB in BIO and DMS in MPS to initiate a joint venture with the Simons Foundation in New York, NY. Support for center-scale projects focused on the Mathematics of Complex Biological Systems will begin in FY 2018.
    - In FY 2018 IOS anticipates support of additional workshops centered on URoL that unify the biological sciences at NSF. Topics will include high throughput phenotyping and the development of implantable nano-sensors, and epigenetic mechanisms underlying robustness and resilience of organisms to environmental change.
  - Division of Environmental Biology
    - A symposium titled: Insect Effects on Ecosystem Services, held September 25-30, 2016, introduced entomologists to broader perspectives on the variety of roles insects play in the delivery of ecosystem services and informed DEB on broader impacts of research investments in insect ecology.
    - A meeting titled: Undergraduates Phenotyping Arabidopsis Knockouts (unPAK) Student Meeting, held June 15-17, 2016, highlighted the development of new techniques for research, comparison of data collection and analysis techniques between institutions, discussion of ways to integrate this research into classroom settings.
    - Two workshops titled, “Forming an integrated understanding of function across fungi”, held in August 2016 and March 2017, brought together biologists studying disparate fungi to develop standards and protocols for comparative studies, especially with respect to genetic sequencing and trait databases. These best practices will enhance data management plans (required as part of full proposals submitted to NSF) from the broader community.
    - In spring 2017, "A Workshop to Explore the Shifting Landscape of Research on Biological Diversity" will bring together U.S. scientists for the purpose of understanding the research

implications of the Nagoya Protocol, which calls for sharing of benefits from the use of genetic resources.

- In 2017, a workshop "Addressing Data Management Challenges within Integrative Biodiversity Projects" will bring together participants from Dimensions of Biodiversity projects to discuss the challenges in making biodiversity data more comparable across terrestrial to marine systems, past and present time-scales, cellular to ecosystem levels of biological organization, and diverse geographical regions.
- Division of Biological Infrastructure
  - A conference titled "Coordinating Global Brain Projects", co-sponsored by DBI and the Kavli Foundation, was held in September 2016 at The Rockefeller University, NY. This conference led to reports in several high-profile journals. The information gleaned from this conference and its subsequent reports are shaping how BIO works with the Office of International Science and Engineering (OISE) to engage funding agencies from the UK, Germany, Japan, Canada, and Israel as partners for NSF's NeuroNex program.
  - A workshop titled, "Optimizing NEON Science" was held in February 2016 in Boulder, CO to highlight areas of opportunity for community engagement of NEON with the research community. White papers documenting the discussions are in preparation, and workshop participants have already begun effective collaborations and a follow-on activity specifically targeted at early-stage researchers is being scheduled.
  - A workshop titled "Increasing Participation of Native Hawaiians and Pacific Islanders in STEM: a workshop focused on removing barriers to participation" was held June 1-2, 2016 in Honolulu, HI to identify barriers to participation in STEM disciplines (specifically biosciences and environmental science) among Native Hawaiians and Pacific Islanders. A number of barriers to STEM access were identified in the report<sup>1</sup> for Native Americans and Pacific Islanders in addition to several recommendations for addressing them.
  - A workshop titled, "Pan-REU PI Workshop: Leveraging Excellence Through Collaboration Across REU Programs" was held April 28-30, 2016 in Arlington, VA. The purpose was to inform the Research Experiences for Undergraduates (REU) program officers through the exchange of best practices in different disciplines. This award was co-funded by all NSF Directorates/Offices offering REU Sites, and each discipline was represented at the meeting. The workshop report<sup>2</sup> made several specific recommendations, but emphasized the need for the creation of a pan REU leadership team to strengthen the pan REU community.

#### Committees of Visitors (COV):

- In FY 2016, BIO held one COV in DBI. The COV convened September 13-15, 2016, at NSF and reviewed division operations and the programmatic portfolio for the three-year period spanning FY 2013-FY 2015. Overall, the COV considered DBI to be on positive trajectory. The COV commended DBI on the improved structure and processes for managing the centers portfolio and these large and mid-scale investments on behalf of BIO. The COV had recommendations for enhancing future operations of DBI: increasing multi-way communication both within DBI and between DBI and other parts of BIO in order to maximize the research impacts of infrastructure investments made by DBI; leverage the expertise the human resources cluster to strengthen efforts for broadening participation across other programs, centers and facilities managed by the division; and make better use

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<sup>1</sup> Hadfield, M.G., Kerr, J.Q., Hess, D.J., Smith, C.M., and Marker, N.L. (2016). Recognizing and removing barriers to STEM careers for Native Hawaiians and Pacific Islanders: report on a workshop at the University of Hawaii at Mānoa. Retrieved from [www.pbrc.hawaii.edu/stem/Final%20Draft%202016-16.pdf](http://www.pbrc.hawaii.edu/stem/Final%20Draft%202016-16.pdf)

<sup>2</sup> NSF Pan REU PI Workshop. (2016). Retrieved from [www.cpaess.ucar.edu/sites/default/files/meetings/2016/documents/2016PanREUPIWorkshopReport\\_Final.pdf](http://www.cpaess.ucar.edu/sites/default/files/meetings/2016/documents/2016PanREUPIWorkshopReport_Final.pdf)

of program officer comments for highly rated proposals that are not recommended for an award. DBI is incorporating these recommendations in its future planning activities.

- In FY 2018, BIO is planning to hold COVs for MCB and IOS.

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

**Number of People Involved in BIO Activities**

	FY 2016 Actual Estimate	FY 2017 (TBD)	FY 2018 Estimate
Senior Researchers	3,701	-	3,500
Other Professionals	1,445	-	1,300
Postdoctoral Associates	1,390	-	1,200
Graduate Students	2,768	-	2,600
Undergraduate Students	5,921	-	5,300
K-12 Teachers	-	-	-
K-12 Students	-	-	-
<b>Total Number of People</b>	<b>15,225</b>	<b>-</b>	<b>13,900</b>

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

**\$123,210,000**  
**-\$12,250,000 / -9.0%**

**MCB Funding**  
(Dollars in Millions)

	FY 2016 Actual	FY 2017 (TBD)	FY 2018 Request	Change Over FY 2016 Actual	
				Amount	Percent
<b>Total</b>	<b>\$135.46</b>	<b>-</b>	<b>\$123.21</b>	<b>-\$12.25</b>	<b>-9.0%</b>
<b>Research</b>	<b>132.76</b>	<b>-</b>	<b>121.37</b>	<b>-11.39</b>	<b>-8.6%</b>
CAREER	16.04	-	14.39	-1.65	-10.3%
<b>Education</b>	<b>2.70</b>	<b>-</b>	<b>1.84</b>	<b>-0.86</b>	<b>-31.9%</b>

MCB supports fundamental interdisciplinary research to uncover the basic principles that describe how information content in cells guides expression of cellular characteristics and is maintained and transmitted to the next generation; how material and energy are taken up, transformed, and flow through biological systems; and how biological molecules assemble into complex structures and compartments with varied functions contribute to the processes required for life. Research at the molecular and cellular scales provides the basis for understanding normal cell processes and healthy cell function. This understanding enables the development of design rules for engineering molecules and cells that contribute to the discovery and biomanufacturing of new drugs to further disease treatment or production of new commercial chemicals.

MCB supports activities in URoL, including basic research to explore origins of life; determine the minimum set of protein and nucleic acid sequences and structures that can sustain life; examine mechanisms of adaptation and homeostasis/robustness of biological systems; identify the repertoire of gene expression that determines the relationship between genotype and phenotype; and develop new theoretical concepts that illuminate 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 utilizes models accompanied by experimental systems in which quantitative measures allow theories to be tested, refined, and validated. MCB gives high priority to interdisciplinary research projects at the interfaces between biology and other research Directorates.

Synthetic Biology in MCB focuses on elucidating normal cellular function by building simple biological systems. The expectation within the division, in partnership with Engineering, is that these forays into designing and building lay the groundwork for complex engineered systems that have practical applications.

Investments in research in plant science at the molecular and cellular scales are part of the MCB strategy to contribute to food security research. Important outcomes of research in systems and synthetic biology and molecular biophysics have led to a greater understanding of photosynthesis, the design of strategies to move nitrogen fixation into photosynthetic organisms (decreasing dependence on fertilizer use), and systems level approaches to understanding drought tolerance in plants.

In general, 65 percent of the MCB portfolio is available for new research grants. The remaining 35 percent supports research and education grants made in prior years.

## **FY 2018 Summary**

All funding decreases/increases represent changes over the FY 2016 Actual.

### **Research**

Research funding decreases -\$11.39 million to a total of \$121.37 million.

- Support for CAREER awards decreases \$1.65 million to a total of \$14.39 million in FY 2018.
- Interdisciplinary research that results in connections across research disciplines contributing to URoL remains a priority for MCB. This support will foster foundational research activities that employ interdisciplinary, quantitative, and theory-based approaches to understand the function and evolution of living systems.
  - Funding for small center scale activities with the Division of Physics (PHY) through the Physics Frontiers Program (\$2.40 million), and DMS through a joint public private partnership with the Simons Foundation (\$600,000) are hallmarks of these investments in FY 2018.
  - Support will be provided for the URoL emphasis through research at the interface of biology and quantitative and predictive sciences to yield insights into the fundamental molecular and cellular principles of life that provide the foundation for all of biology.
  - Investments in synthetic biology will be aimed at supporting and developing new technologies through a foundational understanding of basic biology such as the Clustered Regularly Interspaced Short Palindromic Repeats (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.
  - Efforts to understand how large biopolymer (proteins, DNA, RNA) sequence gives rise to its structure, self-assembly into larger macromolecular complexes such as ribosomes or chromatin, and how sequence and structure gives rise to function of these macromolecular machines that govern all biological processes in living systems will be continued.
  - MCB will 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.

### **Education**

- FY 2018 investments in REU decrease \$890,000 to a total of \$1.71 million and Research Experiences for Teachers (RET) increase \$20,000 to a total of \$130,000.
- MCB continues support of award supplements to enable graduate students to explore career options that reflect the changing workforce needs and employment opportunities in the Nation, including participating in internships in the public and private sectors, attending courses focused on career development, and/or obtaining additional training in specialized areas such as quantitative/computational skills.
- MCB continues to invest in activities to broaden participation of diverse people in STEM fields, through support of RCNs, supplements, and career development activities through professional societies.

**DIVISION OF INTEGRATIVE ORGANISMAL SYSTEMS (IOS)** **\$111,200,000**  
**-\$103,010,000 / -48.1%**

**IOS Funding**  
(Dollars in Millions)

	FY 2016 Actual	FY 2017 (TBD)	FY 2018 Request	Change Over FY 2016 Actual	
				Amount	Percent
<b>Total</b>	<b>\$214.21</b>	<b>-</b>	<b>\$111.20</b>	<b>-\$103.01</b>	<b>-48.1%</b>
<b>Research</b>	<b>186.88</b>	<b>-</b>	<b>108.57</b>	<b>-78.31</b>	<b>-41.9%</b>
CAREER	14.78	-	9.25	-5.53	-37.4%
<b>Education</b>	<b>4.46</b>	<b>-</b>	<b>2.63</b>	<b>-1.83</b>	<b>-41.0%</b>
<b>Infrastructure</b>	<b>22.87</b>	<b>-</b>	<b>-</b>	<b>-22.87</b>	<b>-100.0%</b>
Research Resources	22.87	-	-	-22.87	-100.0%

IOS supports research at the level of organisms, at the meso-scale of biological organization, between molecular/cellular and populations/ecosystems. Research and education support is 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 these processes 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, URoL.

IOS science uses evolutionary principles and comparative approaches to develop predictive theories about the regulatory architecture of gene networks and metabolic pathways. IOS encourages synthetic and interdisciplinary approaches and development of new tools. These approaches span computational, mathematical, and organism levels of inquiry and analysis. IOS-supported research affords new understanding of how a wide diversity of organisms respond and adapt to change in order to improve our understanding of the reciprocal interactions between the biological and physical worlds.

Within IOS, 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.

In general, 62 percent of the IOS portfolio is available for new research grants. The remaining 38 percent supports research and education grants made in prior years.

**FY 2018 Summary**

All funding decreases/increases represent changes over the FY 2016 Actual.

**Research**

Research funding decreases \$78.31 million to a total of \$108.57 million.

- Support for CAREER awards decreases \$5.53 million to a total of \$9.25 million in FY 2018.
- Funding for the Plant Genome Research Program (PGRP) (-\$67.41 million to a total of zero) will move from IOS to EF in FY 2018 to facilitate its role as a central, cross-divisional investment contributing to URoL.

- Support for the Enabling Discovery through Genomic Tools (EDGE) activity in FY 2018 is \$6.0 million. URoL 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 the connection between genomes and resulting phenomes. Through EDGE, IOS will support research directed towards developing and disseminating tools as well as methods for enabling emerging model organisms through genomic manipulations that can directly test the relationship of traits to specific genes.
- IOS will continue its collaboration with the National Institutes of Food and Agriculture (NIFA), of the United States Department of Agriculture (USDA), to support research in the area of Plant Biotic Interactions (PBI). Through this collaboration, IOS and NIFA leverage the integration of activities across the spectrum of basic science supported by NSF and the agricultural research supported by NIFA in areas including phytobiomes, plant pathogens, and plant defenses.
- Support for microbe-organism studies across multiple programs will continue. The Symbiosis, Defense and Self-Recognition (SDS) program supports research (\$4.0 million) in animal-microbial relationships and the interactions between microbes and protozoa. The PBI program will support research (\$5.0 million) on plant-microbe interactions.
- IOS will invest in basic neuroscience research directed towards understanding the development, modification, and activity of the healthy brain during complex natural behaviors. While a significant proportion of BIO's activities related to the BRAIN Initiative will be funded through EF, IOS' investment in neuroscience will support the Understanding the Brain activity, in collaboration with other partners across BIO and NSF. In FY 2018 these activities will focus on opportunities for large-scale data integration, data re-use, and synthesis extending theory.

#### **Education**

- PGRP investments (-\$2.45 million to a total of zero) in postdoctoral research fellowships are moved from IOS to EF in FY 2018
- FY 2018 investments in REU increase \$360,000 to a total of \$2.14 million and RET increase \$260,000 to a total of \$490,000.

#### **Infrastructure**

- PGRP investments (-\$22.87 million to a total of zero) in research resources are moved from IOS to EF in FY 2018 to facilitate its role as a central, cross-divisional investment contributing to URoL.

**DIVISION OF ENVIRONMENTAL BIOLOGY (DEB)**

**\$130,780,000**  
**-\$13,180,000 / -9.2%**

**DEB Funding**  
(Dollars in Millions)

	FY 2016 Actual	FY 2017 (TBD)	FY 2018 Request	Change Over FY 2016 Actual	
				Amount	Percent
<b>Total</b>	<b>\$143.96</b>	<b>-</b>	<b>\$130.78</b>	<b>-\$13.18</b>	<b>-9.2%</b>
<b>Research</b>	<b>141.38</b>	<b>-</b>	<b>128.76</b>	<b>-12.62</b>	<b>-8.9%</b>
CAREER	7.79	-	3.86	-3.93	-50.5%
<b>Education</b>	<b>2.42</b>	<b>-</b>	<b>2.02</b>	<b>-0.40</b>	<b>-16.5%</b>
<b>Infrastructure</b>	<b>0.16</b>	<b>-</b>	<b>-</b>	<b>-0.16</b>	<b>-100.0%</b>

DEB supports fundamental research on earth’s biodiversity and the ecological and evolutionary processes that explain the origin and maintenance of genetic variation in nature, including its history and patterns of speciation and extinction. DEB supports activities in URoL, including research that advances understanding of the functional importance of biodiversity to ecological and ecosystem processes occurring over short and long temporal and spatial scales. The discoveries from this research are the basis for management of the nation’s biological resources, including agricultural and native systems, and prediction of changes in species abundance and ecosystem services over time.

DEB funded research provides the data, knowledge, and modeling capability to forecast the spread of infectious diseases and of invasive species, and their impacts on wild, managed, and agricultural systems. Models developed from biodiversity and ecological research are used to predict drivers environmental change that impact society and enhance the nation’s ability to strategically prepare for environmental threats, and field defense capabilities that are resilient and adaptive.

In general, 66 percent of the DEB portfolio is available for new research grants. The remaining 34 percent supports research and education grants made in prior years.

**FY 2018 Summary**

All funding decreases/increases represent changes over the FY 2016 Actual.

**Research**

Research funding decreases \$12.62 million to a total of \$128.76 million.

- DEB will prioritize basic research that focuses on science related to URoL at scales of biological organization spanning local populations of organisms to regional and continental scale ecosystems. Emphasis will be on the integration of ecology and evolution, and sustaining support for development and testing of theory that transcends disciplinary boundaries to understand biological phenomena that cannot be explained by either discipline alone.
- Support for the Dimensions of Biodiversity program will be sustained at \$11.0 million. Research projects funded by this program provide foundational knowledge on the maintenance and functional properties of the diversity of life on earth. This research informs management and conservation of genetic and other biological resources in the context of dynamic ecosystems.
- Support for the Long Term Ecological Research (LTER) program will decrease \$1.40 million to a total of \$20.30 million, to sustain a national network of sites conducting research on the structure and function of the nation’s ecosystems. The LTER sites encompass a large range of ecosystem types in the

*Directorate for Biological Sciences*

United States, including deserts, mountains, lakes, swamps, prairies, coastal regions, tropical, temperate, and boreal forests, and arctic tundra. Research supported by this program contributes to our understanding of ecosystem services and environmental sustainability.

- Support for the Ecology and Evolution of Infectious Disease program will be sustained at \$6.0 million. This program, which is a partnership with the National Institutes of Health and USDA, funds research to advance basic understanding and develop predictive models for disease risk, including threats to humans, wildlife, farm animals, crop, and native plants.
- Encouragement and support for research using NEON data, samples, and resources to address macro-scale environmental questions in the DEB core programs will continue in anticipation of the completion of NEON construction.

**Education**

- FY 2018 investments in REU decrease \$350,000 to a total of \$1.78 million and RET decrease \$50,000 to a total of \$240,000.

**DIVISION OF BIOLOGICAL INFRASTRUCTURE (DBI)**

**\$169,610,000**  
**+\$25,000,000 / 17.3%**

**DBI Funding**  
(Dollars in Millions)

	FY 2016 Actual	FY 2017 (TBD)	FY 2018 Request	Change Over FY 2016 Actual	
				Amount	Percent
<b>Total</b>	<b>\$144.61</b>	<b>-</b>	<b>\$169.61</b>	<b>\$25.00</b>	<b>17.3%</b>
<b>Research</b>	<b>40.51</b>	<b>-</b>	<b>30.68</b>	<b>-9.83</b>	<b>-24.3%</b>
CAREER	4.41	-	5.81	1.40	31.7%
Centers Funding (total)	33.76	-	21.00	-12.76	-37.8%
Centers for Analysis & Synthesis	18.40	-	6.00	-12.40	-67.4%
Nanoscale Science & Engineering Centers	5.36	-	-	-5.36	-100.0%
STC: BEACON	5.00	-	5.00	-	-
STC: XFeI	5.00	-	5.00	-	-
STC: CCC	-	-	5.00	5.00	N/A
<b>Education</b>	<b>28.59</b>	<b>-</b>	<b>19.64</b>	<b>-8.95</b>	<b>-31.3%</b>
<b>Infrastructure</b>	<b>75.51</b>	<b>-</b>	<b>119.29</b>	<b>43.78</b>	<b>58.0%</b>
CHESS	5.00	-	4.00	-1.00	-20.0%
NEON	-	-	65.00	65.00	N/A
NNCI	0.35	-	0.35	-	-
Research Resources	70.16	-	49.94	-20.22	-28.8%

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 cyberinfrastructure, instrumentation, improvements to biological research collections, living stock collections, field stations, and marine labs. In addition, DBI supports the development of human capital through undergraduate 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. 21st century biological research is evolving into a transdisciplinary and data-driven science that requires a range of infrastructure and a highly trained workforce. DBI funds activities on a scale that ranges from molecular to continental and addresses processes involving the reciprocal interactions between genomes, phenomes, and the environment. These projects, which will be instrumental for URoL, include high-throughput phenotyping, modeling microbial species interactions, biodiversity and ecological forecasting, and mapping the brain connectome.

In FY 2018, DBI will utilize the outcomes of two program evaluations conducted in FY 2017 to leverage the importance of biological research collections in the context of research activities across the directorate and to better serve the instrumentation needs of the biological research community. A priority will be research resources to support innovation and enhance capacity in order to address long term resource needs and the development of a robust STEM pipeline. In particular, a focus on developing new tools and supporting cyberinfrastructure to meet the data integration challenges emerging as part of ecological forecasting associated with NEON or predictive relationships from genomic, environmental, and phenotypic characteristics of biological systems are areas that will be addressed by DBI programs.

In general, 34 percent of the DBI portfolio is available for new research grants and 66 percent funds continuing grants made in previous years.

## **FY 2018 Summary**

All funding decreases/increases represent changes over the FY 2016 Actual.

### **Research**

Research funding decreases \$9.83 million to a total of \$30.68 million.

- Support for centers will decrease \$12.76 million to a total of \$21.0 million.
  - The Centers for Analysis and Synthesis, CyVerse (formerly iPlant) and the National Institute for Mathematical and Biological Synthesis (NIMBioS), as well as the Nanoscale Science and Engineering Centers, Centers for the Environmental Implications of Nanotechnology (CEIN)-UCLA and CEIN-Duke, will have completed their respective funding cycles in FY 2017.
  - Funding for the STCs BEACON, XFEL, and CCC will continue through FY 2018; XFEL is expected to be renewed at the FY 2016 Actual level.
  - Funding for SESync, a Center for Analysis and Synthesis, will continue at current funding levels.
- While the majority of BIO's UtB investment is funded through EF, a significant component 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. The awards made through the new NeuroNex solicitation will be managed in DBI with support from IOS.

### **Education**

- IUSE (-\$240,000 to a total of \$2.50 million) is centralized within DBI through the RCN-UBE program.
- FY 2018 funding for the Postdoctoral Research Fellowships in Biology program is decreased \$3.20 million to a total of \$4.0 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.
- DBI will maintain a contribution (no change; total of \$1.40 million) to NSF INCLUDES to promote the advancement of underrepresented groups in STEM.
- FY 2018 investments in REU decrease \$2.52 million to a total of \$11.09 million and RET decrease \$30,000 to a total of \$30,000.

### **Infrastructure**

- Two facilities will receive continued funding: CHESS (-\$1.0 million to a total of \$4.0 million) and NNCI (no change; total of \$350,000).
- In FY 2018, NEON O&M funding (+\$65.0 million to a total of \$65.0 million) moves from EF to DBI in accordance with the shift in program management and oversight that occurred in FY 2017. For more detailed information on NEON, see the MREFC chapter.
- Research resources decrease \$20.22 million to a total of \$49.94 million.
  - Approximately \$14 million of the decrease is attributed to reduced funding for BIO's research resource programs as assessments, begun in FY 2017, on the effectiveness of these programs are completed and their future directions are determined.
  - Emphases within research resources will be related to the BIO emphasis area, URoL. This will include support for multidisciplinary imaging, digitization of biological specimens, cyberinfrastructure in support of synthetic biology, and high performance computing resources and tools necessary to address priority research initiatives under URoL, 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 of different types of data across spatial and temporal scales and for the large neuroscience investments being made through NeuroNex.

**DIVISION OF EMERGING FRONTIERS (EF)**

**\$137,310,000**  
**+\$51,780,000 / 60.5%**

**EF Funding**  
(Dollars in Millions)

	FY 2016 Actual <sup>1</sup>	FY 2017 (TBD)	FY 2018 Request	Change Over FY 2016 Actual	
				Amount	Percent
<b>Total</b>	<b>\$85.53</b>	<b>-</b>	<b>\$137.31</b>	<b>\$51.78</b>	<b>60.5%</b>
<b>Research</b>	<b>51.44</b>	<b>-</b>	<b>112.26</b>	<b>60.82</b>	<b>118.2%</b>
CAREER	2.66	-	1.76	-0.90	-33.8%
<b>Education</b>	<b>1.12</b>	<b>-</b>	<b>3.80</b>	<b>2.68</b>	<b>239.5%</b>
<b>Infrastructure</b>	<b>32.97</b>	<b>-</b>	<b>21.25</b>	<b>-11.72</b>	<b>-35.6%</b>
NEON	32.97	-	-	-32.97	-100.0%
Research Resources	-	-	21.25	21.25	N/A

<sup>1</sup> In FY 2016, \$20.0 was transferred to the MREFC account for increased NEON construction costs. Including this transfer, EF's total funding in FY 2016 was \$105.53 million. FY 2018 Request funding for EF compared to EF's initial FY 2016 budget is a increase of \$31.78 million or 30.1 percent.

EF identifies, incubates, and supports infrastructure and research areas that transcend scientific disciplines and/or advance conceptual foundations across all of biology. 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). New programs and priority areas, especially those that are cross-cutting, typically begin development in EF and then move to other BIO divisions to become part of the disciplinary knowledge base. Examples include the Advanced Digitization of Biodiversity Collections (ADBC) program which has now transitioned into DBI. In FY 2018, EF will provide support for cross-cutting core activities that contribute to URoL, an emphasis area that began in FY 2017.

The Plant Genome Research Program (PGRP) will transition to EF in FY 2018. 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-energy, development of sources of novel bio-based materials, and adaptation of plants to novel environments. 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.

In general, 46 percent of the EF portfolio is available for new research grants. The remaining 54 percent supports research, education, and infrastructure grants made in prior years.

**FY 2018 Summary**

All funding decreases/increases represent changes over the FY 2016 Actual.

**Research**

Research funding increases \$60.82 million to a total of \$112.26 million.

- PGRP funding (+\$57.41 million to a total of \$67.41 million) will move from IOS to EF in FY 2018 to reflect this program's central role in developing basic knowledge of the structures and functions of plant genomes and translation of this knowledge into a comprehensive understanding of all aspects of economically important plants and plant processes of potential economic value.
- Support for neuroscience activities in EF and will be focused on the NeuroNex program.

## *Directorate for Biological Sciences*

- Support (\$3.0 million) for high performance computing resources and tools necessary to address cross-directorate priority research initiatives under URoL will move from DBI to EF in FY 2018.
- Funding for URoL activities will include support for tools, technologies and modeling approaches to understanding the flow of information from genotype to phenotype across scales, synthetic biology, origins of life, and developing biological theory as a framework for URoL.

### **Education**

- Education investments in EF, through PGRP, will provide support (+\$3.80 million to a total of \$3.80 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 USDA, Agricultural Research Service (ARS).

### **Infrastructure**

- In FY 2018, NEON O&M funding (-\$32.97 million to zero) moves from EF to DBI in accordance with the shift in program management and oversight that occurred in FY 2017. For more detailed information on NEON, see the MREFC chapter.
- With the shift in funding from IOS to EF, research resources (+\$21.25 million to a total of \$21.25 million) will support investments essential to PGRP, including tools for high-throughput analysis of agriculturally important plant phenotypes under field conditions are maintained.