DEPARTMENT OF HEALTH AND HUMAN SERVICES

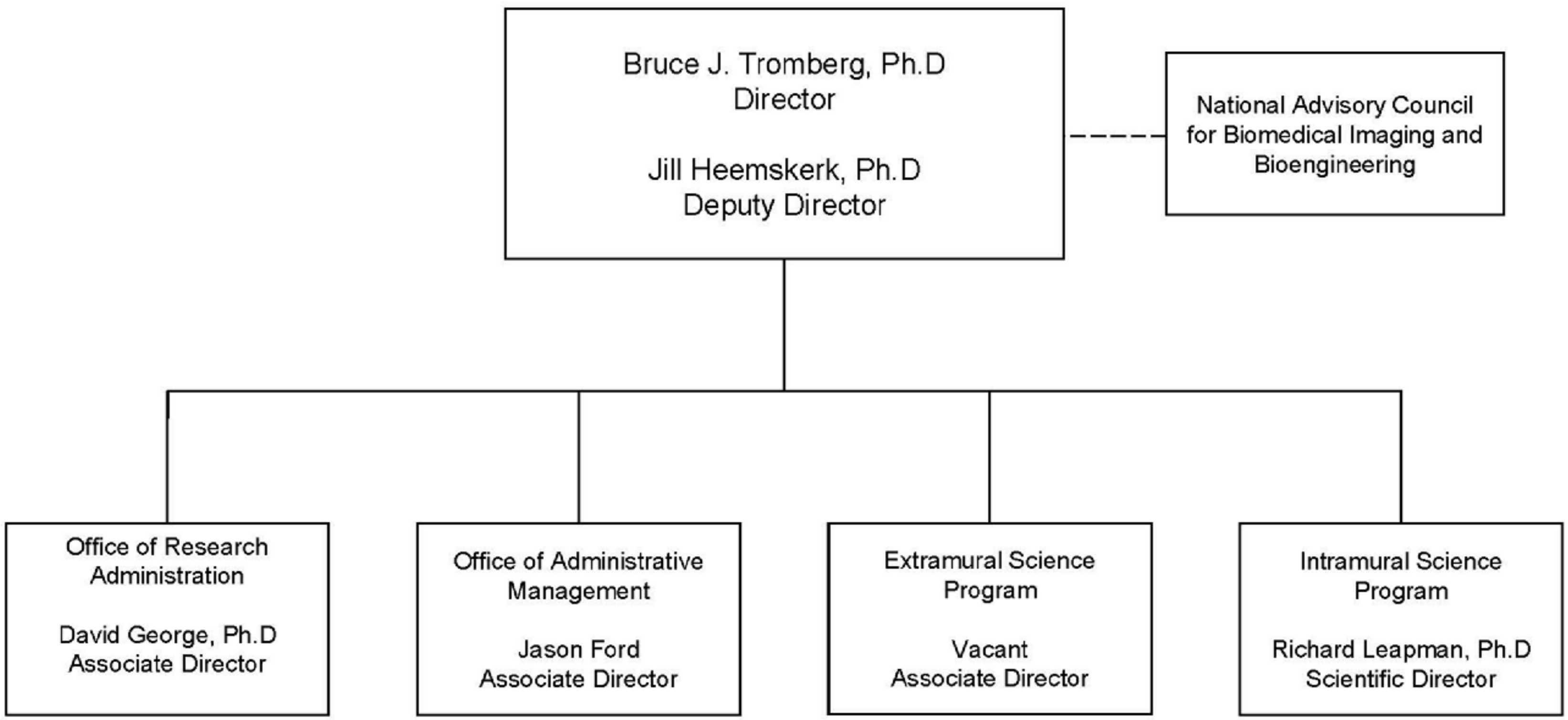
NATIONAL INSTITUTES OF HEALTH

National Institute of Biomedical Imaging and Bioengineering (NIBIB)

FY 2021 Budget — Page No.

National Institute of Biomedical Imaging and Bioengineering

NIBIB ORGANIZATIONAL CHART



NATIONAL INSTITUTES OF HEALTH

National Institute of Biomedical Imaging and Bioengineering

For carrying out section 301 and title IV of the PHS Act with respect to biomedical imaging and bioengineering research, [$403,638,000]*$368,111,000*.

NATIONAL INSTITUTES OF HEALTH
National Institute of Biomedical Imaging and Bioengineering

Amounts Available for Obligation[1]
(Dollars in Thousands)

Source of Funding	FY 2019 Final	FY 2020 Enacted	FY 2021 President's Budget
Appropriation	$389,464	$403,638	$368,111
Mandatory Appropriation: (non-add)	-	-	-
Type 1 Diabetes	*(0)*	*(0)*	*(0)*
Other Mandatory financing	*(0)*	*(0)*	*(0)*
Rescission	0	0	0
Sequestration	0	0	0
Secretary's Transfer	-1,338	0	0
Subtotal, adjusted appropriation	$388,126	$403,638	$368,111
OAR HIV/AIDS Transfers	-13	1,000	0
HEAL Transfer from NINDS	0	0	0
Subtotal, adjusted budget authority	$388,113	$404,638	$368,111
Unobligated balance, start of year	0	0	0
Unobligated balance, end of year	0	0	0
Subtotal, adjusted budget authority	$388,113	$404,638	$368,111
Unobligated balance lapsing	-34	0	0
Total obligations	$388,079	$404,638	$368,111

[1] Excludes the following amounts (in thousands) for reimbursable activities carried out by this account:
FY 2019 - $2,964 FY 2020 - $5,100 FY 2021 - $5,100

NATIONAL INSTITUTES OF HEALTH
National Institute of Biomedical Imaging and Bioengineering

Budget Mechanism - Total[1]
(Dollars in Thousands)

MECHANISM	FY 2019 Final		FY 2020 Enacted		FY 2021 President's Budget		FY 2021 +/- FY 2020 Enacted	
	No.	Amount	No.	Amount	No.	Amount	No.	Amount
Research Projects:	-	-	-	-	-	-	-	-
Noncompeting	449	$173,409	466	$185,558	495	$191,170	29	$5,612
Administrative Supplements	*(15)*	1,724	*(16)*	1,800	*(14)*	1,631	*(-2)*	-169
Competing:	-	-	-	-	-	-	-	-
Renewal	15	7,298	15	7,370	10	4,549	-5	-2,821
New	213	76,287	219	79,278	152	50,987	-67	-28,291
Supplements	0	0	0	0	0	0	0	0
Subtotal, Competing	228	$83,585	234	$86,648	162	$55,536	-72	-$31,112
Subtotal, RPGs	677	$258,718	700	$274,006	657	$248,337	-43	-$25,669
SBIR/STTR	31	12,250	32	12,658	29	11,472	-3	-1,186
Research Project Grants	708	$270,969	732	$286,664	686	$259,809	-46	-$26,855
Research Centers:	-	-	-	-	-	-	-	-
Specialized/Comprehensive	4	$5,270	4	$3,960	4	$3,589	0	-$371
Clinical Research	0	0	0	0	0	0	0	0
Biotechnology	25	32,917	22	27,603	21	25,017	-1	-2,586
Comparative Medicine	0	0	0	0	0	0	0	0
Research Centers in Minority Institutions	0	0	0	0	0	0	0	0
Research Centers	29	$38,187	26	$31,563	25	$28,606	-1	-$2,957
Other Research:	-	-	-	-	-	-	-	-
Research Careers	23	$3,391	26	$4,242	24	$3,845	-2	-$397
Cancer Education	0	0	0	0	0	0	0	0
Cooperative Clinical Research	0	0	0	0	0	0	0	0
Biomedical Research Support	0	0	0	0	0	0	0	0
Minority Biomedical Research Support	0	0	0	0	0	0	0	0
Other	61	8,173	67	8,082	61	7,325	-6	-757
Other Research	84	$11,564	93	$12,324	85	$11,170	-8	-$1,154
Total Research Grants	821	$320,720	851	$330,551	796	$299,585	-55	-$30,966
Ruth L Kirchstein Training Awards:	FTTPs	-	FTTPs	-	FTTPs	-	FTTPs	-
Individual Awards	10	$532	16	$908	14	$823	-2	-$85
Institutional Awards	202	10,371	214	10,588	194	9,596	-20	-992
Total Research Training	212	$10,903	230	$11,496	208	$10,419	-22	-$1,077
Research & Develop. Contracts	8	$15,668	9	$16,936	8	$15,349	-1	-$1,587
(SBIR/STTR) (non-add)	*(3)*	*(134)*	*(3)*	*(141)*	*(3)*	*(128)*	*(0)*	*(-13)*
Intramural Research	26	16,769	32	19,590	32	17,996	0	-1,594
Res. Management & Support	67	24,053	70	26,065	70	24,762	0	-1,303
Res. Management & Support (SBIR Admin) (non-add)	*(0)*	*(221)*	*(0)*	*(232)*	*(0)*	*(210)*	*(0)*	*(-22)*
Construction	-	0	-	0	-	0	-	0
Buildings and Facilities	-	0	-	0	-	0	-	0
Total, NIBIB	93	$388,113	102	$404,638	102	$368,111	0	-$36,527

[1] All items in italics and brackets are non-add entries.

Major Changes in the Fiscal Year 2021 President's Budget Request

Major changes by budget mechanism and/or budget activity detail are briefly described below. Note that there may be overlap between budget mechanism and activity detail and these highlights will not sum to the total change for the FY 2021 President's Budget for NIBIB. The FY 2021 President's Budget request for NIBIB is $368.1 million, a decrease of $36.5 million or 9.0 percent compared with the FY 2020 Enacted level.

Research Project Grants (RPGs) (-$26.9 million; total $259.8 million):

NIBIB will fund 686 RPG awards in FY 2021, a decrease of 46 awards from the FY 2020 Enacted level. This includes 495 noncompeting awards (an increase of 29 awards and $5.4 million from the FY 2020 Enacted level); 162 competing RPGs (a decrease of 72 awards and $31.1 million from the FY 2020 Enacted level); and 29 SBIR/STTR awards (a decrease of 3 awards and $1.2 million from the FY 2020 Enacted level). Noncompeting awards will be funded at a reduced level, 7.4 percent below their full committed level. The average cost of Competing RPG's will decrease by 7.4 percent in FY 2021 versus the FY 2020 Enacted level.

Research Centers (-$3.0 million; total of $28.6 million):
NIBIB will fund 25 Center awards in FY 2021, a decrease of 1 from the FY 2020 Enacted level.

Other Research (-$1.2 million; total of $11.2 million):
NIBIB will fund 85 Other Research awards in FY 2021, a decrease of 8 from the FY 2020 Enacted level.

Research Training Awards (-$1.1 million; total $10.4 million):
NIBIB will fund 208 Full-Time Training Positions (FTTPs) in FY 2021, a decrease of 22 from the FY 2020 Enacted level.

Research and Development Contracts (-$1.6 million; total $15.3 million):
NIBIB will fund 8 R&D Contracts in FY 2021, a decrease of 1 from the FY 2020 Enacted level.

Intramural Research (-$1.6 million; total $18.0 million):
The Clinical Center Management Fund assessment remains flat, while all other activities will be reduced by 9.4 percent, the same as the aggregate reduction for Extramural funding mechanisms.

Research Management & Support (-$1.3 million; total $24.8 million):
Research Management & Support will be reduced by 5.0 percent from the FY 2020 Enacted level.

NATIONAL INSTITUTES OF HEALTH
National Institute of Biomedical Imaging and Bioengineering

Summary of Changes
(Dollars in Thousands)

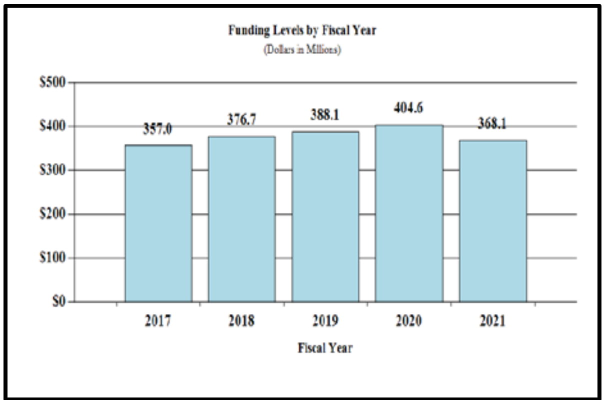
FY 2020 Enacted	$404,638
FY 2021 President's Budget	$368,111
Net change	-$36,527

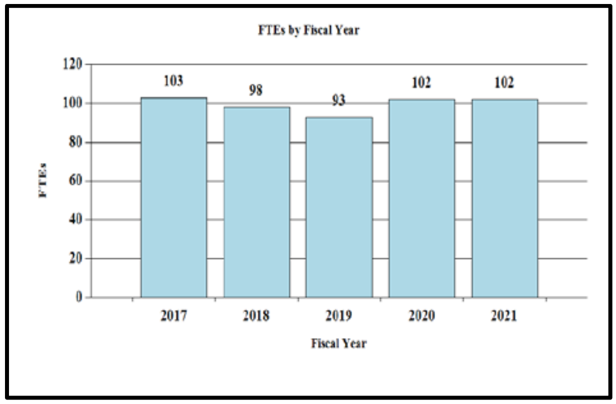
CHANGES	**FY 2021 President's Budget**		**Change from FY 2020 Enacted**	
	FTEs	**Budget Authority**	**FTEs**	**Budget Authority**
A. Built-in:	-	-	-	-
1. Intramural Research:	-	-	-	-
a. Annualization of January 2020 pay increase & benefits	-	$6,479	-	$42
b. January FY 2021 pay increase & benefits	-	6,479	-	94
c. Paid days adjustment	-	6,479	-	-24
d. Differences attributable to change in FTE	-	6,479	-	0
e. Payment for centrally furnished services	-	2,581	-	0
f. Cost of laboratory supplies, materials, other expenses, and non-recurring costs	-	8,936	-	216
Subtotal	-	-	-	$327
2. Research Management and Support:	-	-	-	-
a. Annualization of January 2020 pay increase & benefits	-	$12,674	-	$80
b. January FY 2021 pay increase & benefits	-	12,674	-	197
c. Paid days adjustment	-	12,674	-	-47
d. Differences attributable to change in FTE	-	12,674	-	0
e. Payment for centrally furnished services	-	298	-	-16
f. Cost of laboratory supplies, materials, other expenses, and non-recurring costs	-	11,790	-	124
Subtotal	-	-	-	$339
Subtotal, Built-in	-	-		$666

CHANGES	**FY 2021 President's Budget**		**Change from FY 2020 Enacted**	
	No.	**Amount**	**No.**	**Amount**
B. Program:	-	-	-	-
1. Research Project Grants:	-	-	-	-
a. Noncompeting	495	$192,801	29	$5,443
b. Competing	162	55,536	-72	-31,112
c. SBIR/STTR	29	11,472	-3	-1,186
Subtotal, RPGs	686	$259,809	-46	-$26,855
2. Research Centers	25	$28,606	-1	-$2,957
3. Other Research	85	11,170	-8	-1,154
4. Research Training	208	10,419	-22	-1,077
5. Research and development contracts	8	15,349	-1	-1,587
Subtotal, Extramural	-	$325,353	-	-$33,630
	FTEs	-	FTEs	-
6. Intramural Research	32	$17,996	0	-$1,921
7. Research Management and Support	70	24,762	0	-1,642
8. Construction	-	0	-	0
9. Buildings and Facilities	-	0	-	0
Subtotal, Program	102	$368,111	0	-$37,193
Total changes	-	-	-	-$36,527

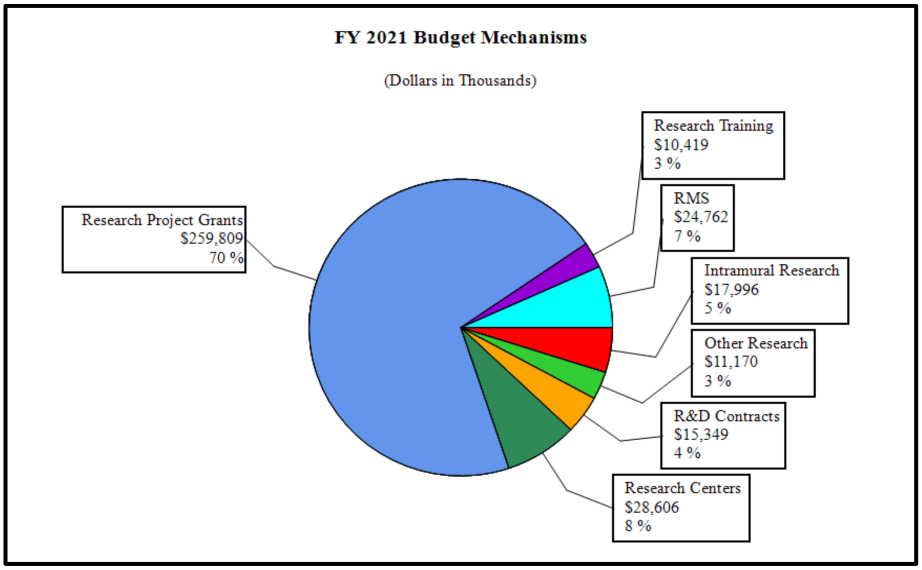
Fiscal Year 2021 Budget Graphs

History of Budget Authority and FTEs:

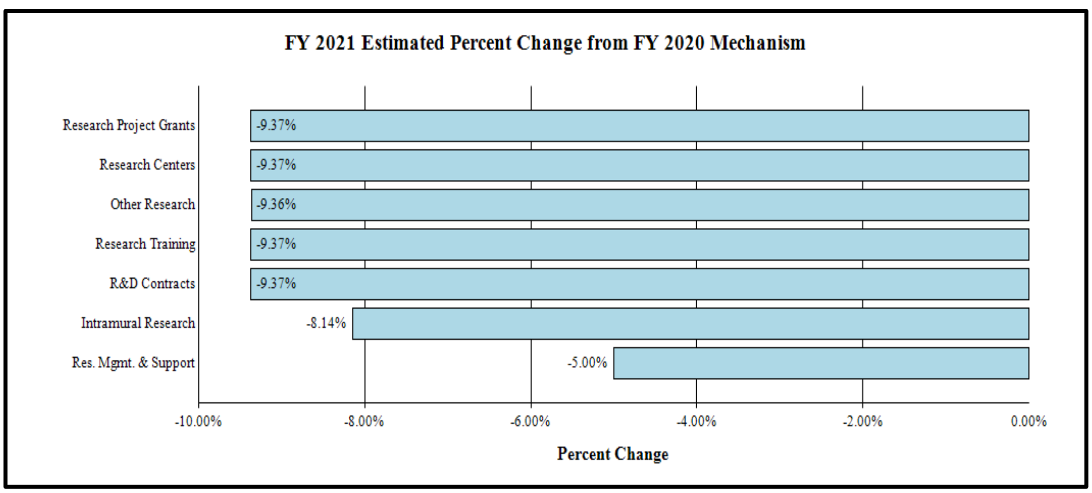




Distribution by Mechanism:



Change by Selected Mechanisms:



NATIONAL INSTITUTES OF HEALTH
National Institute of Biomedical Imaging and Bioengineering

Budget Authority by Activity[1]
(Dollars in Thousands)

	FY 2019 Final		FY 2020 Enacted		FY 2021 President's Budget		FY 2021 +/- FY2020	
Extramural Research	**FTE**	**Amount**	**FTE**	**Amount**	**FTE**	**Amount**	**FTE**	**Amount**
Detail	-	-	-	-	-	-	-	-
Discovery Science and Technology	-	$112,915	-	$116,716	-	$105,782	-	-$10,934
Applied Science and Technology	-	173,525	-	179,367	-	162,564	-	-16,803
Interdisciplinary Training	-	23,166	-	23,946	-	21,703	-	-2,243
Health Informatics Technology	-	37,686	-	38,954	-	35,304	-	-3,650
Subtotal, Extramural	**-**	**$347,291**	**-**	**$358,983**	**-**	**$325,353**	**-**	**-$33,630**
Intramural Research	**26**	**$16,769**	**32**	**$19,590**	**32**	**$17,996**	**0**	**-$1,594**
Research Management & Support	**67**	**$24,053**	**70**	**$26,065**	**70**	**$24,762**	**0**	**-$1,303**
TOTAL	**93**	**$388,113**	**102**	**$404,638**	**102**	**$368,111**	**0**	**-$36,527**

[1] Includes FTEs whose payroll obligations are supported by the NIH Common Fund.

NATIONAL INSTITUTES OF HEALTH
National Institute of Biomedical Imaging and Bioengineering

Authorizing Legislation

	PHS Act/ Other Citation	U.S. Code Citation	2020 Amount Authorized	FY 2020 Enacted	2021 Amount Authorized	FY 2021 President's Budget
Research and Investigation	Section 301	42§241	Indefinite	$404,638,000	Indefinite	$368,111,000
National Institute of Biomedical Imaging and Bioengineering	Section 401(a)	42§281	Indefinite		Indefinite	
Total, Budget Authority				$404,638,000		$368,111,000

NATIONAL INSTITUTES OF HEALTH
National Institute of Biomedical Imaging and Bioengineering

Appropriations History

Fiscal Year	Budget Estimate to Congress	House Allowance	Senate Allowance	Appropriation
2012	$322,106,000	$322,106,000	$333,671,000	$338,998,000
Rescission	-	-	-	$640,706
2013	$336,896,000	-	$337,917,000	$338,357,294
Rescission	-	-	-	$676,715
Sequestration	-	-	-	($16,983,210)
2014	$338,892,000	-	$337,728,000	$329,172,000
Rescission	-	-	-	$0
2015	$328,532,000	-	-	$330,192,000
Rescission	-	-	-	$0
2016	$337,314,000	$338,360,000	$344,299,000	$346,795,000
Rescission	-	-	-	$0
2017[1]	$343,506,000	$356,978,000	$361,062,000	$357,080,000
Rescission	-	-	-	$0
2018	$282,614,000	$362,506,000	$371,151,000	$377,871,000
Rescission	-	-	-	$0
2019	$346,550,000	$382,384,000	$389,672,000	$389,464,000
Rescission	-	-	-	$0
2020	$335,986,000	$408,498,000	$411,496,000	$403,638,000
Rescission	-	-	-	$0
2021	$368,111,000	-	-	-

[1] Budget Estimate to Congress includes mandatory financing.

Justification of Budget Request

National Institute of Biomedical Imaging and Bioengineering

Authorizing Legislation: Section 301 and title IV of the Public Health Service Act, as amended.

Budget Authority (BA):

	FY 2019 Final	FY 2020 Enacted	FY 2021 President's Budget	FY 2021+/- FY 2020
BA	$388,113,000	$404,638,000	$368,111,000	-$36,527,000
FTE	93	102	102	0

Program funds are allocated as follows: Competitive Grants/Cooperative Agreements; Contracts; Direct Federal/Intramural and Other.

Director's Overview

NIBIB's mission is to transform through engineering the understanding of disease and its prevention, detection, diagnosis, and treatment. For nearly two decades, NIBIB-supported research has pioneered groundbreaking advances to create technologies that are essential to extending the healthspan, by personalizing diagnosis and treatment and significantly improving quality of life. As the hub at NIH for expanding technologies across diseases and disorders, NIBIB support is driving research to benefit patients and healthcare professionals and promote further biomedical discovery.

NIBIB is leveraging the rapid progress being made in basic biology and technology including new developments in smart phones, biomaterials, mini-circuits, and computing power to develop futuristic devices and tools that are better, smaller, faster, and more accessible to solve a broad range of biomedical healthcare problems. As these technologies progress, they encourage economic growth, reduce costs, and overcome barriers to access and inclusion. Examples include accurately modeling the ideal medication dose for an individual patient, creating implantable sensors to monitor health on a continual basis, and developing point of care devices to detect and diagnose infections rapidly while the patient is in the clinic, so that treatment can start immediately.

Since its inception, NIBIB has worked to bring the engineering and physical sciences fields together with biology and medicine to encourage a multidisciplinary approach toward solving once-intractable health problems. The Institute continues this arc of further integrating engineering and medicine to understand, detect, and prevent disease and develop new treatments—with an emphasis on translation and commercialization of novel technologies. What may the future hold? Possibilities include noninvasive imaging with laser technologies that can reveal invisible changes in cells before symptoms appear or using mathematical modeling, computation, and robotics to help people with disabilities and injuries live more independently and improve their quality of life.

These types of innovations are achieved through the good stewardship of resources allocated to NIBIB. In recent years, NIBIB has significantly increased the number of talented researchers it has been able to support, especially early stage investigators. NIBIB's Trailblazer Award[1] targets new and early-stage investigators to help them build their careers and pursue a new or emerging research area. This new mechanism has created a unique funding opportunity dedicated exclusively to new and early-stage researchers that did not previously exist.

NIBIB also launched a targeted program to accelerate the translation and commercialization of promising technologies to make them available to patients. An ongoing challenge in technology development is bridging the gap between the scientific innovation that occurs in a lab and achieving viability on the commercial market. NIBIB's program aims to de-risk products, decrease the time to market, and create a robust pipeline of high-quality projects for NIBIB's Small Business Innovation Research and Small Business Technology Transfer programs.

NIBIB also joined with other NIH institutes to expand its Point of Care Technology Research Network. This network develops technologies and information sharing tools that are inexpensive, easy-to-use, portable, and provide timely health status information about patients at the point of care. The program now comprises five centers around the country that accelerate the development of new technologies for areas of high clinical need, including infectious diseases and cardiovascular diseases. These centers support the development of and facilitate the commercialization of new technologies that can transform healthcare, particularly in low-resource settings.

Overall Budget Policy:
The FY 2021 President's Budget request for NIBIB is $368.1 million, a decrease of $36.5 million or 9.0 percent compared with the FY 2020 Enacted level. Noncompeting RPGs will be awarded at a reduced level, 7.4 percent below their full committed level. The average cost of Competing RPGs will decrease by 7.4 percent in FY 2021 versus the FY 2020 Enacted level. For Intramural Research, the Clinical Center Management Fund assessment remains flat, while all other activities will be reduced by 9.4 percent, the same as the aggregate reduction for Extramural funding mechanisms. Research Management & Support will be reduced by 5.0 percent from the FY 2020 Enacted level.

Program Descriptions and Accomplishments

Extramural Research Program

NIBIB supports research and training at universities, hospitals, industries, and research institutions across the country through its Extramural Research Program. The scientific research areas supported by NIBIB cover a range of programs that lead to new, faster, and less costly ways to advance technologies from the blackboard to benchtop to bedside. Major areas of

[1] http://www.nibib.nih.gov/research-funding/trailblazer-r21-awards

research in which NIBIB plans to invest in FY 2021 are: sensing and imaging health and disease; engineered biosystems; quantitative data science, modeling, and computation; advanced therapies and treatments; and workforce training.

Sensing and imaging health and disease. NIBIB-supported research pushes the envelope of current technologies toward more accessible imaging and continual sensing technologies that will increase our knowledge of biological and disease processes to understand how, why, and where in the body diseases may start. The development of these technologies aims to provide pinpoint diagnostic, therapeutic, and preventative solutions. One example of how NIBIB is enhancing imaging technology is the development of next-generation magnetic resonance imaging (MRI) machines. This technology has been tremendously beneficial to see non-invasively inside the body. For many patients, however, the scanning procedure is uncomfortable, claustrophobic, time-consuming, and may be cost-prohibitive. Using new hardware and imaging software, researchers are developing a smaller head-only MRI machine that produces images of just the brain.[2] This head-only MRI will allow patients to see outside of the scanner, have more freedom of movement, and faster scan time. It will also be portable and produce high quality images to show details of brain function, a tumor, or a stroke.

In addition to this type of precise diagnostic tool, monitoring physiology continuously will provide a more complete picture of an individual's health. Counting steps and tracking heart rates are increasingly used to determine how much movement and exercise we are getting throughout the day. But for vital signs such as blood pressure, we only take a snapshot once a year when we visit the doctor. When a medication is prescribed, we typically wait several months until we return to the doctor to see if it is working. Researchers are developing sensors to monitor and track vital signs from the skin surface to obtain a fuller picture of our health.

In one example, researchers created a flexible patch that can accurately and continuously measure central blood pressure.[3] The patch is worn on the skin like a band-aid and could offer more timely feedback on whether a medication is working or when something may be going awry. It measures pressure in the aorta, near the heart, which is far more precise than a typical blood pressure cuff on the arm; thus, it more accurately reflects one's risk for cardiovascular problems. The patch emits ultrasound waves, which are recorded and then translated into a blood pressure waveform to show changes in blood pressure. The peaks and valleys of a waveform represent heart activity, which is used to detect cardiovascular problems. Further development of this type of continuous monitoring device may one day help prevent stroke or heart disease and help to manage conditions such as high blood pressure better.

Engineered biosystems. By combining human biology with engineering approaches, researchers are developing advanced therapies with broad medical applications. Increasingly, research is identifying biomarkers—a measurable indicator of a condition or state—of diseases

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[2] NIH Research Portfolio Online Reporting Tools
projectreporter.nih.gov/project_info_description.cfm?aid=9928254&icde=46451374

[3] Chonghe Wang, et al. Monitoring of the central blood pressure waveform via a conformal ultrasonic device. *Nature Biomedical Engineering*, Sept. 2018, (2), 687–695.

and disorders. Yet, even when a biomarker is known, the ability to measure it rapidly and accurately at the bedside often does not exist. Researchers are creating a 3D printed lab on a chip device to detect a known biomarker (a specific protein) that can identify women at risk of preterm birth to address this challenge.[4] Children born before 37 weeks are considered preterm and are more likely to suffer from severe health complications in the lungs, heart, and brain. Worldwide, approximately one million babies die each year due to the consequences of preterm birth.[5] This device is less expensive, simpler to use, and provides results faster than current methods to help identify and monitor at-risk patients.

Another approach to engineering systems for treating various conditions is a method to manipulate the body's immune system to be more helpful and, in some circumstances, less harmful. For example, in a spinal cord injury the immune system mounts a response that leads to inflammation and scar tissue that further impairs function. This reaction prevents the regeneration of damaged tissue. Researchers are designing nanoparticles that are one ten-thousandth the width of a human hair to act as traffic cops and direct the inflammatory immune cells away from the spinal cord following injury.[6] The nanoparticles then reprogram the immune response to promote the regeneration of damaged tissue. This early-stage research in animals is a new approach to help treat the devastating damage that results from a spinal cord injury.

Quantitative data science, modeling, and computation. This rapidly growing research area develops mathematical methods and computational models based on underlying principles, such as laws of physics, and statistical techniques, such as artificial intelligence. The broad goals are to derive meaningful information from biomedical data, design and simulate new technologies, and predict the behavior of living systems. One example of NIBIB's investment in this evolving area is the development of virtual clinical studies. These studies used computer models of the human body that can be adjusted for size, age, and other variables.[7] In one study, researchers used virtual humans to evaluate the quality of computed tomography (CT) to find the lowest radiation dose that would produce a high-quality image. The Food and Drug Administration recently used this application to assess safety measures of a new imaging approach.

Likewise, researchers are also developing computational tools and artificial intelligence applications to extract more data, and therefore better pictures, from imaging scans using CT.

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[4] Michael J. Beauchamp, Anna V. Nielsen, Hua Gong, Gregory P. Nordin, and Adam T. Woolley. 3D Printed Microfluidic Devices for Microchip Electrophoresis of Preterm Birth. *Biomarkers Analytical Chemistry*, 2019, 91 (11), 7418-7425.

[5] Centers for Disease Control and Prevention
www.cdc.gov/reproductivehealth/maternalinfanthealth/pretermbirth.htm

[6] Jonghyuck Park, Yining Zhang, Eiji Saito, Steve J. Gurczynski, Bethany B. Moore, Brian J. Cummings, Aileen J. Anderson, Lonnie D. Shea. Intravascular innate immune cells reprogrammed via intravenous nanoparticles to promote functional recovery after spinal cord injury. *Proceedings of the National Academy of Sciences,* Jul 2019, 116 (30) 14947-14954.

[7] NIH Research Portfolio Online Reporting Tools
projectreporter.nih.gov/project_info_description.cfm?aid=9750407&icde=45647796

With its growing use, CT scanning contributes to 62 percent of the radiation dosage that people in the United States incur from all imaging modalities.[8] While the risks from this exposure are small, and the benefits significant, public concern has risen with the growing use of CT scans. Medical imaging engineers are using artificial intelligence to convert low-dose CT images into images that are of superior quality, compared to low-dose scans that do not use the artificial intelligence technique.[9] This approach applies post-production methods to medical images and resulted in better information for doctors and patients without disrupting the imaging process itself, making it more appealing for use by hospitals and clinics.

Advanced therapies and treatments. The technology development pipeline is a continuum that begins with basic research of novel ideas and leads to the delivery of interventions to patients. Throughout this process, many challenges must be overcome to reach practical, feasible solutions. One example that illustrates how technologies evolve is in the application of ultrasound, a technology originally developed for diagnostic use, that is increasingly being used for treatment as well. In this instance, researchers supported by NIBIB are developing a technique that focuses sound waves deep inside the brain to perform brain surgery noninvasively and without a scalpel.[10] Treatments using this method are under development for curing movement disorders such as essential tremor, destroying tumors, and opening the blood-brain barrier for selective delivery of therapeutic medicines to precise locations while sparing healthy tissue.

Another example of a technological solution to help improve patient outcomes is the development of a teachable robotic system that integrates perception, planning, and control to perform functions such as self-feeding.[11] Nearly one million adults in the United States have an injury or age-related disability and need someone to help them eat. Engineers started by watching, measuring, and cataloging how people eat different foods. They studied the various ways people use a fork based on the size, shape, stiffness, pliability, and other physical properties of foods such as strawberries, banana pieces, melon cubes, strips of celery, and baby carrots. The researchers then "taught" a robotic arm the strategies needed to pick up food with a fork and gingerly deliver it to a person's mouth. This type of practical intervention offers new independence to people with disabilities and can greatly ease the burden of caregivers.

Commitment to workforce training. NIBIB is committed to increasing diversity in the bioengineering workforce and training the next generation of innovators. NIBIB has created and continues to support programs such as the Enhancing Science, Technology, Engineering, and

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[8] U.S. Census www.census.gov/content/dam/Census/library/publications/2018/demo/p70-152.pdf

[9] Hongming Shan, et al. Competitive performance of a modularized deep neural network compared to commercial algorithms for low-dose CT image reconstruction. *Nature Machine Intelligence*, June 2019 (1), 269–276.

[10] Crake C, Papademetriou IT, Zhang Y, Vykhodtseva N, McDannold NJ, Porter TM. Simultaneous passive acoustic mapping and magnetic resonance thermometry for monitoring of cavitation-enhanced tumor ablation in rabbits using focused ultrasound and phase-shift nanoemulsions. *Ultrasound Med Biol*. Dec 2018. 44 (12) 2609-2624.

[11] Tapomayukh Bhattacharjee, Gilwoo Lee, Hanjun Song, and Siddhartha S. Srinivasa. Towards robotic feeding: role of haptics in fork-based food manipulation. *IEEE Robotics and Automation Letters,* April 2019 4 (2).

Math Educational Diversity (ESTEEMED) initiative. This initiative supports educational activities that increase diversity in the biomedical research workforce through early preparation for underrepresented undergraduate students in STEM fields. This program will be evaluating factors that influence retention rates among underrepresented students during the first two years of undergraduate studies

Engaging with partners to achieve success. NIBIB is active in many trans-NIH programs, including the Brain Research through Advancing Innovative Neurotechnologies® (BRAIN) and Helping to End Addiction Long-term℠ (HEAL) Initiatives, among others. The BRAIN Initiative seeks to revolutionize our understanding of the human brain, supporting research to accelerate the development and application of innovative technologies that will produce a new dynamic picture of the human brain and the complex interaction of cells and circuits within the brain. In addition to supporting the development of technologies to see and record brain function, NIBIB is also supporting research on disseminating resources developed through the BRAIN Initiative and integrating them into neuroscience research practice. Easier access to resources will promote more effective use of these vital research investments.

The HEAL Initiative is supporting research to address the opioid crisis and develop effective and safe non-opioid options for pain management. NIBIB will focus its efforts on supporting the development of medical devices to treat pain under the HEAL initiative. These include the use of minimally and non-invasive targeted therapies that use light, sound, and electrical energy to stimulate precise locations in the nervous system to treat pain.

Program Portrait: Biomedical Technology Resource Centers

NIBIB plans to continue support for its national network of approximately 30 Biomedical Technology Resource Centers (BTRC) and their more than 500 affiliated collaborative and service projects distributed throughout the country. The BTRC program was established to stimulate development and provide access to cutting edge technologies and computational methods throughout the country. These centers support a range of basic, translational, and early stage clinical research spanning a wide variety of urgent healthcare problems. BTRCs bring together multidisciplinary teams of investigators who are engaged in activities that include early stage discovery to validation, dissemination, and commercialization.

In one example, an NIBIB-supported BTRC developed and commercialized a dynamic cooling device combined with a therapeutic laser technology to treat vascular malformations of the skin. The dynamic cooling device laser removes disfiguring birthmarks, such as port-wine stains, that primarily form on the face and neck. It is now widely available globally in commercial medical lasers for skin therapies.

Another collaborative research effort is developing a noninvasive way to monitor blood glucose levels.[12] This method can track glucose throughout the day and importantly, during sleep, a critical time especially for children with diabetes. The device fits on the hand, like a brace, with a small light source embedded in the brace. When light is projected onto the skin, the light reacts with substances in the skin, including glucose. The different reactions are used to measure glucose levels. This approach eliminates the discomfort and inconvenience of using needles to draw blood and measure glucose. Continuous monitor can help people manage diabetes and prevent other health complications. Ongoing work is being done to make the system portable, more convenient, and personalized.

Budget Policy:
The FY 2021 President's Budget request for Extramural Research Programs (ERP) is $325.4 million, a decrease of $33.6 million or 9.4 percent compared with the FY 2020 Enacted level. ERP will give high priority to supporting new and early-career investigators, and priority to investigator-initiated research grants as these are the foundation on which future advances in new biomedical technologies and improved patient care will be developed. Large grants and Center programs will continue to receive support as will investment in other scientific opportunities and high priority areas.

Intramural Research Program (IRP)

The Intramural Research Program (IRP) supports NIBIB's mission to integrate bioengineering with the physical and life sciences by researching basic, translational, and clinical science, and conducting effective training programs in related fields. NIBIB has added new areas of research

[12] Surya P. Singh, Soumavo Mukherjee, Luis H. Galindo, Peter T. C. So, Ramachandra Rao Dasari, Uzma Zubair Khan, Raghuraman Kannan, Anandhi Upendran, Jeon Woong Kang. Evaluation of accuracy dependence of Raman spectroscopic models on the ratio of calibration and validation points for non-invasive glucose sensing. *Analytical and Bioanalytical Chemistry* July 2018 (410) 6469–6475.

in its intramural program, including immunoengineering and mechanobiology. The Immunoengineering Laboratory focuses on finding ways to modify immune responses to implanted devices and to apply principles of immune-mediated tissue regeneration to improve the design of biomaterials. The Mechanobiology Laboratory conducts research on the mechanics and forces within and among cells to determine how these forces influence cell health, development, and behavior.

In one example of the many achievements in NIBIB's IRP, researchers are developing a sophisticated drug delivery system that uses laser light and engineered nanoparticles to activate chemotherapy only at the site of tumors. This approach was tested in a pre-clinical animal model study and was shown to be effective. This type of treatment approach has the potential to release a maximized drug dose within a tumor while minimizing the active drug and its impact on the rest of the body.)[13] [14]

<u>Budget Policy:</u>
The FY 2021 President's Budget request for IRP is $18.0 million, a decrease of $1.6 million or 8.1 percent compared with the FY 2020 Enacted level. The Clinical Center Management Fund assessment remains flat, while all other activities will be reduced by 9.4 percent, the same as the aggregate reduction for Extramural funding mechanisms. High-priority research includes molecular imaging and nanomedicine – for the early diagnosis of disease, monitoring of therapeutic response, and guiding drug discovery, and research on novel technologies for fast, "super resolution" optical microscopy of live cells to accelerate biomedical research.

Research Management and Support (RMS)

RMS activities provide administrative, budgetary, logistical, and scientific support in the review, award, and monitoring of research grants, training awards, and research and development contracts. RMS functions also encompass strategic planning, coordination, communication, and evaluation of the Institute's programs, regulatory compliance, coordination and liaison with other agencies, Congress, and the public. NIBIB's communication efforts include development of tools to help educate and inform the public about the research supported by NIBIB.

<u>Budget Policy:</u>
The FY 2021 President's Budget request for RMS is $24.8 million, a decrease of $1.3 million or 5.0 percent compared with the FY 2020 Enacted level. High priorities for RMS include the scientific support of NIBIB research programs and strategic planning.

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[13] Tang L, Yang Z, Zhou Z, et al. A logic-gated modular nanovesicle enables programmable drug release for on-demand chemotherapy. *Theranostics*, Feb 2019 9(5) 1358–1368.

[14] irp.nih.gov/blog/post/2019/04/cutting-edge-carriers-deliver-controllable-cancer-chemotherapy

NATIONAL INSTITUTES OF HEALTH
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Budget Authority by Object Class[1]
(Dollars in Thousands)

	FY 2020 Enacted	FY 2021 President's Budget	FY 2021 +/- FY 2020
Total compensable workyears:	-	-	-
Full-time equivalent	102	102	0
Full-time equivalent of overtime and holiday hours	0	0	0
Average ES salary	$0	$0	$0
Average GM/GS grade	13.1	13.1	0.0
Average GM/GS salary	$122	$123	$1
Average salary, grade established by act of July 1, 1944 (42 U.S.C. 207)	$0	$0	$0
Average salary of ungraded positions	$128	$129	$1

	OBJECT CLASSES	FY 2020 Enacted	FY 2021 President's Budget	FY 2021 +/- FY 2020
	Personnel Compensation	-	-	-
11.1	Full-Time Permanent	8,929	9,032	103
11.3	Other Than Full-Time Permanent	3,338	3,376	38
11.5	Other Personnel Compensation	384	389	4
11.7	Military Personnel	0	0	0
11.8	Special Personnel Services Payments	1,589	1,607	18
11.9	**Subtotal Personnel Compensation**	**$14,240**	**$14,404**	**$164**
12.1	Civilian Personnel Benefits	4,571	4,750	178
12.2	Military Personnel Benefits	0	0	0
13.0	Benefits to Former Personnel	0	0	0
	Subtotal Pay Costs	**$18,811**	**$19,153**	**$342**
21.0	Travel & Transportation of Persons	304	280	-24
22.0	Transportation of Things	62	57	-6
23.1	Rental Payments to GSA	5	5	0
23.2	Rental Payments to Others	0	0	0
23.3	Communications, Utilities & Misc. Charges	128	114	-14
24.0	Printing & Reproduction	0	0	0
25.1	Consulting Services	3,772	3,213	-559
25.2	Other Services	4,707	3,587	-1,120
25.3	Purchase of goods and services from government accounts	26,133	24,315	-1,818
25.4	Operation & Maintenance of Facilities	327	327	0
25.5	R&D Contracts	698	0	-698
25.6	Medical Care	488	507	19
25.7	Operation & Maintenance of Equipment	3,957	3,532	-424
25.8	Subsistence & Support of Persons	1	1	0
25.0	**Subtotal Other Contractual Services**	**$40,085**	**$35,484**	**-$4,601**
26.0	Supplies & Materials	1,168	1,192	25
31.0	Equipment	2,028	1,822	-206
32.0	Land and Structures	0	0	0
33.0	Investments & Loans	0	0	0
41.0	Grants, Subsidies & Contributions	342,047	310,004	-32,043
42.0	Insurance Claims & Indemnities	0	0	0
43.0	Interest & Dividends	0	0	0
44.0	Refunds	0	0	0
	Subtotal Non-Pay Costs	**$385,827**	**$348,958**	**-$36,869**
	Total Budget Authority by Object Class	**$404,638**	**$368,111**	**-$36,527**

[1] Includes FTEs whose payroll obligations are supported by the NIH Common Fund.

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Salaries and Expenses
(Dollars in Thousands)

OBJECT CLASSES	FY 2020 Enacted	FY 2021 President's Budget	FY 2021 +/- FY 2020
Personnel Compensation	-	-	-
Full-Time Permanent (11.1)	$8,929	$9,032	$103
Other Than Full-Time Permanent (11.3)	3,338	3,376	38
Other Personnel Compensation (11.5)	384	389	4
Military Personnel (11.7)	0	0	0
Special Personnel Services Payments (11.8)	1,589	1,607	18
Subtotal Personnel Compensation (11.9)	**$14,240**	**$14,404**	**$164**
Civilian Personnel Benefits (12.1)	$4,571	$4,750	$178
Military Personnel Benefits (12.2)	0	0	0
Benefits to Former Personnel (13.0)	0	0	0
Subtotal Pay Costs	**$18,811**	**$19,153**	**$342**
Travel & Transportation of Persons (21.0)	$304	$280	-$24
Transportation of Things (22.0)	62	57	-6
Rental Payments to Others (23.2)	0	0	0
Communications, Utilities & Misc. Charges (23.3)	128	114	-14
Printing & Reproduction (24.0)	0	0	0
Other Contractual Services:	-	-	-
Consultant Services (25.1)	3,772	3,213	-559
Other Services (25.2)	4,707	3,587	-1,120
Purchases from government accounts (25.3)	16,188	13,815	-2,373
Operation & Maintenance of Facilities (25.4)	327	327	0
Operation & Maintenance of Equipment (25.7)	3,957	3,532	-424
Subsistence & Support of Persons (25.8)	1	1	0
Subtotal Other Contractual Services	**$28,953**	**$24,476**	**-$4,477**
Supplies & Materials (26.0)	$1,168	$1,192	$25
Subtotal Non-Pay Costs	**$30,615**	**$26,119**	**-$4,496**
Total Administrative Costs	**$49,426**	**$45,272**	**-$4,154**

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Detail of Full-Time Equivalent Employment (FTE)

OFFICE/DIVISION	FY 2019 Final			FY 2020 Enacted			FY 2021 President's Budget		
	Civilian	Military	Total	Civilian	Military	Total	Civilian	Military	Total
Extramural Science Program	-	-	-	-	-	-	-	-	-
Direct:	18	-	18	19	-	19	19	-	19
Reimbursable:	2	-	2	2	-	2	2	-	2
Total:	20	-	20	21	-	21	21	-	21
Intramural Science Program	-	-	-	-	-	-	-	-	-
Direct:	22	-	22	27	-	27	27	-	27
Reimbursable:	4	-	4	5	-	5	5	-	5
Total:	26	-	26	32	-	32	32	-	32
Office of Administrative Management	-	-	-	-	-	-	-	-	-
Direct:	25	-	25	27	-	27	27	-	27
Reimbursable:	-	-	-	-	-	-	-	-	-
Total:	25	-	25	27	-	27	27	-	27
Office of Reseach Administration	-	-	-	-	-	-	-	-	-
Direct:	18	-	18	18	-	18	18	-	18
Reimbursable:	-	-	-	-	-	-	-	-	-
Total:	18	-	18	18	-	18	18	-	18
Office of the Director	-	-	-	-	-	-	-	-	-
Direct:	4	-	4	4	-	4	4	-	4
Reimbursable:	-	-	-	-	-	-	-	-	-
Total:	4	-	4	4	-	4	4	-	4
Total	93	-	93	102	-	102	102	-	102
Includes FTEs whose payroll obligations are supported by the NIH Common Fund.									
FTEs supported by funds from Cooperative Research and Development Agreements.	0	0	0	0	0	0	0	0	0

FISCAL YEAR	Average GS Grade
2017	12.9
2018	12.8
2019	13.1
2020	13.1
2021	13.1

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Detail of Positions[1]

GRADE	FY 2019 Final	FY 2020 Enacted	FY 2021 President's Budget
Total, ES Positions	0	0	0
Total, ES Salary	0	0	0
GM/GS-15	12	12	12
GM/GS-14	22	23	23
GM/GS-13	18	20	20
GS-12	3	3	3
GS-11	2	2	2
GS-10	2	2	2
GS-9	3	3	3
GS-8	0	0	0
GS-7	3	3	3
GS-6	0	0	0
GS-5	0	0	0
GS-4	0	0	0
GS-3	0	0	0
GS-2	0	0	0
GS-1	0	0	0
Subtotal	65	68	68
Grades established by Act of July 1, 1944 (42 U.S.C. 207)	-	-	-
Assistant Surgeon General	0	0	0
Director Grade	0	0	0
Senior Grade	0	0	0
Full Grade	0	0	0
Senior Assistant Grade	0	0	0
Assistant Grade	0	0	0
Subtotal	0	0	0
Ungraded	33	37	37
Total permanent positions	65	68	68
Total positions, end of year	98	105	105
Total full-time equivalent (FTE) employment, end of year	93	102	102
Average ES salary	0	0	0
Average GM/GS grade	13.1	13.1	13.1
Average GM/GS salary	117,527	121,640	122,857

[1] Includes FTEs whose payroll obligations are supported by the NIH Common Fund.