(dollars in thousands)

	FY 2019 Enacted	FY 2020 Enacted	FY 2021 President's Request	FY 2021 Request vs. FY 2020 Enacted	
				$	%
Office of Science					
Advanced Scientific Computing Research	935,500	980,000	988,051	+8,051	+0.8%
Basic Energy Sciences	2,166,000	2,213,000	1,935,673	-277,327	-12.5%
Biological and Environmental Research	705,000	750,000	516,934	-233,066	-31.1%
Fusion Energy Sciences	564,000	671,000	425,151	-245,849	-36.6%
High Energy Physics	980,000	1,045,000	818,131	-226,869	-21.7%
Nuclear Physics	690,000	713,000	653,327	-59,673	-8.4%
Workforce Development for Teachers and Scientists	22,500	28,000	20,500	-7,500	-26.8%
Science Laboratories Infrastructure	232,890	301,000	174,110	-126,890	-42.2%
Safeguards and Security	106,110	112,700	115,623	+2,923	+2.6%
Program Direction	183,000	186,300	190,306	+4,006	+2.2%
Total, Office of Science	**6,585,000**	**7,000,000**	**5,837,806**	**-1,162,194**	**-16.6%**

Appropriation Overview

The Office of Science (SC) is the nation's largest Federal supporter of basic research in the physical sciences and funds programs in physics, chemistry, materials science, biology, environmental science, applied mathematics, and computer and computational science. The SC portfolio has two principal thrusts: direct support of scientific research, and direct support of the design, development, construction, and operation of unique, open-access scientific user facilities. The SC basic research portfolio includes extramural grants and contracts supporting over 23,000 researchers located at over 300 institutions and the 17 DOE national laboratories, spanning all fifty states and the District of Columbia. The portfolio of 28 scientific user facilities serves over 33,000 users per year. SC programs invest in foundational science, including basic research for the advancement of clean energy, to transform our understanding of nature and strengthen the connection between advances in fundamental science and technology innovation.

The SC Request includes ongoing investments to support the Administrations Industies of the Future (IOTF) initiative through research in quantum information sciences (QIS) and artificial intelligence (AI) and machine learning (ML). The Request also supports research efforts in next-generation microelectronics, genomic sciences to inform biosecurity research, and critical scientific infrastructure needs at DOE laboratories. The Request also initiates several new multidisciplinary research initiatives including: data and computational collaboration with NIH, integrated computational and data infrastructure for scientific discovery, next generation biology, rare earth and separation science, revolutionizing polymer upcycling, and strategic accelerator technology. These new initiatives position SC to meet new research demands in an enhanced collaborative effort.

Program Highlights

- **Advanced Scientific Computing Research**
  Advanced Scientific Computing Research (ASCR) supports advanced computational research, applied mathematics, and computer science, as well as development and operation of multiple, large, high performance and leadership computing user facilities and high performance networking. The efforts prioritize basic research in applied mathematics and computer science with emphasis on the challenges of data intensive science, including AI and ML, and future computing technologies. The Request increases support for ASCR's Computational Partnerships with a focus on developing strategic partnerships in quantum computing and data intensive applications, and new partnerships that broaden the impact of both exascale and data infrastructure investments in areas of strategic importance to DOE and SC. The Request funds:
  - Research, development, and design activities to achieve exascale-capable systems with a five fold improvement in true application performance over the Summit system at the Oak Ridge Leadership Computing Facility.

- Foundational research to improve the robustness, reliability, and transparency of Big Data and AI technologies, uncertainty quantification, and development of software tools and initiation of an activity to deploy AI software and technologies to create an integrated computational and data infrastructure across the SC programs and laboratories.
- Support of core research in applied mathematics and computer science, the Scientific Discovery through Advanced Computing (SciDAC) program, and strategic partnerships aimed at understanding the challenges that quantum information and neuromorphic technologies pose to DOE mission applications.
- Support for partnerships with BES, HEP and FES in microelectronics and new data, and AI partnerships with NIH.
- In partnership with other SC programs, continuing support for QIS centers to promote basic research and early stage development to accelerate the advancement of QIS through vertical integration between systems and theory and hardware and software. In addition to the QIS centers, support for early stage research associated with the first steps to establish a dedicated Quantum Network.
- Operations and preparation for upgrades at ASCR's four scientific user facilities, including site preparations and non-recurring engineering efforts at the Leadership Computing Facilities.

- **Basic Energy Sciences**

  Basic Energy Sciences (BES) supports fundamental research to understand, predict, and ultimately control matter and energy at the electronic, atomic, and molecular levels in order to provide the foundations for new energy technologies, to mitigate the environmental impacts of energy use, and to support DOE missions in energy, environment, and national security. The Request funds:
  - Core research activities to support Administration Priorities including QIS, next-generation microelectronics, data analytics and machine learning for data-driven science (AI/ML), exascale computing, next-generation biology, critical materials, polymer upcycling, and strategic accelerator technology.
  - Continuing support for the Energy Frontier Research Centers (EFRCs) as well as the Batteries and Energy Storage and the Fuels from Sunlight Energy Innovation Hubs.
  - Computational materials and chemical sciences to deliver shared software infrastructure to the research communities as part of the Exascale Computing Initiative.
  - In partnership with other SC programs, continuing support for QIS centers to promote basic research early stage development to accelerate the advancement of QIS through vertical integration between systems and theory and hardware and software.
  - Continuing operation of BES user facilities near optimal levels: five x-ray light sources, two neutron scattering sources, and five research centers for nanoscale science that also supports QIS research and related tools development.
  - Five ongoing construction projects: the Advanced Photon Source Upgrade(APS-U), the Advanced Light Source Upgrade (ALS-U) project, the Linac Coherent Light Source-II High Energy (LCLS-II-HE) project, the Proton Power Upgrade (PPU) project at the SNS, and the Second Target Station (STS).
  - Continuing support for two Major Item of Equipment projects: the NSLS-II Experimental Tools-II (NEXT-II) project to continue the phased build-out of beamlines at NSLS-II, and the Nanoscale Science Research Centers Recapitalization project.
  - A new construction project for a Cryomodule Repair and Maintenance Facility (CRMF).

- **Biological and Environmental Research**

  Biological and Environmental Research (BER) supports fundamental research to understand complex biological, biogeochemical, and physical principles of natural systems at scales extending from the genome of microbes and plants to the environmental and ecological processes at the scale of the planet Earth. The Request funds:
  - Core research in biological systems science using approaches such as genome sequencing, secure biodesign, proteomics, metabolomics, structural biology, high-resolution imaging and characterization, including full support of the Bioenergy Research Centers. Integration of this experimental biological information into computational modelsfor iterative testing and validation to advance a predictive understanding of biological systems for use in secure, clean, affordable, and reliable energy for adaptation to industry, as well as contributing to QIS.
  - New efforts in translating biodesign rules to functional properties of novel biological polymers.

- Core research in earth and environmental systems science, with activities focused on scientific analysis and modeling of the sensitivity and uncertainty of Earth system predictions to atmospheric, cryospheric, oceanic, and biogeochemical processes, with continued support of the Energy Exascale Earth System Model.
- Continuing operation of the three BER scientific user facilities: the Joint Genome Institute, the Atmospheric Radiation Measurement Research Facility, and the Environmental Molecular Sciences Laboratory.

- **Fusion Energy Sciences**
  Fusion Energy Sciences (FES) supports research to understand matter at very high temperatures and densities and to build the scientific foundation needed to develop a fusion energy source The Request funds:
  - Research and facility operations at the DIII-D national fusion facility to support the study of high-priority topics identified by community research needs workshops.
  - The National Spherical Torus Experiment Upgrade (NSTX-U) recovery to implement repairs and corrective actions required to obtain robust, reliable research operations, and enhanced collaborative research at other facilities to support NSTX-U research program priorities.
  - Research opportunities for U.S. scientists at overseas superconducting tokamaks and stellerators and other international facilities with unique capabilities, enabled by U.S. hardware and intellectual contributions.
  - In partnership with other SC programs, continuing support for QIS centers to promote basic research early stage development to accelerate the advancement of QIS through vertical integration between systems and theory and hardware and software.
  - Support for SciDAC in partnership with ASCR, research in high-energy-density laboratory plasma science, and discovery plasma science.
  - The U.S. Contribution to the ITER project, focusing on the highest-priority First Plasma hardware components, including the continued fabrication of the central solenoid superconducting magnet modules.
  - Initial design funding for an experimental research end-station at the Linac Coherent Light Source User Facility for the Matter in Extreme Conditions Petawatt upgrade project.
  - The Materials-Plasma Exposure eXperiment project, which will be a world-leading facility for dedicated studies of reactor-relevant heat and particle loads on fusion materials.

- **High Energy Physics**
  High Energy Physics (HEP) supports research to understand how the universe works at its most fundamental level, enabling the discovery of the most elementary constituents of matter and energy, the probing of the interactions among them, and the exploration of the basic nature of space and time. The Request funds:
  - Core research activities to support Administration Priorities: QIS, which opens prospects for new capabilities in sensing, simulation, and computing in support of the National Quantum Initiative; AI/ML, to address cross cutting challenges across the HEP program in coordination with DOE investments in exascale computing and associated AI efforts; next-generation microelectronics; and the Accelerator Traineeship Program for expanded workforce development in research areas of Advanced Technology R&D.
  - Continuing support for QIS centers to promote basic research and early stage development necessary to accelerate the advancement of QIS through vertical integration between systems and theory and hardware and software.
  - Core research activities, with emphasis on the physics of the Higgs boson, neutrinos, dark matter, and dark energy; exploring the unknown; and enabling early and visible scientific results from HEP project investments.
  - R&D that requires long-term investments, including Advanced Technology R&D, Accelerator Stewardship, and cross-cutting efforts in QIS and AI/ML to accelerate discovery in particle physics.
  - Continuing operation of HEP user facilities: Fermilab Accelerator Complex consists of four accelerators that work together to provide world-class particle beams for experiments at the Intensity Frontier; Brookhaven Accelerator Test Facility (ATF) provides high power lasers synchronized with high brightness electron beams, to explore the science of particle acceleration and radiation generation, and to develop new accelerator technologies; and SLAC Facility for Advanced Accelerator Experimental Tests (FACET) provides beam-driven plasma wakefield particle acceleration to carry out experiments.
  - Continuing support to Sanford Underground Research Facility (SURF) to meet DOE expectations of reliable, efficient, and safe operations during the construction of Long Baseline Neutrino Facility/Deep Underground Neutrino Experiment (LBNE/DUNE).

- Continuing support for the highest priority projects identified by the high energy physics community to include Fermilab-hosted LBNF/DUNE and Proton Improvement Plan-II (PIP-II), which will provide the world's highest proton beam intensity of greater than 1.2 megawatts, and the CERN-based, High-Luminosity Large Hadron Collider (HL-LHC) Accelerator, and A Toroidal LHC Apparatus (ATLAS) and Compact Muon Solenoid (CMS) Detector Upgrade Projects, supported in collaboration with international partners.
- Initial funding for the Cosmic Microwave Background-Stage 4 (CMB-S4) Major Item of Equipment. The sensitivity necessary to test the inflation model of cosmology requires designing the next generation CMB project. CMB-S4 will also provide information about dark energy and neutrino properties.
- Design studies support for a new Fermilab Accelerator Control System. Much of the Fermilab accelerator control system dates from the original 1970's construction. Upgrading the control system will allow the Fermilab Accelerator Complex to operate more precisely and efficiently, resulting in better performance and lower operating costs.

- **Nuclear Physics**

  Nuclear Physics (NP) supports research to discover, explore, and understand all forms of nuclear matter The Request funds:
  - High priority world-class nuclear physics research in Quantum Chromodynamics, Nuclei and Nuclear Astrophysics, and Fundamental Symmetries at universities and laboratories and preservation of critical core competencies.
  - Support for QIS efforts to enable precision NP measurements, development of quantum sensors based on atomic-nuclear interactions, and development of quantum computing algorithms, in support of the National Quantum Initiative.
  - Support for the DOE Isotope Program as it continues to introduce new medical isotopes for clinical trials and cancer therapy.
  - Operations of NP Facilities including: the Relativistic Heavy Ion Collider; the 12 GeV Continuous Electron Beam Accelerator Facility; the Argonne Tandem Linac Acceleratory System; and the Facility for Rare Isotope Beams(FRIB).
  - New initiatives in AI and Strategic Accelerator Research and Development to achieve groundbreaking advances in these fields related to Nuclear Physics.
  - Support for final efforts to complete the FRIB at Michigan State University consistent with the performance baseline profile. FRIB will provide world-leading capabilities for nuclear structure and nuclear astrophysics.
  - Continuation of engineering design of the U.S. Stable Isotope Production and Research Center (SIPRC) at ORNL to increase the domestic production capabilities of stable isotopes for scientific, industrial, national security, and medical uses.
  - Continuing support for R&D and design activities for the Electron Ion Collider at BNL.
  - Continuing design and long-lead activities for the SIPRC to mitigate U.S. dependence on foreign sources of enriched stable isotopes for research and applications.
  - Support for fabrication of new NP scientific equipment: the Gamma-Ray Energy Tracking Array Major Item of Equipment (MIE), which will enable the provisioning of advanced, high resolution gamma ray detection capabilities for FRIB and the sPHENIX MIE, which will have enhanced capabilities that will further RHIC's scientific mission by studying high rate jet production; the High Resolution Spectrometer (HRS) to study fast neutron beams at FRIB, the Ton-scale Neutrinoless Double Beta Decay MIE experiment to determine whether the neutrino is its own antiparticle; and the Measurement of a Lepton-Lepton Electroweak Reaction (MOLLER), which will measure the parity-violating asymmetry in electron-electron scattering with the 12 GeV CEBAF machine.

- **Workforce Development for Teachers and Scientists**

  Workforce Development for Teachers and Scientists (WDTS) ensures that DOE has a sustained pipeline of science, technology, engineering, and mathematics workers to meet national goals and objectives, now and in the future.

- **Science Laboratories Infrastructure**
  Science Laboratories Infrastructure (SLI) sustains mission-ready infrastructure and safe and environmentally responsible operations by providing the infrastructure necessary to support leading edge research at the ten SC DOE national laboratories. The Request funds:
  - Three new construction projects: Princeton Plasma Innovation Center and Critical Infrastructure Recovery & Renewal project at Princeton Plasma Physics Laboratory (PPPL), and the Infrastructure Modernization project at Ames.
  - Continuation of 15 ongoing construction projects: the Critical Utilities Rehabilitation project and the Science User Support Center at Brookhaven National Laboratory (BNL); the Seismic and Safety Modernization project, the Linear Assets Modernization project, and the Biological and Environmental Program Integration Center (BioEPIC) at Lawrence Berkeley National Laboratory (LBNL); the CEBAF Renovation and Expansion at Thomas Jefferson National Accelerator Facility (TJNAF); the Craft Resources Support Facility and the Translational Research Capability project at Oak Ridge National Laboratory (ORNL); the Critical Utilities Infrastructure Revitalization project and Large Scale Collaboration Center at SLAC National Accelerator Laboratory (SLAC); the Argonne Utilities Upgrade at Argonne National Laboratory (ANL); the Energy Sciences Capability project at Pacific Northwest National Laboratory (PNNL); the Utilities Infrastructure project and the Integrated Engineering Research Center at Fermi National Accelerator Laboratory (FNAL); and the Tritium System Demolition and Disposal project at PPPL.
  - General purpose infrastructure projects that will address inadequate core infrastructure and utility needs; and support for Payment in Lieu of Taxes, nuclear facilities at ORNL, and landlord responsibilities at the Oak Ridge Reservation.

- **Safeguards and Security**
  Safeguards and Security (S&S) program supports appropriate security measures are in place for the SC mission requirement of open scientific research and to protect critical assets within SC national laboratories. S&S increases by $2.9 million, or 2.6 percent, above the FY 2020 Enacted level. The Request funds:
  - Continued implementation of the Design Basis Threat and Science and Technology Policy mandated physical security modifications at SC laboratories, starting with highest priorities including the protection of personnel.

- **Science Program Direction**
  Program Direction (PD) supports the skilled and motivated Federal workforce that plans, develops, and oversees SC investments in world-leading basic research and scientific user facilities, and provides critical oversight to ten of DOE's national laboratories. The Request funds Salaries and Benefits, Travel, Support Services, Other Related Expenses, and Working Capital Fund requirements.