Science
(dollars in thousands)

FY 2020 Enacted	FY 2021 Enacted	FY 2022 Request
$7,000,000	$7,026,000	$7,440,000

Overview

The Office of Science's (SC) mission is to deliver scientific discoveries and major scientific tools to transform our understanding of nature and advance the energy, economic, and national security of the United States. SC is the Nation's largest Federal sponsor of basic research in the physical sciences and the lead Federal agency supporting fundamental scientific research for our Nation's energy future.

SC accomplishes its mission and advances national goals by supporting:

- *The frontiers of science*—exploring nature's mysteries from the study of fundamental subatomic particles, atoms, and molecules that are the building blocks of the materials of our universe and everything in it to the DNA, proteins, and cells that are the building blocks of life. Each of the programs in SC supports research probing the most fundamental disciplinary questions.
- *The 21st Century tools of science*—providing the nation's researchers with 28 state-of-the-art national scientific user facilities, the most advanced tools of modern science, propelling the U.S. to the forefront of science, technology development, and deployment through innovation.
- *Science for energy and the environment*—paving the knowledge foundation to spur discoveries and innovations for advancing the Department's mission in energy and environment. SC supports a wide range of funding modalities from single principal investigators to large team-based activities to engage in fundamental research on energy production, conversion, storage, transmission, and use, and on our understanding of the earth systems.

SC is an established leader of the U.S. scientific discovery and innovation enterprise. Over the decades, SC investments and accomplishments in basic research and enabling research capabilities have provided the foundations for new technologies, businesses, and industries, making significant contributions to our nation's economy, national security, and quality of life. Select scientific accomplishments in FY 2020 enabled by the SC programs are described in the program budget narratives. Additional descriptions of recent science discoveries can be found at https://science.osti.gov/bes/Highlights/2020.

Highlights and Major Changes in the FY 2022 Request

The FY 2022 Request for SC is $7,440.0 million, an increase of 5.9 percent above the FY 2021 Enacted level, to implement the Administration's objectives in order to advance bold, transformational leaps in U.S. science and technology (S&T), build a diverse workforce of the future, and ensure America remains the global S&T leader for generations to come. The FY 2022 Request supports a balanced research portfolio of basic scientific research probing some of the most fundamental questions in areas such as: high energy, nuclear, and plasma physics; materials and chemistry; biological and environmental systems; applied mathematics; next generation high-performance computing and simulation capabilities; isotope production; and basic research to advance new energy technologies.

The Request increases investments in Administration priorities including basic research on climate change and clean energy, fundamental science to transform manufacturing, and biopreparedness. SC initiates a new activity, Reaching a New Energy Sciences Workforce (RENEW), for targeted efforts to increase participation and retention of underrepresented groups in SC research activities. The request also supports ongoing investments in priority areas including microelectronics, critical materials, quantum information science (QIS), artificial intelligence (AI) and machine learning (ML), exascale computing, integrated computational and data infrastructure for scientific discovery, and accelerator science and technology. These new and ongoing initiatives position SC to meet new research demands through more collaborative, cross-program efforts.

The Request supports SC's basic research portfolio, which includes extramural grants and contracts supporting nearly 28,000 researchers located at over 300 institutions and the 17 DOE national laboratories, spanning all fifty states and the District of Columbia. In FY 2022, SC's suite of 28 scientific user facilities will continue to provide unmatched tools and

capabilities for over 36,000 users per year from universities, national laboratories, industry, and international partners. The Request will also support the construction of new and upgraded user facilities and the R&D necessary for future facilities to continue to provide world class research capabilities to U.S. researchers. SC allocates Working Capital Fund charges for common administrative services to the research programs and the Program Direction account.

Highlights of the FY 2022 Request by Program Office include:

- *Advanced Scientific Computing Research (ASCR)* supports research to discover, develop, and deploy computational and networking capabilities to analyze, model, simulate, and predict complex phenomena important to the DOE and the United States. The ASCR Request of $1,040.0 million, is an increase of $25.0 million, or 2.5 percent, above the FY 2021 Enacted level. The Request will strengthen U.S. leadership in strategic computing with operation of the Nation's first exascale computing system, Frontier, at Oak Ridge National Laboratory, and deployment of a second system, Aurora, at Argonne National Laboratory. The Request also broadens the foundations of AI and QIS, and expands the infrastructure that enables data-driven science. The Request increases support for the Computational Science Graduate Fellowship and the initiation of a new activity, RENEW, to increase participation and retention of underrepresented groups in areas relevant to ASCR. The Request includes $404.0 million for SC's contribution to DOE's Exascale Computing Initiative (ECI) to deploy an exascale computing software ecosystem and mission critical applications to address national needs. A total of $275.0 million of this effort will go to the Leadership Computing Facilities to deploy and operate the exascale systems and testbeds, as well as support early science users and Exascale Computing Project (ECP) project teams. To ensure continued progress during and after the ECI, this Request prioritizes basic research for AI/ML with a focus on foundational research and data intensive science and on future computing and networking technologies, including QIS and a DOE quantum internet. The Request also supports the design of a state-of-the-art scientific high-performance computing data facility focused on the unique challenges of near real-time computing needed to support the explosion of SC scientific data that will serve as the anchor for the integrated computational and data infrastructure initiative efforts. The Request increases support for ASCR's Computational Partnerships and Research and Evaluation Prototypes with a focus on continuing strategic partnerships in quantum computing and networking including the partnerships with other Science programs to support the five QIS Research Centers selected in FY 2020 and other testbeds. New partnerships will enhance DOE's ability to rapidly respond to national emergencies, understand earth systems, develop new clean energy technologies, and facilitate research at DOE facilities. The Request also provides strong support for ASCR user facilities operations to ensure the availability of high performance computing and networking to the scientific community and upgrades to maintain U.S. leadership in these essential areas. This includes planning for an upgrade to National Energy Research Scientific Computing Center and continuing the ESnet-6 upgrade.

- *Basic Energy Sciences (BES)* supports fundamental research to understand, predict, and ultimately control matter and energy at the electronic, atomic, and molecular levels to provide foundations for new energy technologies. The BES Request of $2,300.0 million is an increase of $55.0 million, or 2.4 percent, above the FY 2021 Enacted level. The Request focuses resources toward early-stage fundamental research, the operation and maintenance of a complementary suite of scientific user facilities, and the highest priority facility upgrades. High priority areas in core research include clean energy research, critical materials/minerals research, manufacturing including microelectronics and polymer upcycling, national preparedness, QIS, data science and related infrastructure, exascale computing, and accelerator science and technology. The Request increases funding for the Energy Frontier Research Centers, with a focus on clean energy research. The Request continues support for the multi-disciplinary QIS Research Centers to promote basic research and early-stage development to accelerate the advancement of QIS. The Request continues support for computational materials and chemical sciences to deliver shared software infrastructure to the research communities as part of the exascale computing initiative and supports the Batteries and Energy Storage and the Fuels from Sunlight Energy Innovation Hub awards. The Request also provides funds for the DOE Established Program to Stimulate Competitive Research. BES maintains a balanced suite of complementary tools, including supporting operations of five x-ray light sources and two neutron sources at greater than 90 percent of optimal, and supports the five nanoscale science research centers. Funding is provided for projects nearing completion: the Advanced Photon Source Upgrade project and the Linac Coherent Light Source-II project. The Request provides continued support for the ongoing construction activities for the Advanced Light Source Upgrade project, the Linac Coherent Light Source-II High Energy project, the Proton Power Upgrade project, the Second Target Station project, and the Cryomodule Repair and

Maintenance Facility. The Request continues two Major Item of Equipment projects: the NSLS-II Experimental Tools-II project for the phased build-out of beamlines at NSLS-II and the NSRC Recapitalization project. BES will participate in the RENEW activity with targeted efforts to increase participation and retention of underrepresented groups in areas relevant to BES.

- *Biological and Environmental Research (BER)* supports transformative science and scientific user facilities to achieve a predictive understanding of complex biological, earth, and environmental systems for energy and infrastructure security, independence, and prosperity.
  - BER's support of basic research will contribute to a future of stable, reliable, and resilient energy sources and infrastructures, that will lead to climate solutions, strengthen economic prosperity, and assure environmental justice. The BER Request of $828.0 million is an increase of $75.0 million, or 10.0 percent, above the FY 2021 Enacted level. All BER research is also informed by the community and the federally chartered BER Advisory Committee. The Request for Biological Systems Science supports initiation of the Biopreparedness Research Virtual Environment (BRaVE) to provide a single portal through which a distributed network of capabilities and scientists can work together on multidisciplinary and multiprogram priorities. Support continues for the four Bioenergy Research Centers, performing new fundamental research underpinning the production of fuels and chemicals from sustainable biomass and developing new technological advances for translation of basic research results to industry. Computational Biosciences will integrate prior microbiome efforts within the DOE Systems Biology Knowledgebase to develop integrated networks and computational models of system dynamics and behavior. Research in Biomolecular Characterization and Imaging Science will develop QIS-enabled techniques and advanced sensors for biological research.
  - Earth and Environmental Systems Sciences research activities will focus on Earth system predictions. Urban Integrated Field Laboratories will be initiated, dedicated to the development of an integrated science framework to advance climate and energy research enabling the evaluation of the societal and environmental impacts of current and future energy policies. The Request establishes the National Virtual Climate Laboratory (NVCL) serving as a one stop portal to advance access to climate science from the DOE National Laboratories. The NVCL engagement with the science community will focus on access to local and regional climate science to Minority Serving Institutions (MSIs) and Historically Black Colleges or Universities (HBCUs), connecting frontline communities with the key climate science capabilities at the DOE national laboratories. Planning begins for the National Climate Laboratory or Center affiliated with an HBCU or MSI. The Energy Exascale Earth System Model (E3SM) will include advanced software for running on numerous processors, flexibility toward future DOE computer architectures including exascale systems. Environmental System Science integrates physical and hydrobiogeochemical sciences to provide a predictive understanding of above- and below-surface terrestrial ecosystems. Atmospheric System Research will investigate cloud-aerosol-precipitation interactions using a broad range of observations to support the E3SM capability at spatial scales of 10 km. The Data Management effort will enhance data archiving and management capabilities, including AI/ML tools. Across BER, the new Integrated Computational and Data Infrastructure for Scientific Discovery will deploy a flexible multi-tier data and computational management architecture, including new 5G capabilities. The Request supports operations of BER's three scientific user facilities: the DOE Joint Genome Institute, the Environmental Molecular Sciences Laboratory, and the Atmospheric Radiation Measurement Research Facility (ARM). The ARM user facility will continue acceptance testing and evaluation of the aerial capability Major Item of Equipment acquired in FY 2019. All BER facilities will begin a multiyear instrumentation refresh to ensure these facilities are delivering the state-of-the-art capabilities required by the scientific community. BER will participate in the RENEW activity with targeted efforts to increase participation and retention of underrepresented groups in areas relevant to BER.

- *Fusion Energy Sciences (FES)* supports research to expand the fundamental understanding of matter at very high temperatures and densities and to build the scientific foundation needed to develop a fusion energy source. The FES Request of $675.0 million is a increase of $3.0 million, or 0.4 percent, above the FY 2021 Enacted level. The Request is aligned with the recommendations of the recent Long-Range Plan developed by the Fusion Energy Sciences Advisory Committee. It supports research and facility operations at the DIII-D national fusion facility at 90% of the optimal run time to optimize the tokamak approach to magnetic confinement fusion; continues to support the recovery of the National Spherical Torus Experiment-Upgrade (NSTX-U) and enhanced collaborative research at other facilities to

support NSTX-U research program priorities; and continues to support collaborations by U.S. scientists at overseas superconducting tokamaks and stellarators and other international facilities with unique capabilities. The Request supports research activities in Materials, Fusion Nuclear Science, and Enabling R&D; supports research in QIS both at the QIS Research Centers established in FY 2020 and for core research addressing FES priorities; and continues to support Scientific Discovery through Advanced Computing in partnership with ASCR, research in High-Energy-Density Laboratory Plasma science including LaserNetUS, and General Plasma Science including low-temperature plasmas and microelectronics. The Request expands partnerships with the private sector through the Innovation Network for Fusion Energy program; provides support for the U.S. Contributions to ITER project focusing on the design, fabrication, and delivery of in-kind hardware components and providing construction cash contributions to support the ITER Organization assembly and installation of the hardware contributions from all the ITER Members; and initiates an ITER Research program to start preparing the U.S. fusion community to take full advantage of ITER operations after First Plasma. The Request provides funding for the Matter in Extreme Conditions Petawatt Laser Facility upgrade project at the Linac Coherent Light Source; supports the Materials-Plasma Exposure eXperiment MIE project, which will be a world-leading facility for dedicated studies of reactor-relevant heat and particle loads on fusion materials; and addresses a key recommendation in the Long-Range Plan by supporting a new activity entitled "Future Facilities Studies" focused on the design of next step facilities like a Fusion Pilot Plant. FES will participate in the RENEW activity with targeted efforts to increase participation and retention of underrepresented groups in areas relevant to FES.

- *High Energy Physics (HEP)* supports research to understand how the universe works at its most fundamental level by discovering the most elementary constituents of matter and energy, probing the interactions among them, and exploring the basic nature of space and time itself. The HEP Request of $1,061.0 million is an increase of $15.0 million, or 1.4 percent, above the FY 2021 Enacted level. The Request will focus support on the highest priority elements identified in the 2014 High Energy Physics Advisory Panel Particle Physics Project Prioritization Panel (P5) Report. Support for Research will prioritize efforts that address the P5 science drivers of particle physics, Higgs boson, neutrinos, dark matter, dark energy, and exploring the unknown, and enable early and visible science results from HEP project investments. In coordination with SC, HEP will support the Integrated Computational and Data Infrastructure for Scientific Discovery development of data storage capabilities to handle tens of exabytes of data from future experiments; cross-cutting efforts in AI/ML and edge computing to seek solutions for real-time and extremely high data rate environments; and investments in software development to improve the interface with SC infrastructure and ASCR-supported middleware. HEP will increase QIS R&D and will continue support for multi-disciplinary QIS Research Centers initiated in FY 2020 to accelerate the advancement of QIS through integration between systems and theory, and hardware and software. In coordination with the Accelerator R&D and Production program, HEP will continue and increase support for the Accelerator Science and Technology Initiative to support mid- to long-term R&D to maintain a leading position in key accelerator technologies that define SC's competitive advantage. AI/ML research will continue to tackle the challenges of managing increasingly high volumes and complexity of HEP experimental and simulated data, and to address cross-cutting challenges across the HEP program in coordination with DOE investments in exascale computing and associated AI efforts. HEP research will continue support for multi-disciplinary microelectronics research, including 5G, with ASCR, BES and FES, to accelerate the advancement of microelectronic technologies. The P5 report identified the High-Luminosity Large Hadron Collider accelerator and A Toroidal LHC Apparatus and Compact Muon Solenoid Detector Upgrade Projects as the highest priority in the near-term, and Long-Baseline Neutrino Facility and Deep Underground Neutrino Experiment as the highest-priority large project in its timeframe. To continue SC's strong international partnership with CERN, the FY 2022 Request will support these high-priority projects, and the Proton Improvement Plan-II construction project. The Request will support a new MIE start for the Accelerator Controls Operations Research Network project and will continue support for the next generation Cosmic Microwave Background experiment. The Request will support the operation of the Fermilab Accelerator Complex at 90 percent of optimal, the SLAC Facility for Advanced Accelerator Experimental Tests II operations at 90 percent of optimal, and investments to enhance the Sanford Underground Research Facility to meet DOE expectations for reliable, efficient, and safe operations. Finally, in the FY 2022 Request, the Accelerator Stewardship subprogram moves to the Accelerator R&D and Production program. HEP will participate in the RENEW activity with targeted efforts to increase participation and retention of underrepresented groups in areas relevant to HEP.

- *Nuclear Physics (NP)* supports experimental and theoretical research to discover, explore, and understand all forms of nuclear matter. The NP Request of $720.0 million is a increase of $7.0 million, or 1.0 percent, above the FY 2021

Enacted level. The Request supports safe efficient, and cost-effective operations of four NP scientific user facilities. The Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory recreates new forms of matter and phenomena that occurred in the infant universe. The Continuous Electron Beam Accelerator Facility (CEBAF) at Thomas Jefferson National Accelerator Facility (TJNAF or JLab) extracts information on quarks and gluons bound inside protons and neutrons that formed shortly after the universe began to cool. The Argonne Tandem Linear Accelerator System gently accelerates nuclei to energies typical of nuclear reactions in the cosmos to further our understanding of the ongoing synthesis of heavy elements such as gold and platinum. To maintain U.S. leadership throughout this century and to extend well beyond current scientific capabilities. NP also supports operations of the newly-constructed Facility for Rare Isotope Beams (FRIB) facility and research programs that will begin in FY 2022, and R&D and Preliminary Engineering Design for the Electron-Ion Collider project. The Request also supports non accelerator-based research using the nucleus as a laboratory to search for new physics by observing nature's fundamental symmetries and precision measurements to determine the properties of the neutron and whether the neutrino is its own anti-particle. The Request continues to support the construction of world-leading instrumentation, including the Gamma-Ray Energy Tracking Array, the super Pioneering High Energy Nuclear Interaction eXperiment at RHIC, High Rigidity Spectrometer to realize the full scientific potential of FRIB, and the Measurement of a Lepton-Lepton Electroweak Reaction MIE at JLab. The Request also supports university and laboratory researchers to nurture critical core competencies and enable the highest priority theoretical and experimental activities to target compelling scientific opportunities at the frontier of nuclear science. NP is the primary steward of the nation's fundamental nuclear physics research portfolio providing over 91 percent of the investment in U.S. nuclear physics basic research. The Request also supports the National Nuclear Data Center which collects, evaluates, curates, and disseminates nuclear physics data for basic nuclear research and applied nuclear technologies for global use. Efforts on QIS, in collaboration with other SC programs, for the development of quantum sensors and quantum control techniques continue, as do efforts on data analytics for autonomous decision making which can benefit nuclear physics research and NP accelerator operations. The Request supports the Accelerator Science and Technology initiative to pursue next generation electron ion source developments and advanced approaches in superconducting radio frequency technologies. The Request also supports participation in microelectronics and Integrated Computational & Data Infrastructure for cross-cutting cloud solutions to Big Data storage challenges in Nuclear Physics. NP will participate in the RENEW activity with targeted efforts to increase participation and retention of underrepresented groups in areas relevant to NP. Beginning in the FY 2022 Request, the Isotope Development and Production for Research and Applications subprogram is now a separate program. Funds are requested under the new Isotope R&D and Production Program within SC.

- *Isotope R&D and Production (IRP)* supports National Preparedness for critical isotope production and distribution to ensure functionality even during times of national crisis; efforts focus on mitigating U.S. dependence on foreign supply of key isotopes. The IRP Request is $90.0 million. Isotopes are high-priority commodities of strategic importance for the nation and are essential in medical diagnosis and treatment, discovery science, national security, industrial processes and manufacturing, space exploration and communications, biology, archeology, quantum science and other fields. The Request supports transformative research to develop new or improved production and separation techniques for high priority isotopes in short supply. A high priority remains the dedicated research effort to develop large scale production capabilities of the alpha-emitter actinium-225 (Ac-225), a high priority isotope that has shown stunning success in the treatment of diffuse cancers and infections. The implementation of the Stable Isotope Production Facility MIE continues, with support for pre-operations activities. The Request continues support for the U.S. Stable Isotope Production and Research Center, which will significantly enhance stable isotope production capacity for the nation. The Request continues the FRIB Isotope Harvesting research effort, which adds capabilities to extract and process significant quantities of isotopes from the beam dump of FRIB, supported by the Office of Nuclear Physics. The Request enables participation in the SC Fundamental Science to Transform Manufacturing Initiative to pursue transformative approaches to target manufacturing, such as ink jet printing of thin film targets for isotope production, and modular automated systems for radioisotope purification and processing. Research focusses on facilitating the translation of novel radioisotopes and targeted delivery agents from the laboratory to use in clinical trials for both diagnosis and treatment of disease. As part of the BRaVE Initiative, the program tackles what has become an obstacle and single point failure in the program, the processing of irradiated nuclear reactor targets. Funding will develop short-term reactor target processing capabilities at the University of Missouri Research Reactor and further develop the conceptual design of a new long-term facility at ORNL, the ORNL Radioisotope Processing Facility. Increased investment in the ongoing QIS initiative advances development of cutting-edge technology for the production of isotopes of

interest to QIS. The Request continues the investment in an Isotope Program Traineeship in research to advance workforce development in areas requiring unique skillsets and broaden the diversity of the available workforce pipeline.

- *Accelerator R&D and Production (ARDAP)* supports cross-cutting basic R&D in accelerator science and technology, access to unique SC accelerator R&D infrastructure, workforce development, and public-private partnerships to advance new technologies for use in SC's scientific facilities and in commercial products. The ARDAP Request of $24.0 million will support fundamental research, operation and maintenance of a scientific user facility, and production of accelerator technologies in industry. The Request supports innovative R&D and deployment of accelerator technology, the formation of topically-focused multi-institutional collaborations for accelerator R&D, and workforce development. The Request supports operation of the Brookhaven National Laboratory Accelerator Test Facility for 2,500 hours (100 percent of optimal). Accelerator Production activities support public-private partnerships to develop advanced superconducting wire and cable, superconducting accelerators, and advanced radiofrequency power sources for accelerators.

Reorganization and Restructure Initiative

SC completed the implementation of a reorganization of SC Headquarters in FY 2020. The changes for this reorganization address the needed evolution and re-alignment necessitated by current mission imperatives as well as to position SC for continued success in its strategic priorities. The reorganization established a new Principal Deputy Director position with transferred staff and functions from the existing Deputy Director positions along with new organizational elements. The vacant Deputy Director for Resource Management position was eliminated and the reporting offices and staff reassigned to other SC HQ elements. Also, this reorganization created two new research programs, the Isotope R&D and Production and the Accelerator R&D and Production programs. The FY 2022 Request is the first budget submission with these new research programs. Through workforce analysis and restructuring, SC reviewed, analyzed, and prioritized mission requirements and identified those organizations and functions most in line with the Administration and Department program objectives and SC strategic goals.

Basic and Applied R&D Coordination

Coordination between the Department's basic research and applied technology programs is a high priority within DOE and is facilitated through joint planning meetings, technical community workshops, annual contractor/awardee meetings, joint research solicitations, focused DOE program office working groups in targeted research areas, and collaborative program management of DOE's Small Business Innovation Research and Small Business Technology Transfer programs. Co-funding of research activities and facilities at the DOE National Laboratories and partnership/collaboration-encouraging funding mechanisms facilitate research integration within the basic and applied research communities. SC's R&D coordination also occurs at the interagency level. Specific collaborative activities are highlighted in the "Basic and Applied R&D Coordination" sections of each individual SC program budget justification narrative.

High-Risk, High-Reward Research[a]

SC incorporates high-risk, high-reward, basic research elements in all of its research portfolios; each SC research program considers a significant proportion of its supported research as high-risk, high-reward. Advancing the frontiers of science also depends on the continued availability of state-of-the-art scientific facilities; SC constructs and operates national scientific facilities and instruments that comprise the world's most sophisticated suite of research capabilities. SC's basic research is integrated within program portfolios, projects, and individual awards; as such, it is not possible to quantitatively separate the funding contributions of particular experiments or theoretical studies that are high-risk, high-reward from other mission-driven research in a manner that is credible and auditable. SC incorporates high-risk, high-reward basic research elements in its research portfolios to drive innovation and challenge current thinking, using a variety of mechanisms to develop topics: Federal advisory committees, triennial Committees of Visitors, program and topical workshops, interagency working groups, National Academies' studies, and special SC program solicitations. Many of these topics are captured in formal reports, e.g., *Basic Energy Sciences Roundtable: Chemical Upcycling of Polymers,* Basic Energy Sciences report

[a] In compliance with the reporting requirements in the America COMPETES Act of 2007 (P.L. 110-69, section 1008)

(2019)[a]; *Basic Research Needs for Microelectronics*, joint BES, ASCR, and HEP workshop (2018) [b]; *Basic Research Needs for Scientific Machine Learning; Core Technologies for Artificial Intelligence*, ASCR workshop (2018)[c]; *Building for Discovery: Strategic Plan for U.S. Particle Physics in the Global* Context, by the High Energy Physics Advisory Panel (2014)[d]; *From Long-distance Entanglement to Building a Nationwide Quantum Internet: Report of the DOE Quantum Internet Blueprint Workshop,* ASCR workshop report (2020)[e]; *Basic Energy Sciences Roundtable: Opportunities for Basic Research for Quantum Computing in Chemical and Materials Sciences*, Basic Energy Sciences report (2017); *Basic Energy Science Roundtable: Opportunities for Basic Research for Next-Generation Quantum Systems*, Basic Energy Sciences report (2017) [f]; *Basic Research Needs for Transformative Manufacturing* (2020)[g]; *Basic Research Needs Workshop on Quantum Materials for Energy Relevant Technology,* BES workshop report (2016)[h]; *Grand Challenges for Biological and Environmental Research: Progress and Future* Vision, by the BER Advisory Committee (2017)[i]; *Genome Engineering for Materials Synthesis*, BER workshop report (2018)[j]; *Plasma: at the Frontier of Scientific Discovery*, FES workshop report (2017)[k]; *Powering the Future: Fusion and Plasmas*, FES Advisory Committee Long Range Plan (2020)[l]; *FES Roundtable on QIS* (2018)[m]; *Advancing Fusion with Machine Learning,* joint FES-ASCR workshop report (2019)[n]; *Isotope Research and Production Opportunities and Priorities*, by the Nuclear Science Advisory Committee (NSAC) (2015)[o]; and *Nuclear Physics Long Range Plan*, by the NSAC (2015)[p] and *Quantum Computing and Quantum Information Sciences (QIS),* by the Nuclear Science Advisory Committee (NSAC)[l] (2019).

[a] https://science.osti.gov/-/media/bes/pdf/BESat40/Polymer_Upcycling_Brochure.pdf
[b] https://science.osti.gov/-/media/bes/pdf/reports/2019/BRN_Microelectronics_rpt.pdf
[c] https://science.energy.gov/ascr/community-resources/program-documents/
[d] http://science.osti.gov/~/media/hep/hepap/pdf/May%202014/FINAL_P5_Report_Interactive_060214.pdf
[e] https://www.osti.gov/biblio/1638794/
[f] https://science.osti.gov/~/media/bes/pdf/reports/2018/Quantum_computing.pdf
[g] https://science.osti.gov/-/media/bes/pdf/reports/2020/Transformative_Mfg_Brochure.pdf?la=en&hash=95094B9257DCFD506C04787D96EEDD942EB92EEC
[h] https://science.osti.gov/~/media/bes/pdf/reports/2016/BRNQM_rpt_Final_12-09-2016.pdf
[i] https://science.osti.gov/~/media/ber/berac/pdf/Reports/BERAC-2017-Grand-Challenges-Report.pdf
[j] https://science.osti.gov/-/media/ber/pdf/community-resources/2019/GEMS_Report_2019.PDF?la=en&hash=0D7092AD5416A28207F0F95F94E00921D308A113
[k] https://science.osti.gov/~/media/fes/pdf/program-news/Frontiers_of_Plasma_Science_Final_Report.pdf
[l] https://science.osti.gov/-/media/fes/fesac/pdf/2020/202012/FESAC_Report_2020_Powering_the_Future.pdf?la=en&hash=B404B643396D74CE7EDAB3F67317E326A891C09C
[m] https://science.osti.gov/-/media/fes/pdf/workshop-reports/FES-QIS_report_final-2018-Sept14.pdf
[n] https://science.osti.gov/-/media/fes/pdf/workshop-reports/FES_ASCR_Machine_Learning_Report.pdf
[o] https://science.osti.gov/~/media/ber/pdf/community-resources/Technologies_for_Characterizing_Molecular_and_Cellular_Systems.pdf
[p] https://science.osti.gov/np/nsac/reports/

Scientific Workforce

For more than 60 years SC and its predecessors have fostered the training of a highly skilled scientific workforce. In addition to the undergraduate and graduate research opportunities provided through SC's Office of Workforce Development for Teachers and Scientists, the SC research program offices train undergraduates, graduate students, and postdoctoral researchers through sponsored research awards at universities and the DOE National Laboratories. The research program offices also support targeted undergraduate and graduate-level experimental training in areas associated with scientific user facilities and not readily available in university academic departments, such as particle accelerator and detector physics, neutron and x-ray scattering, nuclear chemistry, and computational sciences at the leadership computing level. To help attract critical talent, SC supports the Early Career Research Program, which funds individual research programs by outstanding Ph.D. scientists early in their careers in the disciplines supported by SC[a]. To retain highly skilled researchers by rewarding scientific excellence and leadership, SC initiated the Distinguished Scientist Fellows opportunity to recognize innovative and accomplished DOE laboratory staff and sponsoring their efforts to develop, sustain, and promote scientific and academic excellence in SC research through collaborations between institutions of higher education and national laboratories. SC coordinates with other DOE offices and other agencies on best practices for training programs and program evaluation through internal DOE working groups and active participation in the National Science and Technology Council's Committee on Science, Technology, Engineering, and Mathematics Education. SC also participates in the American Association for the Advancement of Science's Science & Technology Policy Fellowships program and the Presidential Management Fellows Program to bring highly qualified scientists and professionals to DOE headquarters for a maximum term of two years. The Request initiates a new activity, Reaching a New Energy Sciences Workforce (RENEW), for targeted efforts to increase participation and retention of underrepresented groups in SC research activities. The Office of Science administers and/or bestows several awards to recognize talented scientists and engineers that advance the Department's missions, including the Presidential Early Career Award for Scientists and Engineers (PECASE), Ernest Orlando Lawrence Award, Enrico Fermi Award, and Distinguished Scientist Fellow opportunity. In FY 2022, SC plans to confer up to 10 awards with honorariums of $20,000 each for the Ernest Orlando Lawrence Award.

Cybersecurity

DOE is engaged in two categories of cyber-related activities: protecting the DOE enterprise from a range of cyber threats that can adversely impact mission capabilities and improving cybersecurity in the electric power subsector and the oil and natural gas subsector. SC supports the Cybersecurity Safeguards and Security Departmental Crosscut, which includes central coordination of the strategic and operational aspects of cybersecurity and facilitates cooperative efforts such as the Joint Cybersecurity Coordination Center for incident response, and the implementation of Department-wide Identity, Credentials, and Access Management.

[a] https://science.osti.gov/early-career/